CONTRA COSTA
transportation
authority

Technical Procedures

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This focused revision of the *Technical Procedures* was prepared by Julie Morgan and Ashlee Takushi of Fehr & Peers in close collaboration with John Hoang and Matt Kelly of CCTA. The primary focus of this revision was to align the document to reflect compliance with the requirements of Senate Bill 743 (SB 743) regarding analysis of vehicle miles traveled (VMT) for land use projects that are subject to the California Environmental Quality Act (CEQA), and as directed by the Authority Board in July 2020. As a result, this revision focuses on guidance related to VMT measurement and analysis methods.

The Authority's *Technical Procedures* was originally drafted in 1991 by Ellen Greenberg and Larry Patterson through a consultant agreement with Blayney Dyett Greenberg and subconsultants Patterson and Associates. The August 1992 version of the *Technical Procedures* was updated by Larry Patterson of Patterson and Associates and Brad Beck of Blayney Dyett Greenberg, with the addition of a level of service software package that was prepared by Victor Siu of TJKM Transportation Consultants.

The September 1997 revision to the *Technical Procedures* was prepared in-house by Martin Engelmann and Mark Wagner of Authority staff, with the helpful review of the Technical Modeling Working Group that included John Hall of Walnut Creek, Brian Welch of Danville, John Dillon of San Ramon, Steven Goetz and Dan Pulon from Contra Costa County, and John Templeton from the City of Concord. The 1997 update included much of the original text from the 1992 version with the addition of new sections on modeling procedures that were primarily drafted by Richard Dowling of Dowling Associates, and on the Gateway Capacity Constraint Methodology that was drafted by Martin Engelmann of Authority staff with contributions from Brian Welch of Danville, At van den Hout from Barton Aschman Associates, and Richard Dowling. Professor Dolf May of the UC Berkeley Institute for Transportation Studies also contributed to the 1997 update by reviewing the queuing analysis portion of the constraint procedures.

In 2006 a revision of the *Technical Procedures* was initiated by Maren Outwater and Vamsee Modugula of Cambridge Systematics and subsequently revised by Richard Dowling and Neelita Mopati of Dowling Associates. For that revision, the new subsection on the Origin-Destination Matrix Estimation (ODME) process in Section 8 was drafted by Martin Engelmann of CCTA with assistance from Neelita Mopati, and then finalized with the helpful review of the Technical Modeling Working Group. Editing and figures were prepared by Brad Beck of CCTA. Final document formatting and publication was performed by Dyett & Bhatia.

The most recent comprehensive update was prepared in 2013 by William (Bill) Loudon and Antonios Garafelakis of DKS Associates in close collaboration with Martin Engelmann, Matt Kelly, and Brad Beck of CCTA. The revisions were focused on aligning the document to reflect the transition from Measure C to Measure J and to adopt the Transportation Research Board's (TRB) recently published methods for calculating Level of Service (LOS). The update was prepared with

the helpful review of the Technical Modeling Working Group, whose members included Ray Kuzbari from the City of Concord, Nazanin Shakerin from the Town of Danville, Steve Kersevan from the City of Brentwood, John Cunningham from Contra Costa County, and Phillip Cox of Caltrans. The 2021 update to the GMP related to the implementation of changes to transportation analysis under SB 743 and CEQA was guided by the GMP Task Force members, PlaceWorks, Fehr & Peers, and DKS consultant teams, and Matt Kelly of CCTA. Many other professionals have participated in the development and review of this document over the years. We extend our appreciation to those mentioned above by name and to the many others who helped along the way.

Dedicated to the memory of Michael Kennedy, a traffic-engineering pioneer who helped the original authors develop innovative analysis tools that continue to be used to this day.

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1 INTRODUCTION

1.1 Background

On November 8, 1988, Contra Costa voters approved Measure C, a half-cent sales tax increase to fund transportation improvements and an innovative Growth Management Program. The Contra Costa Transportation Authority (Authority) was established to implement Measure C and its overall goals. Its purpose is to relieve congestion created by past development through road, transit, pedestrian, and bicycle improvements funded by the sales tax increase, and to prevent future development from creating new traffic congestion or deteriorating service levels for fire, police, parks, and other public services in Contra Costa through the Growth Management Program (GMP). Measure C included funding for projects for all modes. The Growth Management Program established a cooperative, multi-jurisdictional planning process requiring participation from all cities, towns, and the County to manage the impacts of growth in Contra Costa.

Measure J, approved by the voters of Contra Costa in November 2004, extended the Measure C half-cent sales tax through 2034. It went into effect on April 1, 2009. A major focus of Measure C was on Level of Service (LOS) standards for non-regional routes and the impacts new development would have on local intersections. Measure J shifted that focus toward the multimodal regional system and away from LOS.

To demonstrate conformance with Measure J requirements, each local jurisdiction must report on its compliance with the Measure J Growth Management Program by completing a Compliance Checklist every two years. The full requirements for compliance are documented in the *Implementation Guide*.[1] The requirements pertaining to transportation analysis and mitigation of identified impacts are summarized in this document.

With the 2021 update to this document, these *Technical Procedures* add a focus on the analysis of vehicle miles traveled (VMT) as required by Senate Bill 743 (SB 743). This VMT guidance is intended to assist lead agencies in their California Environmental Quality Act (CEQA) VMT analysis consistent with the new requirements of the CCTA GMP. However, these *Technical Procedures* also continue to offer guidance on analysis of capacity metrics such as vehicle LOS, speed, and congestion, which continue to be required under some CCTA regulations and which also may be used by local jurisdictions as they attempt to minimize traffic congestion.

1 Contra Costa Transportation Authority, ***Contra Costa Growth Management Program: Implementation Guide***, March 17, 2021.

1.2 Purpose of the *Technical Procedures*

The purpose of this document is to establish a uniform approach, methodology, and tool set that public agencies in Contra Costa may apply to evaluate the impacts of land use decisions on the local and regional transportation system. Compliance with the Measure J Growth Management Program requires that local jurisdictions use these *Technical Procedures* to analyze the impact of proposed development projects, General Plans, and General Plan Amendments. In addition to the *Technical Procedures*, the Authority has published two other supporting documents, the *Implementation Guide* and a *Model Growth Management Element,*[2] which together form the Measure J Implementation Documents for the Growth Management Program. Also available is the Authority's *Guide for Local Compliance with the Contra Costa Congestion Management Program* (February 1993), which can serve as a reference for implementing that program. These are "living documents" that are updated periodically to reflect experience gained in implementing the Growth Management Plan.

Among other things, the *Implementation Guide* outlines the approach and policy direction for establishing Action Plans for Routes of Regional Significance (hereafter referred to as "Action Plans"). These *Technical Procedures* were prepared to help local staff and consultants develop and maintain Action Plans and to apply a uniform method for calculating performance measures and standards in the Action Plans and in other procedures that are part of the implementation of the Growth Management Plan.

The *Technical Procedures* focuses on the specific tools and procedures that CCTA recommends for transportation analyses. Individual agencies may also develop and apply their own policies related to transportation analysis. Transportation analysts should confirm the parameters of the analysis requirements for all agencies with oversight over a project to ensure that the analyses they conduct are in alignment with both the *Technical Procedures* and any additional local requirements.

The *Technical Procedures* emphasize the Authority's countywide travel demand forecasting model (hereafter referred to as the "Countywide Model") since it will be used for many purposes, including the preparation of transportation analyses, the development and upkeep of Action Plans, the revision and updating of local General Plans, and the establishment of facility requirements for new transportation projects.

Since this document is intended to support local agencies in their compliance with the Measure J Growth Management Program, it is focused on conducting transportation analysis for land use projects and does not provide guidance on evaluating other types of transportation projects.

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[2] Contra Costa Transportation Authority, ***Model Growth Management Element***, Pleasant Hill, CA, update underway as of November 9, 2021.

CCTA recommends that each lead agency develop individual methods for analyzing the effects of other types of transportation projects within their jurisdiction.

1.3 Action Plans for Routes of Regional Significance

Local jurisdictions have worked cooperatively through their respective Regional Transportation Planning Committees (RTPCs) to develop Action Plans. These Action Plans are comprised of the following:

- Long-range assumptions regarding future land use based on local general plans;
- Overall policy goals established by the Authority;
- For each route or corridor, Multimodal Transportation Service Objectives (MTSOs) that serve as quantifiable performance measures; and
- Actions to be implemented by the RTPC and participating local jurisdictions. These actions include capital improvements, transit improvements, traffic operations strategies, pedestrian and bicycle facilities, land use policies, transportation demand management (TDM) strategies, or other local projects and programs intended to meet the adopted MTSOs.

The population in Contra Costa is expected to continually increase over time. In addition to resulting in increases in vehicle delay, traffic and congestion are anticipated to exacerbate regional concerns such as safety, climate change, and inequity in the transportation system. Thus, there has been a renewed effort to engage local jurisdictions in a process which seeks to manage impacts to the regional transportation network from development, such that non-transportation issues will also be remedied.

As of this writing in 2022, the Action Plans are being updated to expand their objectives beyond Routes of Regional Significance to include additional transportation priorities, moving from the Growth Management Program's original focus on vehicular routes to include six additional subjects: active transportation, public transportation, climate change, safety, equity, and technology. The Action Plan Update process involves RTPC member jurisdictions' collaboration to identify transportation and planning concerns in their sub-areas, and will result in new quantifiable Regional Transportation Objectives (RTOs) that address all six new subjects. The RTPCs will incorporate the agreed upon RTOs into their updated Action Plans, which will then be forwarded to the Authority for inclusion in the Countywide Transportation Plan (CTP). The *Technical Procedures* may be updated again after the Action Plans are updated, to include additional analysis methods required to comply with new Action Plan RTOs.

1.4 Implementation of Multimodal Transportation Service Objectives (MTSOs) on Regional Routes

Since the adoption of Measure C, each of the RTPCs has established and periodically revised MTSOs in their Action Plans. Examples of MTSOs include average minimum speed, maximum delay, or duration of congestion not to exceed a specified time period. While MTSOs may use the traditional LOS measurement, such as "not exceeding LOS 'D' at all signalized intersections," a review of the adopted Action Plans indicates that some RTPCs favored adoption of more innovative performance measures, such as delay index, severity of congestion, or transit utilization. The Authority regularly monitors the MTSOs, and from time to time the RTPCs reassess the actions, measures, programs, and MTSOs in the Action Plan.

The *Implementation Guide* outlines a process that requires RTPC review of any General Plan Amendment that generates more than 500 net new peak hour vehicle trips or any development project that generates more than 100 net new peak hour vehicle trips. The review process specifies that the local jurisdiction proposing the General Plan Amendment must demonstrate to its RTPC that the proposed General Plan Amendment will not adversely affect their ability to achieve adopted MTSOs.

1.5 General Plan Consistency with Action Plans

The Action Plans are based upon adopted General Plan land uses, the existing road network, and planned improvements to the network. Consistency with the Action Plans must be established for any changes to the General Plan that may adversely affect the ability to meet the MTSOs. The *Implementation Guide* establishes the type and size of amendment that triggers review by the RTPC and defines a step-by-step process for General Plan Amendment review. To be found in compliance with the Growth Management Program, local jurisdictions must follow the review process and use the *Technical Procedures* to conduct the analysis.

The adverse impacts of a proposed amendment on the MTSOs can be offset by adopting local and regional mitigations or by modifying the proposed size and scope of the amendment. The process for RTPC review of General Plan Amendments is detailed in the *Implementation Guide*.

1.6 Transportation Analysis

This document describes in detail the key considerations and requirements for conducting a transportation analysis, as required by the Measure J Growth Management Program. Local jurisdictions are required to prepare this analysis. In most cases, it will be included in the environmental review as required under CEQA. The analysis should be conducted for projects that exceed a trip generation threshold of 100 net new peak hour vehicle trips; however, lower thresholds may be established through the RTPCs and documented in the Action Plans. As set forth in Sections 4 and 5, the transportation analysis report must fully document the approach, methodology, and assumptions used for the analysis.

1.7 Organization of This Report

The *Technical Procedures* has seven sections.

- This first section introduces the document.
- Section 2 describes the procedures for developing the Action Plans.
- Section 3 describes local responsibilities in using the Authority's Countywide Model in evaluating General Plans.
- Sections 4, 5, and 6 outline recommended guidelines for the preparation of transportation analyses required for individual projects:
    - Section 4 describes how to establish the project's characteristics and determine whether it exceeds the trip generation threshold established by the Authority or the RTPC.
    - Section 5 describes how to prepare a VMT analysis for the project.
    - Section 6 provides guidance on conducting a capacity analysis and preparing a transportation analysis report.
- Section 7 contains specifications, policies, and procedures for using the Countywide Model and techniques used for adjusting model output.

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2 ACTION PLANS FOR ROUTES OF REGIONAL SIGNIFICANCE

The adopted Action Plans for Routes of Regional Significance were developed through an intensive multi-jurisdictional, cooperative transportation planning effort aimed at addressing the cumulative impacts of existing and forecast development on the regional transportation system. Each Action Plan establishes overall goals, specific Multimodal Transportation Service Objectives (MTSOs), and recommended actions for a subarea of the county and its respective designated regional routes.

The Action Plans are prepared by the RTPCs.[3] Each committee prepares and adopts one Action Plan, except for the Southwest Area Transportation Committee (SWAT), which oversees two: Lamorinda and the Tri-Valley. The Authority knits the Action Plans together to form the CTP, which is updated every four years.

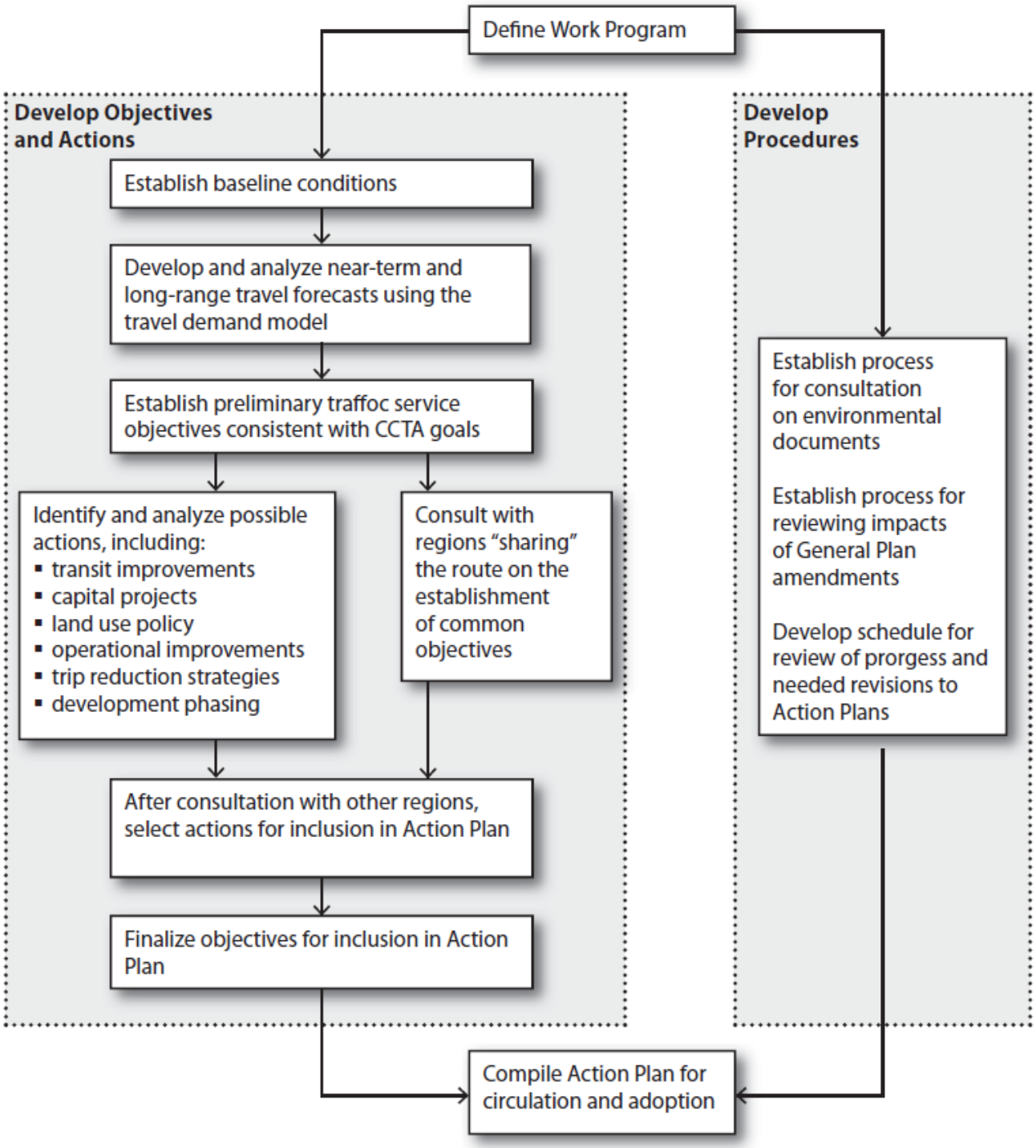
A full description of the Action Plan components and the process for developing the Action Plans is included in the *Implementation Guide*. A flow chart describing the process for development of the Action Plans is provided in Figure 1. The technical work and procedures described in the following sections were used to develop the Action Plans. To update Action Plans, these procedures may need to be used depending on the issues being addressed by the updates and available funding.

2.1 Establishing Baseline Conditions

Baseline conditions are established through an inventory and review of applicable transportation studies, supplemented by available and new traffic and transit data. In most cases, the available data will need to be supplemented with new traffic counts, travel time calculations, vehicle occupancy counts, transit ridership, or other data. The data collection effort should be tailored to the specific Route of Regional Significance to be studied. The effort should focus on data that will likely reflect the anticipated or adopted MTSOs in the corridor and be useful in analyzing the effect of selected actions. Consideration should be given to collecting the following types of traffic information:

3 The four Regional Transportation Planning Committees are West County (WCCTAC), Central (TRANSPAC), East (TRANSPLAN), and South-West (SWAT). The Action Plans for the SWAT region were prepared by the Lamorinda Program Management Committee (LPMC) and the Tri-Valley Transportation Council (TVTC), which is comprised of representatives from both Contra Costa and Alameda Counties. Action Plan development *is required* for Contra Costa jurisdictions and participation in the Tri-Valley Action Plan update *is voluntary* for Alameda County jurisdictions.

Figure 1 – Action Plan Development Process



Traffic Counts. AM and PM turning movement counts may be collected at key intersections along arterial routes. Key intersections are those that are currently operating at the worst LOS, are gateway intersections to important segments of the regional route, or are in areas where significant traffic growth is anticipated. Daily and peak hour volumes should also be collected at various locations needed for developing valid traffic forecasts. Counts should also be conducted on affected freeway ramps that meet the threshold criteria

Travel Time and Delay. Travel time and delay are valuable measures of effectiveness for arterial segments with very high levels of through traffic or where anticipated actions may include traffic signal coordination or high occupancy vehicle (HOV) strategies. Travel time may also be a desirable measure of effectiveness for freeways due to the difficulty and expense in collecting traffic counts on these facilities.

Average Auto Occupancy. Auto occupancy will be an important measure of effectiveness on Regional Routes where HOV lanes may be added or where facility-specific TDM strategies are to be applied.

Transit Data. It will be important to establish baseline conditions for transit service and ridership information in Regional Route corridors that have or are expected to have major transit service provided. For example, in establishing baseline conditions for State Route 4 it may be desirable to establish existing transit mode share. This would provide data to base future comparisons upon and to monitor MTSOs related to transit ridership.

Bicycle/Pedestrian Data. In the case where a Regional Route is adjacent to, or part of a trunk-line bicycle facility or major pedestrian route, it may be beneficial to conduct bicycle/pedestrian counts at locations at or near the Regional Route.

Land Use Data. Near-term traffic projections will be made in developing Action Plans. This will require that data on approved development be prepared as part of the modeling effort. In addition, existing and revised General Plan land use data by traffic analysis zone (TAZ) will be required. The future land use data should reflect revisions made to the General Plan as part of the implementation of the Growth Management Element (GME).

Capital and Operational Improvements. A list of planned improvements to the transportation network should be prepared. These improvements should include anticipated freeway interchange, roadway widening, new arterial streets, operational improvements such as ramp metering or traffic signal coordination, and transit improvements.

2.2 Near-Term Travel Forecasts

Near-term land use assumptions are generally projected 5 to 10 years into the future, consistent with the forecasts of the Association of Bay Area Governments (ABAG), and should reflect, at a minimum, approved and pending developments and projects. The transportation network for the near-term forecasts includes projects under construction, Measure J projects that are

programmed in the current Strategic Plan, programmed State Transportation Improvement Plan (STIP) projects, and funded projects in adopted local five-year capital improvement programs.

2.3 Long-Range Travel Forecasts

Long-range travel demand forecasts are generally prepared for approximately 20- to 30-year planning horizons. In some jurisdictions, this represents build-out of the current General Plan. In other communities, however, available land may not be completely built-out in 20 years. In these cases, reasonable estimates of development should be made based on historical patterns and likely market trends consistent with current ABAG forecasts (See Section 3).

The transportation network for the long-range scenario should include all improvements likely to be completed within the next 20 years. The baseline long-range travel demand forecasts assume completion of projects in the Metropolitan Transportation Commission's (MTC) Financially Constrained Regional Transportation Plan (RTP) and improvements included in local General Plans or other approved planning documents.

2.4 Analysis of Preliminary Multimodal Transportation Service Objectives and Possible Actions

As indicated in Figure 1, the process for the development of MTSOs will be iterative. First the baseline conditions will be established, and the near-term and long-range forecasts prepared. This will provide the basis for the development of the preliminary MTSOs. Once the preliminary MTSOs have been selected, it will be necessary to test the effectiveness of alternative actions in meeting those objectives. Examples illustrating the range and variety of MTSOs are provided in Table 1. A complete list of MTSOs in the Action Plans adopted in 2009 and guidelines for calculating the MTSOs are provided in Appendix B. While there are no examples of bicycle- or pedestrian-related MTSOs from the 2009 Action Plans, creating new bicycle/pedestrian MTSOs is feasible. The latest *Highway Capacity Manual* offers a methodology for quantifying both pedestrian and bicycle LOS in urban and suburban corridors with a grading system from A to F, similar to the methods regularly used for traffic LOS. A brief introduction to this methodology is provided in Section 6.1. Other similar methods for quantifying the performance of pedestrian and bicycle facilities and the LOS they provide are also in use across the country and are documented in the professional literature.

Table 1: Examples of Multimodal Transportation Service Objectives (MTSOs) and Corresponding Actions

MTSO	Representative Actions
Maintain an average speed of 15 MPH for Alhambra Avenue during AM and PM peak hours (Central County)[1]	Pursue planning and funding for Alhambra Avenue improvements and widening.
Delay Index for SR 4 and the SR 4 Bypass: should not exceed 2.5 during the AM or PM Peak Period (East County)[2]	Assist Caltrans and the Contra Costa Transportation Authority (CCTA) in completing the studies and design, and initiate construction for programmed improvements to SR 4 from Loveridge Road to SR 160. Support completion of the phased programmed projects for the SR 4 Bypass from SR 4 to Discovery Bay.
Increase I-80 HOV lane usage by 10% (West County)[3]	Work with Solano County, Vallejo Transit, Caltrans, and MTC to obtain funding in Solano County for HOV lanes between I-80/I-680 and I-80/I-505, Park & Ride lots, ITS projects, and increased express bus services to the Bay Area. Work with the California Highway Patrol to encourage an increase in enforcement of HOV lane requirements for three-person carpools.
Limit the duration of congestion on I-680 to no more than two hours (Tri-Valley)[4]	Construct auxiliary lanes on I-680 from Sycamore to Crow Canyon. Construct northbound HOV lane over Sunol Grade from Fremont to SR 84 and extend the southbound I-680 HOV Lane from North Main to Livorna.
Maintain an hourly average loading factor on BART of 1.5 or less approaching Lafayette Station westbound and Orinda Station eastbound during each and every hour of service (Lamorinda)[5]	Support expansion of BART seat capacity through the corridor and parking capacity east of Lamorinda.

