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Evaluation of the Operation and Accuracy of Five Available Smart Growth Trip Generation Methodologies – APPENDIX A: Key Features and Assumptions of Candidate Methods

September 2011

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APPENDIX A:
Key Features and Assumptions of Candidate Methods

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Appendix A: Key Features and Assumptions of Candidate Methods

Table of Contents

Institute of Transportation Engineers (ITE) *Trip Generation Handbook* Chapter 7 Multi-Use Method

What it is:

A manual procedure for estimating reductions in "external" vehicle trips due to the "internal capture" of travel among land uses within mixed or multi-use development projects.

Where it is used and who uses it:

The tool was developed for estimating the internal capture at planned multi-use projects composed of at least two of the following three land uses: 1) Office, 2) Residential, and 3) Retail. It was developed for projects with a total floor area of between 100,000 and 2 million square feet. The method is explicitly not applicable to Central Business Districts, Suburban Activity Centers, or specific ITE land use classifications that may include a mix of land uses, e.g.: shopping centers, office park/office building with retail, or a hotel with limited retail/restaurant space.

The ITE Multi-use method is used by planners and engineers throughout the U.S. to analyze multi-use projects for traffic impact studies. Users include consultants performing studies and local government staff reviewing studies. The method has been approved by ITE for use since 2004.

Inputs:

This tool requires the applicable ITE land use codes, sizes, and units for the three land uses covered by the method: Office, Residential and Retail.

Outputs:

The tool provides daily and PM peak hour trips by direction (AM peak hour is not estimated).

How it works:

The method starts with ITE single-use rates and adjusts them down by the percentage of internal capture trips among Office, Residential and Retail land uses in order to estimate "baseline" daily and peak-hour vehicle trips.

Knowledge base:

The internal capture percentages are based on detailed surveys of three multi-use projects in Florida.

References:

ITE Trip Generation Handbook, Chapter 7

Support Documents:

The Trip Generation Handbook is the main reference.

Please see the following page for more detailed information on inputs and outputs (output data is hypothetical):

ITE Handbook - Current Mixed / Multi- Use Method

Project Site Size Limitations 1. The site should be between 100,000 and 2 million square feet in size.

Step 1: Document Characteristics of Multi-Use Development

	Notes / Instructions
Name of Development	
Description and ITE code of each Land Use	
Size of Each Land Use	use most appropriate units (i.e. DU, ksf, seats…)

Step 2: Select Time Period for Analysis

Select Time Period weekday Midday, weekday PM, weekday Daily

Step 3: Compute Baseline Trip Generation for Individual Land Uses

If multiple residential uses, compute for each land use individually, then record as single land use on worksheet

Compute Directional Trips enter/exit using ITE rates — can also use local data on rates and directional trips if available

Record Trip Generation Values

Step 4: Estimate Anticipated Internal Capture Rate Between Each Pair of Land Uses

Input Local Data on Internal Capture (if available) Tables 7.1 and 7.2 contain ITE internal capture rates estimated based on a series of studies in Florida--if possible, these rates should be replaced with reliable site-specific data

Steps 5, 6, 7, 8, and 9 have been automated.

Step 5: Estimate "Unconstrained Demand" Volume by Direction

Step 6: Estimate "Balanced Demand" Volume by Direction

Step 7: Estimate Total Internal Trips to/from Multi-Use Development Land Uses

Step 8: Estimate the Total External Trips for Each Land Use

Step 9: Calculate Internal Capture Rate and Total External Trip Gen. for Multi-Use Site

OUTPUTS

SAMPLE:

Project Description (1)	Land Use (2)	ITE Code (3)	Size (4)	Units (5)	Rates (6) Daily	Rates (6) A.M.	Rates (6) P.M.	Rates (6) Midday	Directional Distribution (7) A.M. Entering	A.M. Exiting	P.M. Entering	P.M. Exiting	Midday Entering	Midday Exiting
Specialty Retail Center	Retail	814	7.20	ksf	44.32	6.84	5.02	0	0.48	0.52	0.56	0.44	0	0
High-Rise Residential Condominium/Townhouse	Residential	232	89.30	DU	4.18	0.34	0.38	0.35	0.17	0.83	0.68	0.32	0.43	0.57
High-Turnover Restaurant	Retail	932	0.00	ksf	127.15	13.53	18.49	14.07	0.52	0.48	0.54	0.46	0.53	0.47
General Office Building	Office	710	13.60	ksf	11.01	1.55	1.49	0	0.88	0.12	0.17	0.83	0	0

	Total Trips				Inbound and Outbound Trips					
					A.M.		P.M.		Midday	
	Daily	A.M.	P.M.	Midday	Entering	Exiting	Entering	Exiting	Entering	Exiting
Specialty Retail Center	319	49	36	0	24	25	20	16	0	0
High-Rise Residential Condominium/Townhouse	373	30	34	31	5	25	23	11	15	19
High-Turnover Restaurant	0	0	0	0	0	0	0	0	0	0
General Office Building	150	21	20	0	18	3	3	17	0	0
TOTAL	*842*	*100*	*90*	*31*	*47*	*53*	*46*	*44*	*15*	*19*
INTERNAL CAPTURE %	11%	0%	11%	0%	0%	0%	11%	11%	0%	0%
INTERNAL TRIPS	89	0	10	0	0	0	5	5	0	0
NET TOTAL	***753***	***100***	***80***	***31***	***47***	***53***	***41***	***39***	***15***	***19***

Validation Analyses - ITE Handbook Multi-Use Method

Input Sources and Assumptions

The ITE Handbook Multi-Use Method (found in Chapter 7 of the ITE *Trip Generation Handbook, (2001*) adjusts 8th edition trip generation rates down using internal capture rates between three different land use categories: Office, Residential, and Retail. The method was not applicable for the California Infill sites since these sites were analyzed as single-use sites only. This section details the assumptions, data sources, and analytical processes used to generate ITE Handbook Multi-Use Method estimates of vehicle trips for the ten EPA/SANDAG multi-use sites.

While Gateway Oaks is the only analysis described in detail here, the same assumptions, data sources, and analytical processes were also used for the other sites: Jamboree Center, Park Place, The Villages, Rio Vista Station Village, The Village at Morena Linda Vista, La Mesa Village Plaza, Uptown Center, Hazard Center, and Heritage Center at Otay Ranch.

We began with the categories of land uses specified in the EPA and SANDAG analyses of each project. We then separated land uses for the project into Office, Residential, and Retail and designated land uses that were not Office, Residential, or Retail as "Miscellaneous." Next, we used ITE 8th edition trip generation rates to calculate Daily and PM peak period vehicle trip estimates for each land use. These estimates were then used as inputs to the Multi-Use model to estimate internal vehicle trips based on default (ITE-generated) internal capture rates.

Assumption 1: Since the ITE Handbook Multi-Use method does not provide AM peak internal capture rates, estimates were only calculated for PM Peak and Daily periods.

Assumption 2: Internal capture does not need to be estimated for land use categories other than Office, Retail, and Residential because "Miscellaneous" land uses have negligible internal capture as far as the ITE Handbook Multi-Use methodology is concerned.

Assumption 3: “Retail” includes the following land use categories for these analyses: Specialty Retail Center, Shopping Center, Supermarket, High-Turnover Restaurant, and Fast Food with Drive-Through Window.

The example below shows the inputs used to generate the ITE Handbook Multi-Use analysis for Gateway Oaks in Sacramento.

PROJECT TITLE	Gateway Oaks
PROJECT #:	1
ANALYST:	Josh Miller
DATE:	9/3/2010

TRIP GENERATION

This spreadsheet is intended for estimating trip generation and internal capture for multi-use developments. It uses the information provided in the ITE *Trip Generation Handbook*, 8th Edition.

ID	Project Description (1)	Land Use (2)	ITE Code (3)	Size (4)	Units (5)	Rates (6)				Directional Distribution (7)					
										A.M.		P.M.		Midday	
						Daily	A.M.	P.M.	Midday	Entering	Exiting	Entering	Exiting	Entering	Exiting
A	General Office	Office	710	1,084.00	ksf	11.01	1.55	1.49	0	0.88	0.12	0.17	0.83	0	0
B	Apartment	Residential	220	1,351.00	DU	6.65	0.55	0.67	0.52	0.29	0.71	0.61	0.39	0	0
C	High-Turnover Restaurant	Retail	932	12.00	ksf	127.15	13.53	18.49	14.07	0.52	0.48	0.54	0.46	0.53	0.47
D	Hotel	Misc	310	188.00	Rooms	8.17	0.52	0.61	0.72	0.55	0.45	0.59	0.42	0.56	0.44

Project Description (1)	Total Trips				Inbound and Outbound Trips					
					A.M.		P.M.		Midday	
	Daily	A.M.	P.M.	Midday	Entering	Exiting	Entering	Exiting	Entering	Exiting
General Office	11,935	1,680	1,615	0	1,478	202	275	1,340	0	0
Apartment	8,984	743	905	703	215	528	552	353	0	0
High-Turnover Restaurant	1,526	162	222	169	84	78	120	102	118	104
Hotel	1,536	98	115	135	54	44	67	48	64	51
TOTAL	*23,981*	*2,683*	*2,857*	*1,007*	*1,831*	*852*	*1,014*	*1,843*	*182*	*155*
INTERNAL CAPTURE %	3%	0%	3%	0%	0%	0%	3%	3%	0%	0%
INTERNAL TRIPS	651	0	79	0	0	0	28	51	0	0
NET TOTAL	*23,330*	*2,683*	*2,778*	*1,007*	*1,831*	*852*	*986*	*1,792*	*182*	*155*

SANDAG MXD Version 4.0

What it is:

A spreadsheet tool that calculates adjustments to ITE single-use rates based on land use mix and other user inputs.

