Trip Generation Rate Research

BOSTON REGION MPO METROPOLITAN PLANNING ORGANIZATION

TABLE OF CONTENTS **PAGE**

TABLES

FIGURES

Executive Summary

This research focused on trip generation for the development review process, which typically includes application of Institute of Transportation Engineers (ITE) trip rates or the application of a travel demand model (TDM). This report reviews the range of trip generation estimation approaches, including approaches with sensitivity to area type and active travel modes.

The research also evaluated how trips estimated through the ITE methodologies for selected developments in the Boston Region compare with observed data. Consistent with other studies, the findings of this study show that the ITE over predicts the trip generation.

These comparisons have been interpreted to inform improvements to the ITE trip rates for the Boston Region and to guide enhancements to the Boston Region TDM tools.

The key findings from this study are as follows:

- The selected sample size is insufficient to draw a firm conclusion on the viability of using TDM or ITE in a specific development. Better sample size is needed for any definitive conclusion on specific travel estimation approaches.
- When observed data are compared to ITE estimated trips, land use type showed up as an important factor
    - Residential land use has the least variability between ITE estimates and observed data
    - Retail land use shows a high degree of variability between ITE and observed data
    - The size and mix of the development play an important role in trip estimation.
- Correctly characterizing the area type (that is, urban or suburban) plays an important role in obtaining accurate trip generation rates in the ITE process. For example, the same type of development in two different settings/area types provides very different results.
- Parking availability is a critical variable in trip generation and attraction

Chapter 1—Introduction and Background

1.1 PURPOSE OF THE RESEARCH

The Central Transportation Planning Staff (CTPS), the staff to the Boston Region Metropolitan Planning Organization (MPO), analyzed the forecasting accuracy of trip estimates based on the application of Institute of Transportation Engineers (ITE) trip generation rates to developments in the Boston region. CTPS compared the ITE-based estimates and observed trip making as reported in Travel Monitoring Reports (TMR) for nine recent developments that underwent Massachusetts Environmental Policy Act (MEPA) permitting. CTPS also reviewed approaches to estimating trip making as alternatives to applying the ITE trip generation rates including the Boston region travel demand model, which is maintained by CTPS.

Travel demand models can be applied to estimate trips to and from an area in response to a new development and include sensitivities to the roadway, transit, and nonmotorized networks, accessibility to other households and employment, and land use characteristics. However, travel demand models require a greater effort in data preparation, runtime, and preparing results than the application of ITE trip generation rates. The goal of this research is to identify where trip making estimates based on ITE rates have lower accuracy and inform how a travel demand model could provide more useful information.

According to MEPA and National Environmental Policy Act, any proposed land use development project over certain traffic and environmental thresholds, and involving state or federal land, funds, or action is required to prepare a traffic/transportation impact analysis. This requires an estimation of total trips generated by the development. A common practice for these impact analyses is to apply the rates defined in the ITE *Trip Generation Manual* to estimate the trips associated with each land use component of the proposed development such as households and employment by type. [1]

Trip rates defined in the ITE *Trip Generation Manual* are based on national samples conducted by state and federal agencies as well as private sources. The rates are specific to land uses, time periods, settings, square footage of proposed development, dwelling units, and trip type (vehicle or person). However, due to the nature of the source data, the rates defined in the ITE *Trip Generation Manual* include aggregation error that can be problematic for

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[1] Institute of Transportation Engineers, *Trip Generation Manual*, 10th Edition, 2017; Institute of Transportation Engineers, *Trip Generation Handbook*, 3rd Edition, 2017

application to areas with mature transit systems and mixed-use density. Other studies have found that ITE trip rates overestimate motor vehicle demand for transit-oriented developments and mixed-used developments that have higher rates of transit use and internal capture, respectively. Improved accuracy in these cases would require better sensitivity to transit availability and accessibility and greater segmentation of rates for mixed-use developments.

The forecasting accuracy of ITE trip rates is also limited by the use of aggregate inputs of land use type and housing units rather than the specific households and employment that will occupy the site. [2] For example, housing units are segmented in the ITE *Trip Generation Manual* by high-rise, low-rise, apartment, condominium, attached, or detached whereas the households would be segmented by number of persons, workers, income, and children, which is better correlated to trip making. Of course, aggregate inputs are more readily available when describing a future development, but more specific employment and housing attributes, as is done with a travel demand model, may produce different vehicle trip rate estimates. For example, 100 single-person, high-income households will have different trip making behavior than 100 four-person households with children and a mix of low and medium incomes.

In the Boston region there is a mature transit system and constrained parking, particularly downtown and South and East Boston. Therefore, ITE trip rates are likely to overestimate vehicle trips, particularly for transit-oriented and mixed-use developments, which are common. ITE has recognized this need and is actively working to improve the trip rates for mixed-use areas with transit access (see Section 1.2). This study is aimed to support that effort and identify where the additional effort to estimate trip generation through a travel demand model is worthwhile and the most useful features of a travel demand model in these applications.

This research complements ongoing work in this area by CTPS partner agencies such as the Metropolitan Area Planning Council (MAPC) and the Massachusetts Department of Transportation (MassDOT).

[2] ITE has trip generation rates for different land use types such as industrial (warehousing, manufacturing, data center, utilities), residential (single-family housing, multifamily housing, mid-rise, high-rise, assisted living), lodging (hotel, motel), institutional (schools, private schools, church, university, daycare center, prison, library) and recreational (park, golf course, heath care club, community center).

1.2 RELATED TRIP GENERATION STUDIES IN THE BOSTON REGION

This research is one of several studies in the Boston Region exploring different aspects of trip generation. MAPC and MassDOT are performing work in this area. MAPC recently collected and analyzed before and after data from completed projects to examine ITE rates and coordinated with MassDOT to submit Massachusetts specific trip generation data to ITE. MassDOT is currently funding a study that will develop person-trip data and customized trip rates for land uses within Massachusetts. CTPS will also be studying how parking affects trip generation as part of a Unified Planning Work Program project being funded in fiscal year 2022.

Chapter 2—State of the Practice Review

2.1 LITERATURE REVIEW

This section is a review of previous trip generation research and how the practice has advanced beyond the basic application of standard vehicle-trip rates published in the Institute of Transportation Engineers (ITE) *Trip Generation Handbook*. Two major challenge areas in trip generation estimation are the consideration of trips that will be served locally (that is, internal capture) and the consideration of trips that will travel by non-auto modes. This section discusses how ITE has worked to enhance the practice of using trip rates and other model approaches to estimate trips to better represent internal capture and non-auto modes. The section concludes with a review of research that challenges the practice of estimating trips through a focused study using national rates in addition to non-trip-based metrics for analysis of development impact.

2.1.1 ITE Trip Generation Publications

Using the ITE *Trip Generation Manual* for forecasting trip generation is the standard practice and most widely used method to determine trip generation rates for new developments. ITE's *Trip Generation Manual* currently contains trip generation data points collected between the years 1980 and 2017. The data found in the ITE *Trip Generation Manual* are based on vehicle trips in suburban settings with distinct land uses. The *Trip Generation Handbook*, 3rd Edition, is also updated with the new 10th edition of the *Trip Generation Manual*. The Manual presents the data; the Handbook recommends how to use and interpret the data. The *Trip Generation Handbook* provides new guidance on proper techniques for estimating person and vehicular trip generation rates and guidance for the evaluation of mixed-use developments.[3]

ITE Trip Generation Handbook, 3rd Edition

Chapter six of the ITE *Trip Generation Handbook*, 3rd Edition, discusses a recommended methodology for trip generation for mixed-use developments. The *Trip Generation Handbook* adopts the method for trip estimation from the National Cooperative Highway Research Program (NCHRP), Report 684. The recommended approach involves a nine-step process with several underlying premises. The nine steps of the process are listed below.

Step 1: Determine whether methodology is appropriate for study site.