1 TRANSPAC, ***Central County Action Plan for Routes of Regional Significance***, July 9, 2009.

2 DKS Associates, ***East County Action Plan for Routes of Regional Significance***, August 13, 2009.

3 Kimley-Horn and Associates, ***West County Action Plan for Routes of Regional Significance – 2009 Update***, July 21, 2009.

4 DKS Associates, ***Tri-Valley Transportation Plan and Action Plan Update***, November 30, 2009.

5 DKS Associates, ***Lamorinda Action Plan Update***, December 7, 2009.

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3 GENERAL PLAN ANALYSIS

3.1 General Plan Analysis Requirements

Implementation of the Growth Management Program, as described in the *Implementation Guide*, requires all local jurisdictions in Contra Costa to prepare a Growth Management Element (GME) as part of their General Plan. The Growth Management Element reflects the local jurisdiction's commitment to implement the Measure J Growth Management Plan. In addition to addressing the required components of the Growth Management Plan, a local jurisdiction's Growth Management Element should include an evaluation of General Plan (GP) vehicle miles traveled and an evaluation of General Plan impacts on Routes of Regional Significance, and may also include local standards such as LOS requirements for signalized intersections or performance standards for public services.

When local jurisdictions modify their General Plans, whether through focused amendments or more extensive updates, they must assess the effects of proposed changes in their General Plans on their ability to meet the standards in their Growth Management Element and the Multimodal Transportation Service Objectives (MTSOs) in their Action Plan. Jurisdictions should use the Authority's travel demand forecasting model in the analysis of whether proposed changes in the General Plans—including the adoption or revision of the Growth Management Element itself—will affect their ability to meet these adopted standards and objectives.

3.2 Complete Streets Considerations

Measure J requires that local jurisdictions "shall incorporate policies and standards into its development approval process that supports transit, bicycle and pedestrian access in new development."[4] The growing concern for multimodal mobility is also evident in new federal, state, and regional requirements stating that consideration be given to all modes when planning for Bay Area communities. The Complete Streets Act of 2007 created by California Assembly Bill 1358 amended Government Code Sections related to General Plans and General Plan Guidelines. It required that, commencing on January 1, 2011, cities and counties modifying the Circulation Element of their General Plan must provide a "balanced, multimodal transportation network that meets the needs of all users of the streets, roads, and highways for safe and convenient travel in a manner that is suitable to the rural, suburban, or urban context of the General Plan" (GC 65302(b)

4 Contra Costa Transportation Authority, ***Measure J – Contra Costa's Transportation Sales Tax Expenditure Plan***, as amended through November 7, 2011.

(2) (A). Each new update of the Circulation Element of a General Plan must document how this has been achieved in the plan update.

MTC has developed guidance designed to ensure that all Bay Area projects that get federal funds through MTC are giving adequate attention to the needs of bicyclists and pedestrians. The guidance was designed to ensure that projects are consistent with area-wide bicycle and pedestrian master plans and that projects will not adversely impact mobility for bicyclists and pedestrians. The guidance provided pertains to any project that could affect bicycle or pedestrian use regardless of whether the project is intended to benefit either or both of the modes.

Caltrans has also developed requirements for "Complete Streets" consideration through Deputy Directive 64. This directive states the Department's support for Complete Streets considerations as follows:

> The Department views all transportation improvements as opportunities to improve safety, access, and mobility for all travelers in California and recognizes bicycle, pedestrian, and transit modes as integral elements of the transportation system.

In response to the directive, Caltrans has developed an implementation plan that includes the development of tools and other resources that can be used to apply complete streets concepts in transportation planning and design. Among these resources, the Caltrans *Highway Design Manual* (July 1, 2020), incorporates new provisions related to Complete Streets design. These tools and resources should aid local jurisdictions in updating General Plans in the future.

3.3 Use of the Countywide Model

Local jurisdictions have available to them the Authority's Countywide Model for use in analyzing the transportation effects of General Plan changes. The model can provide baseline traffic (existing) conditions as well as future year forecasts. Development of interim baseline years is also possible (see Section 7). In updating or amending the General Plans, local jurisdictions and consultants should use the most current land use and roadway network data sets available from the Authority.

To use the Countywide Model, local jurisdictions are responsible for identifying changes in the land use data sets and the model's road network and for reviewing, verifying, and analyzing the travel forecast results. These responsibilities for using Countywide Model forecasts are required for future General Plan updates and major General Plan Amendments. Analysis of General Plan Amendments that do not generate significant amounts of additional traffic does not require use of the Countywide Model. The Countywide Model is very useful in determining the transportation effects of major land use decisions. Jurisdictions can use the model data as a tool to understand the relationship between the proposed mix of land uses and the transportation system intended to serve them.

The General Plan analysis should reflect the level of accuracy of the Countywide Model and the uncertainties inherent in a planning horizon of 15 to 20 years. As discussed elsewhere in this document, the Countywide Model is capable of forecasting traffic volumes on most freeways and major arterials within about 10 to 20%, and on minor arterial streets within about 25%. Analysis of intersection turning movements as part of the General Plan analysis should, therefore, recognize the difficulty in predicting land uses within a 20-year planning horizon and the accuracy of the model.

The Authority's Countywide Model was calibrated and validated for a base year by using data from existing conditions provided by ABAG and refined through review by local jurisdictions to reflect adopted General Plans. Local review of the ABAG data, however, was not consistently undertaken by all the local jurisdictions. The data in the model may thus require further review and adjustment. Travel demand forecasting for the long-range forecast of an existing or amended General Plan will require local jurisdictions to estimate the following land use data for each TAZ within their jurisdiction:

- The number, type, and location of residential units to be added;
- The estimated location and quantity of commercial floor space to be added, and the estimated industrial acreage to be developed or floor space to be added;[5]
- Any new special generators such as shopping malls, civic centers, sports facilities, and hospitals; and
- Anticipated changes in the demographic data used by the model (e.g., average household income).

The long-range forecast is intended to describe levels of development consistent with the General Plan that are likely to occur within the next 20 to 30 years.

The Authority's Countywide Model includes a complete road network for the base year and for the future year's corresponding with various financial constraints on investments and for a financially unconstrained "vision." Subsequent model runs will require only that the network be updated to reflect changes to the existing transportation network and proposed facility improvements. Data required by the model will include length, speed, and capacity for each roadway link. Transit network data will include bus lines, rail lines, station locations, fares, speeds, and headways.

3.4 Analyzing Results

The results of the travel forecasting should first be reviewed for accuracy. Once accuracy is established, the local jurisdiction must analyze the results relative to adopted standards,

5 Estimates of gross floor area or acreage for commercial and industrial uses will need to be converted to employment for application in the model.

objectives, policies, and Action Plan MTSOs. The analysis of the results should include the following steps:

Step 1: Review Link Volumes to Determine the Geographic Scope of the Study Area

The link volumes should be reviewed. The model will only provide traffic volumes on roadways that have been coded into the model networks. Potential growth in traffic on routes that are not included in the model should be estimated and the potential for volume increases on these routes evaluated as well.

The geographic scope of the study area may be determined for the purposes of transportation analysis through evaluation of link-level traffic increases. As indicated in Section 4, roadway links and intersections that receive increases in excess of 50 net new peak hour vehicle trips as a result of the proposed General Plan Amendment should be analyzed.

Additional analysis should be conducted for locations where predicted model volumes exceed the 50 net new peak hour vehicle trip threshold. This analysis could include either or both of the following steps:

- Use the turning movement adjustment process described in Section 6 to obtain projected intersection turning movements given the proposed General Plan land uses. Check the accuracy and validity of any instances where future volumes are lower than existing volumes. Use these turning movements to calculate LOS at the selected intersections.

- Prepare a select link analysis for roads suspected of carrying substantial amounts of through traffic. This analysis will provide an approximation of the origins and destinations for traffic on a particular link. Select link analysis can be useful in identifying local opportunities to manage congestion and locations where interjurisdictional efforts are essential.

Step 2: Review Multimodal Transportation Service Objectives and Adopted Actions for Routes of Regional Significance

The current Action Plans developed through the RTPCs include MTSOs that establish quantifiable measures of effectiveness for each Route of Regional Significance. General Plans should also include policies that support the Action Plans. As part of any General Plan update or General Plan Amendment analysis, local jurisdictions should review the impacts of General Plan buildout on these Regional Routes and the ability to achieve MTSOs. This information should be shared with affected RTPCs and local jurisdictions as part of the General Plan Amendment review process outlined in the *Implementation Guide*.

MTSOs vary among the Action Plans. They may include relatively common performance metrics such as VMT or intersection LOS, but also less commonly applied measures, such as delay index (DI), average speed, stopped delay, duration of congestion, or transit related measures, such as

peak hour transit mode share. In each case the analyst must review the model output and determine the appropriate technique for arriving at a conclusion regarding impact of the proposed General Plan Amendment on MTSOs. Guidelines for calculating MTSOs are provided in Appendix B.

Step 3: Consider Changes to Proposed General Plan Amendments

(See also *Implementation Guide.*)

Local jurisdictions may need to revise their proposed General Plans or General Plan Amendments if inconsistencies with Action Plans or an inability to comply with the GME or MTSOs are identified through the analysis. These revisions could include increasing the mix or density of land uses in selected areas or changing the physical transportation infrastructure. Alternatively, the lead agency can make a finding of overriding significance if it is determined that the project will have significant benefits in sectors other than transportation, such as housing, education, air quality, noise, safety, or economic growth.

If a proposed General Plan Amendment or Update requires major transportation system improvements, these should be included as part of the General Plan Amendment or Update, along with improvements in the State Transportation Improvement Program (STIP), Regional Transportation Improvement Program (RTIP), Congestion Management Program (CMP), or the RTP. If a local jurisdiction also intends to provide minor intersection and roadway improvements to support the General Plan Amendment or Update, this fact should also be stated, although the specific projects need not be described. Minor intersection improvements are more appropriately defined in the local Capital Improvement Program. Local jurisdictions should also obtain agreement from any affected transit agency and procure adequate funding for capital investment and operations before adopting policies calling for improved transit service.

Step 4: Document Analysis and Findings

The analysis and results should be documented. They will be used to establish the internal consistency of the General Plan and as a basis for compliance reporting to the Authority.

4 PROJECT ANALYSIS: DEFINING PROJECT CHARACTERISTICS

The Authority's adopted *Implementation Guide* requires that each local jurisdiction prepare a transportation analysis for any project that generates 100 or more new peak hour vehicle trips, as defined later in this section. The Regional Transportation Planning Committees (RTPCs) may adopt a more stringent threshold in the Action Plan for that subarea. Typically this analysis will be part of the lead agency's review of the project and must be completed prior to action on the proposed project.

A local jurisdiction may have studied the impacts of development on a site similar to the proposed project as part of a General Plan Amendment. The jurisdiction may use that previously prepared transportation analysis, provided that it was recently performed (less than five years prior) and is consistent with the *Technical Procedures*. In that case, a supplemental transportation analysis may be prepared for the proposed project that addresses the following:

- Compares the proposed project to the development assumed in the General Plan Amendment and identifies the differences in traffic generation rates and the number of trips generated;
- Identifies how those differences affect the magnitude and timing of impacts identified in the transportation study done for the General Plan Amendment; and
- Proposes changes to mitigation measures suggested in the transportation study for the General Plan Amendment or additional measures to mitigate the impacts of the proposed project.

The transportation analysis may include as many as ten steps:

1. Project definition
2. Trip generation estimation
3. Trip distribution
4. Trip assignment
5. Analysis of VMT effects
6. Selection of study intersections
7. Analysis of traffic, circulation, and parking effects
8. Evaluation of pedestrian, bicycle, and transit effects
9. Development of traffic mitigation measures
10. Report preparation

This section describes the first four steps, from project definition through trip generation and trip assignment. These steps are necessary in order to determine whether the project meets the criteria defined by the Authority or by one of the RTPCs for a full transportation analysis. The trip generation information described in this section will also be used in the VMT analysis described in Section 5. The remaining steps in the transportation analysis, if required, are described in Section 6. The steps of the transportation analysis process are visualized in the flow charts in Figures 2 and 3.

Figure 2 – Trip Generation, Distribution and Assignment Process

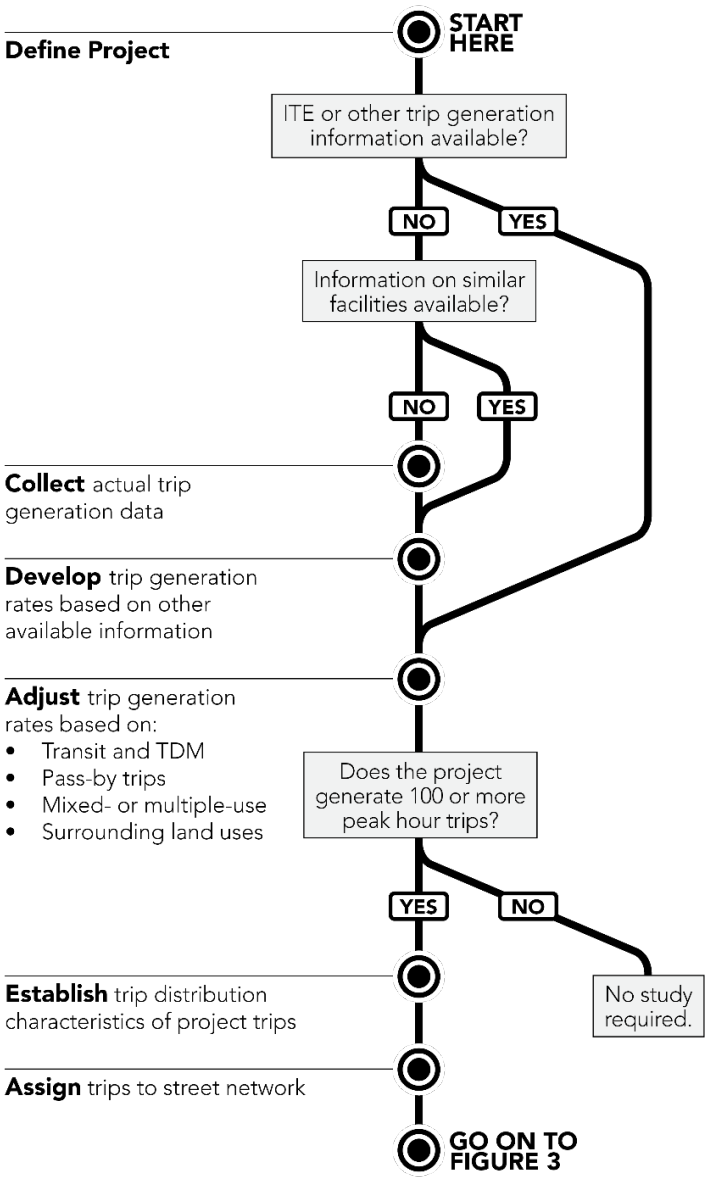
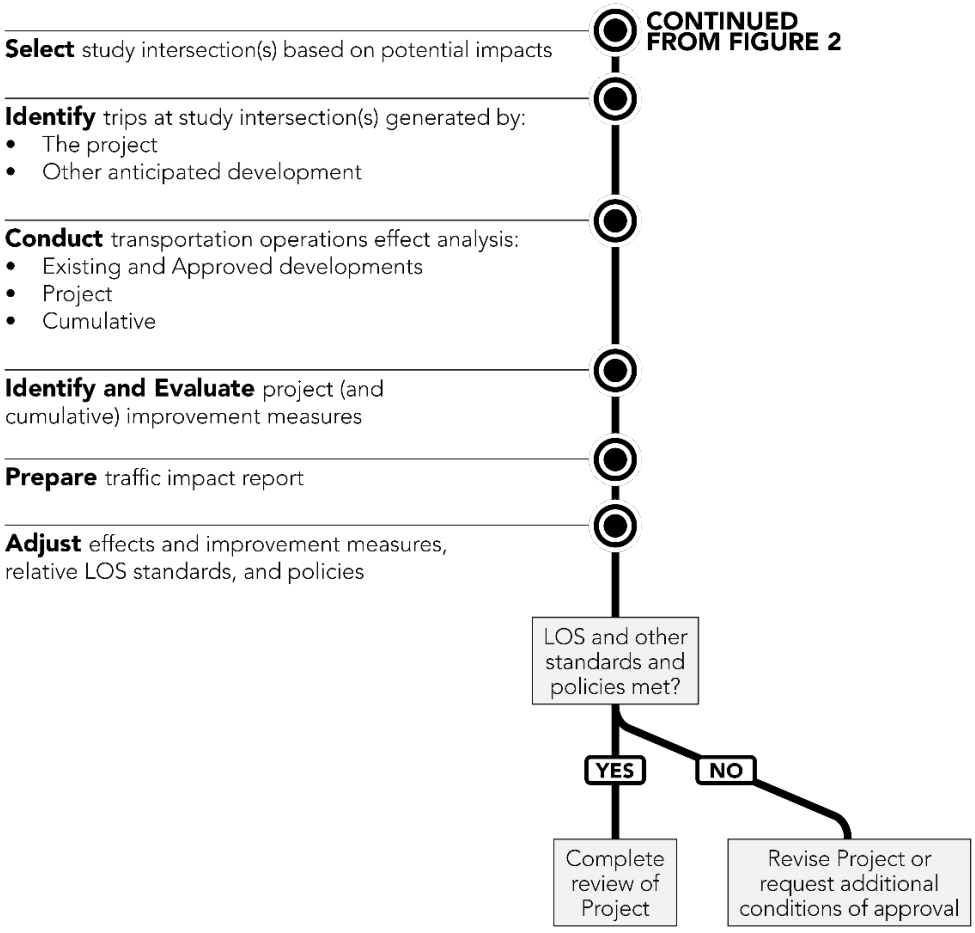


Figure 3 – Transportation Effect and Improvement Analysis Process



The information presented in Sections 4, 5, and 6 provide guidelines for preparing the transportation analysis reports required under the Growth Management Plan. While satisfying the intent of Measure J to provide a uniform method for evaluating the transportation effects of proposed development projects, these guidelines also give traffic engineers and planners considerable latitude to exercise professional judgment in completing the technical analysis.

4.1 Project Definition

The transportation analysis should contain the following information for each proposed development project:

- Project size
- Project location and planned land use
- Distinctive features that could affect trip generation
- A site plan with the access and parking shown

4.2 Trip Generation Estimates

As previously indicated, transportation analysis studies will be required for all projects that generate 100 or more net new peak hour vehicle trips during the peak hour of adjacent street traffic. Some of the RTPCs may have set a lower threshold in their Action Plans. Examples of developments that would require traffic analysis given this threshold are provided in Table 2.

Trip generation rates have been developed for a wide variety of land uses. These are summarized in the latest edition of ITE's *Trip Generation*. The rates have been developed by placing traffic counters at the entrances to individual developments and recording vehicles entering and exiting. The counts are then related to key characteristics of the land use. These normally include number of dwelling units, acreage for residential development, gross square feet, number of employees, and number of parking spaces for commercial development.

For the most common land uses, numerous studies have been used in developing the trip generation rates. In these cases, ITE provides statistical data such as the standard deviation and R-squared. In some cases, however, the published trip generation rates are based on very limited data. In these cases trip generation rates should be verified through alternative source documents or local peak-period field observations of similar uses.

The published trip generation estimates are often described for both the peak hour of the land use (generator) and for the peak hour of adjacent street traffic. For analyzing the effects of a proposed project on the transportation system, trip generation for the peak hour of adjacent street traffic should be used when available. If not available, trip generation for the peak hour of the generator can be substituted.

The average trip generation rate provided by ITE represents a weighted average. The weighting is based on the number of trips with rates within a specified range. This weighted average should be used as a starting point for estimating a project's trip generation.

Table 2: Examples of Developments Meeting the Transportation Analysis Threshold

Peak Hour Vehicle Trips			
Land Use	Size [1,2]	AM	PM
Single Family	106 DU	74	100
Multifamily Housing (Low-Rise)	197 DU	79	100
Hotel	170 Rooms	78	100
Fast Food Restaurant	2.3 KSF	103	76
Shopping Center	30 KSF	25	102
General Office	66 KSF	100	95
Pharmacy/Drugstore	12 KSF	35	102
Multiplex Movie Theater	21 KSF	-	101

1 DU = dwelling unit

2 KSF = 1,000 gross square feet

Source: ITE *Trip Generation* 11th Edition

4.3 Adjustments to Trip Generation Rates

As noted above, trip generation rates represent an average rate for a number of observed projects. A particular project, however, may include specific characteristics that call for adjustments to the average rate to reflect its trip generation characteristics adequately.

A summary of these adjustments and their potential effects on trip generation is outlined in Table 3. Adjustments to this weighted average can be made based on the following considerations:

Transit Usage and Availability. Trip generation rates reflect average conditions for the projects studied. Unfortunately, information about the sites studied is generally not available in the ITE manual. If no transit service is available to the proposed project site, the trip generation rate used should normally be higher than the ITE weighted average. The trip generation rate used for sites adjacent to BART stations should be lower. Any adjustments to the project trip generation rates should be applied only to Home-Based Work (HBW) trips. This will require the segmentation of

project trips by trip purpose. Mode choice information from the Authority's Countywide Model can be used to estimate HBW trips.

TDM Strategies. Published trip generation rates generally do not reflect intensive trip reduction strategies. If TDM goals have been implemented by local ordinance or resolution, or if the proposed project includes a substantive TDM Plan, some reduction in trip generation and VMT for the effect of TDM is permitted. The proposed reduction in maximum peak hour trip generation must be based on evidence, such as surveys from similar developments or publications by organizations recognized as having expertise in this field. Analysts are encouraged to look at the most recent version of the California Air Pollution Control Officers Association (CAPCOA) *Handbook for Analyzing Greenhouse Gas Emission Reductions, Assessing Climate Vulnerabilities, and Advancing Health and Equity,* which provides extensive data on the effects of TDM strategies and offers guidance on how to account for combinations of strategies. The local jurisdiction should keep in mind that traffic impact fees and mitigation requirements may be a function of the number of auto trips being generated by the development. If the assumed trip reductions are not achieved, the available mitigations and fees will not be sufficient to mitigate actual impacts due to underestimation in the transportation analysis.

Pass-by Trips. A significant portion of trips to some retail uses are drawn from the existing traffic stream. Because these pass-by trips do not represent traffic added to the adjacent street network, the estimated trip generation for a facility likely to attract pass-by trips can usually be reduced. These facilities include fast food restaurants, convenience stores, gas stations, and neighborhood shopping centers. The *Technical Procedures* includes information to assist the engineer or planner in estimating the percentage of pass-by trips that can be expected at shopping centers of varied sizes. Data on other types of uses, such as fast food restaurants, have been reported in the *ITE Journal* and other sources.

Mixed Residential/Commercial Use Projects. Large mixed-use projects can reduce trip generation in the project area. This reduction can be attributed to the effect of multi-purpose trips, residents working in the commercial portion of the development, and the creation of new opportunities for non-auto trips. The reduction in trip generation for the transportation analysis, however, should be limited to between 3–6% of all trips generated by the project.

Multi-Use Commercial Sites. Some commercial centers include a combination of uses such as grocery stores, banks, supermarkets, post offices, small office complexes, theaters, and other uses. Some over-estimation of the total trips may result if the trip generation rate for each of these uses is applied to the project. Studies have found that driveway counts at these types of centers can be as much as 25% below the level expected using the combination of available trip generation rates.

Surrounding Land Uses. Trip generation can change based on the surrounding land uses. For example, restaurants in downtown areas can be expected to generate fewer vehicle trips during peak periods than similar facilities in a suburban area. This reflects higher pedestrian activity in the downtown core and a scarcity of parking, which tends to encourage alternative travel modes.

Similarly, apartments in a suburban environment isolated from retail development might have higher trip rates than those within easy walking distance of shopping. The engineer or planner should use judgment in applying this adjustment. The reasons for the adjustment should be documented in the traffic report.

Truck Intensive Uses. When calculating the trip generation for truck intensive uses, the *Highway Capacity Manual* should be consulted to convert truck trips into passenger car equivalents (PCEs). The analysis of facilities such as truck stops, truck transfer facilities, and landfill sites may require conversion to PCEs. Adjustments may be appropriate when analyzing certain types of transportation VMT since heavy trucks are not required to be included in VMT projections used in CEQA transportation analyses.