Where it is used and who uses it:

The San Diego Association of Governments (SANDAG) approved the tool in June, 2010, as an option for estimating the trip generation of smart growth projects in traffic impact studies in the San Diego region. It is particularly suited to mixed-use projects located in urban areas outside of major downtowns.

Developed and validated for use in the San Diego region, this tool begins with SANDAG single-use trip-generation rates, although other rates can also be used. (SANDAG rates are often used elsewhere in California, and to a more limited extent, elsewhere in the US). The tool is used by planners and engineers analyzing smart growth developments for traffic impact studies. Users include consultants performing studies and local government staff reviewing studies.

Inputs:

The key inputs this model requires include: site area (in acres); number of Intersections per square mile in the vicinity of the project; whether transit (bus or rail) is easily accessed from the site; if the project is in an area characterized by small shops (as in a Central Business District or TOD); employment within one mile of the site; and employment reachable within a 30-minute transit trip.

Outputs:

The tool generates daily and AM/PM peak hour trips by direction. It reduces standard SANDAG rates based on three factors: internal capture (trips that do not leave the project site), external (trips extending beyond the project area) walk/bike trips, and estimated external transit trips. If the tool is used to analyze a single-use site, no internal capture component is calculated.

How it works:

SANDAG trip generation rates used to estimate "baseline" daily and peak hour vehicle trip are adjusted based on a set of three regression models, which are also used in the EPA MXD method, that estimate the probability of internal capture or use of transit or walking.

Knowledge base:

Trip reduction factors, also used in the EPA MXD method, are based on regression analysis of land use and travel survey data for 239 multi-use sites in six metropolitan areas: Boston, Atlanta, Houston, Seattle, Portland and Sacramento.

References:

SANDAG website: http://www.sandag.org/

Support Documents:

Trip Generation for Smart Growth (SANDAG 2010)

Forthcoming Journal of Urban Planning and Development article by Reid Ewing et al.

Please see the following table for more detailed information on inputs and outputs for a hypothetical example project: inputs are generally shown in yellow and blue highlighting:

MXD SANDAG TRIP GENERATION MODEL V4		
Project Site Size Limitations	Between 5 and 300+ acres, max. 5,000 dwelling units (d.u.), max. 3 million sq. ft. of commercial use	
Section 1 - General Site Information - *Example*		
Site Name	Example	
Geographic		**Notes / Instructions**
Developed Area (in acres)	14	Include streets, ROW, parking lots, pocket parks. Do not include open space, vacant lots.
Number of Intersections	4	Counts intersections either within or on the perimeter of the MXD (mixed-use development). Does not count most unsignalized driveways or alleys, but does count major entrances to shopping areas or residential developments.
Is Transit (bus or rail) present within the site or across the street?	Yes	Note: This is only used as a way to "zero" out the probability of external trips if no transit is present.
Land Use - Surrounding Area		
Is the site in a Central Business District or TOD?	No	Answering "Yes" will reduce the HBO ("home-based other") and NHB ("non home-based") trip purpose splits for retail use to those found in smaller stores. The nature of the stores (large vs. small) should be the primary factor in the selection here.
Employment within one mile of the MXD	20,773	Does not include employment within the MXD itself
Employment within a 30 minute Transit Trip (Door-to-door)*	70,207	Includes employment within the MXD itself
*Some possible ways to get this are: **Transit skims from a travel demand model** (most defensible, though not always accurate - check for reasonability!), or **GIS analysis**, or **manual method.** For GIS method, must study the transit lines in or adjacent to the site, determine which stops are close enough (taking access time and average wait time into account), and then look at what's around those stops. Use model TAZ data and best-guess percentage of jobs in those TAZs that are close enough to those stops to be within the 30 minute trip. **Rough approximations** of the percentage of jobs at the city level that are within 1/4 (for rail) to ½ mile (for bus) of transit, coupled with employment projections.		
Site Demographics		
Enter Population Directly?	No	If "No", will apply average HH size factors (in section 2) to dwelling units below
Population		Population will be calculated based on dwelling units below and average HH sizes in section 2.
Average Vehicles Owned per Dwelling Unit	1.80	Census 2000 Summary File 3 may provide block group data for the closest block group to the site (choosing table H44 when it prompts you for a table).

Section 2 - Variable Modeling Parameters - input site specific internalization or use default estimates, which are based on NCHRP 365,*Travel Estimation Techniques for Urban Planning,* W. Martin & N. McGuckin (1998).				
Section 3 - Trip Generation				
Description, ITE Code, Quantity, and Units for each land use				
	Daily	AM Peak Hour		PM Peak Hour
Trips from Land uses not covered above ==>	0	0		0
Jobs in those Land Uses	0			
Outputs: ***MXD SANDAG and MXD EPA produce the same types of output, but SANDAG uses its own trip generation rates while EPA uses ITE rates***				
	Estimates for AM Peak Hour, PM Peak Hour, and Daily			
(Example: AM Peak Hour)	HBW	HBO	NHB	Total
Number of "Raw" ITE Trips Subject to Model	289	549	69	907
Number of Trips:				
Internal Capture	15	21	3	39
Walking External	10	62	3	75
Transit External	6	16	2	24
Net # of IXXI Vehicle Trips	**259**	**450**	**61**	**770**

Section 3 - Trip Generation Appendix

Below is a listing of land uses that the SANDAG model supports:

NOTE: Occupied units / spaces	Quantity	Units
Residential		
Estate, Urban or Rural		DU
Single Family Detached		DU
Condominium		DU
Apartment		DU
Mobile Home (Family)		DU
Retail		
Super Regional Shopping Center		ksf
Regional Shopping Center		ksf
Community Shopping Center		ksf
Neighborhood Shopping Center		ksf
Specialty Retail / Strip Commercial		ksf
Supermarket		ksf
Drugstore		ksf
Bank with Drive-Thru		ksf
Discount Store		ksf
Restaurant		
Quality		ksf
Sit-down, High Turnover		ksf
Fast Food (With Drive-thru)		ksf
Fast Food (Without Drive-thru)		ksf
Delicatessen (7 AM - 4 PM)		ksf
Office		
Standard Commercial Office		ksf
Large Commercial Office		ksf
Office Park		ksf
Single Tenant Office		ksf
Corporate Headquarters		ksf
Government (Civic Center)		ksf
Post Office (Community, w/mail drop lane)		ksf
Medical-Dental		ksf
Industrial		
Industrial / Business Park (with commercial)		ksf
Industrial / Business Park (no commercial)		ksf
Industrial Plant		ksf
Manufacturing		ksf
Warehousing		ksf
Storage		ksf
Science Research & Development		ksf
Lodging		
Hotel (w/convention facilities, restaurant)		Occ. Room
Motel		Occ. Room
Resort Hotel		Occ. Room
Misc. Uses		
Movie Theater		screen
Religious Facility		ksf
Gas Station (w/Food Mart and Car Wash)		Pump
Hospital		Bed
Convalescent / Nursing Facility		Bed
Library		ksf
Park (developed with meeting rooms and sports facilities)		acre
Transit Station (Light Rail with Parking)		occupied pkg space
Park & Ride Lot		occupied pkg space
Education		
University		Student
Junior College		Student
High School		Student
Middle / Junior High		Student
Elementary		Student
Day Care		Student

EPA MXD Version 4.0

What it is:

A spreadsheet tool that calculates adjustments to ITE single-use rates based on land use mix and other user inputs. .

Where it is used and who uses it:

The tool was developed under the U.S. Environmental Protection Agency (EPA) to supplant the current Institute of Transportation Engineers (ITE) Multi-use method that is described in the ITE *Trip Generation Handbook*, Chapter 7. It is particularly suited to projects located in urban areas outside of significant Central Business Districts (CBDs). This tool is intended for use by planners and engineers throughout the U.S. for analyzing smart growth developments as a part of traffic impact studies. Users include consultants performing studies and local government staff reviewing studies. The method is still under review by an external panel that includes ITE.

Inputs:

Key inputs required include: site area (in acres); number of Intersections per square mile in the vicinity of the project; whether transit (bus or rail) is easily accessed from the site; if the site is in an area characterized by small shops (as in a Central Business District or TOD); and employment within a 30-minute transit trip from the site.

Outputs:

The tool generates daily and AM/PM peak hour trips by direction. It estimates reductions from standard ITE rates due to three factors: internal capture (trips that do not leave the project site), external (extending past project area) walk/bike trips and estimated external transit trips. If the tool is used to analyze a single-use site, no internal capture component is calculated.