[3] Institute of Transportation Engineers, *Trip Generation Manual*, 10th Edition, 2017; Institute of Transportation Engineers, *Trip Generation Handbook*, 3rd Edition, 2017

Step 2: Estimate person trip generation for individual on-site land uses.
Step 3: Estimate proximity between on-site land use pairs.
Step 4: Estimate unconstrained internal person trip capture rates with proximity adjustment.
Step 5: Estimate unconstrained demand between on-site land use pairs.
Step 6: Estimate balanced demand between on-site land use pairs.
Step 7: Estimate total internal person trips between on-site land use pairs.
Step 8: Estimate total external person trips for each land use.
Step 9: Calculate overall internal capture and total external vehicle trip generation. (ITE *Trip Generation Handbook*, 3rd Edition, 2017)

2.1.2 Internal Trip Capture and Mixed-Use Developments

Mixed-use developments have the potential to reduce the rates of trips leaving the site because residents may choose to use local services. This phenomenon is known as internal trip capture. Since 2010, several efforts have been made to improve the consideration of internal trip capture in the application of ITE trip rates for estimation. This section describes a subset of these research efforts. Work in this area was also included in the Central Transportation Planning Staff report from 2020 titled *Innovations in Estimating Trip Generation* (CTPS 2020)

US Environmental Protection Agency (EPA) Mixed-Use Trip Generation Model (TGM)

In 2010, the EPA, in collaboration with the consulting firm Fehr & Peers and ITE, developed a mixed-use trip generation model. This model was developed in recognition of the shortcomings of the standard ITE method of estimating traffic for site development. It is an open-source spreadsheet tool that calculates reductions in trips from the standard TGM methodology for mixed-use developments. The model takes into consideration several factors such as geographic, demographic, and land use characteristics that impact mixed-use development trip making. It is a relatively flexible tool that can use national average values or local values customized and input by the user (US EPA2019).

National Cooperative Highway Research Program (NCHRP) Report 684

NCHRP Report 684, “Enhancing Internal Trip Capture Estimation for Mixed-Use Developments,” analyzed internal-capture relationships of mixed-use development sites and examined the travel interactions among six individual types of land uses: office, retail, restaurant, residential, cinema, and hotel. The methodology presented in NCHRP Report 684 is the methodology adopted by the ITE *Trip Generation Handbook* as the preferred methodology for handling mixed-use development sites except that it adds three land uses (restaurant, hotel, and cinema), expands the basis for the internal capture factors (from three developments in one state to six developments in three states), and adds proximity adjustments for some land uses and pairs (Bochner et al 2011).

EPA Mixed-Use Trip Generation Model Plus (MXD+)

Since the EPA MXD open-source tool was developed and released in 2010, several firms have used it as a basis for developing more advanced modeling tools. The MXD+ model developed by consulting firm Fehr & Peers is one example. The MXD+ method is an approach that combines the strengths of the methodologies presented in the EPA MXD model and in the NCHRP Report 684. The MXD+ method combines all of the project characteristics considered by the NCHRP Report 684 and the EPA MXD models into one.

According to some researchers, the MXD+ method is a robust method that eliminates the ITE systematic overestimation of traffic. Unlike the EPA MXD tool, however, the MXD+ tool is not open source (Fehr & Peers 2020).

2.1.3 Non-Auto Mode Trip Generation

Recent trip generation research and work has sought to better represent the trip making characteristics of non-auto mode trip generation, specifically, trips made by people who walk, bicycle, or use transit (Combs 2020). This section discusses some of the research efforts to better represent non-auto modes.

A white paper prepared for the Federal Highway Administration in 2015 titled *Bicycle and Pedestrian Forecasting Tools: State of the Practice* presents the range of tools that exist for analyzing bicycle and pedestrian travel behavior across the geographic level of analysis (local, corridor, regional) as well as the tool type (sketch, aggregate demand, network based). Regional models with a detailed network and sketch planning tools can be used to produce demand estimates, each with its own strengths and weaknesses. Data outputs from these models can be used as inputs for other models to reduce the amount of new data and the analysis that needs to be conducted; although, conversion of existing vehicular-focused models to a bike/ped scale requires significant effort. In addition, there are tools specifically designed for bike-sharing programs. These tools will not be discussed in this report (Aoun, et al 2015).

ITE Trip Generation Handbook, 3rd Edition

Chapter five of the ITE *Trip Generation Handbook*, 3rd Edition, discusses person trip generation. The *Trip Generation Handbook* recognizes that trip generation estimates that contain only vehicle trips do not properly account for sites that are used by transit, pedestrians, and bicycles. It also discusses a recommended methodology for adjusting the baseline vehicle trip estimates contained in the *Trip Generation Manual*. The method for estimating multimodal site person trips involves adjusting baseline vehicle trips from the *Trip Generation Handbook*. There are no comprehensive data on person trip rates per site; therefore, it is necessary to work from vehicle trips. This is the same approach used in the mixed-use trip estimates of the manual, described in the previous section on internal trip capture. The *Trip Generation Handbook* notes that as national databases on sites include more data on person trips, this approach may change in the future (ITE, *Trip Generation Handbook*, 3rd Edition, 2017). The recommended approach for estimating person trip generation is a five-step approach:

> Step 1: Estimate baseline vehicle trips from the *Trip Generation Handbook* using standard trip rates.
> Step 2: Convert baseline vehicle trips to baseline person trips using occupancy rates.
> Step 3: Estimate mode shares and vehicle occupancies based on conditions associated with characteristics of the study site and its surrounding context.
> Step 4: Apply the mode shares to estimate the number of person trips by mode.
> Step 5: Calculate the estimated number of adjusted vehicle trips using the number of adjusted person trips by mode from the prior step. (ITE *Trip Generation Handbook*, 3rd Edition, 2017)

NCHRP Report 770 and NCHRP Project 08-36

NCHRP Report 770 and NCHRP Project 08-36 delve deeply into bicycle and pedestrian trip generation, mostly in the context of regional models but also for tools appropriate for more localized or corridor studies.

NCHRP Report 770 presents methods and tools for practitioners to estimate bicycling and pedestrian demand in the context of corridor project level analyses. The methods outlined in the report were sensitive to bike and pedestrian infrastructure, land use characteristics, topography, and sociodemographic characteristics. The report reviewed a variety of methodologies that Metropolitan Planning Organizations and departments of transportation employ to model not just trip generation but route and mode choice for non-auto trips (Kuzmyak et al 2014).

For trip generation of bicycle and pedestrian trips, the report focused on two models, PedContext and MoPeD, both of which were developed by the University of Maryland National Center for Smart Growth. PedContext is the more detailed of the two models and includes mode choice, distribution, and assignment features in addition to pedestrian trip generation. The model produces walk trip productions and attractions for seven different trip purposes derived from travel survey information from the New York metropolitan area, which also included land use accessibility measures for specific trip purposes. Unlike PedContext, MoPeD only includes the home-based-work and non-home-based trip purposes. The drivers of trip generation for MoPeD are vehicle ownership, street connectivity, residential development, and commercial land use mix. Neither of these tools directly address bicycle travel but the authors of the report suggest they would be easily adapted for use with the bicycle mode (Kuzmyak et al 2014).

NCHRP Project 08-36/Task 141 (2019) was an extension to the NCHRP Project 08-78 (NCHRP Report 770). Project 08-36 recapped the recommendations for innovation coming out of 770, and with regard to trip generation, recommended that a more refined level of geography would be useful for bicycle and pedestrian trip generation (the Pedestrian Analysis Zone, as opposed to the Transportation Analysis Zone [TAZ]). This is because pedestrian and bicycle trips tend to be shorter in length and with many TAZs end up being counted as intrazonal (origin and destination within one zone) (The Rand Corporation 2019).

The project describes preprocessor approaches (steps occurring before the first step in the traditional four-step approach) as enhancements. One of the models cited as falling into this category is the Portland Pedestrian Model, a GIS-based accessibility model that splits trips before trip generation into either motorized or nonmotorized trips (The Rand Corporation 2019).

Facility Demand Models

Facility Demand Models are models that use demographic, geographic, and roadway characteristics to estimate nonmotorized travel demand. These models are designed mainly for local project planning rather than regional or state forecasting models. The three papers below present a survey of implementations of models that estimate bicycle and pedestrian travel demand based on infrastructure and demographic characteristics.

Le and others found that built environment characteristics were significant predictors of pedestrian and bicycle travel. Land use, transportation infrastructure, and sociodemographic characteristics were used to develop correlations with pedestrian and bicycle travel based on data from 20 different metropolitan areas from across the United States (Le, Buehler, Hankey 2018).

In Bicycle Trip Forecasting Model: Cincinnati Metropolitan Case Study, the study authors (who developed a bicycle demand model) identified several significant variables that are predictive of bicycle demand. The study used multiple linear regressions to identify significant variables correlated to bicycle trip generation. The variables identified included number of students in the household, number of workers in the household, as well bicycle infrastructure variables such as number of students in the household, number of workers in the household, and within the household's bicycle trip study boundary—the length of bike lanes, length of bike shared paths, length of bike shared roads, length of signed bike routes, number of bike racks, and area of parkland. The primary data source used in that study was the Cincinnati metropolitan area household survey (Wei, Ai, and Ramirez-Bernal 2013).