Local jurisdictions and RTPCs can also develop additional trip generation adjustments as necessary to respond to local conditions that might result in higher or lower trip generation rates than published rates. The adjusted peak hour trips in the peak direction for a project would be calculated as follows:

1. Obtain weighted average trip generation rate from ITE or equivalent source.
2. Apply rate to size of proposed development to obtain total gross peak hour project trips.
3. Adjust trip rate up or down to reflect project-specific characteristics, including:
    - Transit usage and availability,
    - TDM strategies and effectiveness (if such strategies are committed to as part of the project description),
    - Mixed-use project characteristics,
    - Multi-use sites (no other adjustment permitted), and
    - Surrounding land uses.
4. For retail uses, reduce the gross peak hour trips to reflect pass-by trips or diverted linked trips (no other adjustments permitted).
5. Result is total adjusted peak hour project trips.

Table 3: Summary of Trip Generation Adjustments

Adjustment	*Expected Range of Adjustment (%)*	*Comments*
Transit Usage	+3 to -3	Use the Authority's model modal split results to verify
TDM (when included in project description)	Refer to CAPCOA *Handbook for Analyzing Greenhouse Gas Emission Reductions*	Should reflect local experience

Pass-By[1]	Refer to ITE's *Trip Generation Handbook*, 3rd Edition[2]	Applies to shopping centers, fast food restaurants, and other retail uses
Mixed-Use	0 to -6	Applies to mixes of residential and commercial uses
Multi-Use[2]	0 to -25	Applies to multi-use commercial sites expected to attract multi-purpose trips
Surrounding Uses	0 to -5	See description on previous page

[1] If Pass-By or Multi-Use trip generation reductions are used, no other reductions are permitted.

[2] Current pass-by rates are also documented on the ITE website in addition to the latest

4.4 Trip Distribution and Assignment

Few development projects will be large enough to justify a special run of the Countywide Model to distribute and assign project trips. Instead, project generated trips can be distributed and assigned manually using the model to predict background traffic. Existing directional split information, turning movement counts, and local knowledge may all contribute to predicting the distribution of project trips.

For most projects, manual assignment techniques can adequately assess intersection impacts. Manual assignment requires the engineer or planner to estimate the likely routes that traffic generated by the project would use. Computer programs have been developed to assist in the manual assignment process by doing the mathematical bookkeeping for the engineer or planner. They are generally available to local jurisdictions at a reasonable cost. Manual assignment programs may be developed using any spreadsheet program such as Excel or a software package such as TRAFFIX or Vistro.

The local jurisdiction should also attempt to maintain an inventory of "approved trips." This inventory can be maintained on any of the above programs or a separate database. This database would include existing traffic counts plus the anticipated turning movement volumes from approved projects. This information is extremely useful in obtaining consistency among transportation analysis studies and provides the basis for analyzing cumulative transportation effects.

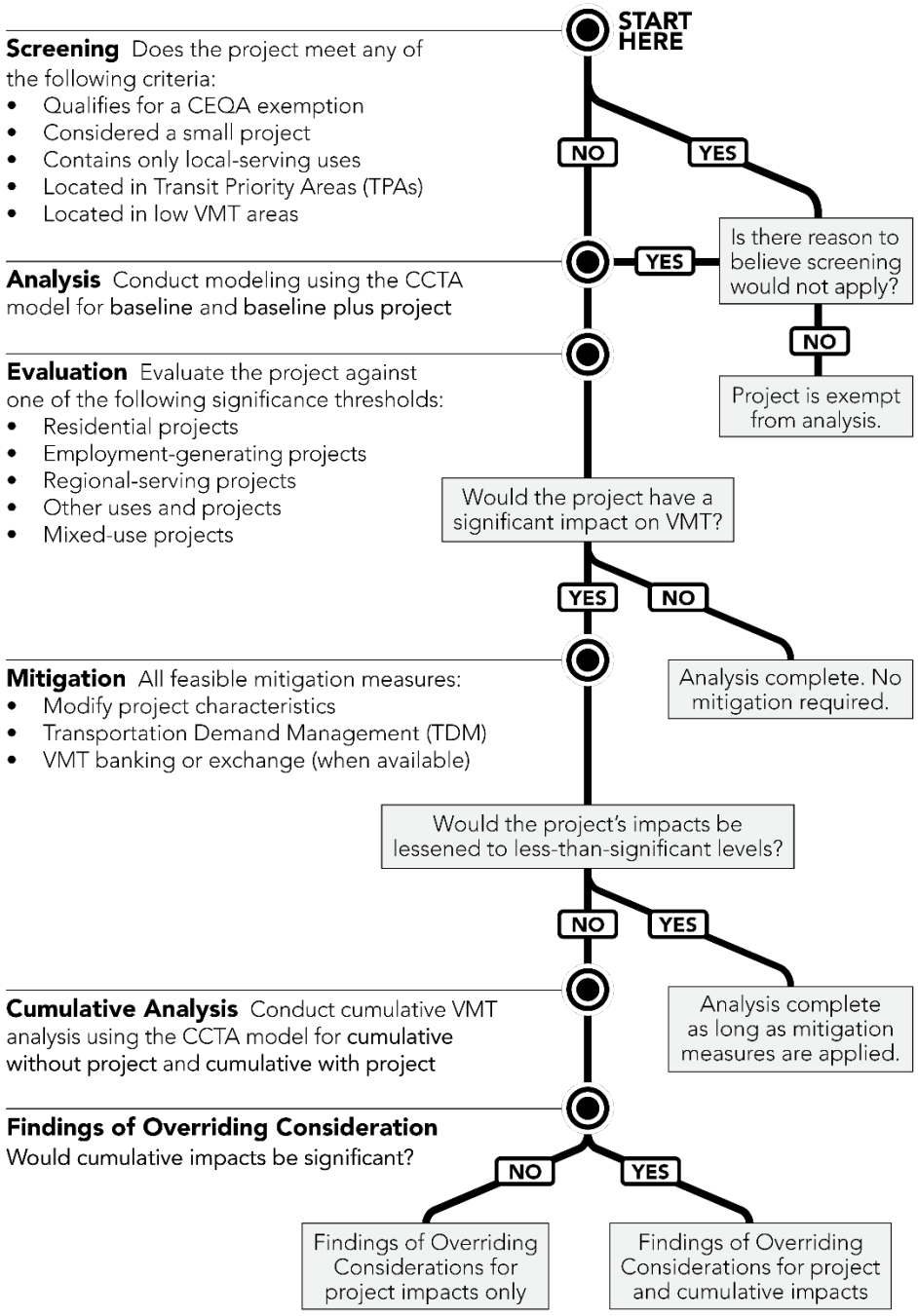
5 PROJECT ANALYSIS: VMT ANALYSIS

A key element of Senate Bill (SB) 743, signed in 2013, is the elimination of automobile delay and LOS as the sole basis of determining transportation impacts under CEQA. The updated CEQA guidelines, released in December 2018, recommend VMT as the most appropriate measure of a project's transportation impacts. This section focuses on the methods and procedures recommended for analyzing the VMT associated with a proposed project, as required for CEQA analysis. Figure 4 depicts the VMT analysis process.

All projects will need to undergo at least a VMT screening procedure and may be required to complete a full VMT evaluation, regardless of whether the project meets the Authority's or the lead agency's requirements for a comprehensive transportation analysis. The trip generation results described in the previous section will be used in the initial VMT screening process.

It is important to note that SB 743 does not prevent a lead agency from continuing to analyze delay or LOS as part of other plans (e.g., the general plan), studies, or ongoing network monitoring as part of an informational, non-CEQA analysis; such an analysis is further explained in Section 6.

Figure 4 – VMT Analysis Process



5.1 Project VMT Screening

There are five screening criteria lead agencies can apply to screen projects out of conducting project-level VMT analysis. Even if a project satisfies one or more of the screening criteria, lead agencies may still require a VMT analysis if there is evidence that the project has characteristics that might lead to a significant amount of VMT.

5.1.1: CEQA Exemption. Any project that is exempt from CEQA is not required to conduct a VMT analysis.

5.1.2: Small Projects. Small projects can be presumed to cause a less-than-significant VMT impact. Small projects are defined as having 10,000 square feet or less of non-residential space or 20 residential units or less, or otherwise generating less than 836 VMT per day.[6]

5.1.3: Local-Serving Uses. Projects that consist of Local-Serving Uses can generally be presumed to have a less-than-significant impact absent substantial evidence to the contrary, since these types of projects will primarily draw users and customers from a relatively small geographic area that will lead to short-distance trips and trips that are linked to other destinations. Local-serving uses are uses expected to draw users from no more than a 2- to 3-mile radius, and may include local-serving public facilities, schools, or retail businesses, among others. A qualitative assessment to determine whether a use is local-serving may be appropriate in some cases, and local jurisdictions may develop focused definitions of local-serving uses that they consider appropriate in their local context.

5.1.4: Projects Located in Transit Priority Areas (TPAs). Projects located within a TPA can be presumed to have a less-than-significant impact absent substantial evidence to the contrary. This exemption would not apply if the project:

- Has a Floor Area Ratio of less than 0.75;
- Includes more parking for use by residents, customers, or employees than required by the lead agency (if the agency allows but does not require the project to supply a certain amount of parking);
- Is inconsistent with the applicable Sustainable Communities Strategy (as determined by the lead agency, with input from the MTC); or

[6] This threshold ties directly to the California Governor's Office of Planning and Research (OPR) *Technical Advisory* which notes that CEQA provides a categorical exemption for existing facilities, including additions to existing structures of up to 10,000 square feet, so long as the project is in an area where public infrastructure is available to allow for maximum planned development and the project is not in an environmentally sensitive area. (CEQA Guidelines, § 15301, subd. (e)(2).) Using statewide average data from the California Statewide Household Travel Survey (CHTS), the amount of daily VMT associated with 10,000 square feet of non-residential space is 836 VMT. Also using statewide average CHTS data, this level of VMT is associated with 20 housing units. Therefore, absent substantial evidence otherwise, it is reasonable to conclude that the addition of 20 housing units or 10,000 square feet of non-residential space could be considered not to lead to a significant impact.

- Results in a net reduction in multi-family housing units.

5.1.5: Projects Located in Low VMT Areas. Residential and employment-generating projects located within a low VMT-generating area can be presumed to have a less-than-significant impact if the project is similar to the existing land uses in the area and absent substantial evidence to the contrary.

A low VMT area is defined as follows:

- For housing projects: Geographic areas (defined by the TAZs in the CCTA Model) within a city that have existing Home-Based VMT per capita that is 85% or less of the existing citywide average, or geographic areas (defined by the TAZs in the CCTA Model) within the unincorporated County that have existing home-based VMT per capita that is 85% or less of the existing countywide average.

- For employment-generating projects: Geographic areas (defined by the TAZs in the CCTA Model) within a city or the unincorporated County that have existing Home-Work VMT per worker that is 85% or less of the existing nine-county Bay Area regional average.

There is no definition of a low VMT area for Regional-Serving and Other Projects, since these projects always require a VMT Analysis (unless they are screened out under criteria mentioned above). A webmap featuring the most current VMT results from the CCTA model, VMT averages at the Bay Area region and countywide level, and related guidance is available on CCTA's website here: https://ccta.net/planning/.

Mixed-use projects may qualify for the use of this screening criterion if they include only housing, employment-generating uses and local-serving uses, and can reasonably be expected to generate VMT per resident and/or per worker that is similar to the existing land uses in the low VMT area.

5.2 VMT Analysis and Thresholds of Significance

A project not excluded from VMT analysis through the screening process described above shall be subject to a VMT analysis to determine if it has a significant VMT impact. See Appendix A for further detail on how the model should be used to analyze the scenarios.

THRESHOLDS OF SIGNIFICANCE

The following describes the specific VMT metrics and significance thresholds that should be used in evaluating different project types:[7]

Residential Projects should use the Home-Based VMT per capita metric to evaluate project generated VMT. The project generated Home-Based VMT per resident constitutes a significant impact if it is higher than 85% of the Home-Based VMT per resident in the subject municipality or unincorporated CCTA subregion (for areas outside of municipalities) or 85% of the existing countywide average Home-Based VMT per resident, whichever is less stringent.

Employment-Generating Projects should use the Home-Work VMT per worker metric for project generated VMT estimates. This metric deviates from the Governor's Office of Planning & Research (OPR) *Technical Advisory* due to regional characteristics that require a refined approach to address Contra Costa County issues. The project generated Home-Work VMT per worker constitutes a significant impact if it is higher than 85% of the Home-Work VMT per worker in the subject municipality or unincorporated CCTA subregion (for areas outside of municipalities) or 85% of the existing Bay Area region-wide average Home-Work VMT per worker, whichever is less stringent.

Regional-Serving Projects should use the metric of total study area VMT and should define a VMT study area over which to evaluate that metric. The project generated VMT constitutes a significant impact if the baseline project generated total VMT per service population is higher than 85% of the existing countywide average total VMT per service population.

Other Uses and Projects need to be analyzed using a methodology developed by the lead agency specifically for the project, prepared and documented based on available data and taking into account the specific methodologies and thresholds identified in this document.

Mixed-Use Projects may be analyzed using a combination of techniques described above, as follows:

- Mixed-use projects that contain a combination of housing, employment-generating and regional-serving uses may choose to evaluate each use separately using the metrics and significance thresholds described above for those uses.

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[7] The metrics of "Home-Based VMT per capita" and "Home-Work VMT per worker" are taken from the production-attraction trip matrices in the CCTA model, which is a stage of the modeling process in which trips are still categorized by purpose. This stage of the modeling process does not yet include truck trips, so these VMT metrics do not include the VMT associated with trucks. This is consistent with the guidance from the OPR Technical Advisory, in which it interprets the Section 15064.3 language referring to automobile VMT as being focused on light-duty passenger vehicles. The "total VMT per service population" metric is taken from the final origin-destination trip matrices in the CCTA model and therefore it does include the VMT associated with trucks. Per the OPR guidance it is acceptable to include truck VMT when needed for modeling convenience, as long as the Analyst ensures there is an apples-to-apples comparison by using the same vehicle types in each step of the analysis process.

- Mixed-use projects that include a local-serving component may ignore that component for analysis purposes, and analyze only the remaining uses. Note that it may be more beneficial to the project to conduct a full analysis that takes account of on-site local-serving uses, since this analysis can take credit for reductions in trips resulting from the on-site mix.

In all cases, the analyst should consider whether that approach will effectively capture the likely interactions between the different uses. Other analytical options that would capture interactions between different uses are to analyze the project by conducting a full run of the CCTA model, or to use a sketch planning tool designed to estimate the trip generation effects of a mixed-use project.

5.3 VMT Mitigation Strategies

If the analysis conducted in Section 5.2 indicates that the project would have the potential to cause a significant VMT impact per one or more of the significance thresholds defined above, then mitigation is required. CEQA requires that all feasible measures be implemented to reduce identified impacts to less-than-significant levels.

METHOD OF CALCULATING MITIGATION REDUCTIONS

The analyst, working with the lead agency and applicant, shall specify a series of mitigation measures, each of which shall have a specific percent level of VMT reduction assigned to it. Reduction levels may be derived from the CAPCOA Handbook or from other defensible and well-documented sources. In each case, the analyst shall explain the basis for the reduction applied, and shall also consider interactions among the mitigation measures that make them cumulatively less effective than they are by themselves.

Each reduction shall be applied to the appropriate set of VMT associated with the project, until the project-generated VMT is reduced to a less-than-significant level or all feasible mitigation strategies have been applied.

REQUIRED LEVELS OF MITIGATION

In order to reduce impacts to less-than-significant levels, the proposed mitigation measures must reduce VMT to the relevant threshold as defined in Section 3 above.

TYPES OF MITIGATION

To mitigate VMT impacts, the following actions could be taken (see Appendix A for further details):

- Modify the project's characteristics to reduce VMT generated by the project. This might involve changing the density or mixture of land uses on the project site, or changing the

project's location to one that is more accessible by transit or other travel modes. The effectiveness of such changes should be modeled using the analysis techniques described in Table 3, above.

- Implement TDM or physical design measures to reduce VMT generated by the project. The TDM measures proposed as mitigations must be additional to any TDM that was included in the project description and that was already incorporated into the project's trip generation calculations as described in Table 3 above.
- Participate in a CCTA-approved VMT impact fee program and/or VMT mitigation exchange/banking program, to the extent such a program is available, as a schedule and budget for implementation that has not been identified.

It is important to recognize that the effects of each mitigation action will vary depending on the context in which it is implemented and the types of trips to which it applies. It is the analyst's responsibility to review the available research and suggest a level of VMT reduction that is reasonable under the circumstances. Please see Appendix A for further details.

5.4 CEQA Assessment – Significant and Unavoidable Impacts, Cumulative Analysis, and Findings of Overriding Consideration

FINDINGS OF OVERRIDING CONSIDERATION

If the lead agency includes all feasible measures described in Section 5.3 and those measures are insufficient to fully mitigate the impact, then the VMT impact must be classified as significant and unavoidable. The lead agency may still approve the project, as allowed by CEQA, by making a finding of overriding consideration.

Before making such a finding and approving the project, the lead agency must also conduct a cumulative VMT analysis for the project, as described below.[8]

CUMULATIVE ANALYSIS

Projects that are unable to mitigate their project-specific VMT impacts to less-than-significant levels require a cumulative VMT analysis.

The cumulative VMT analysis for a project involves understanding additions to overall VMT within the study area that will come from both the subject project and other pending projects, or where the subject project could change travel patterns associated with other projects and land uses. This analysis is needed to address circumstances where an individual project might affect

[8] As per OPR's guidance, cumulative VMT analysis is not necessary for projects that are found to have a less-than-significant impact on VMT at the project level.

travel patterns associated with other developments in the broader area; this might happen for a variety of reasons, such as that the project offers different housing, employment, or other opportunities than would otherwise exist in the area and that causes other users to change their travel decisions, or because the drivers and transit users generated by the project take up available system capacity and cause other users to change their travel routes or modes.

The project's cumulative effect on VMT should be measured by defining a VMT study area and calculating the total VMT occurring on all network links inside that study area, in both the Cumulative without Project and Cumulative with Project scenarios.

To allow for a reasonable comparison between those two scenarios, the total study area VMT should be normalized in some fashion to reflect the differing numbers of people within the study area that might exist under the two scenarios. For example, if the project adds residents to the study area, then it would be reasonable to present the VMT results as total study area VMT divided by number of study area residents. If the project adds employees to the study area, then it would be reasonable to use total study area VMT divided by number of study area employees. The exact method for normalizing the VMT number is not critical; what is essential is that the same method be used for both the Cumulative without Project and the Cumulative with Project scenarios, to allow for a commensurable comparison between the two scenarios.

Cumulative Threshold. Cumulative VMT impacts should be considered significant if there is a net increase in the total study area VMT normalized to the number of people within the study area, when comparing Cumulative without Project to Cumulative with Project conditions.

Additional Significant Impact and Findings of Overriding Consideration. If the cumulative VMT analysis finds a significant impact, this impact shall be considered to be significant and unavoidable, and must therefore be called out in the project's EIR and subject to the Finding of Overriding Consideration described earlier in this section.

5.5 Documentation of VMT Analysis

The results of the VMT analysis described in this section should be documented for review by the lead agency and other stakeholders. If the project is required to complete a comprehensive transportation analysis report, then the VMT evaluation should be included as one section in that report (see Section 6 and Appendix E for a description and outline of a Transportation Analysis Report). If the project is not required to complete a transportation analysis report, the VMT analysis should be documented in a stand-alone technical memorandum, including sufficient detail to allow the reviewer to understand the analytical steps and conclusions.

6 PROJECT ANALYSIS: LOCAL TRANSPORTATION ANALYSIS

As described in Sections 4 and 5, SB 743 does not prevent a lead agency from continuing to analyze delay or LOS as part of other plans (e.g., the General Plan), studies, or ongoing network monitoring as part of an informational, non-CEQA analysis. This section includes guidance on the traffic capacity and other analysis that may be required as part of the transportation analysis report.

6.1 Selection of Study Intersections

Study intersections will be selected after local staff have completed and approved the trip generation, distribution, and assignment results, and have confirmed that LOS must be analyzed. As a rule, the analysis should include any signalized intersection to which at least 50 net new peak hour vehicle trips would be added by the project. This level of impact will normally reflect a 1–3% increase in critical volumes. Projects just meeting the threshold for transportation analysis will normally require analysis of only the intersection(s) adjacent to the site. Larger developments will require the analysis of a larger number of intersections. Engineering judgment may be used to eliminate intersections from the analysis that are not controlling intersections or where critical movements are not affected as the project only adds through movements. The elimination of study intersections where 50 or more trips are projected to be added by the project should be done in consultation with the city engineer or transportation engineer for the local jurisdiction in which the affected intersection is located. The traffic study should also fully document the rationale for eliminating intersections from the analysis.

Evaluation of unsignalized intersections may also be considered for analysis. Traffic counts at study intersections should be conducted in accordance with the Traffic Counting Protocol documented in Appendix C.

Study intersections should be selected without consideration for jurisdictional boundaries. Study intersections should also include arterial and ramp intersections defined as Routes of Regional Significance, as appropriate. If the proposed project adds more than 50 net new peak hour vehicle trips to a freeway ramp, the impact of the project on freeway MTSOs should be evaluated. Project-specific impacts should be mitigated at these locations consistent with the Action Plans adopted by the RTPCs.

6.2 Level of Service Analysis

A Transportation Analysis needs to consider the potential effect of a project on transportation conditions using performance measures and standards contained in the local General Plan, the MTSOs from the Action Plan for Routes of Regional Significance, and the standards for the CMP network. The results of the analysis should be compared with standards set forward in these documents. Other measures of performance or effects may also be included to provide a more comprehensive multimodal assessment of the project's potential effects including quality and safety of service. The transportation analysis should include, as a minimum, consideration of the following scenarios:

- Existing conditions at or near the time of analysis (**Existing Conditions**);
- Existing conditions plus the project (**Existing Plus Project Conditions**);
- Future-year baseline conditions for a forecast year after the year the project being analyzed is to be implemented (**Future Year No Project Conditions**). The conditions will include all approved land use changes and development that is consistent with the General Plan and expected to occur within the time frame of the project. It will also include transportation projects programmed for implementation prior to the forecast year and approved mitigation measures required for approved or planned projects. This scenario will be used with the next to identify the incremental cumulative impact of the project; and
- Future-year baseline conditions plus the project that is being analyzed (**Future Year with Project Conditions**). This condition should include all mitigations proposed for the project to meet applicable standards.

For projects expected to be phased over several years, the analysis horizon should extend beyond completion of the final phase, but separate traffic analysis may be required for each phase depending on the size of each phase and the time between phases. All capital improvements in the Capital Improvement Program that will affect traffic capacity at the study intersections should be considered in the cumulative transportation analysis.

Analysis of LOS may be required by the lead agency. LOS should be calculated for each study intersection for the weekday morning (AM) and weekday evening (PM) peak hours as appropriate. For certain types of development, including some retail or recreational uses, midday or weekend day LOS calculations may be appropriate. Selection of additional peak periods for study will be at local discretion.

Roadway LOS at signalized intersections should be calculated using the latest *Highway Capacity Manual* operational method unless the calculation is being compared to an MTSO or other standard that was established using the methodology previously adopted by the Authority, known as CCTALOS, in which case the CCTALOS method may be used. To ensure consistent application of procedures for analyzing LOS at signalized intersections in Contra Costa, guidelines have been developed for how each procedure should be applied and the parameter or default values should

be used. One of the significant operational method changes in the latest *Highway Capacity Manual* is that a saturation flow rate is calculated based on the more detailed intersection geometry and operating parameters that are required as inputs for this method. A default saturation flow rate is no longer needed. Guidelines for the use of the CCTALOS methodology in Contra Costa are provided in Appendix D. Potential impacts from vehicle queuing may be estimated using analysis programs, such as Synchro or HCS-Signal, which apply queuing analysis procedures of the latest *Highway Capacity Manual*. Guidelines for the estimation of other MTSOs besides intersection LOS are contained in Appendix B.