How it works:

ITE trip generation rates used to estimate "baseline" daily and peak hour vehicle trips are adjusted based on a set of three regression models that estimate the probability of internal capture or use of transit or walking/bicycling.

Knowledge base:

Trip reduction factors are based on regression analysis of land use and travel survey data for 239 multi-use sites in six metropolitan areas: Boston, Atlanta, Houston, Seattle, Portland and Sacramento.

References:

User guide formatted as an update to the ITE *Trip Generation Handbook.*

Support Documents:

Research Summary (not published; available on the Practitioner Panel list-serve).

Forthcoming Journal of Urban Planning and Development article by Reid Ewing et al

Please see the following table for more detailed information on inputs and outputs for a hypothetical example project. Inputs are generally shown in yellow and blue highlighting:

Project Site Size Limitations	Between 5 and 300+ acres, max. 5,000 dwelling units (d.u.), max. 3 million sq. ft. of commercial use		
Section 1 - General Site Information - *Example*			
Site Name	Example		
Geographic		**Notes / Instructions**	
Developed Area (in acres)	14	Include streets, ROW, parking lots, pocket parks. Do not include open space, vacant lots.	
Number of Intersections	294	Counts intersections either within or on the perimeter of the MXD (mixed-use development). Does not count most unsignalized driveways or alleys, but does count major entrances to shopping areas or residential developments.	
Is Transit (bus or rail) present within the site or across the street?	Yes	Note: This is only used as a way to "zero" out the probability of external trips if no transit is present.	
Land Use - Surrounding Area			
Is the site in a Central Business District or TOD?	No	Answering "Yes" will reduce the HBO ("home-based other") and NHB ("non home-based") trip purpose splits for retail use to those found in smaller stores. The nature of the stores (large vs. small) should be the primary factor in the selection here.	
Employment within one mile of the MXD	20,773	Does not include employment within the MXD itself	
Employment within a 30-minute Transit Trip (Door-to-door)*	70,207	Also includes employment within the MXD itself	
*Some possible ways to get this are: **Transit skims from a travel demand model** (most defensible, though not always accurate - check for reasonability!), or **GIS analysis**, or **manual method.** For GIS method, must study the transit lines in or adjacent to the site, determine which stops are close enough (taking access time and average wait time into account), and then look at what's around those stops. Use model TAZ data and best-guess percentage of jobs in those TAZs that are close enough to those stops to be within the 30-minute trip. **Rough approximations** of the percentage of jobs at the city level that are within 1/4 (for rail) to ½ mile (for bus) of transit, coupled with employment projections.			
Site Demographics			
Enter Population Directly?	No	If "No", will apply average HH size factors (in section 2) to dwelling units below	
Population		Population is automatically calculated based on dwelling units below and average HH sizes in section 2.	
Average Vehicles Owned per Dwelling Unit	1.80	Census 2000 Summary File 3 block group data may provide data for the closest block group to the site (choosing table H44 when it prompts for a table). Or use default estimates, which are based on NCHRP 365,*Travel Estimation Techniques for Urban Planning,* W. Martin & N. McGuckin (1998)	
Section 2 - Variable Modeling Parameters – requires site-specific internalization rates, or the use default estimates based on NCHRP 365,*Travel Estimation Techniques for Urban Planning, W. Martin & N. McGuckin (1998)*			
Section 3 - Trip Generation			
Description, ITE Code, Quantity, and Units for each land use			
	Daily	AM Peak Hour	PM Peak Hour
Trips from Land uses not covered above ==>	0	0	0
Jobs in those Land Uses	0		
Outputs: *MXD SANDAG and MXD EPA methodologies produce the same types of output, but the SANDAG MXD methodology uses SANDAG's trip generation rates, while the EPA MXD methodology uses ITE rates*			
	Estimates for AM Peak Hour, PM Peak Hour, and Daily		

(Example: AM Peak Hour)	HBW	HBO	NHB	Total
Number of "Raw" ITE Trips Subject to Model	289	549	69	907
Number of Trips:				
Internal Capture	15	21	3	39
Walking External	10	62	3	75
Transit External	6	16	2	24
Net # of IXXI Vehicle Trips	**259**	**450**	**61**	**770**

Validation Analyses – EPA & SANDAG MXD Methods

Input Sources and Assumptions:

The EPA/SANDAG MXD method requires a moderate amount of site-specific data. The accuracy of this model depends on the availability of the inputs. Most input data can be obtained from site plans and aerial photography, while demographic data and needed information on surrounding employment can be obtained from either regional agencies or the Census. The method was applied to the 10 EPA/SANDAG multi-use sites and the 12 California infill sites.

Base Vehicle-Trip Generation Estimates for the 10 EPA/SANDAG Sites:

ITE Trip Generation (8th edition) equations were used to estimate baseline peak hour directional vehicle trips for Gateway Oaks, Jamboree Center, Park Place, and The Villages. SANDAG *Traffic Generators* rates were used to generate baseline trip estimates at Rio Vista Station Village, La Mesa Village Plaza, Uptown Center, Hazard Center, and Heritage Center at Otay Ranch.

Key Input Data Sources and Assumptions for all sites:

Data or Assumption	***EPA/SANDAG Sites***	***Infill Sites***
Area (in acres) & Number of Intersections	Calculated from site plan and aerial photographs	U.S. Census Bureau's LED OnTheMap, assumed intersection density within site equal to intersection density in the surrounding area
Whether Transit (bus or rail) present at site	Based on current transit maps	Based on current transit maps
Whether the site in a Central Business District or TOD[1]	Aerial photographs (Google Earth)	Aerial photographs (Google Earth)
Employment within one mile of the MXD	Census data using GIS	U.S. Census Bureau's LED OnTheMap
Employment within a 30-minute Transit Trip	MPO model skims	MTC and SANDAG model skims (SCAG skims not available as of 10-12-10
Household size (where applicable)	MPO data or Census data for the closest block group	Default values (based on national averages)
Vehicles Owned per Dwelling Unit	MPO data or Census 2000 Summary File 3 block group data for the closest block group to the site	Census 2000 data (total block group vehicles divided by total dwelling units)
Basic Trip Rates	SANDAG trip rates and ITE Trip Generation 8th Edition equations	ITE Trip Generation 8th Edition average rates

This example shows the inputs used to generate the analysis for San Diego's Uptown Center:

Section 1 - General Site Information				
Site Name:				Uptown Center
Geographic				
Area (in acres)				14.13
Number of Street Intersections				4
Is Transit (bus or rail) present within the site?				Yes
Land Use - Surrounding Area				
Is the site in a Central Business District or Transit Oriented Development?				No
Employment within one mile of the site (number of jobs)				15,722
Employment within a 30-minute transit trip of site				271,368
Site Demographics				
Population - Enter Directly?				No
("No" means default values of Population and Employment ratios are used)				
Average Vehicles Owned per Dwelling Unit				1.35
Average Household Size		*Default Values:*		**Source:**
	Estate, Urban or Rural	3.2		Default Value
	Single Family Detached	3.2		Default Value
	Condominium	1.56		SANDAG Database
	Apartment	1.56		SANDAG Database
	Mobile Home (Family)	2.5		Default Value

National Cooperative Highway Research Program (NCHRP) 8-51 Multi-Use Method

What it is:

A spreadsheet tool for estimating reductions in external vehicle trips due to internal capture of travel among land uses at mixed or multi-use development projects.

Where it is used and who uses it:

The tool was developed for estimating “internal capture” (e.g., trips that do not leave a project) at planned multi-use projects that have: two or more revenue-producing land uses; internal pedestrian and vehicular connectivity; and shared parking among some or all uses. This method was developed for projects with at least 100,000 square feet of building space and overall size of up to 300 acres. Since it may supplant the current Institute of Transportation Engineers (ITE) Trip Generation Handbook multi-use methodology, the ITE limitations on development type should presumably also apply: e.g., it should not be applied to projects located within Central Business Districts, Suburban Activity Centers, or ITE land use classifications with the potential for a mix of land uses, such as shopping centers, office park/office building with retail, or a hotel with limited retail/restaurant space. Though the NCHRP 08-51 method is still under review, it is expected to be available by the end of 2010 for use in transportation impact analyses of multi/mixed use developments.

Inputs:

Key inputs for this method include the number and quantity of the seven land uses covered by the method: Office, Retail, Restaurant, Cinema/Entertainment, Residential, Hotel, and All Other Land Uses. For these land use categories, the spreadsheet tool requires Total, Entering, and Exiting trips (calculated from existing ITE rates). In addition, the tool requires local estimates of mode split and vehicle occupancy. For the PM peak hour estimate, users are asked to provide average walking distances between select land uses.

Outputs:

AM and PM peak hour trips by direction (Daily trips are not estimated). Please see the following page for more detailed information on Inputs and outputs.

How it works:

ITE trip generation rates are used to estimate directional peak hour vehicle trips (e.g., # of vehicles entering and exiting the boundaries of a land use project during peak morning and evening travel times). The model adjusts these estimates using "Adjusted Internal Capture Rates" in Tables 7.1a and 7.2a. These tables are essentially the Internal Capture Rate tables 7.1 and 7.2 from the ITE Handbook with added rates for trips between Cinema/Entertainment, Restaurant, Hotel, and other land uses. For PM peak hour estimates, these internal capture rates are adjusted for average walking distances between select land uses; there was insufficient data to allow this option for the AM Peak hour.