An example of an Aggregate Demand Model can be found in the research by the Utah Collaborative Transportation Study from 2013. Aggregate demand models are typically regression models that create an equation using activity level data and influencing attributes such as population density, land use diversity, and distance to transit to determine demand for active transportation (Aoun et al 2015). This was a study co-managed by the Utah Department of Transportation and the Utah Transit Authority in partnership with the Wasatch Front Regional Council. The study used a GIS-based latent demand model that used population and employment densities, distance to major destinations, land use types, and network connectivity to develop a bicycle pedestrian demand model. This GIS-based model was used to prioritize projects based on the relative demand of a particular corridor (Utah Collaborative Transportation Study 2013).

2.1.4 Challenges to Using Trip Generation Rates for Development Analysis

Household Surveys

In the paper *Phantom Trips: Overestimating the Traffic Impacts of New Development,* Millard-Ball compares the trip making rates found in the ITE *Trip Generation Manual* against the trip making rates found in household travel surveys. The paper described two comparison methods—cross sectional and longitudinal—used to compare ITE trip generation trip making to the trip making rates from household surveys. Both comparison methods were made at the national level. The household survey used was the National Household Travel Survey, a survey conducted by the Federal Highway Administration that is considered the authoritative source on the travel behavior of the American public. The conclusion of the paper was that ITE trip generation rates are over-represented, as compared with household travel surveys (Millard-Ball 2015).

Millard-Ball posits that the overestimation in the ITE *Trip Generation Manual* is due to the manual predicting an average rate, not a marginal rate. Trips entering or leaving a site are not usually new but are usually diverted from somewhere else. As the scale of the analysis grows from local to regional or national, this effect is magnified.

Using Vehicle Miles Traveled (VMT) instead of Level of Service (LOS)

There are examples in California where a development impact analysis is measured using VMT-based measures, rather than the LOS measures. Many jurisdictions in California have concluded that VMT is a more appropriate metric for measuring a project's potential impact than LOS. Jurisdictions in California use a variety of methods and tools to estimate VMT including travel demand models, tools that adjust ITE trip generation estimates, and statistical models that draw relationships between project characteristics and VMT.

One study examined three developments in Davis, California, comparing development analysis outcomes using VMT and LOS as the development measures. That study found that the two performance metrics lead to very different results about the significance of transportation impacts from the three developments. The LOS-based metric supported an increase in roadway capacity whereas the VMT-based metric supported an increase in transit, bicycle, and walk accessibility. Therefore, the mitigation required from an LOS-based metric evaluation would have more auto travel than with a VMT-based metric evaluation (Lee 2018).

2.2 STATE OF PRACTICE IN OTHER STATES AND AGENCIES

As of the writing of this report, the Virginia Transportation Research Council is preparing a report on incorporating the 10th Edition ITE Trip Generation Rates into Virginia Department of Transportation (VDOT) regulations.

As a part of the VDOT study, investigators emailed a questionnaire regarding trip generation and the ITE *Trip Generation Manual,* 10^{th} Edition, to state Departments of Transportation and transportation agencies. Invitations to complete the questionnaire were sent to state representatives in early June 2020. As of the writing of this report a total of 31 states responded to the survey.

The questionnaire asked how jurisdictions are handling the issues of internal capture and mode split in light of the fact that trip rates in the 10^{th} edition are lower than in previous editions. Roughly half of the respondents to this question indicated that they are further reducing trip rates to account for internal capture and mode split while roughly half of respondents indicated they were not reducing the published rates.

The questionnaire also asked whether jurisdictions have adopted the four area types from the 10^{th} edition—Center City Core, Dense Multi-Use Urban, General

Urban/Suburban, and Rural—to classify developments. Most jurisdictions that responded answered that they have adopted the land use classification system from the 10th edition. Two state Departments of Transportation, California and Wisconsin, reported use of their own custom designed framework for land use classifications.

Several questions inquired about which approaches from which versions of the ITE *Trip Generation Manual* were appropriate for internal capture trips, external walk/bike trips, external transit trips, and pass-by/diverted trips. In response to a question about internal capture trips within a mixed-use setting, respondents reported using many of the tools described in NCHRP 365, regional travel demand models, general heuristics, or customized locale specific tools.

In response to a question about how respondents adjusted trip generation based on transportation demand management strategies or policies, 26 of the 29 responses reported that they did adjust trip generation to reflect a transportation demand management strategy. A notable example is the District of Columbia, where vehicle trips are capped for developments with a low ratio between available parking spaces and units.

Finally, a question of alternative methodologies revealed that the majority of respondents recommended use of travel demand models as well as household surveys and site-specific studies as alternatives to estimating trip generation.

Chapter 3—Analysis of Institute of Transportation Engineers-Based Trip Estimation Accuracy

Central Transportation Planning Staff (CTPS) analyzed the accuracy of trips estimated for recent developments across the region to understand how the limitations of the Institute of Transportation Engineers (ITE) trip rate methodology identified in Chapter 2 play out for developments in the Boston region. This analysis helps inform the application of trip generation estimation practices and indicates where the region travel demand model could improve the prediction accuracy.

A variety of development attributes were needed to assess how ITE trip rates performed under different land uses and transit accessibilities as well as the size and mix of the development itself. To support the categorization of developments, CTPS developed a new area type taxonomy based on the density of population and employment and the access to transit of different types and service levels.

The next section of this chapter describes the transit-accessible density area type taxonomy followed by a presentation of the developments analyzed and assessment of the forecasting accuracy.

3.1 TRANSIT-ACCESSIBLE DENSITY CATEGORIZATION

As described above, the ITE *Trip Generation Manual,* 10th Edition, specifies four-levels of area types (settings): Center City Core, Dense Multi-Use Urban, General Urban/Suburban, and Rural. Area type is expected to have a significant impact on trip generation. If two identical developments are considered, one in a dense urban environment and the other in a rural environment, it is to be expected that they would generate a different number of trips, that is they would have a different trip rate for the development. This is due to the improved accessibility of denser neighborhoods facilitating multiple small trips, as opposed to a more spread-out development that encourages travelers to combine the need for services into fewer, longer trips.

To support this analysis, CTPS has developed new area type categories reflective of transit accessibility and density. The transit-accessible density categorizations are expected to improve trip generation estimates for developments that are transit oriented or mixed use. Table 1 shows the new area types that CTPS has developed and the criteria that were used to develop them.

Figure 1 is a map of the resulting area type categorizations. Figure 2 is the same map featuring a close up of the Boston area.

Table 1
Transit Accessible Densities-Based Area Types

Area Type	Criteria: Transit Access	Criteria: Density
CBD	50 percent of TAZ land area is within one-half mile of heavy rail station(s) serving two or more lines.	Urban Density (> = 10,000)
	50 percent of TAZ land area is within one-fourth mile of the green line stations(s) served by all four lines.	Urban Density (> = 10,000)
Dense Urban	TAZ within one-half mile of heavy rail station(s)	Any
	TAZ within one-half mile of commuter rail station(s)	Urban Density (> = 10,000)
	TAZ land area is within one mile of bus station(s) with five minutes or less headway	Urban Density (> = 10,000)
Urban	TAZ within one-half mile of commuter rail station(s)	Urban Density (> = 10,000)
	TAZ land area is within one mile of bus station(s) with five minutes or less headway	Urban Density (> = 10,000)
Fringe Urban	TAZ within one mile of heavy rail station(s)	Any
	TAZ within one-half mile of light rail station(s)	Any
	TAZ land area is within one-half mile of bus station(s) with 15 minutes or less headway	Suburban density (5,000–9,999)
	TAZ within one-half mile of commuter rail station(s)	Suburban density (5,000–9,999)
Suburban	TAZ within one-half mile of any transit lines(s)	Any
Rural	All Remaining TAZs	Any

Notes: Heavy Rail (Orange Line, Blue Line, Red Line); Light Rail (Green Line, Silver Line); Commuter Rail (CR); Any transit line (excludes CR and private bus); Density = (Population + Employment)/Area in sq mile. CBD = Central Business District. TAZ = Transportation Analysis Zone.