Although not required specifically by Measure J, CEQA requires an analysis of air quality impacts if a project exceeds specific thresholds. These thresholds vary according to the criteria pollutant. Thresholds have been established for Reactive Organic Gases (ROG), Oxides of Nitrogen (NOx), Carbon Monoxide (CO), Particulate Matter (PM10 and PM2.5), and Greenhouse Gases (GHG). Measures must be identified and evaluated that will mitigate the negative air quality impacts of the projects if the threshold level is exceeded.[9] The GHG analysis is not required and the threshold values do not apply if it can be demonstrated that the project is in compliance with a "Qualified GHG Reduction Strategy" or if the project is classified as "Transit Priority."

6.3 Multimodal Level of Service

In Contra Costa, as in many other parts of the country, there has been interest in LOS for modes other than automobile. A variety of procedures for defining LOS for pedestrians, bicyclists, and transit users have been developed and used by local, regional, and state agencies over the years. One source for a standardized methodology is documented in the *Highway Capacity Manual*, which defines LOS by roadway segment separately for pedestrians, bicyclists, and transit, as well as methods for pedestrian and bicycle LOS at intersections.

Analysis of multimodal LOS is not required for compliance with the GMP or current Action Plans. If undertaken, analysts should use procedures that are well-supported in the research literature and should provide thorough documentation of the methods, assumptions, and results.

6.4 Analysis of Traffic Effects

The transportation analysis should develop and incorporate appropriate improvement measures to offset impacts that are found to have exceeded the thresholds of significance as identified in the CEQA and non-CEQA analyses. For example, projects included in the Capital Improvement Program that may affect transportation analysis study intersections should be analyzed in the Future Year Baseline Conditions and the Future Year Baseline Plus Project Conditions scenarios as

9 Bay Area Air Quality Management District, ***California Environmental Quality Act: Air Quality Guidelines***, Updated May 2017, page 2-4.

potential mitigations. Furthermore, as appropriate, the transportation analysis should disclose secondary effects that the proposed mitigation measures could generate. By way of example, the secondary effect generated by adding approach lanes to an intersection could include an increase in pedestrian crossing time. This program could include a local traffic mitigation fee or a requirement that each development provide funding for its share of cumulative impacts. Measure J also requires each local jurisdiction to participate through the appropriate RTPC in a regional transportation mitigation program.

Three options exist when the transportation analysis identifies significant impacts even after mitigation through the 5-year Capital Improvement Program or conditions on the project:

- Modify the project so that the project's effects meet adopted standards or objectives;
- Make findings that considerations other than traffic justify the proposed project; or
- Deny the project.

Approval of the project without following these procedures may result in noncompliance with the Authority's Growth Management Program, and could subsequently cause withholding of Local Street Maintenance and Improvement funds.

6.5 Transportation Analysis Report

The required Transportation Analysis report must fully document the approach, methodology, and assumptions of the analysis. It should clearly explain the reasons for any adjustments to the weighted average trip generation rates and assumptions used for trip distribution and assignment. Figures should be used to help illustrate those assumptions. The report should summarize the results of the VMT analysis described in Section 5, including any maps used to analyze project generated VMT or a project's effect on VMT. Any changes to the model that affect the output, including, but not limited to, network coding, land use changes, trip generation rates, or peak hour factors, should be well documented and included in the Transportation Analysis report. Recommended mitigation measures should be clearly stated and should indicate the relative share of the mitigation costs assigned to the project. If a LOS analysis is required, calculations should be presented in table form or included in a figure, along with traffic volumes and calculations sheets included as an appendix to the report. Results for the study intersections should be calculated with and without the proposed improvement measures. A typical transportation analysis report is outlined in Appendix E.

7 TRAVEL DEMAND FORECASTING

7.1 Overview of the Countywide Model

The analysis of the transportation system as a whole and of its components, as well as its relationship to land use decisions, requires an understanding of potential future travel patterns. Computerized travel demand forecasting models originally developed by transportation researchers in the 1960s are now broadly accepted and widely applied throughout the international transportation engineering community. Typically, these models employ land use, transportation-supply, and demographic information to predict future travel demand and mode of travel, and are considered by industry professionals to be the best tool available for evaluating the impacts of significant changes in land use policies or major improvements to the transportation system. This section of the *Technical Procedures* provides an overview of the Authority's computerized travel demand forecasting model (the Countywide Model) and summarizes the specifications, policies, and procedures. Model users are encouraged to obtain the detailed *CCTA Model User Guide*[10] for operating the model from the Authority.

It should be noted that, as of the 2021-2023 timeframe, the Authority is undertaking the development of a new model system that will be a tour-based model instead of the previously used trip-based model. When the new tour-based model is completed and ready for application, this chapter of the *Technical Procedures* will be updated to reflect the methods and procedures needed to apply the new model. In the interim, model users are encouraged to consult with Authority staff to ensure they are using the most current model version available.

The purposes of the Authority's travel model are as follows:

- For use in developing Action Plans required as part of the adopted Growth Management Plan.
- As a consistent technical tool for use by local jurisdictions to analyze and update local General Plans as may be necessary to incorporate the Growth Management Element.
- To analyze a project's impact on VMT.
- To assess the transportation effects of Specific Plans, General Plan Amendments, and projects that generate more than 100 net new peak hour vehicle trips.

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[10] Kittelson & Associates, Inc. with Caliper Corporation, ***CCTA Decennial Model Update – CCTA Model User Guide***, prepared for the Contra Costa Transportation Authority, Walnut Creek, CA, March 2016.

- To fulfill the requirements of the CMP function, such as identifying trips that can be discounted in an Exclusions Study.
- To assess project impacts for Strategic Plan Project Delivery (Measure J), Corridor Studies, design studies, and EIR/EIS studies.
- For the analysis of CMP deficiency plans.
- For development of regional mitigation and fee programs.
- For CEQA-related analysis of the above-listed uses.

The usefulness of the model in analyzing major amendments to a General Plan or in studying major transportation corridors is well-documented. The travel demand forecasting model is less useful for the analysis of minor changes in the street network or in TDM programs. Table 4 provides examples of both appropriate and inappropriate uses of the models.

Table 4: Examples of Appropriate and Inappropriate Model Applications

Appropriate Applications	*Inappropriate Applications*
Assessing project generated VMT and a project's effect on VMT.	Quantifying shifts in auto congestion within a longer peak period.
Assessing transportation effects of a development project or a major change in General Plan Land Uses.	Evaluating effects of a new right turn lane at an intersection.
Assessing transportation effects of a new major roadway.	Evaluating through travel at an intersection.
Estimating through travel in a corridor.	Estimating the potential for casual carpooling at an existing transit station.
Estimating regional changes in transit ridership.	
Estimating changes in travel patterns over time.	

Measure J required the Authority to develop and maintain a travel demand forecasting model that would support multi-jurisdictional participation in the Growth Management Program. The CMP further requires that the Authority, as the Congestion Management Agency (CMA) for Contra Costa, maintain a land use database and travel forecasting model that is consistent with the region's database and model. The CMA is also responsible for specifying which components of the model to apply for various types of analysis.

The Authority's Countywide Model was adapted from a model maintained by MTC, and focuses on Contra Costa and the Alameda County portions of the Tri-Valley, including Dublin, Livermore, and Pleasanton. The Countywide Model is available for use by public agencies and private

consultants throughout Contra Costa. It comprises the uniform transportation analysis tool that ensures consistency among travel projections, even when they are prepared by different and sometimes competing entities.

The RTPCs should use the Countywide Model to undertake Action Plan updates, and local jurisdictions should use the model for General Plan updates, transportation analysis studies (VMT analysis and LOS if required), and related growth and congestion management efforts. Furthermore, the Authority will use the Countywide Model to evaluate MTSOs on the regional system and future congestion on the CMP network. Various agencies, including the Authority, Caltrans, and local jurisdictions, are also encouraged to use the Countywide Model for corridor studies, environmental review, and project-related planning and design.

The Countywide Model runs on the TransCAD® 5.0 software platform. The software incorporates traffic assignment algorithms that can rapidly and accurately compute traffic flows and estimate mode choice. The GIS enhancements and native support for many different database types makes the model more user-friendly. The last major update of the CCTA model was prepared in April 2019.[11] The Countywide Model is calibrated to 2010 count data and was updated to incorporate assumptions consistent with the 2017 RTP prepared by MTC, Plan Bay Area 2040. The Countywide Model will be updated to incorporate assumptions from Plan Bay Area 2050, approved in 2021, during the current process of updating the Action Plans and CTP. Full model documentation is available on CCTA's website.

Within Contra Costa, the Technical Modeling Working Group (TMWG) has helped to guide the Authority's model development process. The TMWG serves as a subcommittee to the Authority's Technical Coordinating Committee (TCC). The TCC initially created the TMWG specifically to address issues of model care, "feeding," and application through the congestion and growth management program. In 1998, the TCC assigned the TMWG the responsibility to oversee and guide technical aspects of the decennial model update. As issues arise, the TMWG reports its recommendations to TCC for consideration and adoption. The TMWG oversees the modeling specifications, policies, and procedures set forth in this section and anticipates reviewing and updating them periodically.

Although LOS-related outputs from the model are no longer required for CEQA purposes, lead agencies may require such outputs for their own planning purposes and/or for air quality and noise analysis.

7.2 Countywide Model Input Requirements

The Countywide Model incorporates MTC's BAYCAST-90 five-step forecasting process (auto ownership, trip generation, trip distribution, mode split and assignment) to predict travel patterns. The Countywide Model includes data from local jurisdictions within Contra Costa and

[11] Reference April 2019 transmittal

the Tri-Valley and is consistent with data developed by ABAG. As a result, the travel forecasts reflect the cumulative effect of predicted changes in land use and planned roadway improvements within the framework of MTC's RTP for the Bay Area.

The TAZ structure of the 2010 Countywide Model was updated from the older 1099 MTC zone system to the MTC 1454 zone system. Almost 300 new zones were added in transit-oriented developments (TOD) and ABAG's Priority Development Areas (PDAs) inside the County. The 2010 Contra Costa Countywide Model contains a total of 3,146 TAZs including gateway zones. There are 3,120 internal TAZs, of which there are 1,495 zones in Contra Costa County.

Land use and demographic data are required for each TAZ. The demographic data provides the basis for estimating trip generation. Both the demographic and transportation network data are used in predicting trip distribution patterns and mode of travel. The model land use and demographic inputs for traffic zones within Contra Costa consist of the following ten variables:

- Number of Households
- Household Population
- Employed Residents
- Household Income (expressed in 2000 dollars)[12]
- Retail Employment
- Service Employment
- Other Employment
- Total Acres within the Zone
- High School Enrollment
- College Enrollment

The land use data for the model is updated every two to four years through the allocation of ABAG's new Projections series data. The Authority's Land Use Information System (LUIS) provides land use data sets that correspond with the following levels:

- *Baseline*. Development that existed and was occupied in the base year. The current model is set up to run for years 2000, 2010, and ten-year increments thereafter, through 2040. In addition, through interpolation, the model is capable of running any intervening year (such as 2017).
- *Approved Projects*. Development that received approval from a city or the County but was either not constructed or not occupied in the base year but corresponds with a 5- to 10-year outlook.
- *Proposed Projects*. Development projects considered likely to be completed within the next 20 years but that have not yet completed the approval process.

[12] Household income feeds into MTC's auto ownership model and is later considered in trip distribution and mode split.

- *Build Out*. Development potential remaining in each traffic zone after completion of all approved and proposed projects based on General Plan designations and probable market forces in a 25- to-30-year time frame or beyond.

The first LUIS database was issued by the Authority in 1992 and reflected consistency with ABAG's *Projections '90* forecasts. LUIS has been updated numerous times since then using the most recent ABAG projects. Further updates will continue as necessary to maintain consistency with the regional model.

LUIS is public record and is available to local jurisdictions, other public agencies, and interested members of the public and private sector. These data are useful for a variety of planning applications beyond transportation, including energy and water resource assessment.

For areas outside of Contra Costa and the Tri-Valley, the TAZ structure is equivalent to MTC's zone system. Data for these zones are taken directly from MTC's model.

The highway and transit networks for the Countywide Model are based on the existing and planned transportation system, including freeways, arterials, major collectors, and selected minor collectors and include virtually all signalized intersections in the study area. The transit network is based on MTC's transit networks with refinements based upon local review by the transit operators. For both highway and transit networks, detailed networks within Contra Costa have been combined with MTC networks outside the County.

The Countywide Model uses the auto ownership, trip generation, trip distribution, and mode choice modules in MTC's BAYCAST-90 model.

7.3 Output Options

As described in Section 5, CEQA requires the analysis and mitigation of project generated VMT or a project's effect on VMT. To calculate project generated VMT, the Authority's Countywide Model outputs production-attraction and origin-destination matrices, along with distance skims. The project's effect on VMT can be evaluated by calculating the total amount of VMT occurring within a defined geographic area (also known as the "boundary method" of VMT calculation). Additionally, the Countywide Model can generate highway and transit outputs for the AM and PM peak hour, AM and PM peak period (four hours), and daily traffic volumes. Output from the model can be provided in the form of data listings and/or computer plots. Examples of model output include link volumes, intersection turn movements, volume-to-capacity (v/c) ratios, vehicle hours traveled (VHT), and vehicle hours of delay. Model outputs are also used for sections outside of transportation, such as air quality and noise. The model provides sufficient detail to permit travel demand forecasts down to the level of minor collector roadways. However, it does not include residential streets.

7.4 Link-Level Output Adjustments

Ideally, the Authority's models should be well validated on all links. Other factors, such as variations in traffic count data and budget limitations, however, make it unfeasible to continue the validation adjustment procedures indefinitely. At some point, the model validation effort must reach closure. The point of closure occurs when the links in the model have been validated to the extent necessary to meet the validation targets established in this document. To account for remaining differences between base-year model output and actual counts, a link volume adjustment process has been established.

As illustrated in Figure 5, the process involves assessing the difference between actual counts and base-year model outputs. The "Model Correction Volume," which is the difference between existing counts and the base-year validation model run, is applied to the base year and projections.

When developing intersection turning movement forecasts, the adjustment process should be applied to intersection approach and departure volumes, as described in the next subsection. Alternatively, link-level adjustments can be made within the forecasting model through the implementation of the Origin-Destination Matrix Estimation (ODME) process, as described in Appendix F.

7.5 VMT Metrics

The output from each model run will include total VMT per service population, Home-Based VMT per capita, and Home-Work VMT per worker, which should be evaluated as described in Section 5 above. In addition, to calculate the total study area VMT, the analyst would define a VMT study area and the VMT occurring on all network links inside that study area should be summed.

7.6 Intersection Turning Movements and Level-of-Service Options

Although it is no longer a CEQA requirement, a LOS analysis may be required by a lead agency. While the Countywide Model will store intersection turning movements, separate software is needed to calculate LOS at signalized intersections. To obtain reasonable intersection turning movements from the model, adjustment of the raw model output is required using a technique known as the Furness Method. This adjustment technique has been automated and is summarized below and in Figures 5 and 6.

Step 1 Calculate the Model Correction Volume for each network link (i.e., the difference between the projected peak hour volume for the validation run and actual peak hour traffic volumes).

Step 2 Determine the forecast peak hour approach and departure volumes for each signalized intersection to be studied by adding the Model Correction Volume to the model output.

Step 3 Develop turning movement volumes that are consistent with the approach and departure volumes by balancing projected turning movements with actual turning movement volumes using an iterative process. This balancing process is summarized in Figure 6.

Step 4 Check reasonableness by comparing adjusted turning movement volumes with both the existing count data and the raw model output.

Step 5 Review volume adjustments that do not appear reasonable and, if appropriate, revise adjustments.

Figure 5 – Link Adjustment Process

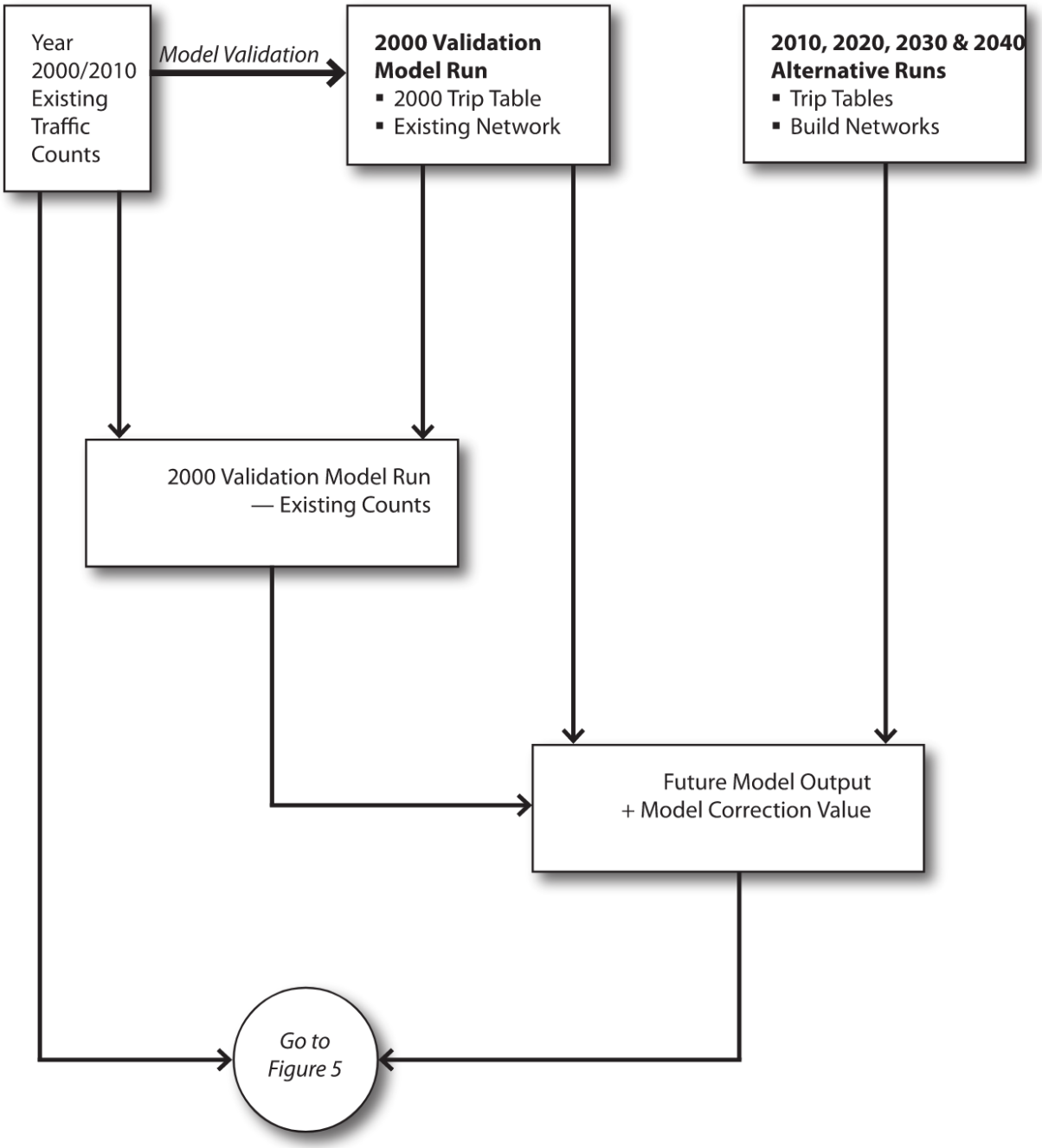
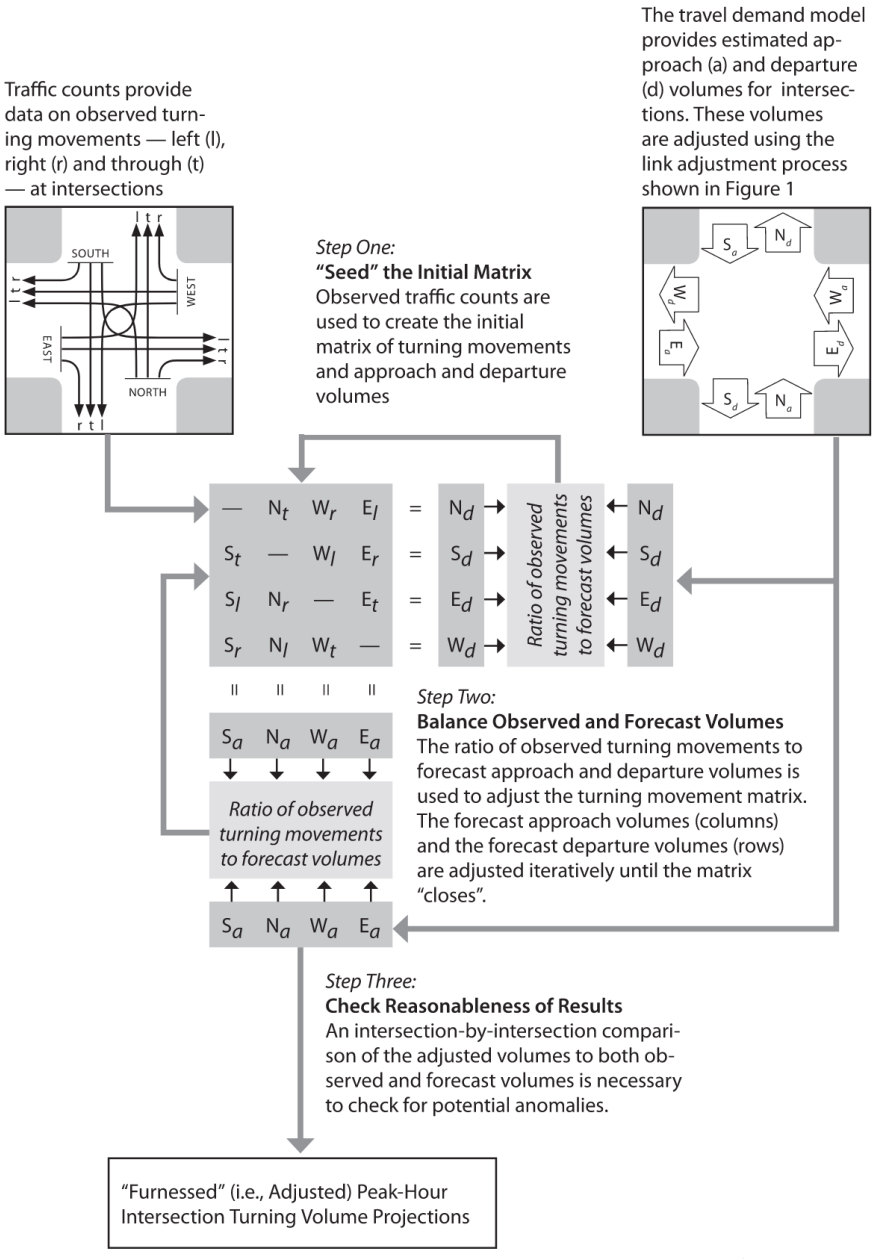


Figure 6 – Intersection Turning Movement Adjustment Process (the "Furness" Method)



This methodology works well except in the following cases:

- The model network places a centroid connector at an intersection.
- The future forecast adds a new leg to an intersection.
- A major new roadway is located near an intersection.

In the first case, the network coding should be carefully checked in the study area and zone centroid connectors should be moved to a new location that is adequately removed from adjacent intersections.

The second exception introduces a more difficult challenge because there is no existing data that can be used to validate the approach volume for a new leg to an intersection. The Furness process in this case may be bypassed and the analyst may elect to use the raw model output data if it appears reasonable or they may elect to perform manual adjustments as appropriate. If the Furness method is used, approach and departure volumes from the model output should be carefully checked and, if necessary, adjusted. The Furness matrix may be "seeded" with the raw turning volumes from the forecast model output.[13] The traffic analyst also has the option of inputting hand-calculated approach volumes based upon Institute of Transportation Engineers (ITE) vehicle trip generation calculations for the land uses on the road leg being added to the intersection.

The final exception could occur when the model includes a major new roadway near the intersection. In this case, manual adjustments may be needed where the distribution of forecast approach and departure volumes change significantly.

7.7 Select Link Analysis

The Countywide Model is capable of performing select link analysis that can identify the origin and destination zones for traffic on a specific network link. Select link analysis may be used for defining benefit districts for fee programs, assessing percentages of through traffic for Routes of Regional Significance, and evaluating traffic exclusions for CMP LOS monitoring. The origin-destination information is generated by the trip assignment module of the TransCAD model and the analysis is referred to as Select Zone/Link Analysis. Where feasible, the results of select link analysis should be compared with observed origin-destination surveys to determine the level of validation for the specific link being analyzed.