Knowledge base:

The adjusted internal capture percentages among uses is based on detailed data collected at three multi/mixed-use sites (two in Texas, one in Georgia) conducted for the NCHRP 8-51 study, as well as data from a prior study in Florida.

References:

NCHRP 8-51 Internal Trip Capture Estimator Version 8 062810 (to be published).

Support Documents:

Draft Final NCHRP 8-51 report: Revised Phase 1 Methodology July 2010 (not publicly available).

Detailed information on Inputs and outputs (Example data is for Gateway Oaks project in Sacramento):

NCHRP 8-51 Use Method

Project Site Size Limitations:
The site should be between 100,00 square feet and 300 acres (based on study and validation sites)

Land Use Information

Notes / Instructions

Name of Development
Land Use Codes, Descriptions, Quantity, and Units

Entering, Exiting, Total according to ITE rates

Directional Trips
SAMPLE:

Table 1-A: Base Vehicle-Trip Generation Estimates (Single-Use Site Estimate)

Land Use	Development Data (*For Information Only*)			Estimated Vehicle-Trips		
	ITE LUCs[1]	Quantity	Units	Total	Entering	Exiting
Office	710	1,084.30	ksf	1681	1,479	202
Retail			ksf		0	0
Restaurant	932	12.00	ksf	162	84	78
Cinema/Entertainment					0	0
Residential	220	1,351.00	DU	743	215	528
Hotel	310	188.00	rooms	98	54	44
All Other Land Uses[2]				0		
Total				2684	1832	852

Table 2-A: Mode Split and Vehicle Occupancy Estimates

Land Use	Entering Trips			Exiting Trips		
	Veh. Occ.	% Transit	% Non-Motorized	Veh. Occ.	% Transit	% Non-Motorized
Office	1.06	7.24%	3.44%	1.06	7.24%	3.44%
Retail	1.33	0.69%	9.30%	1.33	0.69%	9.30%
Restaurant	1.33	0.69%	9.30%	1.33	0.69%	9.30%
Cinema/Entertainment	1.72	1.89%	6.97%	1.72	1.89%	6.97%
Residential	1.33	0.69%	9.30%	1.33	0.69%	9.30%
Hotel	1.72	1.89%	6.97%	1.72	1.89%	6.97%
All Other Land Uses[2]	1.33	0.69%	9.30%	1.33	0.69%	9.30%

Note by project team: Vehicle trips are computed using mode split and vehicle occupancy data above. This data is particularly hard to find, and it is the greatest challenge to using this method. For PM trips, tool requires Table 3-A: Average Land Use Interchange Distances (ft. walking distance) between uses.

Outputs*

Table 5-A: Computations Summary			
	Total	Entering	Exiting
All Person-Trips	3,161	2,063	1,098
Internal Capture Percentage	4%	3%	6%
External Vehicle-Trips[3]	2,307	1,588	719
External Transit-Trips[4]	137	117	20
External Non-Motorized Trips[4]	176	93	83

Table 6-A: Internal Trip Capture Percentages by Land Use		
Land Use	Entering Trips	Exiting Trips
Office	2%	8%
Retail	N/A	N/A
Restaurant	23%	38%
Cinema/Entertainment	N/A	N/A
Residential	2%	1%
Hotel	3%	5%

*These outputs can only be calculated for Peak AM and Peak PM time periods.

Validation Analyses - NCHRP 8-51 Method

Input Sources and Assumptions - 10 EPA/SANDAG Multi-Use Sites

The Internal Trip Capture Estimation Tool for Mixed-Use Developments (referred to as NCHRP 8-51) is a spreadsheet tool that requires a relatively small set of site-specific data compared to URBEMIS. Because it has relatively few inputs, the accuracy of this model depends substantially on the accuracy of this data, particularly data on the mode split of trips to and from the site. This section details the assumptions, data sources, and analytical processes used to generate NCHRP 8-51 estimates of vehicle trips for ten EPA/SANDAG multi-use sites. While Morena Linda Vista is the only analysis described in detail here, the same assumptions, data sources, and analytical processes were also used for the remaining sites: Gateway Oaks, Jamboree Center, Park Place, The Villages, Rio Vista Station Village, La Mesa Village Plaza, Uptown Center, Hazard Center, and Heritage Center at Otay Ranch.

Table 1-A/P: Base Vehicle-Trip Generation Estimates: Tables 1-A and 1-P are the input cells of the spreadsheet for basic trip generation data in the AM and PM peak hours respectively. In accordance with NCHRP 8-51 recommendations, ITE 8th edition trip generation rates were used to estimate peak hour directional trips for each of the land use categories.

Table 2-A and 2-P: Mode Split and Vehicle Occupancy Estimates: NCHRP 8-51 recommends the use of peak hour, directional mode split and vehicle occupancy data collected from sites with similar characteristics. Because this data was not available, detailed daily mode split and vehicle occupancy data from the San Francisco region's Metropolitan Transportation Commission (MTC) were used. However, no other California regional planning agency provided such data for this analysis.

The following three assumptions were made at each EPA/SANDAG multi-use site for mode split in Tables 2-A and 2-P:

Assumption 1: MTC daily mode split data[1] collected in the Bay Area are suitable for use as peak hour data for smart growth sites in California. This mode split data was used to estimate mode split at the ten EPA/SANDAG sites as no local data was available. Since the Bay Area has a higher mode split for transit and walking than the remainder of California, this assumption may bias estimates of vehicles downward at these sites. However, smart growth sites outside of the Bay Area are likely to have mode splits closer to those of the Bay Area than do conventional developments.

Assumption 2: MTC mode split and vehicle occupancy data for various site categories is suitable for sites outside the Bay Area with similar characteristics. MTC has separate mode split and vehicle occupancy data for the following categories: within 1/2 mile of rail station (or ferry terminal), within 1/2 mile to 1 mile of rail station, and greater than 1 mile from rail station. The MTC separates the "greater than 1 mile" category into Urban, High-Suburban, Low-Suburban, and Rural.

Assumption 3: The same set of mode split and vehicle occupancy data can be applied to both entering and exiting trips.

Table 3-P: Average Land Use Interchange Distances: These represent walking distances between uses on the site. These inputs are specific to PM peak hour vehicle trip estimation. Due to the limited site-specific data available, we computed PM peak hour trips without inputting average land use interchange distances.

Assumption 4: PM peak hour vehicle trip estimates calculated without interchange distances are still indicative of the model's overall performance. Test runs were conducted using an interchange distance based on half the length of the site. For the three largest sites over 100 acres (Gateway Oaks, Jamboree Center and Park Place), this results in average walking distances of nearly a half-mile or more among some land uses within the site. Such distances would result in less internal capture, and an estimated 4-7 percent increase in external vehicle trips at these sites (which would in turn reduce the accuracy of the estimates compared to available ground counts). For smaller sites (e.g. the six San Diego sites which are all 16 acres or smaller), including the interchange distances has a negligible effect on the PM peak hour estimates.

Input Sources and Assumptions - 12 California Infill Study Sites

Assumptions 3 and 4 above for the EPA/SANDAG sites were also applied to the twelve selected California Infill study sites. Since these are very small sites (generally one building), and because these were treated as single-use sites, the Average Land Use Interchange Distances criteria do not apply.

Table 1-A/P: Base Vehicle-Trip Generation Estimates: The ITE 8th edition trip generation rates specified for each site in the CA Infill Study report were used.

Table 2-A/P: Mode Split and Vehicle Occupancy Estimates: We used the actual mode splits obtained via intercept surveys provided for each site in the Infill Study report.

The example below shows the inputs used to generate the NCHRP 8-51 analysis for Morena Linda Vista, a multi-use site located in San Diego.