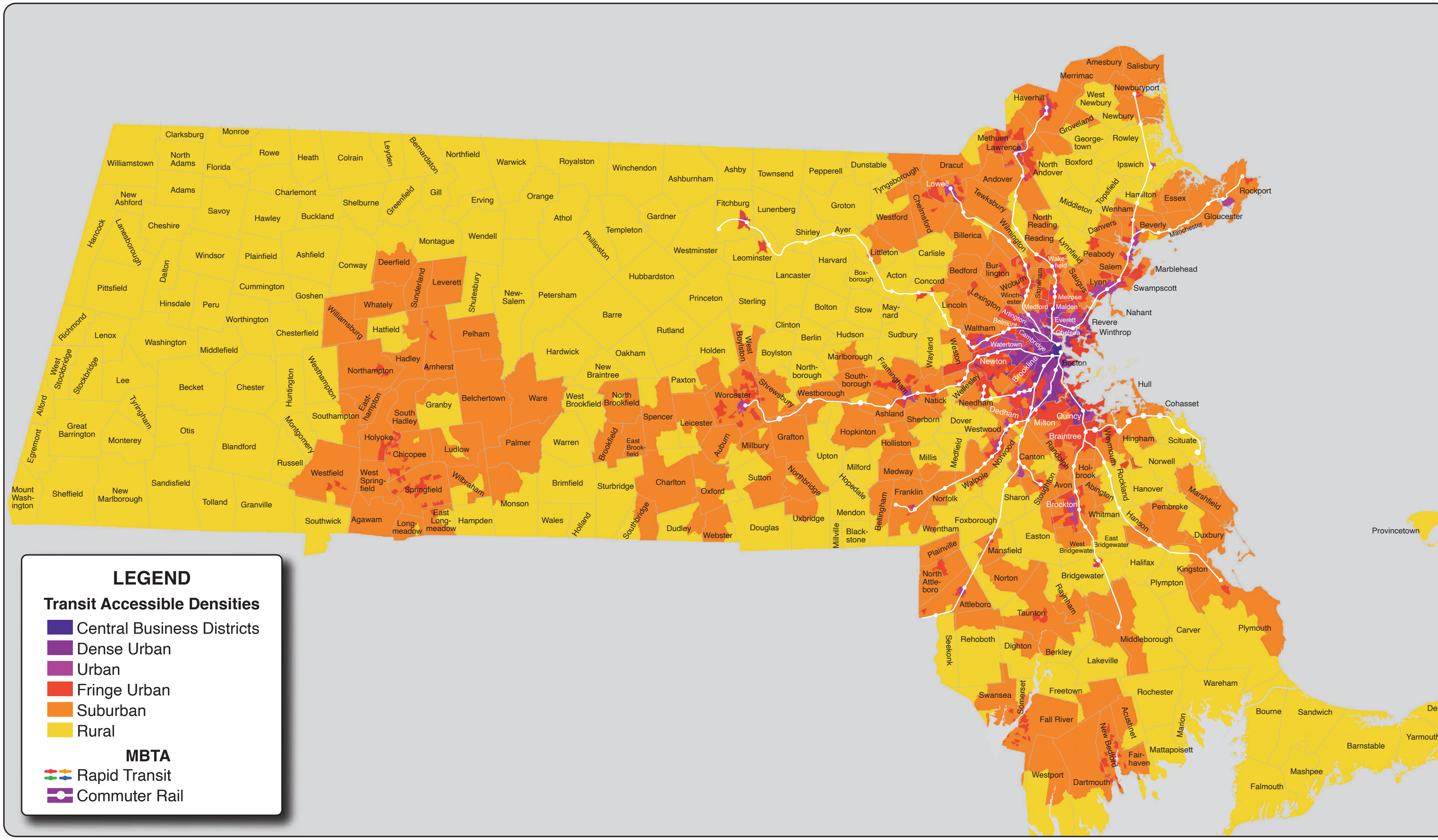

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Figure 1:
Transit Accessible Densities-Based Area Types
with MBTA Commuter Rail

Trip Generation
Rate Research

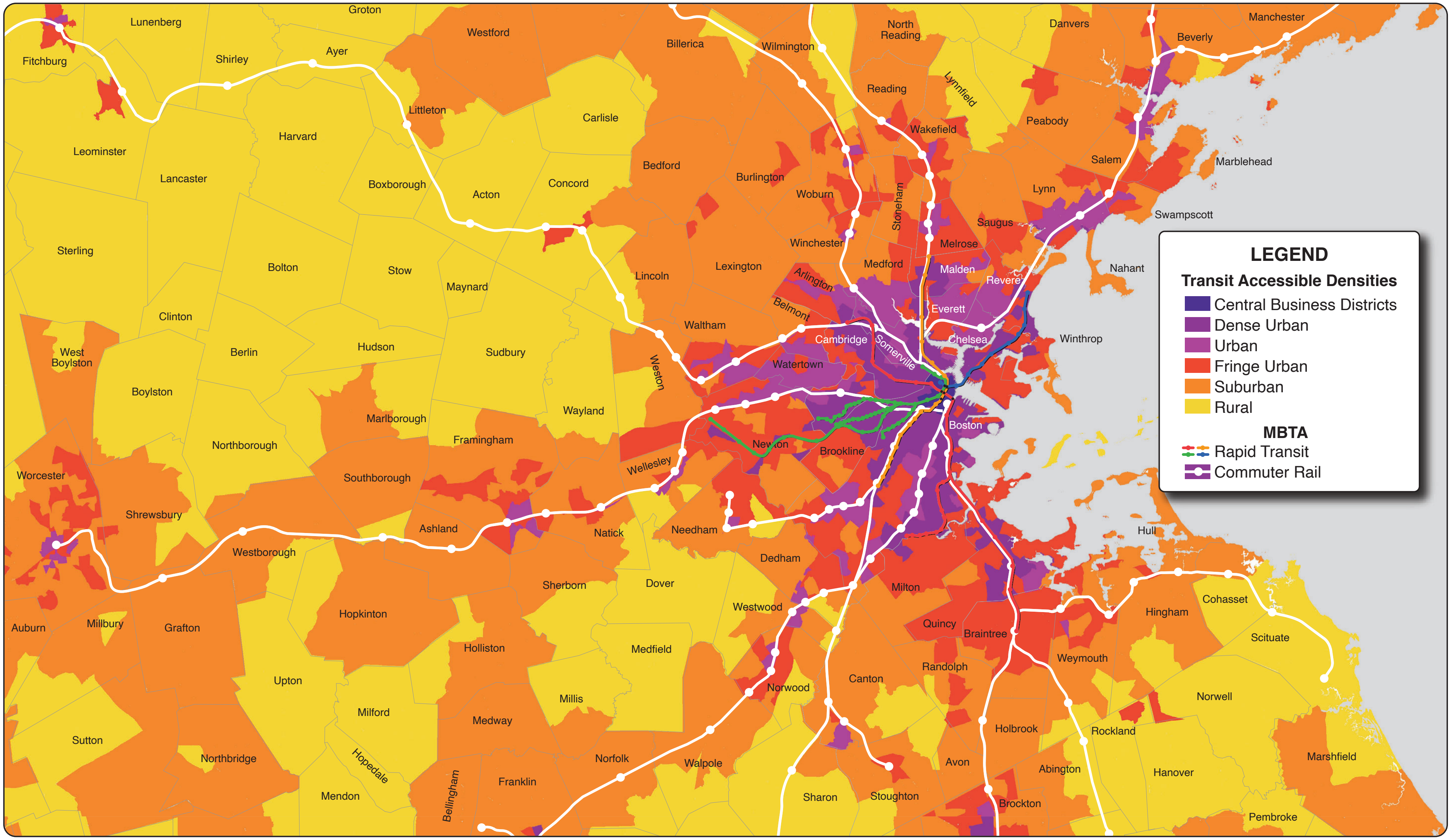

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Figure 2:
Transit Accessible Densities-Based Area Types
(Eastern Massachusetts) with MBTA Commuter Rail

Trip Generation Rate Research

3.2 SELECTED DEVELOPMENTS

Massachusetts Department of Transportation (MassDOT) and Massachusetts Environmental Policy Act (MEPA) require certain completed developments to monitor traffic volumes associated with a site after project completion. One of the outputs of this monitoring process is a Transportation Monitoring Report (TMR) that reports the traffic entering and exiting the site drives for the development. This section presents a comparison of the estimated trips in the MEPA submissions with the observed trips reported in TMRs for nine different developments in the Boston region. For the selected nine developments, the trips estimated for submission to the MEPA process followed the rates and methods defined in the ITE *Trip Generation Manual*.

The development projects selected for analysis required a MEPA review due to their size and scope potentially having an impact on the environment.[4] The selected projects represent different land uses (residential, commercial, and retail) and area types (dense urban to rural). There was also variety among the projects in terms of the size and scope of the developments. Table 2 provides the basic information about the selected projects that were analyzed. Table 3 provides the trip generation comparison between ITE-based estimated trips and observed trips for these nine developments. Figure 3 shows the location of the projects that were studied in this analysis.