7.8 Gateway Constraints

As outlined in Appendix G, the Countywide Model can be used directly to adjust peak hour volumes on major routes. This type of adjustment, called Gateway Constraints, may be necessary

[13] Note: "Seeding" the Furness matrix with zeros will result in a turning movement output of zero. To obtain reasonable output for the new approach leg, the matrix must be seeded with non-zero, positive integers. The raw model output turning volumes should suffice for this purpose.

under two scenarios: 1) When further adjustments to the model are required to meet the observed model validation targets, or 2) When future traffic volumes generated by the model are excessively high and need to be adjusted to account for known capacity constraints or bottlenecks at a specified location.

7.9 Model Specifications

The Countywide Model is fully consistent with MTC's model. Any revisions undertaken to the Authority's models must therefore conform to the specifications set forth below and be consistent with MTC's model. As MTC's model continues to evolve, the Authority may periodically update the Countywide Model to reflect MTC's model, provided those updates are feasible, practical, and cost-effective.

TRIP GENERATION

Trip production and attraction models are based on household survey data from the most recent trip-based MTC BAYCAST-90 model, which is based on the MTC Travel Surveys used to develop the RTP. This approach results in models that reflect unique Contra Costa travel behavior characteristics. The models produce estimates of average daily (weekday) person trips by individual trip purpose using cross-classification at the production end and linear regression at the attraction end.

The basic regional trip purposes—Home-Based Work, Home-Based Shopping/Other, Home-Based Social/Recreational, Home-Based School and Non-Home-Based—are drawn from the MTC model,[14] which was calibrated to the observed data. Home-Based School trips are further separated into grade school, high school, and college. Specific production and attraction models are estimated and validated for each indicated trip purpose.

As specified in the model documentation, special generators were developed for regional parks, regional shopping centers, unique industrial areas, and large concentrations of senior housing (in excess of 4,000 units) that have unique trip generation characteristics. Schools do not need to be identified as special generators since these are specifically identified as separate trip purposes.

The trip generation equations used in the Authority's models will permit consideration of TDM strategies. The equations, however, are used consistently for all TAZs. Assigning different trip generation rates for individual TAZs to reflect differing levels of TDM is possible but not recommended. Alternatively, analysis of the potential impacts of TDM can be incorporated into the transportation analysis report conducted as part of development review.

[14] Travel Demand Models for the San Francisco Bay Area (BAYCAST-90) Technical Summary, Metropolitan Transportation Commission, Planning Section, June 1997.

TRIP DISTRIBUTION

Trip distribution is performed using a standard gravity model approach with a large number of iterations to ensure better adherence to the target trips and productions. The Countywide Model is capable of incorporating the three-dimensional matrix balancing within TransCAD to implement the trip distribution. This technique can be applied to ensure the county-to-county trip movements match MTC county-to-county trips (this is the third dimension of the balancing process). The Countywide Model accomplishes consistency with MTC's county-to-county trip tables by virtue of the model's strict adherence to the MTC model structure and algorithms as they exist for the RTP. As MTC's model has evolved, diversion from the county-to-county trip tables now requires application of the "third" matrix balancing dimension. Moreover, MTC has migrated to a tour-based model, which further requires three-dimensional balancing.

To address these issues, the CCTA model should be iterated until closure is reached. Because gravity models are highly sensitive to zone size, the MTC F-Factor values have been re-calibrated for use in Contra Costa. Any factors used in the validation must be held constant for the forecast horizon years.

The TransCAD software performs matrix balancing for attractions and productions, rather than the traditional normalization to attractions only. The model explicitly represents in-commuting workers from outside the nine-county Bay Area. External trip matrices were developed from MTC external trip tables and updated with origin-destination surveys that were available in the vicinity of these external trips at the time of the decennial model update. As new information becomes available from MTC, adjoining counties, and other MPOs, the external trip matrices may be updated.

The TransCAD setting for trip distribution matrix balancing should be set at a minimum of 100 iterations to ensure closure of the matrix balancing process.

The MTC consistency requirements state that county-to-county Home-Based work and total person trips should match MTC trip tables within 1% or 10,000 trips, whichever is higher. The three-dimensional balancing approach should ensure that this consistency requirement is met.

MODE CHOICE

Each of MTC's regionally estimated mode choice models are implemented directly as part of the Countywide Model update. The 3,120 zone system has a fully functional mode choice estimation model for all zones. Adjustments may be made to each model's bias constants to reflect (1) the change in zone system size and definition, and (2) the differences in transit path building when using TransCAD instead of MTC's CUBE multi-path-building algorithms.

For Home-Based Work trips, total person trips are split into walk, bike, transit-walk access, transit-drive access, drive-alone auto, 2-person auto, and 3+ person auto using a multimodal logic model. The Authority's Countywide Model estimates 2 person and 3+ person HOVs for Home-

Based Work, Home-Based Shop/Other, and Home-Based Social-Recreational trips, and provides for their separate assignments on the highway network. The mode choice models are applied for all inter-and intra-county trips, as opposed to previous models where the inter-county mode shares were derived directly from the MTC trip tables. This will require that, for mode choice and assignment purposes, the transit networks developed for the full nine-county area and the highway networks must both be retained for all modeling applications.

AUTO OWNERSHIP AND OTHER MODE SPLIT MODEL INPUT ASSUMPTIONS

To maintain consistency with MTC's model, estimates of model input assumptions for the base and future year mode split—such as auto ownership levels, income, auto operating costs, tolls, fares, and parking costs—are obtained directly from the latest approved and published MTC regional model forecasts for the RTP. Use of these estimates provides the ability to reflect the dynamic influence of changing auto ownership patterns on mode choice without relying upon less sophisticated and more aggregate cross-classification or regression estimates. The Authority implements these types of updates to the model as part of the periodic model update process.

TRAFFIC ASSIGNMENT

Vehicle trip tables are created directly from the mode choice model output for three individual time periods: AM peak period (6 to 10 AM), PM peak period (3 to 7 PM), and the off-peak period (all remaining hours). Traffic volumes resulting from the peak period assignments are further processed to produce AM peak hour and PM peak hour volumes. Vehicle occupancies used to calculate vehicle trips by purpose are based upon MTC's occupancies. The conversion of daily vehicle trips to each individual time period was based initially upon the MTC Travel Survey diurnal distribution factors provided by MTC. The conversion can be modified subsequently based upon comparisons of actual and estimated traffic volumes by link. These factors may be modified only where a systematic pattern exists (for example, peak spreading evident on the Bay Bridge) or where an obvious variation from the time period of analysis exists (for example, the attraction of trip ends in the AM peak hour for major regional shopping centers occurs near the end of the AM peak period, and spills over into the off-peak).

Vehicle trip assignments are made for each time period using the stochastic user equilibrium assignment algorithm available within TransCAD software. Following these assignments, a daily traffic volume is calculated by summing the volumes from the three time periods. Output transit trips are created for the same three time periods and assigned to the transit networks.

Park-and-ride vehicle trips to BART stations are included in the highway assignment. Transit park-and-ride trips are initially estimated during the transit path-building step, representing one leg of a transit trip where park-and-ride trips go from a TAZ to a nearby BART station. A matrix of park-and-ride vehicle trips is created and added to the AM peak hour vehicle trip matrix for

assignment. For the PM peak hour, the matrix is transposed and then added to the trip table for assignment.

INTER-COUNTY TRIPS

Inter-county trips are defined as those trips that have one or both endpoints outside of Contra Costa but still within the nine-county MTC region.[15] The Countywide Model treats inter-county trips the same as intra-county trips.

Inter-county trips are estimated using the same models as the internal trips for Contra Costa. This approach is possible because the 3,120-zone Countywide Model contains the full level of detail for MTC zones so that the models can be applied easily to any geographic study area.

REGIONAL EXTERNAL TRIPS

Regional external trips are defined as those trips with one endpoint outside of the MTC nine-county Bay Area. External through trips and transit trips are considered negligible.

The Countywide Model addresses trips that enter and leave the MTC region on State Route 4, I-580 and State Route 160, specifically. This was implemented by including production and attraction estimates by purpose for these highways at the point where they enter the MTC region. These estimates of external trips are added to the external trip tables developed by MTC for all other regional external stations. Transit trips coming in from external stations are added to the transit trip tables where appropriate. The ACE train, for example, constitutes an external transit link. External trip tables are added to the internal trip tables prior to the application of peaking factors so that they are included in all time period trip tables. External trip tables can be developed either as vehicle trips (for auto assignments) directly or as person trips (for transit assignments) based on the origin of the data used to estimate these tables.

The Countywide Model could conceivably be expanded to include San Joaquin County as a part of the TAZ structure rather than as an external. In Santa Clara County, the VTA has taken steps to add some outlying counties. Until MTC decides to expand its model, the external counties in its model will continue to be treated using a trip-table technique to estimate in-and-out commuting for the Bay Area. Should the Authority choose to explore the addition of TAZs outside of the Bay Area, either in the context of the Countywide Model or for a specific corridor study, the expanded model would be developed in consultation between the Authority and MTC.

Trip lengths are truncated at the model's boundaries. The CCTA model has an Excel-based post-processor that includes a factor that is applied to each TAZ to represent the average length of

[15] Internal zones for the Decennial Model are defined as any of the detailed zones within the previous four subarea models. For the Tri-Valley model, this included the Tri-Valley portion of Alameda County.

trips that have one end in that TAZ and one end outside the model area.[16] This factor has been derived from an analysis of origin-destination data (acquired from StreetLight Data) at all the major gateways between Contra Costa County and the model boundary. The purpose of this factor is to account for the portion of trips that occur outside the model area, in order to be consistent with the OPR *Technical Advisory* recommendation that VMT analysis should avoid truncating trips at model boundaries.

THE LAND USE INFORMATION SYSTEM (LUIS) DATABASE

The Authority maintains a detailed LUIS as part of its modeling effort. As shown in Figure 7, the Authority's LUIS is based upon the initial inputs received from ABAG at the census tract level and provided to the CMAs. The TAZ structure of the 2010 Countywide Model was updated from the older 1099 MTC zone system to the MTC 1454 zone system. In addition, the internal TAZs in Contra Costa County were reviewed in the ABAG identified PDAs. Significant additional TAZs were added in areas that had TOD and PDAs. Almost 300 new zones were added inside the County.

The 2010 Contra Costa Countywide Model contains a total of 3,146 TAZs including gateway zones. There are 3,120 internal TAZs out of 1,495 zones in Contra Costa County. The TAZs in the Bay Area counties outside of Contra Costa County are generally consistent with the MTC Regional TAZs, except for additional TAZ detail in the adjacent Tri-Valley area.

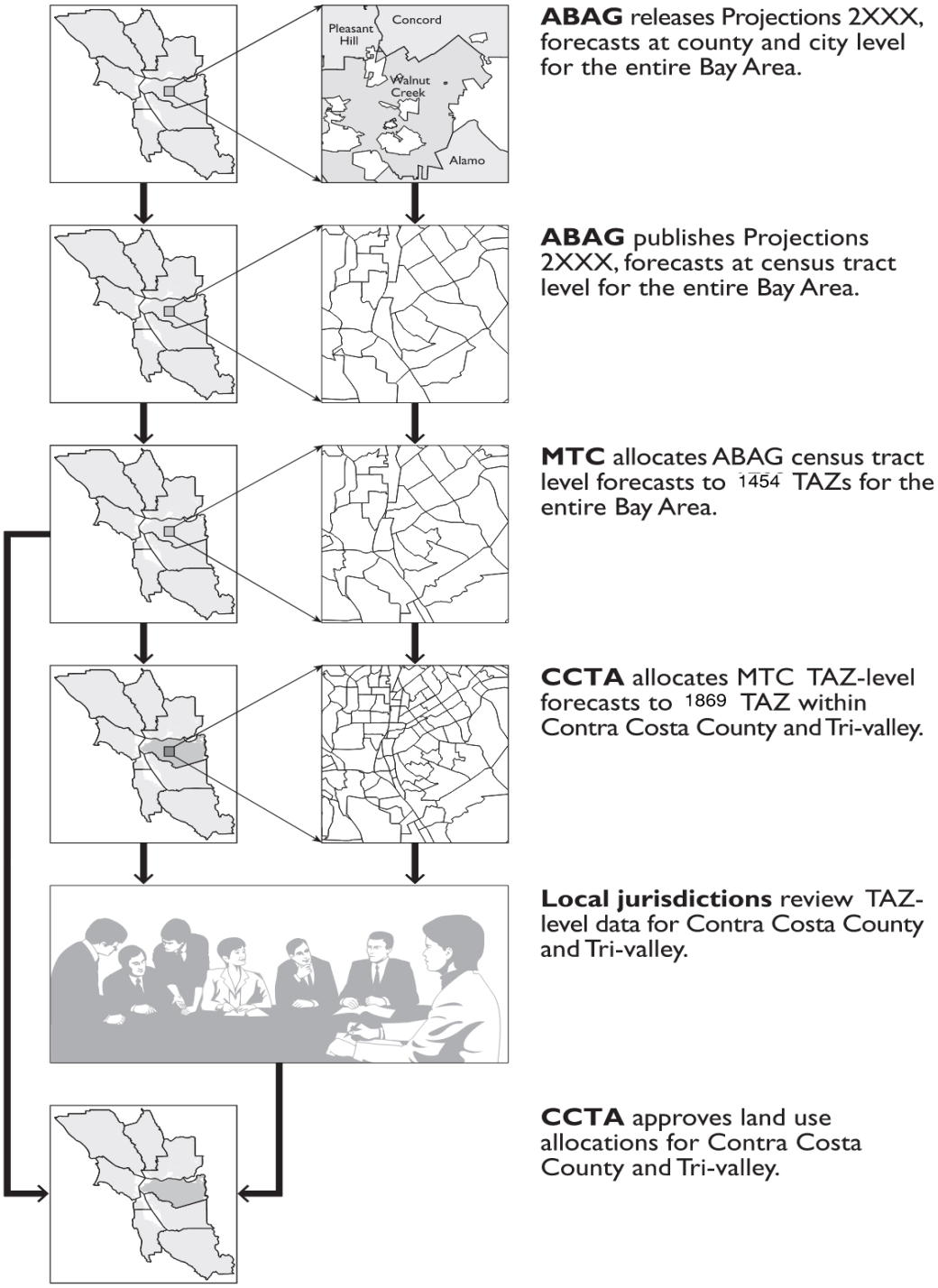
Full documentation of the LUIS approach, methodology, and results are available in separate reports.

Future travel demand forecasts are generally prepared for the near-term (5- to 10-year), the mid-term (15- to 20-year) and the long-range (25- to 30-year) time horizons. The land use changes for each of these planning periods was estimated based on the remaining development potential (vacant capacity) in each zone, given General Plan zoning and likely market forces. Citywide and census tract forecasts are controlled to ABAG forecast totals. The land use data results are then reviewed by the local jurisdictions to ensure consistency with local General Plans.

Subsequent updates to the land use database will continue to be made by disaggregating ABAG's latest Projections series data by census tract, in accordance with the latest available information for vacant capacity and based upon the zonal allocations.

[16] CCTA SB743 Support: Transmittal of VMT Calculation Script and Instructions, November 6, 2020.

Figure 7 – Land Use Information System Methodology



Complete documentation of the LUIS methodology, approach, and results is available from the Authority upon request. The LUIS uses Microsoft Access® software.

BASE AND SUBAREA NETWORKS

The highway and transit networks for the Countywide Model were initially developed by combining the four subarea model networks and updating the attributes to represent a calibration year. These networks were then combined with the MTC validation networks and adjusted for any differences that may have occurred between the calibration years of the models. The capacity, speed, frequency, dwell time, walk access, auto access, and transfer network coding conventions used in the Countywide Model were reviewed and updated. These updated conventions have been maintained when new transit and highway network details were added.

External highway network links outside of Contra Costa are coded with coding conventions followed by MTC. The Countywide Model can accommodate different coding conventions for networks within Contra Costa and for networks outside the county to provide flexibility for the differences desired for local planning applications.

The near-term (5- to 10-year) network generally reflects existing conditions plus completion of the following:

- All projects currently under construction;
- All Measure J projects in the current seven-year cycle of the Strategic Plan;
- Currently programmed STIP projects; and
- Locally funded projects programmed in each jurisdiction's five-year Capital Improvement Program.

The financially constrained long-range (15- to 20-year) network should generally reflect all projects included in the near-term network, plus the following:

- Projects included in MTC's most recent RTP Financially Constrained alternative;
- Local projects shown in local General Plans or other approved planning documents, consistent with the RTP, and fully funded within the timeframe of the long-range forecast; and
- Locally funded (Measure J) projects that are specified in the Expenditure Plan.

The financially unconstrained networks include all the projects in the financially constrained network, plus unfunded projects on MTC's long-range horizon, along with all projects listed in the Authority's Comprehensive Transportation Project List (CTPL).[17]

[17] See Appendix B for the 2017 Countywide Comprehensive Transportation Plan, CCTA, September 2019.

7.10 Validation

Every ten years the Countywide Model is recalibrated and validated to observed traffic counts. The last major calibration was to 2000, with a subsequent validation to 2010 counts. Due to the "Great Recession," the 2010 counts were generally lower than the 2000 counts, and therefore were not used for a recalibration of the model. The model output is compared with the average daily traffic as well as AM and PM peak hour and peak period data. Counts were made in accordance with the traffic counting protocol shown in Appendix B. The following validation targets are used in evaluating the adequacy of the validation process. All model re-validation exercises should meet the validation criteria listed below:

1. Screenline and Cordon Line Validation

Highway and transit volumes were validated to the common countywide screen-lines and cordon line shown in Figure D-1 through D-4 of Appendix H. Year 2000 and 2010 traffic count data for these countywide screen-lines are also listed in Appendix H. For complete reports of the screenline counts and model comparisons, see the *Contra Costa Decennial Model Update: Model Documentation*.

The total highway AM and PM peak hour volumes crossing each cordon line and screenline shall be within 10% of the AM and PM peak hour counts (total and in the peak direction) for all screen-lines. The same criteria shall apply to the transit volumes.

2. Link Level Validation

The 2000 forecast volumes were reviewed using available data as well as an understanding of traffic demand in the area. Links with volumes significantly below or above expected levels were identified, and possible model adjustments considered.

3. Intersection Approach Volumes, Turning Movements, and Level of Service Calculations

The existing traffic volume and street geometry used for calculating existing AM and PM peak hour LOS was generated for each study intersection and reviewed for reasonableness and accuracy. The LOS calculation sheets were reviewed as well.

The unadjusted 2000 model estimated approach volumes and turning movements were compared to actual count data in easily readable tabular format. The Authority LOS program's v/c results using the actual turning counts were compared in tabular format to the v/c results using the unadjusted model estimated turning movements.

4. Freeway Mainline and Ramp Volumes

The goal of each sub-area model was to validate against having counts at 65% of the ramps and on 65% of the mainline segments. (Mainline counts can be derived from ramp counts.) 80%[18] or more of the model estimates for ramps and mainline sections were required to fall below the curves shown in Figure 8.

5. Aggregate Validation Targets

Aggregate validation targets for vehicle trips include the following:

- 75% of freeway link volumes within 20% of actual counts
- 50% of freeway link volumes within 10% of actual counts
- 75% of link volumes on arterials with 10,000 vehicles or more per day within 30% of actual counts
- 50% of link volumes on arterials with 10,000 vehicles or more per day within 15% of actual counts
- 50% of all study intersection approach and/or departure volumes with greater than 1,000 vehicles per hour within 20% of actual counts
- 30% of all study intersection approach and/or departure volumes between 500 and 1,000 vehicles per hour within 20% of actual counts

In addition, the following criteria shall apply to the model-estimated street approach volumes for all study intersections (regardless of volume):

- 75% of links within 30% of actual counts
- 50% of links within 15% of actual counts

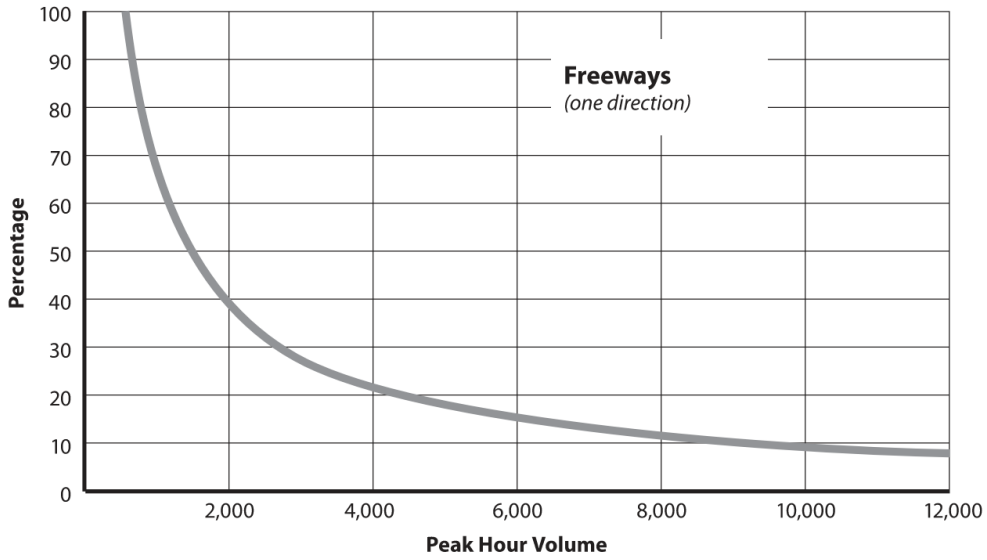
***Note**: For some intersection approach volumes, an adjacent cordon line count may also be available. The match between the intersection count, which is performed manually, and the adjacent cordon line count, which is performed by machine, may vary depending on a variety of factors. Both data sets may be combined to achieve a best "fit" for the calibration.*

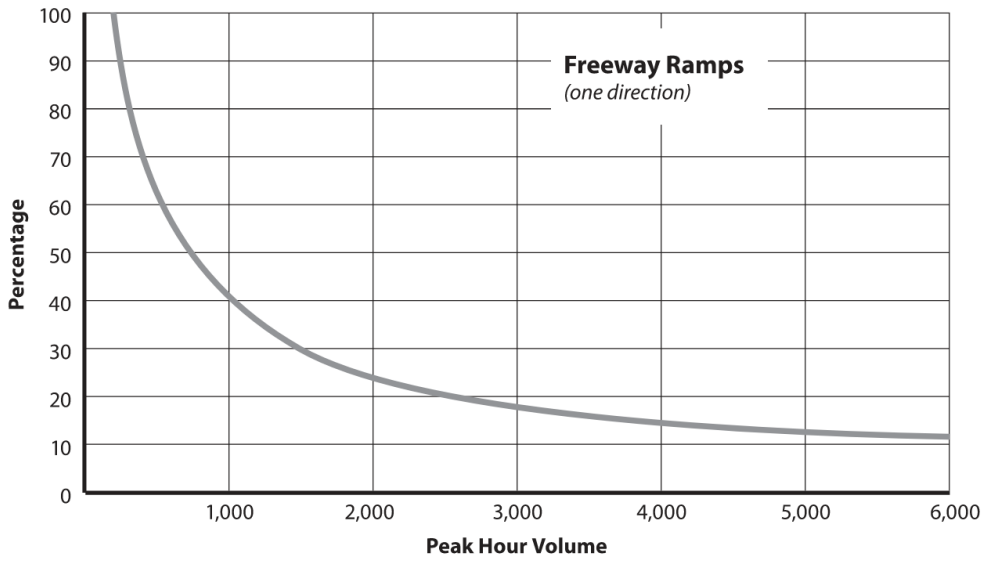
Transit boardings and alightings should be within 10% for BART lines. Overall boardings and alightings for buses should be within 20% for bus lines.

Validation targets were initially achieved through use of K factors, peak hour percentages, and diurnal factors. As outlined below, further validation adjustments were performed using Origin Destination Matrix Estimation (ODME). In all cases, the factors used to achieve the validation must be held constant when developing future year forecasts.

[18] The Caltrans goal of 95% was demonstrated to be infeasible within specific corridors. Traffic counts made on different days on the same corridor did not meet this 95% criterion.