[1]Data Source: MTC StaRS Appendix E Tables (in Volume 2): http://www.mtc.ca.gov/planning/smart_growth/stars/

NCHRP 8-51 Internal Trip Capture Estimation Tool			
Project Name:	Morena Linda Vista	Organization:	UCD
Project Location:	San Diego, CA	Performed By:	Josh Miller
Scenario Description:		Date:	9/2/2010
Analysis Year:		Checked By:	
Analysis Period:	AM Street Peak Hour	Date:	

Table 1-A: Base Vehicle-Trip Generation Estimates (Single-Use Site Estimate)

Land Use	Development Data (*For Information Only*)			Estimated Vehicle-Trips		
	ITE LUCs[1]	Quantity	Units	Total	Entering	Exiting
Office	710		ksf	0	0	0
Retail	814	8.00	ksf	40	22	18
Restaurant			ksf	397	212	185
Cinema/Entertainment	710			0	0	0
Residential	220	176.00	DU	118	72	46
Hotel	310		rooms	0	0	0
All Other Land Uses[2]	93	165.00		219	127	92
Total				774	433	341

Table 2-A: Mode Split and Vehicle Occupancy Estimates

Land Use	Entering Trips			Exiting Trips		
	Veh. Occ.	% Transit	% Non-Motorized	Veh. Occ.	% Transit	% Non-Motorized
Office	1.15	29.42%	16.14%	1.15	29.42%	16.14%
Retail	1.34	13.40%	21.98%	1.34	13.40%	21.98%
Restaurant	1.34	13.40%	21.98%	1.34	13.40%	21.98%
Cinema/Entertainment	1.77	13.94%	28.82%	1.77	13.94%	28.82%
Residential	1.34	13.40%	21.98%	1.34	13.40%	21.98%
Hotel	1.77	13.94%	28.82%	1.77	13.94%	28.82%
All Other Land Uses[2]	1.34	13.40%	21.98%	1.34	13.40%	21.98%

Table 3-A: Average Land Use Interchange Distances (Feet Walking Distance)

Origin (From)	Destination (To)					
	Office	Retail	Restaurant	Cinema/Entertainment	Residential	Hotel
Office						
Retail						
Restaurant						
Cinema/Entertainment						
Residential						
Hotel						

Table 4-A: Internal Person-Trip Origin-Destination Matrix*

Origin (From)	Destination (To)					
	Office	Retail	Restaurant	Cinema/Entertainment	Residential	Hotel
Office		0	0	0	0	0
Retail	0		3	0	3	0
Restaurant	0	15		0	10	0
Cinema/Entertainment	0	0	0		0	0
Residential	0	1	12	0		0
Hotel	0	0	0	0	0	

Table 5-A: Computations Summary

	Total	Entering	Exiting
All Person-Trips	1,034	578	456
Internal Capture Percentage	9%	8%	10%
External Vehicle-Trips[3]	456	257	199
External Transit-Trips[4]	127	72	55
External Non-Motorized Trips[4]	208	117	91

Table 6-A: Internal Trip Capture Percentages by Land Use

Land Use	Entering Trips	Exiting Trips
Office	N/A	N/A
Retail	55%	25%
Restaurant	5%	10%
Cinema/Entertainment	N/A	N/A
Residential	14%	21%
Hotel	N/A	N/A

[1]Land Use Codes (LUCs) from *Trip Generation Informational Report*, published by the Institute of Transportation Engineers.
[2]Total estimate for all other land uses at mixed-use development site-not subject to internal trip capture computations in this estimator
[3]Vehicle-trips computed using the mode split and vehicle occupancy values provided in Table 2-A
[4]Person-Trips
*Indicates computation that has been rounded to the nearest whole number.

Estimation Tool Developed by the Texas Transportation Institute

NCHRP 8-51 Internal Trip Capture Estimation Tool			
Project Name:	Morena Linda Vista	Organization:	UCD
Project Location:	San Diego, CA	Performed By:	Josh Miller
Scenario Description:		Date:	9/2/2010
Analysis Year:		Checked By:	
Analysis Period:	PM Street Peak Hour	Date:	

Table 1-P: Base Vehicle-Trip Generation Estimates (Single-Use Site Estimate)

Land Use	Development Data (*For Information Only*)			Estimated Vehicle-Trips		
	ITE LUCs[1]	Quantity	Units	Total	Entering	Exiting
Office				0	0	0
Retail	814	8.00	ksf	54	26	28
Restaurant				354	182	172
Cinema/Entertainment				0	0	0
Residential	220	176.00	DU	97	28	69
Hotel				0	0	0
All Other Land Uses[2]	93	165.00		188	150	38
Total				693	386	307

Table 2-P: Mode Split and Vehicle Occupancy Estimates

Land Use	Entering Trips			Exiting Trips		
	Veh. Occ.	% Transit	% Non-Motorized	Veh. Occ.	% Transit	% Non-Motorized
Office	1.15	29.42%	16.14%	1.15	29.42%	16.14%
Retail	1.34	13.40%	21.98%	1.34	13.40%	21.98%
Restaurant	1.34	13.40%	21.98%	1.34	13.40%	21.98%
Cinema/Entertainment	1.77	13.94%	28.82%	1.77	13.94%	28.82%
Residential	1.34	13.40%	21.98%	1.34	13.40%	21.98%
Hotel	1.77	13.94%	28.82%	1.77	13.94%	28.82%
All Other Land Uses[2]	1.34	13.40%	21.98%	1.34	13.40%	21.98%

Table 3-P: Average Land Use Interchange Distances (Feet Walking Distance)

Origin (From)	Destination (To)					
	Office	Retail	Restaurant	Cinema/Entertainment	Residential	Hotel
Office						
Retail						
Restaurant						
Cinema/Entertainment						
Residential						
Hotel						

Table 4-P: Internal Person-Trip Origin-Destination Matrix*

Origin (From)	Destination (To)					
	Office	Retail	Restaurant	Cinema/Entertainment	Residential	Hotel
Office		0	0	0	0	0
Retail	0		11	0	4	0
Restaurant	0	10		0	5	0
Cinema/Entertainment	0	0	0		0	0
Residential	0	16	19	0		0
Hotel	0	0	0	0	0	

Table 5-P: Computations Summary

	Total	Entering	Exiting
All Person-Trips	926	516	410
Internal Capture Percentage	14%	13%	16%
External Vehicle-Trips[3]	382	216	166
External Transit-Trips[4]	108	61	47
External Non-Motorized Trips[4]	175	99	76

Table 6-P: Internal Trip Capture Percentages by Land Use

Land Use	Entering Trips	Exiting Trips
Office	N/A	N/A
Retail	74%	41%
Restaurant	12%	7%
Cinema/Entertainment	N/A	N/A
Residential	24%	38%
Hotel	N/A	N/A

[1]Land Use Codes (LUCs) from *Trip Generation Informational Report*, published by the Institute of Transportation Engineers.
[2]Total estimate for all other land uses at mixed-use development site-not subject to internal trip capture computations in this estimator
[3]Vehicle-trips computed using the mode split and vehicle occupancy values provided in Table 2-P
[4]Person-Trips
*Indicates computation that has been rounded to the nearest whole number.

Estimation Tool Developed by the Texas Transportation Institute

URBEMIS 2007 (version 9.2.4)

What it is:

A software tool compatible with Windows operating systems that estimates vehicle trips and associated air emissions based on user-specified inputs and selected mitigation measures.

Where it is used and who uses it:

URBEMIS (which stands for "urban emissions") is commonly used to estimate air quality emissions, including greenhouse gas (GHG), associated with proposed land use development projects in California. URBEMIS was originally developed by the California Air Resources Board (CARB) in the 1980s. Since the late 1990s, it has been supported and expanded by a consortium of air quality management districts throughout California. URBEMIS is used in California for compliance with the California Environmental Quality Act (CEQA), which requires assessment of air quality emissions for significant proposed land use projects. Also, some air quality management districts in California require the use of URBEMIS as part of their Indirect Source Rules. This tool is also used by some consultants to estimate trip generation for traffic impact analyses of proposed land use development projects.

Inputs:

Estimating "unmitigated" operational vehicle trips requires only inputting the amount and size of various land uses in a project by ITE land use classification. It also includes a set of motor vehicle "operational mitigation measures" that can be specified to estimate reductions in daily and yearly vehicle trips, VMT, and associated emissions for several land use and transportation strategies. Depending on the number of operational mitigation measures the user selects, URBEMIS input data requirements can be significant.

Outputs:

URBEMIS provides detailed information on air pollution and GHG emissions. It also provides vehicle miles travelled (VMT) and vehicle trips both *with* and *without* selected operational mitigation measures for each project. However, URBEMIS does not provide mode split or AM/PM peak hour trips.

What it is used for and how it works:

URBEMIS currently uses the Institute for Transportation Engineers (ITE) 7th Edition *Trip Generation* rates[2] data to allow users to estimate "baseline" total daily vehicle trips and associated vehicle-related emissions for a variety of land use classifications. For mobile source emissions, URBEMIS uses updated California vehicle emission rates provided by CARB. Operational mitigation measures available in URBEMIS are of two types: 1) Physical (e.g., # of buses within 1/4 mile of center of site, % of arterials with bike lanes or direct parallel routes, # of housing units within 1/2 mile of center, etc. which can be measured from site plans and maps), and 2) Demand Management (such as parking cash-out and provision of free transit passes), which requires information from site managers. *Please see the following pages for more detailed information on motor vehicle operational mitigation measures, inputs, and outputs.*

Knowledge base:

[2] The 8th Edition (2008) is the latest version of ITE Trip Generation.

This version of URBEMIS uses ITE (7th Edition) rates with EMFAC 2007 input files. Percent reduction formulas for operational mitigation measures are derived from a number of research sources, which are well described and documented in the User's Manual (available via the website).