[4] MA Code of Regs 11.16. 301 CMR 11.00.

Table 2
Transportation Monitoring Report (TMR) Development Details

Proj No.	TMR Project	Town	Development Type	Size	Area Type	Observation Year
1	225, Binney Street	Cambridge	Office	307,900 sq ft	Dense Urban	2015
2	Campanelli Business Park	Uxbridge	Warehouse	1,400,000 sq ft	Rural	2020
3	Upland Woods	Norwood	Residential	262 units	Suburban	2018
4	Southfield	Weymouth	Residential Nursing Facility	580 units 46 beds	Rural	2016
5	Walmart	North Adams	Retail	160,000 sq ft	Rural	2014
6	Meadow Walk	Sudbury	Retail Residential	80,000 sq ft 353 units	Rural	2019
7	Hingham Shipyard	Hingham	Retail Restaurant Health Club Cinema Residential Office Day Care	138,956 sq ft 1022 seats 8,700 sq ft 1000 seats 247 units 8,871 sq ft 9,973 sq ft	Fringe Urban	2014
8	Mansfield Crossing	Mansfield	Retail	395,000 sq ft	Suburban	2011
9	Chestnut Hill Square	Newton	Retail Office Retail Commercial	86,512 sq ft 60,700 sq ft 61,756 sq ft 29,640 sq ft	Fringe Urban	2018

Table 3
Trip Generation Comparison for Selected Developments

TMR Developments		Projected Trips			Observed Trips			% Difference (Avg. Weekday)
Proj No.	**TMR Project**	**AM* Peak Hour**	**PM* Peak Hour**	**Avg. weekday**	**AM** Peak Hour**	**PM** Peak Hour**	**Avg. weekday**	**Projected vs. Observed**
1	225, Binney Street	175	155	1,213	65	67	477	154%
2	Campanelli Business Park	136	152	*1,921*	48	71	*787*	144%
3	Upland Woods	132	162	1,712	104	104	1,230	39%
4	Southfield	*296*	*360*	3,847	*254*	*305*	3,282	17%
5	Walmart	*340*	738	8,500	*232*	533	5,794	47%
6	Meadow Walk	340	645	7,920	297	645	7,478	6%
7	Hingham Shipyard	580	1,275	*14,333*	456	861	*10,483*	37%
8	Mansfield Crossing	*695*	1,635	17,380	*453*	1,030	11,332	53%
9	Chestnut Hill Square	414	1,239	13,446	469	1,029	12,220	10%
	Grand Total	**3,108**	**6,361**	**70,272**	**2,378**	**4,645**	**53,083**	**32%**

The numbers highlighted are estimated due to unavailability of these numbers in TMR
* Computed peak-hour volume
** Reported TMR peak-hour volume
Avg. = average. TMR = transportation monitoring report

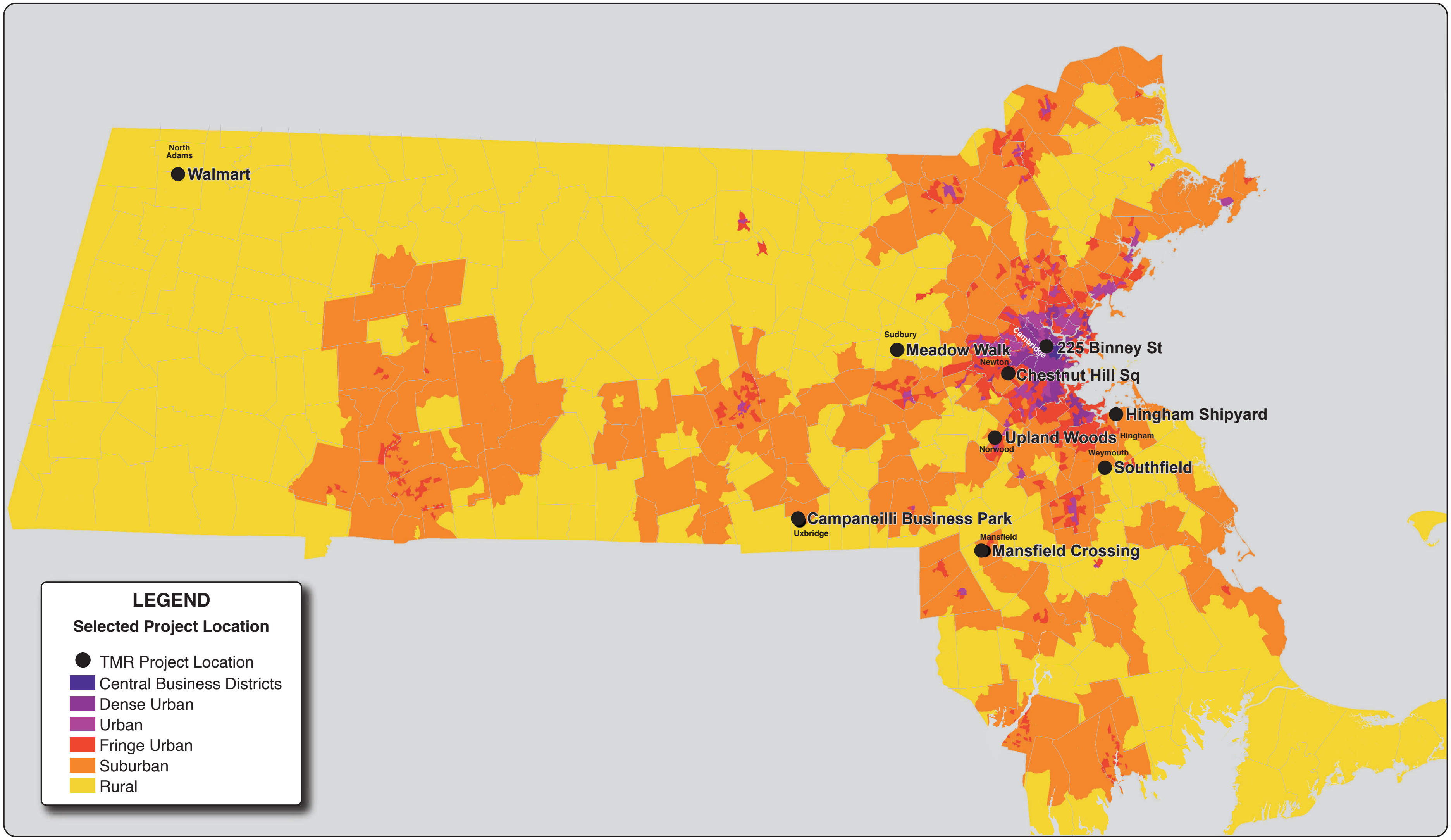

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Figure 3:
TMR Selected Project Locations

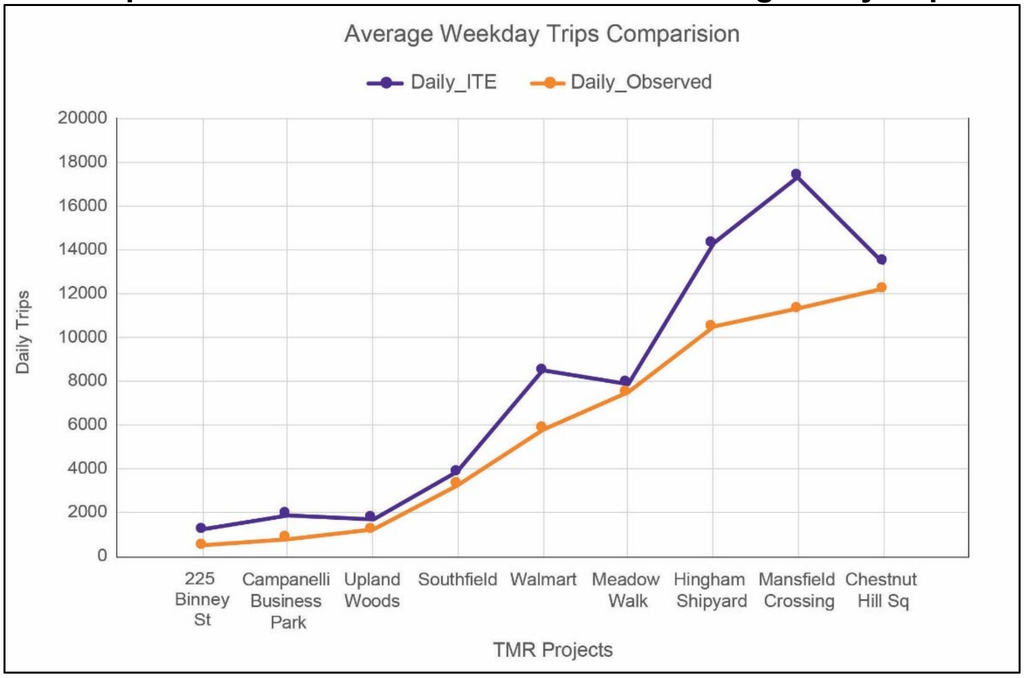
Trip Generation Rate Research

3.3 ANALYSIS OF TRIP ESTIMATION ACCURACY

Similar to other studies, CTPS found that the estimated trip rates were higher than observed (Combs 2020; Walters et al 2013; Millard-Ball 2015). As expected, average weekday estimated trips were higher than the observed counts for all developments selected in this study with larger percentage differences for smaller developments. Peak-hour accuracy was improved with a few examples of the estimated trips at or below the observed trips.