Figure 8 – Maximum Percentage Deviation for Freeways and Freeway Ramps





This chart can be used if model output is compared to actual traffic counts at 65 percent of locations. The acceptance criteria are:

- The percent deviation should be within the target shown in the charts, and
- The deviation between the total assigned traffic and the total counted traffic volume should be within five percent.

Model Users may wish to conduct additional focused validation exercises for specific projects. If additional traffic counts are obtained for such exercises, the counts should be conducted in accordance with the Traffic Counting Protocol contained in Appendix C.

The TransCAD model includes a "macro" that will generate screenline comparisons and a validation report. Model users are required to generate this report and submit it to the Authority to demonstrate that the base-year validation conforms to the requirements of this section. Depending upon the modeling application, however, full compliance with the Authority's validation criteria through iterative adjustments to the model may be difficult to achieve given budgetary and scheduling constraints. Therefore, an automated adjustment technique for molding the model to available count data is also available, as outlined below.

The Authority's Countywide Model was calibrated and validated to the furthest extent possible using puristic techniques. That is, no post-processing adjustments were made to the model to force it to match observed traffic count data. Only the "pure" input data and the model algorithms were used to generate the baseline outputs. With this approach, and following extensive review by local jurisdictions, 93% of the validation targets in the Authority's *Technical Procedures* were met. To reach closure on the remaining 7% of the validation targets, the modeling consultant, Dowling Associates, Inc., invoked a post-processing technique called Origin Destination Matrix Estimation (ODME) that would adjust O–D pairs in the vehicle trip table to match selected target volumes. Guidelines for the application of ODME are contained in Appendix F.

To review the ODME pilot test results, please refer to the Technical Memorandum TMWG dated February 1, 2006 (included with Appendix F). Contained in that memo is a full description of the ODME procedure, its origins, methodology, flow charts depicting the process, and a description of issues that arose through tests on a variety of ODME applications.

7.11 Consistency with the MTC Regional Model

The passage of the CMP legislation in 1990 introduced new requirements for counties to maintain model consistency with their respective Metropolitan Planning Organization. As the designated CMA for Contra Costa, the Authority must maintain models and land use databases that are consistent with MTC's models and databases. MTC has adopted a "Checklist for Modeling Consistency" to which the Authority has adhered in developing its Countywide Model.[19] Consistency with the MTC modeling approach helps ensure that use of the Authority's Countywide Model can be used in project-level air quality analyses as outlined in MTC's Resolution 3757.

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19 Metropolitan Transportation Commission, ***Guidance for Consistency of Congestion Management Programs with Regional Transportation Plan, Appendix B: MTC Checklist for Modeling Consistency for CMPs***, Oakland, CA, June 2011.

While every effort is made to achieve consistency with MTC's models, the consistency requirements themselves are evolving annually. Therefore, model users are encouraged to consult with Authority and MTC staff before using the Authority's models for a specific application. Depending upon the proposed type of model application, the model user may need to adjust the Authority's models to meet MTC's consistency requirements. Authority staff is available to participate in these dialogues and assist model users in achieving required consistency.

Travel demand models are always being enhanced and the Authority maintains an on-going dialogue with MTC staff to ensure an understanding of MTC's consistency requirements. MTC has developed the next generation of the regional travel model, a tour-based model that applies a series of statistical models to predict the behavior of individual households and persons. The initial version of this model system is referred to as "Travel Model One" and additional refinements continue to be made in subsequent model systems referred to as "Travel Model 1.5" and "Travel Model Two." The latest version of the guidance for model consistency allows CMAs to discuss their CMA model's relationship to either the prior trip-based model (BAYCAST-90) or to Travel Model One. As in previous checklists, the CMA models must use demographic, economic, and land use forecasts that are "consistent" but not necessarily identical to census-level data provided by ABAG. A CMA may reallocate within the county but must consult with the cities, ABAG and MTC about the reallocation. The CMA's county total must be within 1% of ABAG's for population, households, jobs and employed residents. Outside of the county, the land use variable must either match ABAG's or those of the CMA for the other counties. Network assumptions outside of the county of the CMA must match those of MTC's model, and network assumptions inside the county must be more detailed. Pricing assumptions for automobile operating costs, transit fares and bridge tolls must match those in the MTC model, or the CMA must provide an explanation of why the assumptions used by the CMA are different. Methods used by the CMA to model automobile ownership, trip generation, trip location or distribution, mode choice and route assignment must match those of either MTC's Travel Model One or BAYCAST-90 Model or use forecasts produced by them, or the CMA must submit a description of the methods it proposes to use for review and approval by MTC.

7.12 Policies and Procedures

GENERAL

Users should evaluate all model output carefully for reasonableness. Forecast output should be adjusted by comparing actual counts to the model validation output. The detailed procedure for adjusting link level and turning movement model output are presented in Section 7.

NETWORK REVISIONS

Any revisions to the regional network should be undertaken in consultation with the project proponent, RTPC, and Authority staff. The network should be revised within the project study

area to identify and correct existing coding errors. Previous model versions may have connected zone centroids to the roadway network intersections. As a general convention, when moving zone centroid connectors, connections to intersections should be avoided, as this will result in erroneous intersection turning movement outputs (see Section 5.4).

ZONE STRUCTURE

Any revisions to the zone structure should be undertaken in consultation with Authority staff. Changes in the zone structure represent a significant level of effort to implement and should be considered as part of the model update process rather than ongoing model refinements. These changes must be reflected in the land use database and should not be undertaken without sufficient network level of detail to support the changes.

LAND USE INFORMATION SYSTEM (LUIS)

The Authority may elect to update the countywide LUIS periodically (every two to five years) depending on identified needs. These updates will be based upon census tract information from ABAG's latest Projections series. Full documentation of the most recent updates to the LUIS is available from the Authority upon request.

MODEL OWNERSHIP

The Decennial Model is the property of the Authority until it sunsets. In the Tri-Valley, the Countywide Model is jointly owned by the Authority and the Alameda County Transportation Commission through a separate ownership agreement. The Authority and local jurisdictions that are licensed or interested in becoming licensed TransCAD users may cooperatively wish to negotiate reduced joint licensing/maintenance fees for TransCAD. Appendix I contains the Authority's Model Use Agreement.

MODEL OVERSIGHT

Oversight of the Countywide Model development shall begin at the TMWG level and is carried through to the TCC. The group shall report modeling activities and issues to the TCC and shall meet as required to coordinate modeling efforts, model updating, database management, or other functions defined by the TCC.

USE OF THE GATEWAY CAPACITY CONSTRAINT METHODOLOGY

Model users may, in consultation with the affected RTPC and Authority staff, apply the Gateway Capacity Constraint Methodology as specified in Appendix G of this document. The Gateway Capacity Constraint Methodology may be used when peak hour traffic entering or leaving a study area far exceeds roadway capacity. Numerous criteria, as set forth in Appendix G, must be met in

order to justify using this methodology. In addition, the user must fully document the rationale, procedure, and results of applying it.

7.13 Maintenance and Use of the Countywide Model

The Countywide Model is available for use by the Authority, the County, and the cities within Contra Costa and the Tri-Valley. Consultants under contract to the Authority, the County, or the cities within Contra Costa may be given the model data sets upon written request by the interested party. Alameda jurisdictions may contact ACTC to obtain the Countywide Model. The TransCAD databases may be obtained from the Authority by entering into a Model Use Agreement with the Authority. As shown in Appendix I, the Use Agreement specifies and limits the purposes for which the model can be applied. It also sets forth conditions of model ownership and requirements for documenting any changes made to the Authority's models. The Authority's decision to release the model databases to a prospective user shall be made in consultation with the affected RTPC(s). Upon completion of the work, each user must provide the Authority with full copies of the revised data sets and documentation of any changes made. Documentation of the TransCAD databases and model is available for review in the Authority's library or through the CCTA website at www.ccta.net.

Copies of the model and data sets shall not be distributed by any party other than the Authority. Language, approved by the Authority, prohibiting the unauthorized duplication or use of the model(s) should be included in any consultant contract that includes the use of any Authority model. Language should also be included indicating ownership by the Authority of all data and model runs prepared as part of the project.

Compliance with all TransCAD licensing and copyright agreements shall be maintained by all agencies and consultants using the sub-area models.

MAKING CHANGES TO THE BASELINE MODELS

For each application of the Countywide Model, additional iterations of validation, zone refinement, and network adjustments may be desirable. Record copies of the baseline validation runs, data sets, and forecasts shall be maintained by the Authority. If changes to the baseline models are made, the following documentation must be prepared and submitted to the Authority upon request:

- Purpose of the revisions
- Date of the work
- Base data sets used
- File names and descriptions
- Description of revisions
- Summary of findings
- Local agency contact

- Consultant and Project Manager
- Complete set of disks containing model as revised
- Version number and date of TransCAD software used
- The complete TransCAD databases and programs shall be delivered to Authority offices on electronic media.

MODEL AND DATABASE MAINTENANCE AND UPDATING

Current versions of the Countywide Model and the library of model runs will be maintained at the Authority offices. The Authority will make the most up to date version of the model data sets available to qualified model users. Decisions regarding which data set to use, and the extent of additional updates required, shall be made in consultation with RTPC, Authority, and MTC staff.

The TMWG will, from time to time, determine if any maintenance or update functions need to be carried out on the Authority's models and databases. Maintenance and update requirements will depend primarily on MTC's requirements and the continued designation of the Authority as CMA for Contra Costa. Should the CMP function be discontinued, the need for model updates and maintenance will become less frequent.

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Appendix A – VMT Analysis Methodology for Land Use Projects in Contra Costa

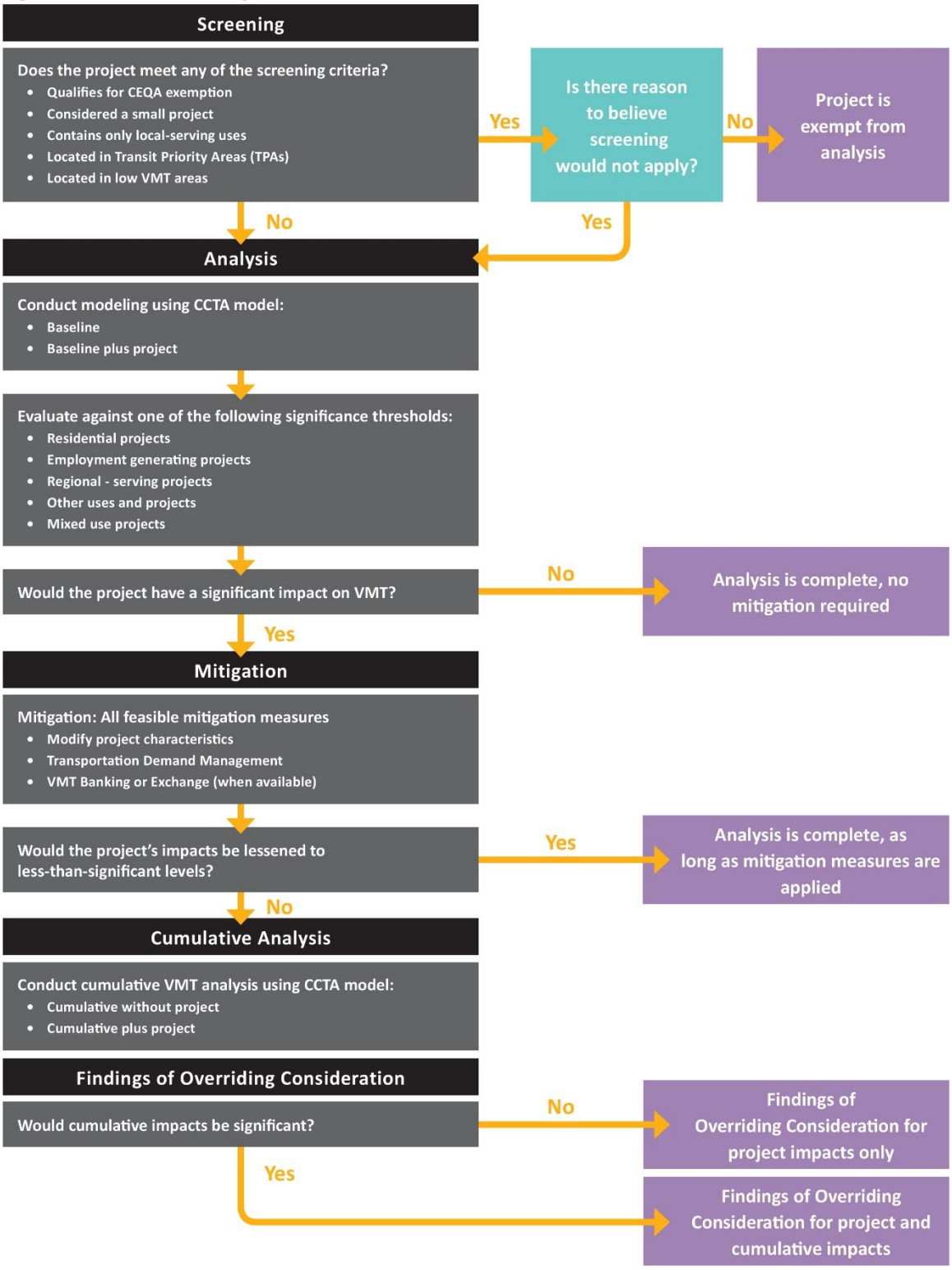
This document describes CCTA's recommended methodology for compliance with the requirements of Senate Bill 743 (SB 743) regarding analysis of vehicle miles traveled (VMT) for land use projects that are subject to the California Environmental Quality Act (CEQA). This guidance is intended to assist lead agencies in their CEQA VMT analysis consistent with new requirements of the CCTA Growth Management Program (GMP). The lead agency[1] will determine which projects are subject to CEQA and will oversee the VMT analysis. Figure 1 illustrates the CCTA CEQA VMT analysis process described in Sections 3, 4, and 5.

Compliance with the requirements of this document is mandatory for fulfillment of local jurisdictions' requirements under the CCTA GMP. Jurisdictions will be considered to be in compliance so long as they follow the procedures outlined here, regardless of whether these procedures result in exemption of a project from VMT analysis, a finding that a project would have no significant VMT impact, mitigation of a project to achieve less-than-significant levels of impact, or findings of significant unavoidable impacts accompanied by findings of overriding consideration. It should be noted that all land use projects will need to undergo at least a VMT screening procedure and may be required to complete a full VMT evaluation, regardless of whether the project meets the Authority's requirements for a comprehensive transportation analysis under the GMP.

Local jurisdictions may choose to apply methods and thresholds that are more stringent than those outlined in this document, and would still be considered to be in compliance with CCTA GMP requirements. Lead agencies have the ultimate responsibility for determining the most appropriate way to comply with CEQA when conducting environmental review of their projects; nothing in this document should be construed as legal advice nor should it take the place of consultation with the lead agency's CEQA experts.

[1] As explained in the definitions, Lead agency refers to the 19 incorporated jurisdictions in Contra Costa County, the County of Contra Costa, or any other agency overseeing and certifying a CEQA document.

Figure 1 – CCTA VMT Analysis Process



The methodology and thresholds contained in this document, including the Target VMT Reduction of 85% of baseline levels (which is the same as 15% below baseline levels), are based largely on guidance from the Governor's Office of Planning and Research (OPR) entitled *Technical Advisory on Evaluating Transportation Impacts in CEQA* (also referred to as the *Technical Advisory*), dated December 2018 (https://opr.ca.gov/docs/20190122-743_Technical_Advisory.pdf). CCTA staff may amend this methodology, including the Target VMT Reduction, if there is new guidance from OPR or other relevant agencies and/or if new substantial evidence indicates that a reduction of more than 15% of existing baseline is needed in order to achieve the state's greenhouse gas reduction goals. Analysts implementing this methodology for individual project assessments should clearly document the assumptions, procedures, and methods used to reach conclusions about the VMT analysis.

The methods outlined in this document primarily rely on the CCTA travel demand forecasting model (referred to in this document as the "CCTA Model" and sometimes also referred to as "The Countywide Model") to generate estimates of trip length and VMT for different land use types in different locations. Simple single-use projects may not require a new application of the CCTA model and may only need to refer to maps and tables of model outputs available from CCTA. Most projects will require the application of the model to represent the proposed project's land use and location characteristics and to prepare a robust analysis of a project's effect on VMT.

The guidance contained in this document is intended to apply to the VMT evaluation of land use projects. Evaluating the VMT effects of land use plans should be directed by each lead agency, following the same concepts and principles outlined in this document.

The evaluation of VMT impacts is also required as part of the CEQA review of transportation projects, which is not addressed in this document. Each lead agency should develop methods and thresholds to apply to the environmental review of transportation projects for which that agency is responsible. The OPR *Technical Advisory* contains guidance (see pages 19-25 of the OPR *Technical Advisory*) on conducting environmental analysis of transportation projects, including a list of project types that are considered to be unlikely to lead to substantial or measurable increases in VMT. Another source of guidance for lead agencies comes from Caltrans, which has produced guidance to address the evaluation of VMT impacts of projects on the State Highway System (see *Transportation Analysis Framework First Edition: Evaluating Transportation Impacts of State Highway System Projects*, dated September 2020 (https://dot.ca.gov/-/media/dot-media/programs/sustainability/documents/2020-09-10-1st-edition-taf-fnl-a11y-new-.pdf), and *Transportation Analysis under CEQA First Edition: Evaluating Transportation Impacts of State Highway System Projects*, dated September 2020 (https://dot.ca.gov/-/media/dot-media/programs/sustainability/documents/2020-09-10-1st-edition-tac-fnl-a11y-new-nov2021.pdf)). Please note that in some cases transportation projects will be recommended as mitigations for land use projects, and the analyst should evaluate the VMT effects of such transportation projects as well.

1. Definitions

Analyst. Refers to the person conducting the VMT impact analysis, usually a lead agency staff person or a transportation or CEQA consultant.

Baseline year. The base year of the CCTA model used to represent existing conditions. Note that the model is not updated every year, so there may be a discrepancy between the base year of the model and the current year. CCTA may provide VMT metrics that are interpolated between different model years in order to match the current year more closely. In all cases, CEQA requires using the best data currently available.

CCTA (or Countywide) Model. CCTA maintains a travel demand model for use in producing forecasts of future transportation system usage. The model is a four-step, trip-based model that encompasses the entire nine-county Bay Area region, with additional zonal and network detail within Contra Costa County. CCTA maintains a detailed database of land use and demographic data incorporated in the model, based on census-tract-level forecasts prepared by the Association of Bay Area Governments (ABAG). Analysts should refer to Chapter 5 of the CCTA *Technical Procedures* for a complete description of the model and how to acquire and apply it. Analysts may also contact CCTA for additional guidance. A new script has recently been developed for the CCTA Model in order to extract VMT metrics for each traffic analysis zone (TAZ) in the county, as described in this document. In addition, adjustments have recently been made to account for the portion of trip length that occurs outside of the nine-county Bay Area region that is covered by the CCTA model. These adjustments were needed to comply with the OPR guidance to account for the full lengths of all trips, and not truncate trips at the model boundary. Similar adjustments should continue to be applied whenever the CCTA model is updated or when other alternative methods are used to produce VMT estimates, to ensure that the full length of each trip is captured.

CEQA. The California Environmental Quality Act: This statute requires identification of any significant environmental impacts due to certain state or local actions including approval of new development or infrastructure projects. The process of identifying these impacts is typically referred to as the environmental review process.

Employment Generating Uses/Projects. Office, industrial, logistics, or other land uses where most of the activity at the site is related to employment functions.[2]

Home-based VMT. VMT for trips that begin or end at a residence.

Home-work VMT. VMT associated with commute trips between a residence and an employment-generating use, also referred to as home-based-work trips.

Horizon year. The planning horizon year used for cumulative analysis. Currently, the horizon year of the CCTA model is 2040.

Lead Agency. The 19 incorporated Contra Costa jurisdictions in Contra Cost County, the County of Contra Costa, or another government agency responsible for preparing and certifying a given CEQA document.

[2] Analysis of non-employee trips (such as those made by trucks) is not required for Employment-Based Uses since it is assumed these trips are either 1) incidental compared to employee trips and/or 2) constitute trips to and from way points along a trip from a vehicle's ultimate origin to its ultimate destination.

Level of Service (LOS). A metric that assigns a letter grade to transportation network performance. The most common application of LOS in jurisdictions has been to measure the average amount of delay experienced by drivers along a roadway segment or at an intersection during the most congested time of day and to assign a rating ranging from LOS A (fewer than 10 seconds of delay) to LOS F (more than 80 seconds of delay). Per the requirements of SB 743, LOS and other measures of vehicle delay are no longer to be used in determining significant impacts under CEQA.

Local-Serving Uses/Projects. Land uses that are expected to draw users from a local area, typically no more than a 2- to 3-mile radius. The definition of local-serving uses may vary by jurisdiction. These uses may generally include local-serving public facilities such as a branch library, a police or fire station, neighborhood-based schools, and local-serving retail businesses such as grocery stores, coffee shops or dry cleaners.

Low VMT Areas. Areas within a local jurisdiction where the existing VMT is 85% or less of the jurisdiction's average (for home-based VMT) or of the Bay Area region-wide average (for work-based VMT). The areas will be defined by the TAZs contained in the CCTA Model. A map of the VMT results is available on the CCTA website. The analyst should confirm these maps are up to date and represent the latest available information.

Mixed Use Projects/Uses: Projects that consist of a mix of uses otherwise described in this document.

Other Uses/Other Projects: Uses and projects which do not qualify as Residential, Employment-Generating, Local-Serving, or Regional-Serving (all of which are defined in this document).

Physical Design Measures. VMT reduction strategies that involve changes to the built environment. Examples include changes to the density or mixture of land uses, or the installation of new pedestrian or bicycle facilities.

Regional-Serving Uses/Projects. Land uses that are expected to draw users from a region that is larger than that for "local-serving uses," meaning a radius that is typically up to 3 miles. The definition of regional-serving uses may vary by jurisdiction. These uses may generally include regional-serving public facilities such as a regional library or museum, private schools and colleges, hospitals, movie theaters and other entertainment, and regional retailers such as furniture stores, shopping malls, and big box retailers.

Residential Uses/Projects: Uses and projects consisting solely of residential units such as single-family and multi-family units.

Target VMT Reduction. The level of VMT reduction defined by the lead agency as being necessary to avoid a significant VMT impact. Consistent with OPR recommendations, the target reduction in this document is being set at 15% below the existing VMT (equivalent to 85% of existing VMT).

Total VMT. All the VMT from all types of vehicles and for all trip purposes.

Traffic Analysis Zone (TAZ). A geographic polygon somewhat similar to a census block group that is used in a travel model to represent an area of relatively homogenous travel behavior.

Transit Priority Area (TPA). An area of close proximity to a significant transit mode, defined as a one half-mile area around an existing major transit stop or an existing stop along a high-quality transit corridor. Public Resources Code, § 21064.3 defines major transit stop as a site containing an existing rail transit station, a ferry terminal served by either a bus or rail transit service, or the intersection of two or more major bus routes with a frequency of 15 minutes or less during the morning and afternoon peak commute periods. Public Resources Code, § 21155 defines a 'high-quality transit corridor' as a corridor with fixed route bus service with service intervals no greater than 15 minutes during peak commute hours. Locations of the Transit Priority Areas (TPAs) in Contra Costa County can be found in maps available on the CCTA website.[3] The analyst should confirm these maps are up to date and represent the latest available information.

Transportation Demand Management (TDM). Strategies that are intended to reduce vehicular travel through programs and projects that maximizes traveler choices through information, encouragement, and incentives geared toward modifying travel behavior and choices.

Truck Trips. Trips made by heavy vehicles. Per the OPR recommendations and their interpretation of Public Resources Code, §15064.3, VMT analysis for transportation impact purposes can focus solely on automobile travel and can exclude truck trips. Truck trips are included in the analysis of other environmental topic areas, such as air quality, noise, and greenhouse gas emissions.

Vehicle Miles Traveled (VMT). A metric that captures the total amount of vehicular travel by measuring the number of vehicle trips generated and the length or distance of those trips. For transportation impact analysis purposes, VMT is usually measured on a typical weekday, and can be expressed in several ways, such as total VMT, total VMT per service population (residents plus employees), home-based VMT per resident, and home-based work VMT per employee.