References:

Official website: http://urbemis.com/

Support Documents:

URBEMIS9 Users Manual Main Body.pdf and URBEMIS9 Users Manual Appendices.pdf

Below is a table from URBEMIS9 Users Manual Appendices.pdf that summarizes the maximum reductions to ITE rates from operational mitigation measures available in URBEMIS software:

Figure D-3. Summary of Recommended Trip Reductions

	Residential	Non-Residential	Comments
Physical Measures			
Net Residential Density	Up to 55%	N/A	
Mix of Uses	Up to 9%	Up to 9%	
Local-Serving Retail	2%	2%	
Transit Service	Up to 15%	Up to 15%	
Pedestrian/Bicycle Friendliness	Up to 9%	Up to 9%	
Physical Measures sub-total	*Up to 90%*	*Up to 35%*	
Demand Management and Similar Measures			
Affordable Housing	Up to 4%	N/A	
Parking Supply	N/A	No limit	Only if greater than sum of other trip reduction measures
Parking Pricing/Cash Out	N/A	Up to 25%	
Free Transit Passes	25% * reduction for transit service	25% * reduction for transit service	
Telecommuting	N/A	No limit	Not additive with other trip reduction measures (see text)
Other TDM Programs	N/A	Up to 2%, plus 10% of the credit for transit and ped/bike friendliness	
Demand Management sub-total[3]	*Up to 7.75%*	*Up to 31.65%*	

(Note: Net Residential Density is a component of the Mix of Uses measure.)

Detailed Description of Methodology:

URBEMIS 2007 9.2.4			
*(yellow background denotes model **inputs**)*		*(green background denotes model **output**)*	
Project Site Size Limitations: For use in analyzing proposed land use development projects; not recommended for entire jurisdictions. (note: Developments that are larger than 0.5 miles across must be broken into smaller pieces for the purposes of determining the transit service index. The average of all units would then be used.)			
Project and Operational Mitigation Information			
Site Name			
Geographic			**Notes / Instructions**
Air District/County	e.g. Sacramento		Some areas of California do not have EMFAC files; in these cases, users may select "Statewide."
Operational Emission Sources	**Pass-by Trips**	Yes/No	Other MXD (mixed-use development) methods do not adjust for pass-by trips, so recommended "No."
	Double-Counting Correction		Intended to prevent double-counting of internal trips, since internal trips are excluded from trip estimate already, so recommended "No."
Operational Mitigations Selected and Data Inputs			For mitigations, input data is only required for the measures which are selected
Mix of Uses	# of housing units within 1/2 mile radius, includes the # of units in development		Can be **difficult** to obtain, and model is highly sensitive to this variable. Manual approach involves estimating % of census block groups that 1/2 mile radius covers. This variable may be problematic unless the user finds a reliable way to accurately estimate it.
	Employment within 1/2 mile radius		One source for this figure is the Census Bureau's LED OnTheMap, which is available online at: http://lehdmap4.did.census.gov.
Local Serving Retail	Presence of local serving retail (e.g., grocery store, pharmacy, hardware store, dry cleaners, corner store, café, stationary store, gym, etc.)	Yes/No	
Transit Services	# of daily weekday buses stopping w/in 1/4 mile of site		These may have to be manually counted using Google earth or a GIS application to identify stops within 1/4 (for bus) and 1/2 (for rail) mile radius of the center of the site, as well as the website of the local transit authority to obtain schedule counts.
	# of daily rail or rapid transit buses stopping w/in 1/2 mile of site		
	# of dedicated daily shuttle trips		
Bike and Pedestrians	# of intersections per square mile		Can be obtained manually by counting “valences” intersections for the project or in the project vicinity. within MXD and dividing by

			acreage/640.
	Percent of streets within 1/2 mile with sidewalks on one side	(%)	
	Percent of streets within 1/2 mile with sidewalks on both sides	(%)	
	Percent of arterials/collectors with bike lanes (or where suitable, direct parallel routes exist)	(%)	
Affordable Housing	% of units dedicated to low-income housing	(%)	
Transportation Demand Measures			
Parking, Transit Passes			
	Daily Parking Charge		Yes/No
	Free Transit Passes		Yes/No
	Parking Price (nonresidential)		$
Telecommuting			% participating
	Employee Telecommuting Program	Yes/No	(%), Avg. days/week
	Compressed work schedule 3/36	Yes/No	(%)
	Compressed work schedule 4/40	Yes/No	(%)
	Compressed work schedule 9/80	Yes/No	(%)
Other Transportation Demand Measures			
	Secure Bike Parking	Yes/No	
	Showers/changing facilities provided	Yes/No	
	Guaranteed ride home program	Yes/No	
	Car-sharing services	Yes/No	
	Information on transportation alternatives	Yes/No	
	Dedicated employee transportation coordinator	Yes/No	
	Carpool matching program	Yes/No	
	Preferential carpool/vanpool parking	Yes/No	
Parking Supply (nonresidential)			
Actual Parking Spaces Provided		Note: separate input for each indicated land use type	
Step 2: Land Use Data			
		Quantity	**Units**
Residential			
	Single family housing		DU
	Apartments low rise		DU
	Apartments mid rise		DU
	Apartments high rise		DU
	Condo/townhouse general		DU
	Condo/townhouse high rise		DU
	Mobile home park		DU
	Retirement community		DU
	Congregate care (assisted living) facility		DU
Educational			
	Day-care center		ksf
	Elementary school		ksf
	Junior high school		ksf
	High school		ksf
	Junior college (2 years)		ksf
	University/college (4 years)		students
	Library		ksf

Place of worship		ksf
Recreational		
City park		acres
Racquet club		ksf
Racquetball/health		ksf
Quality restaurant		ksf
High turnover (sit-down) restaurant		ksf
Fast food rest. w/ drive thru		ksf
Fast food rest. w/o drive thru		ksf
Hotel		rooms
Motel		rooms
Large Retail		
Free-standing discount store		ksf
Free-standing discount superstore		ksf
Discount club		ksf
Regional shopping center		ksf
Electronic superstore		ksf
Home improvement superstore		ksf
Retail		
Strip mall		ksf
Hardware/paint store		ksf
Supermarket		ksf
Convenience market (24 hour)		ksf
Convenience market w/ gas pumps		ksf
Gasoline/service station		pumps
Commercial		
Bank (with drive-through)		ksf
General office building		ksf
Office park		ksf
Government office building		ksf
Government (civic center)		ksf
Pharmacy/drugstore with drive-through		ksf
Pharmacy/drugstore without drive-through		ksf
Medical office building		ksf
Hospital		ksf
Industrial		
Warehouse		ksf
General light industry		ksf
General heavy industry		ksf
Industrial park		ksf
Manufacturing		ksf
Blank		
Blank (Edit this description)		ksf/acres/other

Outputs

	Estimated Daily Vehicle Trips	Notes:
URBEMIS (Operational Unmitigated)	e.g. 24,322	Uses ITE trip generation rates *without* any operational mitigations
URBEMIS (Operational Mitigated)	**e.g. 19,423**	URBEMIS **estimate *with* selected operational mitigations**
Note: URBEMIS does not provide peak AM and PM trip estimates. Some consultants obtain these from ITE trip data and apply them to URBEMIS outputs.		

Validity Analyses - URBEMIS 2007 9.2.4

Input Sources and Assumptions

This section details the assumptions, data sources, and analytical processes used to generate URBEMIS estimates of vehicle trips for the ten EPA/SANDAG sites and the 12 California infill sites. Of the methods used in this study, URBEMIS 2007 9.2.4 is the most data intensive. The limited data available for the sites and URBEMIS's data requirements for selected vehicle operational mitigation measures made it necessary to collect data from a number of different sources. (note: "Mitigation Measures" in URBEMIS refer to both physical characteristics of a site and its vicinity, such as its density and transit availability, as well as demand measurement measures such as parking charges. See the last page for a detailed explanation of URBEMIS mitigation measures and their assumed efficacy.)

10 EPA/SANDAG Multi-Use Sites

While Gateway Oaks is the only site analysis described in detail here, the same assumptions, data sources, and analytical processes were used for the remaining sites: Jamboree Center, Park Place, The Villages, Rio Vista Station Village, La Mesa Village Plaza, Uptown Center, The Village at Morena Linda Vista, Hazard Center, and Heritage Center at Otay Ranch.

Following are the data sources and assumptions used for various URBEMIS vehicle "operational mitigations:"

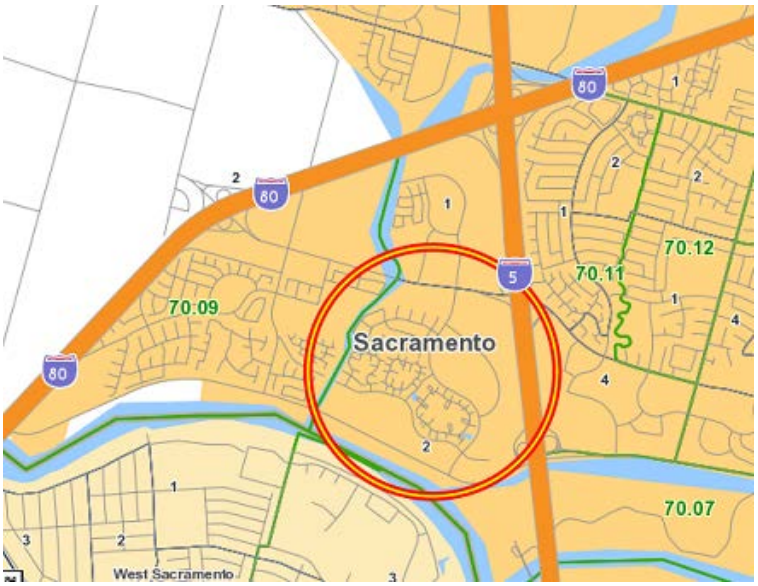
Number of housing units within a ½-mile radius of site: The Census Bureau's LED OnTheMap (a tool available online at http://lehdmap4.did.census.gov) was used to generate a ½-mile radius around each site, selecting "Block Groups" for the Add Layer Selection. The percentage of each block group within a ½-mile radius of each site was estimated visually. Google Earth Pro was used to find the number of households in each block group (Nielsen Claritas, 2009). Lastly, the percentage of each block group within 1/2 mile of the site was multiplied with the number of households in that block group.