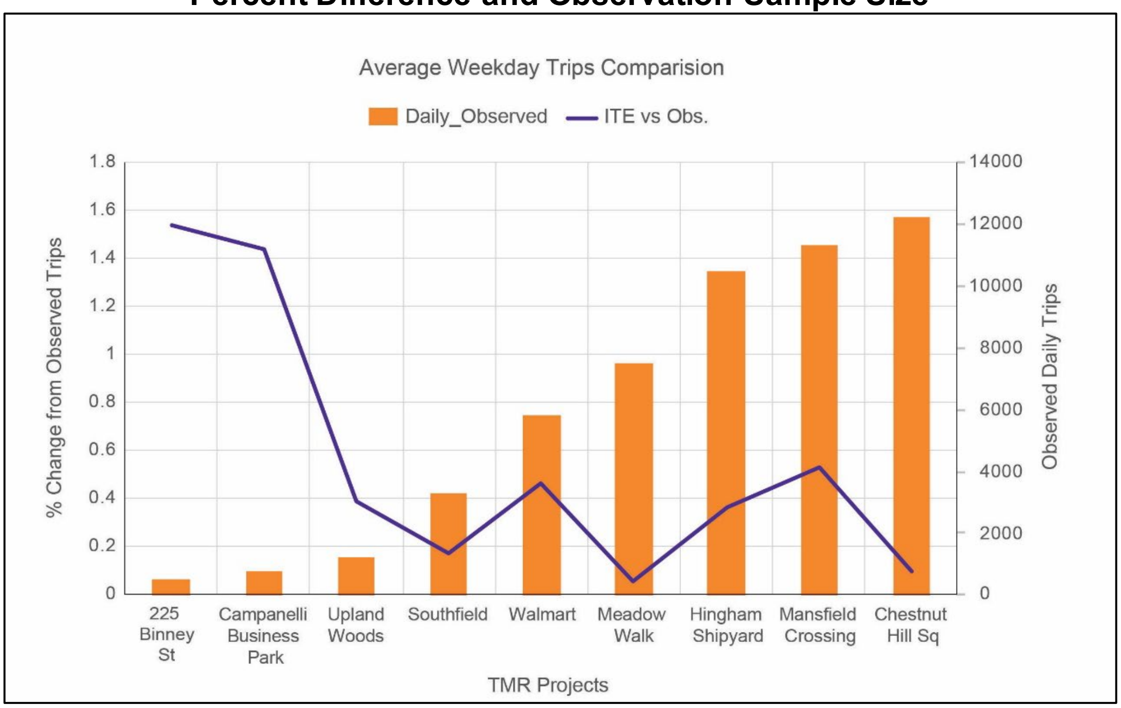
Figure 4 shows the average weekday estimate and count magnitudes. Here, the estimates are quite close in some instances, but are consistently above the observed with the largest magnitude discrepancies for Hingham Shipyard, Mansfield Crossing, and Walmart. Figure 5 shows the percentage difference as a line plot and the average weekday counts as a bar. Here, the largest discrepancies are seen with the smaller development, although Hingham Shipyard, Mansfield Crossing, and Walmart still stand out. The larger percentage differences for smaller developments are to be expected as small developments may have a degree of variability in terms of trip making characteristics while increases in development size will tend to balance out that variability.

Figure 4
Comparison between ITE and Observed Average Daily Trips



ITE = Institute of Transportation Engineers. TMR = transportation monitoring reports.

Figure 5
Comparison between ITE and Observed Average Daily Trip Percent Difference and Observation Sample Size



ITE = Institute of Transportation Engineers. Obs. = observed. TMR = transportation monitoring reports.

3.3.1 Retail Developments

Two exclusive retail developments were analyzed for this study: a Walmart in North Adams (Walmart) and a retail development in Mansfield (Mansfield Crossing). These two had among the highest magnitude differences between estimated and observed for the study set.

Given their rural and suburban area types respectively, the discrepancy is probably not due to trips made by non-auto modes. Also, given the single development purpose, retail, and lack of a residential component to the development, there is unlikely to be a high degree of internal capture. However, Mansfield Crossing currently advertises a mix of stores and restaurants, so it could also be that the described development cannot include full detail of the fully built site. The discrepancy could in part be explained by the factors converting from square foot to trips and not adequately capturing distribution of showroom to backroom space. Finally, the estimates may also be high due to competition from other sites and saturation in the market and is an example of the challenge with applying an average, rather than marginal rate, as Millard-Ball explains.

As the data from the TMRs is for developments that are by definition new, it is important to note that new retail developments tend to attract trips at a level that is higher than more mature retail developments. This is an observation validated by common experience. Newer retail developments may garner attention and publicity that older developments do not.

3.3.2 Residential Developments

Two residential developments were analyzed in the study, one in Norwood (Upland Woods) and another, a residential nursing facility in Weymouth (Southfield). Together, the estimated trips exceed the observations by 56 percent.

Upland Woods advertises inclusion of one parking space per lease with additional fees for garaged spaces.[5] The distribution of unit size (one to three bedrooms) and parking availability can lead to very different household types (children, seniors) and trip-making behavior.

Residents of the Southfield development are likely older with a lower rate of workers making regular commutes and potentially no children. Households in the later lifecycle stages (empty nesters, retirees) may have a lower trip rate.

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[5] https://www.cottonwoodoneuplandapts.com/faq (accessed 11/27/2021)

Another potential reason for the discrepancy could be the occupancy rate for the developments versus what was assumed in the original estimates.

3.3.3 Warehouse Development

One warehouse development was analyzed in the study, a 1.4 million square foot warehouse in Uxbridge. Estimated trips for this development exceed the observed by 144 percent.

There is a great deal of variability in warehouse type and this variability makes accurate trip generation challenging. For example, the level of automation in warehouses is variable, with some warehouses requiring relatively few employees while other warehouses are relatively more employee intensive. Information on what kind of warehouse was built in Uxbridge was not provided in the documentation. It is also important to note that the observations were made in 2020, a year with unique travel behaviors and conditions.

3.3.4 Mixed-Use Developments

There were two developments included in this analysis that included a mix of residential and commercial uses, one in Hingham (Hingham Shipyard) and one in Sudbury (Meadow Walk). Meadow Walk is a mix of residential and retail while Hingham Shipyard is a mix of residential, retail, and office. Together the ITE over-predicted trip generation at these sites by 43 percent, although the Meadow Walk trip estimates were highly accurate with six percent difference.

It is notable that the trip estimates for the rural mixed-use development (Meadow Walk) were much more accurate than the fringe-urban mixed-used development (Hingham Shipyard). Hingham Shipyard has a higher potential for internal capture trips given the greater variety of commercial development. Hingham Shipyard is also near to the Massachusetts Bay Transit Authority (MBTA) Hingham Ferry Terminal.

3.3.5 Office Development

The office development analyzed in this study is in Cambridge (225 Binney Street). Trips estimated for this development exceeded the observations by 154 percent. The 225 Binney Street development is in a dense urban land use close to the MBTA Kendall Square Red Line subway station and good pedestrian and bike infrastructure. Moreover, the 225 Binney Street development has restricted parking for the office tenants, which will constrain vehicle trips to and from the site. So, consideration of parking constraint for this type of development plays a critical role in trip generation estimation.

3.3.6 Mixed Commercial Development

One development analyzed was a mix of office and retail. That development is located in Newton (Chestnut Hill Square). The estimated trips were close to the observed for this development (10 percent high).

Although the Chestnut Hill Square development is in a fringe-urban land use, it is a substantial walk (more than one mile) from the MBTA Green Line Chestnut Hill station and along Route 9, a busy arterial.