VMT Reduction Strategies: Strategies intended to reduce VMT, including TDM and physical design measures.

VMT Study Area. A geographic area over which the project's effect on total VMT will be evaluated. The study area should be defined such that it captures the reasonably foreseeable VMT changes associated with the project, but not so large that the effects of the project get swamped by broader economic and land use changes. In many instances, a city boundary would be a reasonable study area; in cases where a project is located at the edge of a city or in an unincorporated area, or if the project is very large such that it is likely to affect travel patterns in neighboring cities, then a subregion of the County or even the entire County might be a more appropriate study area.

[3] https://ccta1.maps.arcgis.com/apps/webappviewer/index.html?id=4135020bb272458f824152fedb78a088

2. Project Screening

There are five screening criteria that lead agencies can apply to screen projects out of conducting project-level VMT analysis. Even if a project satisfies one or more of the screening criteria, lead agencies may still require a VMT analysis if there is evidence that the project has characteristics that might lead to a significant amount of VMT.

2.1: CEQA Exemption. Any project that is exempt from CEQA is not required to conduct a VMT analysis.

2.2: Small Projects. Small projects can be presumed to cause a less-than-significant VMT impact. Small projects are defined as having 10,000 square feet or less of non-residential space, or 20 residential units or less, or otherwise generating less than 836 VMT per day.[4]

2.3: Local-Serving Uses. Projects that consist of Local-Serving Uses can generally be presumed to have a less-than-significant impact absent substantial evidence to the contrary, since these types of projects will primarily draw users and customers from a relatively small geographic area that will lead to short-distance trips and trips that are linked to other destinations.

2.4: Projects Located in Transit Priority Areas (TPAs). Projects located within a TPA can be presumed to have a less-than-significant impact absent substantial evidence to the contrary. This exemption would not apply if the project met any of the following criteria:

1. Has a Floor Area Ratio (FAR) of less than 0.75;
2. Includes more parking for use by residents, customers, or employees than required by the lead agency (if the agency allows but does not require the project to supply a certain amount of parking);
3. Is inconsistent with the applicable Sustainable Communities Strategy (SCS) (as determined by the lead agency, with input from the Metropolitan Transportation Commission (MTC)); or
4. Results in a net reduction in multi-family housing units.

2.5: Projects Located in Low VMT Areas. Residential and employment-generating projects located within a low VMT-generating area can be presumed to have a less-than-significant impact if the project is similar to the existing land uses in the area and absent substantial evidence to the contrary.

A low VMT area is defined as follows:

[4] This threshold ties directly to the OPR *Technical Advisory* which notes that CEQA provides a categorical exemption for existing facilities, including additions to existing structures of up to 10,000 square feet, so long as the project is in an area where public infrastructure is available to allow for maximum planned development and the project is not in an environmentally sensitive area. (CEQA Guidelines, § 15301, subd. (e)(2).) Using statewide average data from the California Statewide Household Travel Survey (CHTS), the amount of daily VMT associated with 10,000 square feet of non-residential space is 836 VMT. Also using statewide average CHTS data, this level of VMT is associated with 20 housing units. Therefore, absent substantial evidence otherwise, it is reasonable to conclude that the addition of 20 housing units or 10,000 square feet of non-residential space could be considered not to lead to a significant impact.

- For housing projects: Geographic areas (defined by the TAZs in the CCTA Model) within a city that have existing home-based VMT per capita that is 85% or less of the existing citywide average, or geographic areas (defined by the TAZs in the CCTA Model) within the unincorporated County that have existing home-based VMT per capita that is 85% or less of the existing countywide average.
- For employment-generating projects: Geographic areas (defined by the TAZs in the CCTA Model) within a city or the unincorporated County that have existing home-work VMT per worker that is 85% or less of the existing regional (SF Bay Area) average.
- There is no definition of a low VMT area for Regional-Serving and Other Projects, since these projects always require a VMT Analysis as described in Section 3 of this document (unless they are screened out under Criteria 2.1 through 2.4).

Mixed-use projects may qualify for the use of this screening criterion if they include only housing, employment-generating uses and local-serving uses, and can reasonably be expected to generate VMT per resident and/or per worker that is similar to the existing land uses in the low VMT area.

3. Projects Requiring VMT Analysis

A project not excluded from VMT analysis through the screening process described above shall be subject to a VMT analysis to determine if it has a significant VMT impact.

Analysis Scenarios

The following scenarios should be addressed in the VMT analysis:

- Baseline conditions: The most current version of the baseline CCTA model should be used to determine the baseline VMT for the TAZ in which the project is set. This information is available from the VMT screening maps on the CCTA website.
- Baseline plus project: If the project is a simple, single-use project that is very similar to other developments that already exist in that TAZ, the analyst may conclude that the project generated home-based VMT per capita or the home-work VMT per worker will be the same as the existing VMT per capita or per worker in that TAZ; in that instance, a separate Baseline plus Project model run would not be required. However, if the project contains one or more uses, or a mix of uses, that does not exist in the TAZ, then a model run is required. In this case, the proposed land use(s) should be added to the baseline condition for the relevant TAZ, or the model land use inputs should be otherwise modified so as to adequately represent the project's characteristics. A full baseline model run should then be performed. The analyst should review the model output to confirm reasonableness of the results and to check production and attraction balancing to ensure that the project's effect is being captured.

VMT Metrics and Significance Thresholds

The output from each model run will include total VMT per service population, home-based VMT per capita, and home-work VMT per worker, which should be analyzed as described below. In addition, to calculate the total study area VMT, the analyst would define a VMT study area, and the VMT occurring on all network links inside that study area should be summed.

The following describes the specific VMT metrics and significance thresholds that should be used in evaluating different project types:[5]

Residential Projects should use the home-based VMT per capita metric to evaluate project generated VMT. The project generated home-based VMT per resident constitutes a significant impact if it is higher than 85% of the home-based VMT per resident in the subject municipality or unincorporated CCTA subregion (for areas outside of municipalities) or 85% of the existing countywide average home-based VMT per resident, whichever is less stringent.

Employment-Generating Projects should use the home-work VMT per worker metric for project generated VMT estimates. The project generated home-work VMT per worker constitutes a significant impact if it is higher than 85% of the home-work VMT per worker in the subject municipality or unincorporated CCTA subregion (for areas outside of municipalities) or 85% of the existing Bay Area region-wide average home-work VMT per worker, whichever is less stringent.

Regional-Serving Projects should use the metric of total study area VMT and should define a VMT study area over which to evaluate that metric. The project generated VMT constitutes a significant impact if the baseline project generated total VMT per service population is higher than 85% of the existing countywide average total VMT per service population.

Other Uses and Projects need to be analyzed using a methodology developed by the lead agency specifically for the project, prepared and documented based on available data, and take into account the specific methodologies and thresholds identified in this document.

Mixed-Use Projects may be analyzed using a combination of techniques described above, as follows:

- Mixed use projects that contain a combination of housing, employment-generating and regional-serving uses may choose to evaluate each use separately using the metrics and significance thresholds described above for those uses.
- Mixed use projects that include a local-serving component may ignore that component for analysis purposes, and analyze only the remaining uses. Note that it may be more beneficial to the project to conduct a full analysis that considers on-site local-serving uses, since this analysis can take credit for reductions in trips resulting from the on-site mix.

In all cases, the *analyst should consider whether that approach will effectively capture the likely interactions between the different uses*. Other analytical options that would capture interactions between different uses

[5] The metrics of "home-based VMT per capita" and "home-work VMT per worker" are taken from the production-attraction trip matrices in the CCTA model, which is a stage of the modeling process in which trips are still categorized by purpose. This stage of the modeling process does not yet include truck trips so these VMT metrics do not include the VMT associated with trucks. This is consistent with the guidance from the OPR *Technical Advisory*, in which it interprets the Section 15064.3 language referring to automobile VMT as being focused on light-duty passenger vehicles. The "total VMT per service population" metric is taken from the final origin-destination trip matrices in the CCTA model and therefore it does include the VMT associated with trucks. Per the OPR guidance it is acceptable to include truck VMT when needed for modeling convenience, as long as the Analyst ensures there is an apples-to-apples comparison by using the same vehicle types in each step of the analysis process.

are to analyze the project by conducting a full run of the CCTA model, or to use a sketch planning tool designed to estimate the trip generation effects of a mixed-use project.

4. VMT Mitigation Strategies

If the analyst concludes that the project would have the potential to cause a significant VMT impact per one or more of the significance thresholds defined above, then mitigation is required. CEQA requires all feasible measures to be implemented to reduce identified impacts to less-than-significant levels.

Method of Calculating Mitigation Reductions

The analyst, working with the lead agency and applicant, shall specify a series of mitigation measures, each of which shall have a specific percent level of VMT reduction assigned to it. Reduction levels may be derived from the CAPCOA Handbook (summarized in Appendix 1) or from other defensible and well-documented sources. In each case, the analyst shall explain the basis for the reduction applied, and shall also consider interactions among the mitigation measures that make them cumulatively less effective than they are by themselves.

Each reduction shall be applied to the appropriate set of VMT associated with the project, until the project-generated VMT is reduced to a less-than-significant level or all feasible mitigation strategies have been applied.

Required Levels of Mitigation

In order to reduce impacts to less-than-significant levels, the proposed mitigation measures must reduce VMT to the relevant threshold as defined in Section 3 above.

Types of Mitigation

To mitigate VMT impacts, the following actions could be taken:

- Modify the project's characteristics to reduce VMT generated by the project. This might involve changing the density or mixture of land uses on the project site, or changing the project's location to one that is more accessible by transit or other travel modes. The effectiveness of such changes should be modeled using the analysis techniques described in Section 3, above.
- Implement transportation demand management (TDM) or physical design measures to reduce VMT generated by the project. A description of such options is included below. The TDM measures proposed as mitigations must be in addition to any TDM measures that may have been included in the project description and incorporated into the project's trip generation calculations.
- Participate in a CCTA-approved VMT impact fee program and/or VMT mitigation exchange/banking program, to the extent such a program is available.

VMT Reductions from TDM and Physical Design Measures

TDM and physical design measures that could potentially be applicable in Contra Costa County are described in the California Air Pollution Control Officers Association (CAPCOA) *Handbook for Analyzing Greenhouse Gas Emission Reductions, Assessing Climate Vulnerabilities, and Advancing Health and Equity,* 2021, as summarized in Appendix 1. The analyst and lead agency should apply judgment to determine which measures are feasible in a particular local context. It should be noted that availability, applicability, and effectiveness of VMT mitigation measures is continuing to evolve and the evaluation of TDM measures should be updated periodically as new information becomes available. Any evaluation of the effectiveness of VMT reduction measures should recognize that many TDM strategies are dependent on things that are likely to change over time, such as the level of priority a building tenant places on achieving trip reductions, or the frequency of nearby transit services. As such, actual real-time VMT reduction cannot be reliably predicted, and ongoing monitoring should be considered to ensure that mitigation expectations are being met.

The effectiveness of each strategy shown in Appendix 1 will vary depending on the context in which it is implemented and the types of trips to which it applies. It is the analyst's responsibility to review the available research and suggest a level of VMT reduction that is reasonable to apply to the project being studied, considering the project's specific characteristics and the context in which it would be constructed.

It should also be noted that the incremental benefit of each VMT reduction strategy will diminish as strategies are combined together. Therefore, the analyst should carefully document how the interaction between TDM strategies is accounted for. The CAPCOA Handbook provides guidance on how to account for combinations of strategies.

5. Significant and Unavoidable Impacts, Cumulative Analysis and Findings of Overriding Consideration

Findings of Overriding Consideration

If the lead agency includes all feasible measures described in Section 4 above and those measures are not sufficient to fully mitigate the impact, then the VMT impact will be classified as significant and unavoidable. The lead agency may still approve the project, as allowed by CEQA, by making a finding of overriding consideration.

Before making such a finding and approving the project, the lead agency must also conduct a cumulative VMT analysis for the project, as described below.[6]

Cumulative Analysis

Projects that are unable to mitigate their project-specific VMT impacts to less-than-significant levels require a Cumulative VMT analysis.

[6] As per OPR's guidance, cumulative VMT analysis is not necessary for projects that are found to have a less-than-significant impact on VMT at the project level.

The cumulative analysis of a project involves understanding the project's effect on overall VMT within its study area. This analysis is needed to address circumstances where an individual project might affect travel patterns from other developments in the broader area; this might happen for a variety of reasons, such as the project offering different housing, employment or other opportunities than would otherwise exist in the area and that causes other users to change their travel decisions, or because the drivers and transit users generated by the project take up available system capacity and cause other users to change their travel routes or modes.

The project's effect on VMT should be measured by defining a VMT study area and calculating the total VMT occurring on all network links inside that study area, in both the cumulative without project and cumulative with project scenarios. To allow for a reasonable comparison between those two scenarios, the total study area VMT should be normalized in some fashion to reflect that there are different numbers of people within the study area (i.e., because the project has added people to the study area as compared to the without project scenario). If the project adds residents to the study area, it would be reasonable to present the VMT results as total study area VMT divided by number of study area residents. If the project adds employees to the study area, it would be reasonable to use total study area VMT divided by number of study area employees. The exact method for normalizing the VMT number is not critical; what is essential is that the same method be used for both the cumulative without project and the cumulative with project scenarios, to allow for an apples-to-apples comparison between the two scenarios.

Specific steps in the process are defined below:

Model Runs. The Cumulative VMT analysis will be based on two CCTA Model runs:

- Cumulative without project: The most current version of the horizon year of the CCTA model. If development similar to that found in the proposed project is already foreseen in the subject TAZ in the "cumulative without project" model, this development should be subtracted from the "cumulative without project" scenario before this model run is conducted.
- Cumulative with project: Unless development similar to that found in the proposed project is already foreseen in the subject TAZ in the "cumulative without project" model, the proposed land use(s) should be added to the "cumulative without project" condition for the TAZ, or a separate TAZ should be created to contain the proposed land use(s). The analyst should also consider whether it would be advisable to offset the addition of these proposed land uses by lessening projected increases in development in other TAZs, particularly if the proposed project is substantial in size such that it might change the distribution of future developments. This recognizes that individual land use projects will generally not change the region-wide totals for population and employment growth, but will influence localized land use and VMT impacts.

Cumulative Threshold. Cumulative VMT impacts should be considered significant if there is a net increase in the total study area VMT normalized to the number of people within the study area, when comparing cumulative no project to cumulative with project conditions.

Additional Significant Impact and Findings of Overriding Consideration. If the Cumulative VMT Analysis finds a significant impact, this impact shall be considered to be significant and unavoidable, and

must therefore be called out in the project's EIR and subject to the Finding of Overriding Consideration described earlier in this section.

Appendix 1. Summary of Potential VMT Reduction Strategies

All the information presented here comes from the transportation section of the CAPCOA *Handbook for Analyzing Greenhouse Gas Emission Reductions, Assessing Climate Vulnerabilities, and Advancing Health and Equity*, 2021. For ease of reference, the numbering of each strategy matches the number presented in the Handbook.

It should be noted that a few of the strategies presented in the Handbook are focused purely on the reduction of greenhouse gas emissions from transportation sources rather than on VMT reduction; one example is a strategy to provide charging infrastructure for electric vehicles. Such strategies would not be applicable as VMT mitigations, and thus are not presented here.

Additionally, it should be emphasized that the percent VMT reduction shown in the table below is the maximum possible under ideal circumstances and will not be applicable in many situations. In fact, in some circumstances the range of potential VMT reductions for a particular strategy starts at 0% and extends upward to the maximum shown here. The analyst is urged to consult the CAPCOA Handbook for important guidance about how to evaluate VMT reduction strategies in specific situations.

	Strategy	Types of Trips Affected	Maximum Potential VMT Reduction for Affected Trips
Project-Scale Strategies			
1	Increase residential density	All trips from project site	30%
2	Increase job density	All trips from project site	30%
3	Provide Transit-Oriented Development	All trips from project site	31%
4	Integrate affordable and below market rate housing	Trips from multifamily residential sites	28.6%
5	Implement commute trip reduction program (voluntary)	Commute trips	4%
6	Implement commute trip reduction program (mandatory implementation and monitoring)	Commute trips	26%
7	Implement commute trip reduction marketing	Commute trips	4%
8	Provide ridesharing program	Commute trips	8%
9	Implement subsidized or discounted transit program	All trips from project site	5.5%
10	Provide end-of-trip bicycle facilities	Commute trips	4.4%
11	Provide employer-sponsored vanpool	Commute trips	20.4%
12	Price workplace parking	Commute trips	20%
13	Implement employee parking cash-out	Commute trips	12%
15	Limit residential parking supply	All trips from project site	13.7%
16	Unbundle residential parking costs from property cost	All	15.7%
Community-Scale Strategies			
17	Improve street connectivity	All	30%

	Strategy	Types of Trips Affected	Maximum Potential VMT Reduction for Affected Trips
18	Provide pedestrian network improvements	All	6.4%
19	Construct or improve bike facilities/bike boulevards	All trips on parallel roadways	0.8%
20	Expand bikeway network	All	0.5%
21	Implement carshare program	All	0.15%
22	Implement bikeshare/scootershare program	All	0.07%
23	Provide community-based travel planning	All	2.3%
24	Implement market price public parking	All	30%
25	Extend transit network coverage/hours	All	4.6%
26	Increase transit service frequency	All	11.3%
27	Implement transit-supportive roadway treatments	All	0.6%
28	Provide bus rapid transit	All	13.8%
29	Reduce transit fares	All	1.2%

Source: *Handbook for Analyzing Greenhouse Gas Emission Reductions, Assessing Climate Vulnerabilities, and Advancing Health and Equity*, CAPCOA, 2021.

Further Description of VMT Reduction Strategies

Project-Scale Strategies

1. Increase residential density: This strategy focuses on increasing density of dwelling units to minimize vehicle travel in terms of both the number of trips and the length of those trips.
2. Increase job density: This strategy focuses on increasing density of jobs to minimize vehicle travel in terms of both the number of trips and the length of those trips
3. Provide transit-oriented development (TOD): This strategy requires the project to be built in a compact and pedestrian-friendly location with good access to public transit. TOD encourages higher public transit ridership and helps to reduce the need to own a vehicle or the number of vehicles owned by a household by incentivizing individuals to use transit.
4. Integrate affordable and below market rate housing: This strategy focuses on integrating affordable and below market rate housing to provide more opportunities for lower income families to live closer to job centers and near transit.
5. Implement commute trip reduction program (voluntary): This strategy implements a voluntary employer program to reduce vehicle travel by encouraging employees to carpool, bike, walk, and take public transit.
6. Commute trip reduction program (mandatory implementation and monitoring): This strategy implements a mandatory employer program to discourage single-occupancy vehicle trips and incentivize alternative modes of travel. Employer can provide transit subsidies and bicycle infrastructure to incentivize transit and bicycle ridership, and deter vehicle use by limiting or charging for parking on site.

7. Implement commute trip reduction marketing: This strategy implements an employer program to promote and educate employees on travel choices for their commute, including public transit routes, bicycle routes, and carpooling programs.
8. Provide ridesharing program: This strategy implements an employer rideshare program that includes a permanent transportation management association. Successful implementation requires designating parking spaces for rideshare vehicles and providing an app or website to coordinate ridesharing.
9. Implement subsidized or discounted transit program: This strategy is an employer program that provides subsidized or discounted transit passes to employees to incentivize transit use.
10. Provide end-of-trip bicycle facilities: This strategy requires employer-funded installation of bicycle facilities including parking, lockers, and showers.
11. Provide employer-sponsored vanpool: This strategy implements an employee vanpool service that provides flexible transportation for small groups (between 5 and 15 people). Vanpools can encourage mode shifts from single-occupancy vehicles to carpool trips, reducing commute VMT.
12. Price workplace parking: This strategy will impose parking fees at work places, to discourage driving to work.
13. Implement employee parking cash-out: This strategy requires employers to provide employees with a choice to pay for parking or forgo their parking spot in exchange for a cash subsidy equal to the price of the parking space.
14. Limit residential parking supply: This strategy reduces the total parking spaces available at a residential site. Parking scarcity makes driving less convenient and disincentivizes reliance upon an automobile, encouraging a shift to other modes of transportation.
15. Unbundle residential parking costs from property cost: This strategy separates the costs associated with parking from the property costs at a residential site and requires residents to pay separately for parking spaces they use, to discourage automobile ownership by making it more expensive.

Community-Scale Strategies

16. Improve street connectivity: This strategy would increase intersection density (i.e., by converting cul-de-sacs or dead-end streets to grid streets) to promote improved connectivity to facilitate shorter trips, encourage more walking and biking, and reduce greenhouse gas emissions.
17. Provide pedestrian network improvement: This strategy involves enhancing pedestrian sidewalk networks by expanding sidewalk coverage and repairing substandard sidewalks.
18. Construct or improve bicycle facilities or bike boulevards: This strategy involves the construction or improvement of a bicycle lane or bike boulevard that connects to a larger bikeway network.
19. Expand bikeway network: This strategy increases the miles of bicycle facilities within a bikeway network, while improving the visibility, signage, and comfort levels of the bicycle facilities.
20. Implement a carshare program: This strategy promotes carsharing by increasing access to carshare vehicles (whether conventional or electric) in the community.
21. Implement a bikeshare or scootershare program: This strategy establishes a program for shared use of mobility devices, including conventional bicycle, electric bicycles, or scooters.
22. Provide community-based travel planning (CBTP): This strategy provides travel planning assistance for targeted residences in a multi-family residential community. Travel plans provide

customized information and incentives to encourage mode shifts and reduced vehicle trips, reducing VMT and greenhouse gas emissions.

23. Implement market price public parking (on-street): This strategy establishes a pricing scheme for on-street parking in a community, especially in areas with a high concentration of retail and employment.
24. Extend transit network coverage or hours: This strategy expands transit network through geographic range or operation hours to encompass service to the project site.
25. Increase transit service frequency: This strategy increases transit service, improving the rider experience by reducing waiting times and travel times.
26. Implement transit-supportive roadway treatments: This strategy implements improvements to transit routes serving the community with a combination of roadway infrastructure improvements and traffic signal modifications that can reduce travel time. Examples include dedicated bus lanes, transit signal priority, and curb extensions for passenger boarding.
27. Provide Bus Rapid Transit: This strategy converts an existing bus route to a bus rapid transit (BRT) system, with exclusive right-of-way, limited-stop service, advanced technology vehicles, and efficient fare-payment system.
28. Reduce transit fares: This strategy reduces fares for transit services for a particular site or community. Reducing the cost of transit can encourage higher ridership and outweigh the revenue benefits of a higher fare.

Appendix B – Guidelines for Calculating Multimodal Transportation Service Objectives

Introduction

This appendix describes the process by which some of the more complex Multimodal Transportation Service Objectives (MTSOs) from the five Contra Costa Action Plans prepared by each region are to be calculated for future-year forecasts. It lists the locations where the measures are applied, the source data for current conditions, and how the MTSO is to be calculated for future-year forecasts.

The original concept of MTSOs grew out of a Measure C requirement. The program was carried forth in the adopted Measure J, where the Growth Management Program states that local jurisdictions shall work with the RTPCs (through the Action Plan process) to identify Routes of Regional Significance, set MTSOs for those routes, and establish actions for achieving those objectives. Further, each MTSO is to be quantifiable and to have a target date for attaining the MTSO.

The MTSOs can be divided into two general categories -- level-of-service and non-level-of-service. Level-of-service definitions are specifically related to the national methods established by sources such as the Transportation Research Board and are described in detailed in the *Technical Procedures* or other appendices. The non-level-of-service MTSOs are not guided by professionally-accepted national sources; some are clarified in the *Technical Procedures* and others are not. Most rely on forecasts developed as part of the Countywide Model, which is addressed in the *Technical Procedures* in Chapter 5.

This appendix supplements the processes described in the *Technical Procedures*, explaining the methods that should be used to calculate MTSOs in the proposed 2009 Action Plans. Where these are not addressed in the *Technical Procedures*, the appropriate methods to monitor, forecast and determine compliance are presented.