The sum of households within 1/2 mile of the site for all block groups was assumed to approximate the total number of housing units within a ½-mile radius of the site. This map shows the map of census block groups and a ½-mile radius around the Gateway Oaks site.

Assumption: On average, households are distributed evenly within the geographic boundaries of each census block group.

Employment within a ½-mile radius: LED OnTheMap was used to estimate the number of jobs within a ½-mile radius of each site using the following settings: for **Data Settings**, "Workplace area" was selected under Live or Work, "2008" for year, "All Jobs" for Job Type, and "All workers" for Labor Market Segments. For **Study Area Selection**, Google placemarks were imported for site location, "Block Groups" was selected for Add Layer Selection, and a radius of 1/2 mile was added for Add Buffer to Selection. "Work Area Profile Analysis" was selected for **Map Overlay/Report**. From these parameters, LED OnTheMap generated a report with an estimate of the **total number of jobs within a ½-mile radius** of the center of the site.

Transit services (# of daily buses, trains, shuttles): The "transportation" layer on Google Earth was used to locate transit stations within a ¼- and ½-mile radii of the site (these radii were generated using LED OnTheMap and imported into Google Earth). Google Earth also lists the routes for each stop and provides links to the local transit provider websites. These transit



provider sites post daily route schedules for each station. The number of unique buses stopping within 1/4 mile of the site was estimated using these schedules (avoiding double-counting buses that stopped multiple times within 1/4 of the site). This process was repeated for trains and shuttles where applicable (within a ½-mile radius of sites).

Percent of arterials/collectors with bike lanes (or where suitable, direct parallel routes exist): As with sidewalks, these were visually estimated using Google Maps. Where available, local bicycling maps were used to verify bicycle routes. Arterials were considered to be all streets colored yellow on Google Maps (as suggested by Ann Cheng of TransForm). Percentages were roughly estimated according to distances of road segments with and without bike lanes/direct parallel routes.

12 California Infill Study Sites

Number of housing units within a ½-mile radius: Residential density (DU/acre) provided for each site in the Infill Study report was multiplied by the # of acres within a ½-mile radius (approx. 503).

Employment within ½-mile radius: Employment density (# of workers/acre) provided for each site in the Infill Study report was multiplied by the # of acres within a ½-mile radius of each site.

Transit services: The same manual approach was used as for the 10 EPA/SANDAG sites (please see description above).

Percent of arterials/collectors with bike lanes (or where suitable, direct parallel routes exist): This input was visually estimated as for the EPA/SANDAG multi-use sites.

# of intersections per square mile: LED OnTheMap was used to draw a polygon around each site, and intersections were manually counted and divided by the area (in sq miles) of the polygon.

Assumption: The number of intersections per square mile within the site is approximately equal to the intersections per square mile in the area surrounding it (as the infill sites are too small to have intersections within their boundaries).

Peak Hours and URBEMIS output: Following a method used by the consulting firm Nelson-Nygaard, peak trips were derived from the URBEMIS daily vehicle trip estimates using ITE Trip Generation 8th edition peak-hour percentages for each land use category. (note: URBEMIS does not directly generate peak hour trips, and daily trip generation is calculated using ITE Trip Generation 7th edition rates.)

The following example shows the inputs used to generate the URBEMIS analysis for Gateway Oaks in Sacramento.

Site **Name**	**Gateway Oaks**		**Source/Notes**
	Geographic		
latitude		38.61	Mark Feldman, Google Earth placemarks[3]
longitude		-121.52	Mark Feldman, Google Earth placemarks
Address		2332 Gateway Oaks Dr, Sacramento, CA	Google Maps
AQMD		Sacramento	
Area (in acres)		227	EPA[4]
ITE Codes	**Land Use Classifications**		
	# of Dwelling Units		
220	Multi-Family	1,351	Low-Rise Apartments (Visual)[5], EPA
	Retail Floor Space (ksf)		
932	High Turnover Restaurant	12	EPA
	Office Floor Space (ksf)		
710	Non-Medical	1,084	EPA
310	**Hotel Rooms**	188	EPA
Operational Emission Sources			
Pass-by Trips		No	
Double-Counting Correction		No	
Operational Mitigations Selected and Data Inputs Used			
Mix of Uses			
# of housing units within 1/2 mile radius of site. Note: This includes the number of units in the site		1,613	Nielsen Claritas (2009), Google Earth Pro
Employment within 1/2 mile radius of site		4,108	U.S. Census Bureau LED OnTheMap
Local Serving Retail			
Presence of local serving retail - includes grocery store, pharmacy, hardware store, dry cleaners, corner store, café, stationary store, gym, etc.		Yes	

[3] Source: Mark Feldman of Fehr & Peers Consultants, who produced them for the 12 EPA/SANDAG multi-use study sites in California.
[4] The source "EPA" refers to CA Hilighted MXDSitesTripGenerationModelValidationEPAFinalSubmittedtoITE.xls.
[5] A visual inspection was done using Google Maps images to determine whether the apartments were Low-, Mid-, or High-rise.

Transit Services		
# of daily weekday buses stopping w/in 1/4 mile of site	57	http://www.sacrt.com/
# of daily rail or rapid transit buses stopping w/in 1/2 mile of site	0	
# of dedicated daily shuttle trips	0	
Bike and Pedestrians		
# of intersections per square mile within the site	85	EPA
Percent of streets within 1/2 mile of site with sidewalks on one side	100%	Google Maps[6]
Percent of streets within 1/2 mile of site with sidewalks on both sides	100%	Google Maps
Percent of arterials/collectors with bike lanes (or where suitable, direct parallel routes exist)	80%	No bike routes (visually on Google Maps) - El Camino and I-5
Outputs	**Estimated Daily Trips**	
URBEMIS (Operational *Unmitigated*)[7]	24,322	URBEMIS 2007 9.2.4 without mitigations
URBEMIS (Operational Mitigated)	**19,897**	URBEMIS 2007 9.2.4 using above inputs

Descriptions of Selected Operational Mitigation Measures

The following excerpts from the URBEMIS User's Manual describe each selected operational mitigation measure. (Note: additional text beyond the Manual is italicized.)

Mix of Uses

Trip reduction = (1- (ABS (1.5 * h e) / (1.5 * h + e)) 0.25) / 0.25 * 0.03
h = study area households (or housing units), e = study area employment.

This formula assumes an "ideal" housing balance of 1.5 jobs per household and a baseline diversity of 0.25. The maximum possible reduction using this formula is 9%. Negative reductions of up to 3% can result when the housing to jobs ratio falls to levels less than the baseline diversity of 0.25. This reduction takes into account overall jobs-population balance.

Local Serving Retail

The presence of local serving retail can be expected to bring further trip reduction benefits, and an additional reduction of 2% is assumed. This is towards the lower end of the values presented in the research, in order to avoid double counting with the diversity indicator.

Transit Services

[6] In most cases, 100% of streets within 1/2 mile of sites had sidewalks on both sides (excluding freeways)-these were estimated visually using Google Maps.
[7] "Operational Unmitigated" is the combined daily trip generation for all land uses in site from ITE Trip Generation, 7th edition.

The Transit Service Index emphasizes frequency but with greater weighting given to rail services. Greater weight is also given to dedicated shuttles, in recognition of the fact that these are likely to be more closely targeted to the needs of the development. The Transit Service Index is determined as follows:

Number of average daily weekday buses stopping within 1/4 mile of the site; plus
Twice the number of daily rail or bus rapid transit trips stopping within 1/2 mile of the site; plus
Twice the number of dedicated daily shuttle trips;
Divided by 900, the point at which the maximum benefits are assumed. (This equates to a BART station on a single line, plus four bus lines at 15-minute headways.)

As well as existing service, planned and funded transit service should be included in the calculation. Purely demand responsive service *(such as public "Dial-A-Ride")* should not be included. A maximum trip reduction of 15% is assumed. To account for non-motorized access to transit, half the reduction is dependent on the pedestrian/bicycle friendliness score. This ensures that places with good pedestrian and bicycle access to transit are rewarded.