3.4 SUMMARY OF KEY FINDINGS

- Development occupancy is critical to support an assessment of estimation accuracy (All)
- Trip estimates for retail-only developments may be susceptible to overestimation due to average, rather than marginal, trip rate application (Walmart, Mansfield Crossing)
- Parking constraints suggest a strong impact on vehicle trips (Upland Woods, 225 Binney Street)
- Convenient access to transit may explain fewer vehicle trips (225 Binney Street, Hingham Shipyard), while less convenient access to transit may explain more vehicle trips (Chestnut Hill Square, Meadow Walk)
- Household lifecycle and size may have systematic variation on trip rates per residential unit (Southfield)
- Type of mix in mixed-use developments may have an effect in variability of results accuracy (Meadow Walk, Hingham Shipyard)
- Area type/setting (urban, suburban, and rural) have an impact in relation to different type of land uses.

Chapter 4—Central Transportation Planning Staff Travel Demand Model and Next Steps

This chapter gives an overview of the Central Transportation Planning Staff (CTPS) travel demand model and discusses how the lessons learned from this research could be used to enhance the CTPS travel demand model (TDM) and where further research is warranted.

4.1 TDM: OVERVIEW OF THE MODELING PROCESS

CTPS has maintained a model to estimate average weekday travel behavior in the Boston region for more than four decades. The current model, TDM19, was used by the Boston Region Metropolitan Planning Organization for the 2019 Long-Range Transportation Plan (LRTP) and is currently used for growth rate calculations in addition to client-directed roadway and transit studies. TDM19 is a standard four-step model implementation with the key addition of an auto-ownership pre-processor step to estimate the auto-ownership levels by transportation analysis zone (TAZ) and a transit parking constraint component that updates the transit and highway trip tables in response to parking availability at transit stations.

TDMs are abstract representations of the demand for travel and the transportation network supply. Figure 6 shows the primary steps of the model with the demand components in blue boxes and supply components in green. The intermediate data estimated by each component is indicated between the boxes. Note that all intermediate data estimated by the model are organized by individual TAZ or through pairs of TAZs as trip tables, which are matrices with a TAZ index.

Demand Components

The estimation of trips in the model begins with the generation of trips produced and attracted (trip ends) by TAZ. Trip ends produced by purpose and household vehicle ownership are calculated using demographic and socioeconomic data. Similarly, the number of trip ends attracted by purpose are calculated using the type of employment (Basic, Service, Retail). The trip productions and attractions are segmented into primarily occurring during the AM and PM peak (PK) travel periods or in the midday or night off-peak (OP) travel periods.

The trip ends are then distributed to connect each produced trip end with an attraction end for the peak and off-peak periods. Trip ends are distributed based on highway travel times and the number of attractions in the TAZ.

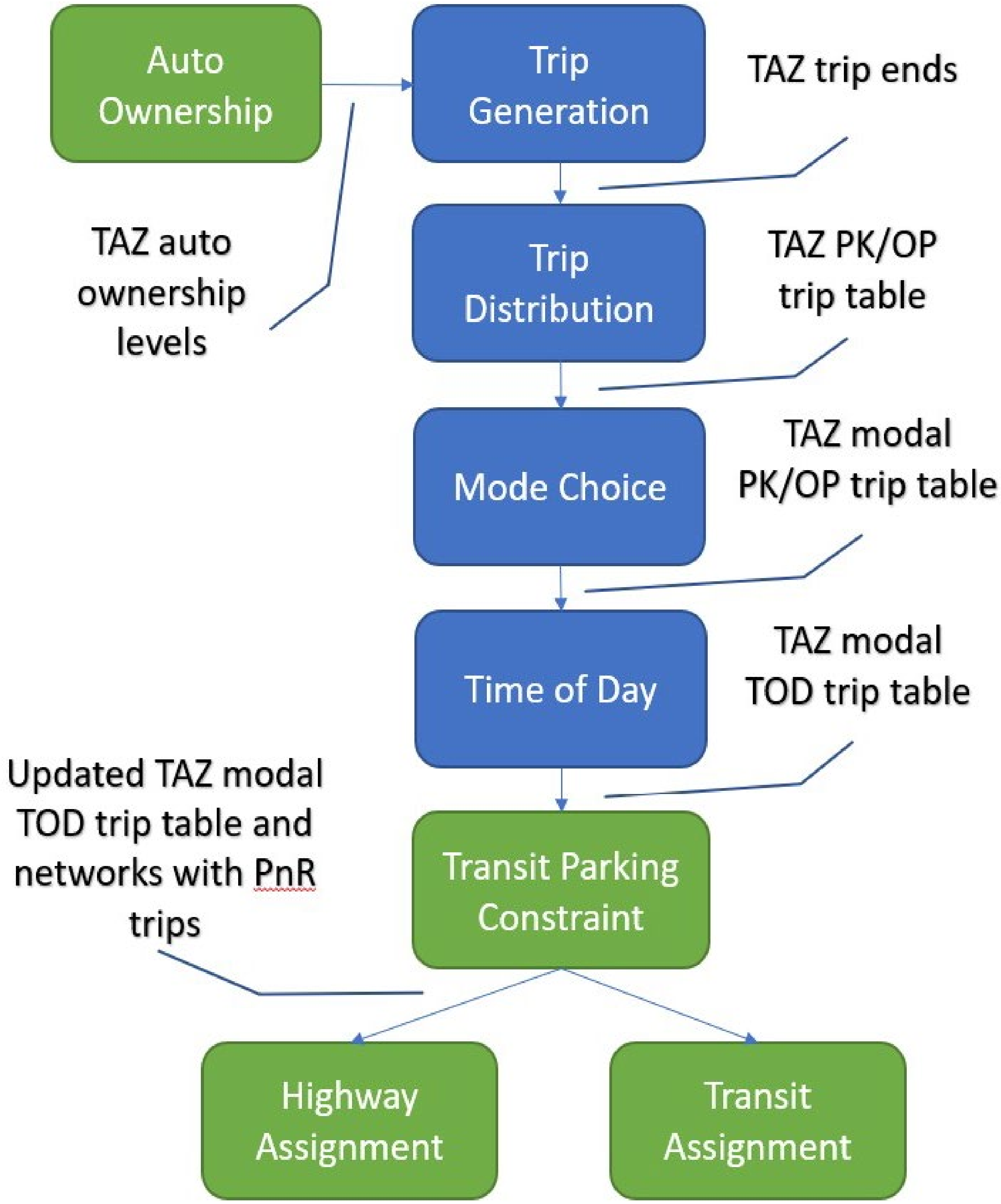
The model then estimates the mode by which each trip will travel (auto by occupancy, walk/bike, or transit) based on the travel time and cost associated with each mode, household vehicle ownership, and characteristics of the production and attraction TAZ. Finally, each trip that is produced and attracted is segmented into one of four times of day (TOD) for the outbound (production to attraction) and inbound (attraction to production) directions.

Supply Components
The auto ownership step is considered a supply component in the sense that it is estimating the availability of using a personal auto for travel, similar to how the transit network estimates the availability of transit for travel.

The transit parking constraint step updates the estimated demand for trips that use the park and ride lots at transit stations to be consistent with the available parking spaces.

The highway and transit assignment steps estimate the trip routing or path for each TOD period. Highway assignment produces a new set of congested travel times on each link in the network that can then be used to rerun trip distribution until the model converges.

Figure 6
The Boston Region Metropolitan Planning Organization
Four-Step Travel Demand Modeling Process



OP = off peak. PK = peak. PnR = Park & Ride. = TAZ = transportation analysis zone. TOD = time of day.

4.2 POTENTIAL MODEL ENHANCEMENT BASED ON LESSONS LEARNED

CTPS is currently developing a new model set to support the 2023 LRTP. The development of a new model set, known as TDM23, presents an opportunity for CTPS to incorporate the lessons learned about vehicle trip estimation in this study into the next generation of the TDM. The following section discusses considerations CTPS will take in developing TDM23.

4.2.1 Refined Segmentation by Area Type

As discussed above, dense development with mixed uses and robust transit and active mode infrastructure is expected to produce different rates of travel per household and commercial unit as well as different mode shares.

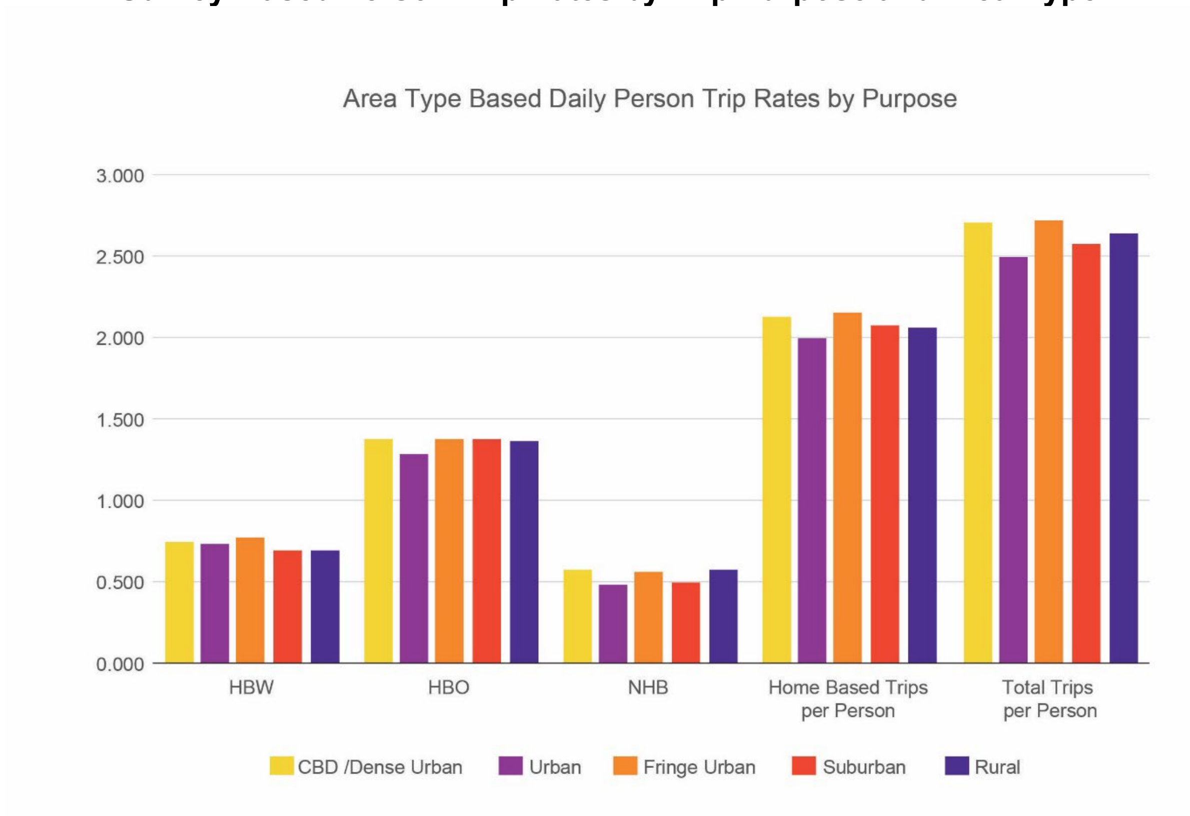
Updates to trip generation production and attraction rates as well as the mode choice utilities will be tested against the transit-accessible density categorization defined in Section 3.1. A summary of the rates for home-based work (HBW), home-based other (HBO), and non-home-based (NHB) trips by the transit-accessible density of the household TAZ is shown in table 4. Figure 7 shows the person trip rates by purpose segmented by area types.

Table 4
Trip Rates from the 2011-MTS
HH Survey-Based Person Trip Rates by Area Type

Area Type	HBW	HBO	NHB	Home Based Trips per Person	Total Trips per Person	HH Survey Sample Size
CBD/Dense Urban	0.749	1.380	0.579	2.129	2.708	1,972
Urban	0.728	1.282	0.485	2.011	2.496	1,105
Fringe Urban	0.774	1.375	0.566	2.149	2.715	1,862
Suburban	0.689	1.383	0.504	2.071	2.575	5,605
Rural	0.697	1.362	0.578	2.059	2.638	3,704

Note: In 2012, in cooperation with MassDOT, CTPS completed a statewide household travel survey, which was conducted over an 18-month period between June 2010 and November 2011. This travel survey was named the 2011 Massachusetts Travel Survey (referred to as 2011-MTS). Through this effort, more than 10,000 households across the state were surveyed with every member of the household completing a travel log associated with one average weekday.
CBD = central business district. CTPS = Central Transportation Planning Staff. HBW = home-based work. HBO = home based other. HH = household. NHB = non-home based. MassDOT = Massachusetts Department of Transportation. MTS = Massachusetts Travel Survey.

Figure 7
HH Survey-Based Person Trip Rates by Trip Purpose and Area Type



CBD = central business district. HBW = home-based work. HBO = home based other. HH = household. NHB = non-home based. MassDOT = Massachusetts Department of Transportation.

The trip rates that result seem to reinforce intuition about trip making, which is that trip makers in rural areas tend to be more efficient with their trips, making fewer trips per person than their more urbanized counterparts. Auto usage and trip length may be key factors in this dynamic. The additional time and expense attendant with auto usage may force trip makers to be more judicious about their trip making than their more urbanized counterparts. In more urbanized areas, the level of trip making increases. The trip lengths presumably are shorter in urbanized areas and the options for trip destinations and modes—transit, bike and walk—are greater. These factors alone or in combination may result in higher trip rates for urbanized areas.

Interestingly, in this new categorization “fringe urban” trip making is higher than more urbanized areas trip making for all trip purposes. One attributing factor for higher trip making in this area type can be due to lower congestion and more multimodal options available for travel.

The HBO trip purpose has the highest trip rate for all area types. This may be because several different types of trips (shopping, recreation, school, and pick up and drop off) are included within the HBO purpose. Consistent with the larger trend of lower trip-making activity for less urbanized areas, the lowest rate of trip making for the HBW purpose is in the suburban and rural area types. The NHB trip purpose in the CBD area type has the highest trip rate of all the area types, which is reflective of the number of shopping opportunities available in the CBD.

4.2.2 Vehicle Constraints

Based on the nine analyzed developments, two key contributing factors for the vehicle trip generation are vehicle ownership and parking availability. The TDM has a vehicle availability model associated with its trip generation model.

TDM23 will review and revise the vehicle availability model and include trip segments for households with zero vehicles, vehicles less than drivers (that is, an insufficient number of vehicles for all household members who could drive), and vehicles greater than or equal to drivers (that is, a sufficient number of vehicles for all household members who could drive). CTPS is working to collect parking capacity data for significant areas in the region. As the data are collected and organized, a more explicit parking capacity constraint will be tested as well in TDM23.

4.2.3 Employment Segmentation

Another important observation from the analyzed developments is that different types of employment land uses show changing responses in trips. The retail and warehouse land uses show a high degree of variability in projected versus observed trip generation.

Currently, CTPS's TDM has three types of employment categories: basic, service, and retail. For TDM23, CTPS will evaluate employment categories using 10 employment sectors to estimate trip attraction rates, rather than just the three categories. This will help refine trip attraction rates and increase accuracy of trip attraction model.

Table 5
Employment Categories by Sectors

Model Segment	NAICS Codes	Description
1	23	Construction
2	61, 62	Educational Services, Health Care and Social Assistance
3	52, 53	Finance and Insurance, Real Estate Rental and Leasing
4	92	Public Administration
5	51	Information
6	44, 45, 71, 72	Retail Trade; Arts, Entertainment, and Recreation; Accommodation and Food Services
7	31, 32, 33	Manufacturing
8	81 (11, 21)	Other Services (includes agriculture and mining)
9	54, 55, 56	Professional, Scientific, and Technical Services; Management of Companies and Enterprises; Administrative and Support and Waste Management and Remediation Services
10	22, 42, 48, 49	Utilities, Wholesale Trade, Transportation, and Warehousing

NAICS = North American Industry Classification System.

4.3 RESEARCH NEXT STEPS

It is difficult to draw firm conclusions from the developments that were analyzed because the sample size (nine projects) is limited; however, the breadth of development types and their locations provided useful insight into trip generation in Massachusetts.

This study has demonstrated the regularly comparing previous travel estimates with real-world observations to identify areas of improvement for future models and applications. CTPS intends to build on this set of travel monitoring reports (TMR) and leverage these examples to evaluate future generations of the travel demand model. Expanding the number of sites from which TMRs are collected would provide additional insight into aspects of trip generation that are specific to Massachusetts.

Key areas for further study include the following:

- Effects of parking constraints. CTPS will also be studying how parking affects trip generation as part of a Unified Planning Work Program project being funded in fiscal year 2022
- Refinement of commercial vehicle activity by area type
- TDM23-based analysis for the selected nine TMR projects

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Thank You

Our sincere thank you to the following people for contributing their knowledge and time.

Name	**Affiliation**
Lionel Lucien	MassDOT
Alison Felix	MAPC
Ed Bromage	CTPS
Ben Dowling	CTPS
Rebecca Morgan	CTPS