Trip reduction = t * 0.075+ t * ped/bike score * 0.075
Where: t = transit service index

Bike and Pedestrian

The pedestrian/bicycle factor is calculated as follows:

Ped/bike factor = (network density + sidewalk completeness + bike lane completeness) / 3
Where: Network density = intersections [sum of valences] per square mile / 1300 (or 1.0, whichever is less)
Sidewalk completeness = % streets with sidewalks on both sides + 0.5 * % streets with sidewalk on one side
Bike lane completeness = % arterials and collectors with bicycle lanes, or where suitable, direct parallel routes exist

A maximum reduction of 9% is assumed. The trip reduction is calculated as:

Trip reduction = 9% * ped/bike factor

Parking Supply and Daily Parking Charge

In some cases where the number of site-specific parking spaces supplied was readily available, the Parking Supply and Daily Parking Charge mitigation measures were applied. URBEMIS assumes a maximum trip reduction of 25% for projects that commit to introducing parking pricing. The maximum reduction applies to prices of $6 per day or greater (in 2004 dollars). The trip reduction will therefore be as follows:

Trip reduction = daily parking charge / 6 * 0.25

The parking supply mitigation measure uses the Institute of Transportation Engineers Parking Generation, 3rd Edition handbook as the baseline. It applies only to non-residential land uses. The trip reduction is calculated as follows:

Trip reduction = 1- (Actual parking provision / (ITE Parking Generation rate * # units)

MTC Travel Survey-Based Vehicle Trip Adjustment Method

What it is:

A manual method that adjusts ITE vehicle trip rates using a regional travel survey conducted in 2000 by the Metropolitan Transportation Commission (MTC) in the San Francisco Bay Area.

Where it is used and who uses it:

The method is experimental. The data it is based on is from the San Francisco Bay Area; therefore its most appropriate application is in that region. It potentially can also be applied elsewhere in California that assuming density and transit proximity affect travel behavior in a similar manner. Alternatively, regional travel surveys specific to that region could be used to estimate vehicle trip rates.

To date, the method has only been used by the study team. However, others, including members of the Practitioners Panel, have voiced interest in developing a travel survey-based method.

Inputs:

This method requires project information sufficient to apply ITE trip rates, as well as information on surrounding area land use density and proximity to transit.

Outputs:

Key outputs from this method include daily and AM/PM peak hour trips by direction, as well as the estimated reduction from ITE rates.

How it works

This method adjusts ITE rates using project-vicinity characteristics. ITE vehicle trip generation rates are assumed to be representative of low-density suburban areas, given that this is where most ITE vehicle trip generation studies are performed. The method adjusts rates downward for other development contexts, based on vehicle trip rates found in these contexts as defined by density and transit proximity, based on data from the MTC regional travel survey.

Knowledge base:

This method currently utilizes travel survey data from the Bay Area Station Area Residents Study, conducted by MTC. It could potentially utilize data from other regions; however, to date, no other California planning agencies have analyzed household travel surveys in this manner.

References:

MTC website for StaRS: http://www.mtc.ca.gov/planning/smart_growth/stars/

Support Documents:

Various reports at the above website.

Please see the following page for more detailed information on inputs and outputs:

MTC Travel Survey-based Vehicle Trip Adjustment Method

The MTC Station Area Residents' Study (StaRS, 2006) set geographic areas (or buffers) around each rail and ferry stop in the Bay Area (in the case of MUNI, buffers were around the light rail stops). The buffers around rail/ferry stops defined three distance categories: within ½ mile, ½ mile to 1 mile, and greater than 1 mile. The study placed households into one of the three distance categories based on the location of the household with respect to the nearest rail/ferry stop. For households beyond one mile from a rail/ferry station, the study disaggregated them by population density using Census 2000 block group data. The four population density categories, along with examples of cities and communities for each group, were as follows:

1) Urban 10,000 or more persons/square mile e.g., San Francisco, Berkeley, Oakland.
2) High-Suburban 6,000 to 9,999 persons/ square mile, e.g., Palo Alto, Vallejo, Richmond, San Leandro.
3) Low-Suburban 500 to 5,999 persons/ square mile, e.g., Lafayette, Walnut Creek, Sausalito.
4) Rural Less than 500 persons/square mile e.g., Oakland Hills, Point Reyes Station, Guerneville.

Travel behavior within these categories was then extensively analyzed. Table 1 summarizes how vehicle driver trips per household vary among categories, normalized to the low-suburban category. The low-suburban density is used as the baseline, since this corresponds to the environment in which ITE trip generation rates data are typically collected.

TABLE 1: Vehicle Trip Factors Based on MTC StaRS Data

	Proximity of Household to Rail Station or Ferry Terminal					
	Within 1/2 mile	1/2 mile to 1 mile	Greater than 1 mile and Density /sq. mile			
Travel Characteristic:			Urban	High-Suburban	**Low-Suburban**	Rural
Vehicle Driver Trip Factor (percent driving compared to Low-suburban baseline)	**58.8%**	**75.4%**	**76.1%**	**91.9%**	**100.0%**	**94.4%**

The tool applies "vehicle trip factors" to ITE trip rates using the project vicinity density and station vicinity characteristics per Table 1 above (based on data presented in Table 4 in the MTC StaRS report). The method explicitly covers two important "D" factors – Density and Distance to Transit. While factors can also be developed for other travel modes, the vehicle trip factor is all that is currently used because ITE publishes only vehicle generation data.

A Hypothetical Example of the Method:

Project: A 150-unit Condominium development in a high-suburban density area (6,000-10,000 du/acre)

Vehicle Trip Reduction:

Multi-family housing (Unadjusted) ITE vehicle trips (LU 230):	801 daily vehicle trips
Apply vehicle trip factor for high-density suburban:	91.9% x 900 = 736 vehicle trips
Result after application of factor:	-65 vehicle trips

Validity Analyses – MTC Survey-Based Method

Input Sources and Assumptions

This section details the assumptions, data sources, and analytical processes used to generate estimates of vehicle trips for the sample sites. The survey-based method used in this study has modest data requirements. It requires classification of the project site into one of three distance-to-transit categories based on whether the site is: 1) within 1/2 mile, 2) between 1/2 and 1 mile, or 3) beyond 1 mile of a rail or ferry station.

For households beyond one mile from a rail or ferry station, the method requires further classification of project sites by population density, based on Census block groups. There are four population density categories (with examples from the San Francisco Bay Area) :[8]

1) Urban: 10,000 or more persons/square mile (e.g., San Francisco, Berkeley, Oakland).
2) High-Suburban: 6,000 to 9,999 persons/ square mile (e.g., Palo Alto, Vallejo, Richmond, San Leandro).
3) Low-Suburban: 500 to 5,999 persons/ square mile (e.g., Lafayette, Walnut Creek, Sausalito.)
4) Rural: Less than 500 persons/square mile (e.g., Oakland Hills, Point Reyes Station, Guerneville.)

Transit proximity: Google Maps were used to determine whether the site is located within 1/2 mile or 1 mile of a rail/ferry station.

Density: Calculated in persons/sq mile, this was determined by multiplying residential density (dwelling units (DU)/acre) for the project's Census block group by the number of acres in a

[8] MTC Station Area Residents Study (Volume 1) pp. 6-7; available at: http://www.mtc.ca.gov/planning/smart_growth/stars/

square mile (640), and then multiplying this quantity (DU/sq mi) by the average number of persons per DU obtained from Census data for the city.

Once this data is compiled, this data is used to produce a vehicle trip factor that can be used to adjust the ITE trip data for the project using the project vicinity density and station vicinity characteristics.

For this application, the initial focus was on five California Infill Sites in the San Francisco Bay Area because the survey method is based Bay Area survey data, so the method is most appropriate for these sites. The methodology was then extended to the other cordon count sites located in other regions.

The illustration below shows the transit station proximity and density classification for the California infill sites, along with the resulting trip adjustment factor applied to ITE trip rates for each project analyzed. For example, the four Los Angeles area projects are in the urban density category, and ITE trip rates are factored by 76.1% (highlighted in blue).

			MTC Survey-based Method	
			Transit-Density	Vehicle Trip
Site #**	Site Name	Address	Classification	Adjustment
1	Chain Clothing Store	1333 Broadway, Oakland, CA	<1/2 mile TrSta	58.80%
2	1388 Sutter Street	1388 Sutter Street, San Francisco, CA 94109	<1/2 mile TrSta	58.80%
3	Central City Association of Los Angeles	626 Wilshire Boulevard, Los Angeles, CA 90017	<1/2 mile TrSta	58.80%
4	Horizon	505 Front Street, San Diego, CA 92101	<1/2 mile TrSta	58.80%
5	Atria*	101 Market Street, San Diego, CA 92101	<1/2 mile TrSta	58.80%
-	-	-	<1/2 mile TrSta	58.80%
6	10351 Santa Monica Boulevard	10351 Santa Monica Boulevard, Los Angeles, CA	Urban	76.10%
7	Wilshire Pacific Plaza	12301 Wilshire Boulevard, Los Angeles, CA	Urban	76.10%
8	Archstone Santa Monica on Main	2000 Main Street, Santa Monica, California	Urban	76.10%
9	Archstone Pasadena	25 South Oak Knoll Avenue, Pasadena, CA	Urban	76.10%
10	Archstone Fox Plaza	1390 Market St., San Francisco, CA 94102	<1/2 mile TrSta	58.80%
11	Pazzia Caffe and Trattoria	337 3rd Street, San Francisco, California	<1/2 mile TrSta	58.80%
12	Bong Su	311 3rd Street, San Francisco, California	<1/2 mile TrSta	58.80%
	*Atria has data reported for both a residential and commercial component (above).			
	**Site numbers have been assigned with regard to the order in which sites are reported.			