Delay Index – Peak Hours

The most prominent non-level-of-service measures used in the Action Plans are those related to the Delay Index. The Delay Index is defined as:

Delay Index (DI) = congested travel time/free-flow travel time

Locations Where Applied

The following locations are listed as places where the Delay Index is reported:

West County Action Plan
- I-80
- San Pablo Dam Road

Central County Action Plan
- Interstate 680
- SR 242
- State Route 4

East County Action Plan
- State Route 4

Tri Valley Action Plan
- I-680
- I-580
- State Route 84

Lamorinda Action Plan
- State Route 24
- Pleasant Hill Road
- San Pablo Dam Road/Camino Pablo

Source Data for Current Conditions

The determination of the Delay Index is developed through monitoring stations reported through the most recent CCTA Monitoring Report. The report information is provided every two years.

In instances where the Monitoring Report is deemed inaccurate or incomplete, a revised sampling may be conducted. This sampling is to consist of travel-time runs during the anticipated peak hour of congestion in the corridor direction. The sampling should be made on a Tuesday, Wednesday or Thursday on non-holiday weeks when elementary and secondary schools as well as colleges are in session.

For Lamorinda, the Delay Index value should include consideration of travel time on the ramps as well as mainline travel time where ramps exist.

Process to Develop Projected Performance

The projected performance of the Delay Index may be calculated by estimating the additional congested travel time that is expected to occur on the link. This estimation is possible by using the loaded networks from the CCTA Countywide Travel Demand Model during peak hours, which contain a congested speed estimate for each link. This estimate of congested time by link may be summed for the mixed-flow lanes of the route for the nearest base year (such as 2010) and for the horizon year or year of completion (such as 2020 or 2030). The differences in summations would then be divided by the number of years between the forecasts (such as 10 or 20 years) for an annual forecast increase in travel time. This additional travel time would then be applied to the base-year monitoring results (annual travel-time increase multiplied by the number of years) to determine if the project impact would be significant at the compliance horizon year.

Steps:

1. Prepare AM and PM peak-period runs of the CCTA Countywide Travel Demand Model for the baseline year nearest the year for which the most recent MTSO monitoring data are available.
2. Estimate the congested travel time for the route of regional significance by summing the congested travel times for all the mixed-flow lane links of the route.
3. Prepare AM and PM peak-period runs of the CCTA Countywide Travel Demand Model for the available future year closest to the forecast year and for a network reflecting Action Plan projects.
4. Estimate the congested travel time for the route of regional significance summing the congested travel times for all the mixed-flow lane links of the route
5. Subtract the congested route travel time for the baseline year from the value for the forecast year and divide by the number of years separating the two modeled years to get an estimate of the annual increase in congested travel time for the route.
6. Multiply the average annual increase in congested route travel time by the number of years between the most recent MTSO monitoring data and the forecast year and add this increment of travel time to the MSTO monitoring value.
7. Divide the estimate of future year congested travel time to the estimate of uncongested travel time for the route that was used in the most recent monitoring report to get the new forecast-year estimate of Delay Index for the route.

Delay Index – Non-peak Hours

Locations Where Applied

The following locations are listed as places where the Delay Index is reported:

West County Action Plan
I-80 from Solano County Line to Alameda County Line

Lamorinda Action Plan
SR 24

Source Data for Current Conditions

The determination of the Delay Index is developed through monitoring stations reported through the Performance Evaluation Management Systems (PEMS) information that is available from Caltrans, and applying these results in a manner similar to those at peak hours as described in the CCTA Monitoring Report. The report information is provided every two years.

In instances where the PEMS data are not available or are deemed inaccurate or incomplete, a revised sampling may be conducted. This sampling is to consist of travel-time runs during the specified non-peak time period on non-holiday weeks/weekends when elementary and secondary schools as well as colleges are in session.

Process to Develop Projected Performance

Where the non-peak Delay Index is for weekdays (Lamorinda), the baseline Delay Index from the most recent monitoring would be extrapolated by adding an increase in delay for each non-peak hour by using the CCTA Countywide Travel Demand Model to estimate the off-peak (mid-day) link volumes for a base year and a forecast year. From this, an annual percentage change in off-peak can be estimated and an appropriate number of new trips can be added to the baseline volume by hour based on the number of years between the base year and the forecast year. The annual percentage change for an off-peak period should be applied to all hours within that period. The baseline distribution of volume by hour should be derived from the monitoring data. The change in travel time by hour can be estimated by using a volume-delay function in the CCTA Countywide Travel Demand Model for the links of interest.

Steps:

1. Prepare midday runs of the CCTA Countywide Travel Demand Model for the baseline year nearest the year for which the most recent MTSO monitoring data are available.
2. Estimate the congested travel time for the route of regional significance summing the congested travel times for all the mixed-flow lane links of the route.

3. Prepare midday runs of the CCTA Countywide Travel Demand Model for the available future year closest to the forecast year and for a network reflecting Action Plan projects.
4. Estimate the congested travel time for the route of regional significance summing the congested travel times for all the mixed-flow lane links of the route.
5. Subtract the congested route travel time for the baseline year form the value for the forecast year and divide by the number of years separating the two forecast years to get an estimate of the annual increase in congested travel time for the route.
6. Multiply the average annual increase in congested route travel time by the number of years between the most recent MTSO monitoring data and the forecast year and add this increment of travel time to the MSTO monitoring value.
7. Divide the estimate of future year congested travel time to the estimate of uncongested travel time for the route that was used in the most recent monitoring report to get the new forecast-year estimate of Delay Index for the route.

Duration of Congestion

Locations Where Applied

Tri Valley
- I-680
- SR 84

Source Data for Current Conditions

The estimate for "duration of congestion" should be based on monitoring stations reported through the Performance Evaluation Management Systems (PEMS) information that is available from Caltrans and reported in the most recent CCTA Monitoring Report. The report information is provided every two years.

In instances where the Monitoring Report is deemed inaccurate or incomplete and PEMS data are not available, a revised sampling may be conducted. This sampling is to consist of travel-time runs during the hours of 6 A.M. and 7 P.M. The sampling should be made on a Tuesday, Wednesday or Thursday on non-holiday weeks when elementary and secondary schools as well as colleges are in session. An average operating speed for the mixed-flow lanes of each segment should be developed for each half-hour period. A congested half-hour is one that has an average operating speed of 35 miles peer hour or less or the segment exceeds the delay-index target if one exists.

Process to Develop Projected Performance

Forecasts of average operating speed by half-hour period for each segment of interest should be developed by using forecasts from the CCTA Countywide Travel Demand Model. The baseline operating speeds from the most recent monitoring would be extrapolated by adding an increase in travel time for each hour by using the CCTA Countywide Travel Demand Model to estimate the peak and off-peak (mid-day) link volumes) for a base year and a forecast year. From this, an annual percentage change in volume for each half-hour period of interest can be estimated using either the percentage change for the Peak or the percentage change for the off-peak (mid-day) and an appropriate number of new trips can be added based on the number of years between the base year and the forecast year. The change in speed can be estimated by using a volume-delay function in the CCTA Countywide Travel Demand Model for the links of interest.

Steps:

1. Prepare AM and PM peak period runs of the CCTA Countywide Travel Demand Model for the baseline year nearest the year for which the most recent MTSO monitoring data are available
2. Estimate the congested travel time for the route of regional significance summing the congested travel times for all the mixed-flow lane links of the route to get the total vehicle hours of travel
3. Multiple the volumes on each link by the length of the link to get the total vehicle miles of travel by link.

4. Sum the VMT by link over all of the mixed flow lanes for the length of the route to get the total VMT for the route.
5. Divide the total VMT for the route by the congested VHT for the route to get the average travel speed
6. Prepare midday runs of the CCTA Countywide Travel Demand Model for the baseline year nearest the year for which the most recent MTSO monitoring data are available
7. Estimate the congested travel time for the route of regional significance summing the congested travel times for all the mixed-flow lane links of the route to get the total vehicle hours of travel
8. Multiple the volumes on each link by the length of the link to get the total vehicle miles of travel by link.
9. Sum the VMT by link over all of the mixed flow lanes for the length of the route to get the total VMT for the route.
10. Divide the total VMT for the route by the congested VHT for the route to get the average travel speed
11. Prepare midday runs of the CCTA Countywide Travel Demand Model for the available future year closest to the forecast year and for a network reflecting Action Plan projects

Volume-Capacity Ratio

Locations Where Applied

Tri Valley
SR 84

Source Data for Current Conditions

Volume-Capacity Ratio is the ratio of traffic volume to the capacity of the roadway. The volume Capacity Ratio can be monitored by observing the traffic volumes at key points or links being analyzed. The traffic volume is then divided by the operational capacity of the roadway of interest for the length of the peak-period specified. The capacity of each roadway link is available in the network description for each model year in the CCTA Countywide Travel Demand Model.

Process to Develop Projected Performance

Volume-Capacity Ratio for a future analysis year can be calculated by using the CCTA Countywide Travel Demand Model to get link assignment volumes for the forecast year and for the baseline year for which traffic count data are available. The differences (i.e. growth) in link volumes are then added to the traffic count data to estimate the traffic volume for the forecast year. This estimate of future-year volume is then divided by the hourly-capacity of the roadway multiplied by the number of hours in the peak-period being analyzed.

Steps:

1. Prepare AM and PM peak period networks of the CCTA Countywide Travel Demand Model for the baseline year nearest the year for which the most recent MTSO monitoring data are available.
2. Prepare AM and PM peak period networks of the CCTA Countywide Travel Demand Model for the future year.
3. Subtract the volumes for each peak period between the future and base year to determine the anticipated traffic growth by the designated horizon year. If the base year traffic data does not match the future year data, some factoring of the anticipated growth may be necessary.
4. Apply the anticipated traffic growth to counts from the most recent MTSO monitoring program to determine the estimated volumes.
5. Determine capacity based upon lane capacity and number of lanes listed in the prior MTSO exercise for a representative segment of roadway.
6. Divide the projected, adjusted travel model volumes by the capacity calculated on the representative segment to determine the volume-capacity ratio.

Mode Split

Locations Where Applied

Tri Valley

Source Data for Current Conditions

Mode split is the percentage of peak-period travelers that use transit as the mode of travel. Mode split is generally measured through extensive home interview and work place surveys. Information on commute trip mode share is also available every decade from the U.S. Census. Between decennial Census counts, transit ridership may be monitored, and changes in transit ridership may be used to update decennial mode splits.

Process to Develop Projected Performance

Peak-period Mode Split for future forecast years can be estimated using the CCTA Countywide Travel Demand Model. The model produces mode-specific person trip tables. These person trip tables may be summed on origins or summed on destinations for specific zone groups (e.g., an Action Plan area). The Mode Split MTSO can be estimated by dividing the total number of transit person trips by the total number of person trips (all modes) for a pre-specified set of TAZs. If mode split forecasts are available from the CCTA model for both the baseline year (for which monitoring data are available) and for the future forecast year, then the change in transit Mode Split can be applied to the baseline monitoring value to more reliably estimate future-year mode splits.

Steps:

1. Prepare runs of the CCTA Countywide Travel Demand Model for the future year.
2. Prepare tables showing total number of person trips, grouped for the TAZs in the specific study area.
3. Prepare tables showing total number of transit person trips, grouped for the TAZs in the specific study area.
4. Divide the total number of transit person trips by the total number of person trips to calculate the future year mode share.
5. If alternative sources are available from monitoring efforts or other reasons (such as household surveys), prepare the CCTA Countywide Travel Demand Model for the baseline year nearest the year for which the most recent MTSO monitoring data are available.
6. If Step 5 is undertaken, then calculate the model base year mode share by dividing the total number of transit person trips by the total number of person trips to calculate the base year mode share.
7. If Step 5 is undertaken, then apply the change in percentage between the base and future years to calculate anticipated future mode shares.

Average Vehicle Ridership

Locations Where Applied

Tri Valley

Source Data for Current Conditions

This MTSO is the ratio of total person commute trips to vehicles used for commuting. Average Vehicle Ridership is generally measured through extensive home interview and/or work place surveys. Information on commute trip mode share is also available every decade from the U.S. Census. Average Vehicle Ridership can be estimated from the Census data.

Process to Develop Projected Performance

Average Vehicle Ridership for commute trips for a future forecast year can be estimated using the CCTA Countywide Travel Demand Model. The model provides estimates of person trips by mode from or to a specified set of zones. The Average Vehicle Ridership is estimated by dividing the total number of person trips by the number of vehicle used for those trips. The number of vehicles used can be estimated by applying average vehicle occupancy for each mode. For the Tri-Valley the following average occupancies have been used:

- Drive Alone 1 person per vehicle
- Shared Ride 2 2 people per vehicle
- Shared Ride 3 3.5 people per vehicle
- Transit No vehicle is included in the calculation

By developing the estimates of person trip by mode from all of the zones within the area covered by the MTSO, an estimate of the Average Vehicle Ridership of residents commuting from the area can be developed. By developing an estimate of person trips by mode to all zones in the area of interest, an estimate of the Average Vehicle Ridership of trip makers employed in the area can be developed. If these estimates are developed for the baseline year for which monitoring data are available and for the future forecast year, the difference in Average Vehicle Ridership can be added to the baseline monitoring value to get the forecast year value for the MTSO.

Steps:

1. Prepare runs of the CCTA Countywide Travel Demand Model for the future year.
2. Prepare tables showing total number of person trips, grouped for the TAZs in the specific study area.
3. Prepare tables showing total number of person trips by each mode (drive alone, two-person vehicles, three or more person vehicles, and transit riders), grouped for the TAZs in the specific study area.

4. Calculate the number of vehicle trips for each mode -- by dividing the two-person carpool totals by 2, and the three-or-more person carpools by 3.5, (Drive-alone person trips and vehicle trips are the same number).
5. Sum the total number of vehicles by adding the number of drive-alone vehicle/person trips, the number of vehicles in two-person carpools, and the number of persons in three-or-more-person carpools.
6. Calculate the Average Vehicle Occupancy by dividing the total number of person trips by the total number of vehicle trips for the future year.
7. If alternative sources are available from monitoring efforts or other reasons (such as household surveys), prepare the CCTA Countywide Travel Demand Model for the baseline year nearest the year for which the most recent MTSO monitoring data are available.
8. If Step 7 is undertaken, then calculate the model base year average vehicle occupancy as outlined in steps 2 through 6.
9. If Step 7 is undertaken, then apply the change in percentage between the base and future years to calculate anticipated future average vehicle occupancy.

Average Speed

Locations Where Applied

Central County
- Alhambra Avenue
- Clayton Road
- Contra Costa Boulevard
- Pacheco Boulevard
- Pleasant Hill Road
- Taylor Boulevard

Tri-Valley
- I-680
- I-580

Source Data for Current Conditions

Estimating average vehicular speeds for selected roadways is similar to computing the Delay Index in that both MTSOs are based on segment or route travel times. Average vehicular speeds and segment length (or distance) can be extracted from Caltrans' Performance Evaluation Management Systems (PeMS) website. The report information is provided every two years.

Arterial Roadways are not part of the PeMS system. In these cases, the current conditions should be measured as described in the CCTA Monitoring Report. The report information is provided every two years.

Process to Develop Projected Performance

The projected performance of the aver travel time may be calculated by adding the forecasted additional congested travel time that is expected to occur on the link to the current condition. This estimation is possible by using the loaded networks from the CCTA Countywide Travel Demand Model during peak hours, which contain a congested speed estimate for each link. This estimate of congested time by link may be summed for the mixed-flow lanes of the route for the nearest base year (such as 2010) and for the horizon year or year of completion (such as 2020 or 2030). The differences in summations would then be divided by the number of years between the forecasts (such as 10 or 20 years) for an annual forecast increase in travel time. This additional travel time would then be applied to the base-year monitoring results (annual travel-time increase multiplied by the number of years) to determine if the project impact would be significant at the compliance horizon year.

Steps:

1. Prepare AM and PM peak-period runs of the CCTA Countywide Travel Demand Model for the baseline year nearest the year for which the most recent MTSO monitoring data are available.
2. Estimate the congested travel time for the route of regional significance by summing the congested travel times for all the mixed-flow lane links of the route.
3. Prepare AM and PM peak-period runs of the CCTA Countywide Travel Demand Model for the available future year closest to the forecast year and for a network reflecting Action Plan projects.
4. Estimate the congested travel time for the route of regional significance summing the congested travel times for all the mixed-flow lane links of the route
5. Subtract the congested route travel time for the baseline year from the value for the forecast year and divide by the number of years separating the two modeled years to get an estimate of the annual increase in congested travel time for the route.
6. Multiply the average annual increase in congested route travel time by the number of years between the most recent MTSO monitoring data and the forecast year and add this increment of travel time to the MSTO monitoring value.
7. Divide the estimate of future year congested travel time to the estimate of uncongested travel time for the route that was used in the most recent monitoring report.
8. Divide the resulting travel time by the segment distance to determine the average congested speed.

Vehicles in HOV Lane

Locations Where Applied

East County
State Route 4

West County
I-80

Source Data for Current Conditions

The HOV volumes reported in this MTSO are determined from the HOV lane utilization report published by Caltrans District 4.

Process to Develop Projected Performance

Future HOV-lane utilization may be calculated by adding the forecasted additional vehicles that are expected to use the HOV lane to the observed current HOV utilization. This estimation is possible by extracting peak-hour or peak-period HOV volumes from the CCTA Countywide Travel Demand Model loaded networks. The growth in HOV utilization would then be divided by the number of years between the forecasts (such as 10 or 20 years) for an annual forecast increase in HOV volumes. This additional annual volume would then be applied to the base-year monitoring results (volumes multiplied by the number of years) to determine if the project impact would be significant at the compliance horizon year.

Steps:

1. Determine number of vehicles from most recent HOV performance report. (Note that Caltrans produces peak hour volume reports annually.)
2. Prepare AM and PM peak-hour assignments of the CCTA Countywide Travel Demand Model for the baseline year nearest the year for which the most recent MTSO monitoring data are available.
3. Prepare AM and PM peak-hour assignments of the CCTA Countywide Travel Demand Model for the available future year closest to the forecast year and for a network reflecting Action Plan projects.
4. Obtain the number of vehicles listed in the HOV lane from the model, using a representative link segments in the model, determined by finding the maximum volume on a link in the base year.
5. Determine an annual increase in HOVs from the base to the future year by dividing the number of additional vehicles by the number of years between the assignments.
6. Determine the actual HOV utilization by adding the change in Step 5 to the number of vehicles in Step 1.

BART Load Factors

Locations Where Applied

Lamorinda

Source Data for Current Conditions

Lamorinda has proposed a BART Load Factors as a new MTSO as part of the 2008 Action Plan Update. The measure is defined by dividing the number of passengers entering the Lamorinda area in the peak direction (Westbound in the AM and Eastbound in the PM) for all trains during that period by the number of seats on those trains. The data necessary to calculate this MTSO for monitoring is available from BART. BART's fare card data facilitates passenger loading estimation for any link in the system for a specified time period. Average weekday (hourly) Load Factor estimates are required to determine whether the MTSO for BART Load Factor is met in any monitoring period.

Process to Develop Projected Performance

Future-year forecasts of the BART Loading Factor can be developed using the CCTA Countywide Travel Demand Model and information about any proposed or programmed changes in BART service frequency, train length or seats per train. The first step in the process is to develop estimates of changes in BART ridership during the AM and PM peak-periods and during the off-peak-periods by comparing the future-year forecast for any period with a base-year model estimate for a year in which monitoring data are available. The percentage change in ridership for each period can be calculated by dividing the change ridership by the base-year monitoring data. The percentage change for the period should then be applied to all hours within the period to get an estimate of the future-year BART ridership for each hour of the day. The future-year ridership by hour should be divided by the number of seats available for each hour to get the BART Loading Factor for each hour. The number of seats available buy hour can be estimated by adjusting the base-year seats of service based on any proposed or programmed changes.

Steps:

1. Determine the current load factors from most recent performance report. (Note that BART has the ability to produce representative entry/exit trip tables for daily or peak/off-peak times.)
2. Prepare peak and off-peak transit assignments of the CCTA Countywide Travel Demand Model for the baseline year nearest the year for which the most recent MTSO monitoring data are available.
3. Prepare peak and off-peak transit assignments of the CCTA Countywide Travel Demand Model for the available future year closest to the forecast year and for a network reflecting Action Plan projects.

4. Obtain the projected number of riders from the two model assignments, using a representative link segments in the model, determined by finding the maximum volume on a link in the base year.
5. Determine an annual increase in transit riders from the base to the future year by dividing the number of additional riders by the number of years between the assignments.
6. Determine the adjusted, projected number of riders by adding the change in Step 5 to the number of vehicles in Step 1.
7. Determine the number of seats in the current condition during peak and off-peak periods by multiplying the number of bart seats per car by the number of cars during the peak period (with the number of cars potentially estimated by the number of trains multiplied by the number of cars per train).
8. Determine the percentage increase in the number of trains assumed in the peak and off-peak transit networks for the base and future years by comparing the train headways in the model. (Model headways are typically the inverse of the number of trains.)
9. Multiply the capacity increase percentage in Step 8 by the number of seats in Step 7.
10. Divide the number of adjusted, projected number of riders in Step 6 by the capacity in Step 9. (It is acceptable to have more riders than seats).

Minimum Bus Frequency

Locations Where Applied

Lamorinda
    Pleasant Hill Road

Source Data for Current Conditions

Lamorinda has proposed a Minimum Bus Frequency on Pleasant Hill road as a new MTSO as part of the 2008 Action Plan Update. The measure is defined as the composite number of buses per direction per hour for all routes serving the corridor between Taylor Blvd and Acalanes High School during peak commute and school times (6:30 AM – 9:30 AM and 3:30 PM – 6:30 PM). There is currently no bus service on Pleasant Hill Road. In the future monitoring can be performed by simply extracting peak-period headways from published bus schedules.

Process to Develop Projected Performance

Future-year forecasts of this MTSO can be developed using the increment method, whereby the number of hourly directional buses (for all routes) for all proposed new transit services are added to the MTSO's baseline value.

Steps:

1. Determine the bus frequency from most recent bus schedules. (No service is provided in 2008.)
2. Compare transit peak-period headways in the CCTA Countywide Travel Demand Model for the available base year close to the monitoring year, and an available future year closest to the forecast year and for a network reflecting Action Plan projects. (The base year has no service coded in the Model.)
3. Determine the change in the number of buses (if any) between the base year and future year.
4. Apply the change in headways to the current bus frequency from the most recent bus schedules (if any service is provided) to calculate the projected bus frequency, and compare to the MTSO to determine if the minimum is achieved.

Side-street Wait Time

Locations Where Applied

Lamorinda

- Pleasant Hill Road
- San Pablo Dam Road/Camino Pablo

Source Data for Current Conditions

The Action Plan for Camino Pablo and San Pablo Dam Road includes an MTSO specifying the maximum side-street wait time for vehicles waiting to access San Pablo Dam Road cannot exceed one cycle length. In the 2008 Action Plan Update, Lamorinda has also proposed that this MTSO be applied to Pleasant Hill Road. The measure is monitored through on-site observations. For future-year MTSO forecasting, base-year peak-period turning-movement counts are required at each study intersection where MTSO monitoring was performed.

Process to Develop Projected Performance

Intersection Level of Service analysis procedures are described in Chapter 4 and Appendix C and Appendix D of the *Technical Procedures*. Turning-movement traffic volumes for the routes of regional significance and their side-street approaches should be forecasted using the CCTA Countywide Travel Demand Model. The increment method should be used to estimate future turning-movement volumes to be used in the intersection LOS analysis, whereby model-estimated growth in turning-movement volumes are added to counted baseline turning-movement volumes. The intersection LOS procedure should be used to determine whether the intersection threshold level of service can be achieved while providing sufficient green time to meet side-street demand at least 95% of the time during the peak commute hours.

Steps:

1. Prepare peak and off-peak traffic assignments of the CCTA Countywide Travel Demand Model for the baseline year nearest the year for which the most recent MTSO monitoring data are available.
2. Prepare peak and off-peak traffic assignments of the CCTA Countywide Travel Demand Model for the available future year closest to the forecast year and for a network reflecting Action Plan projects.
3. Utilize the CCTA intersection turning movement adjustment method to calculate future traffic volumes.
4. Use the *2010 Highway Capacity Manual* procedure for evaluating level of service to estimate average vehicle delay for the side street.

West County Area-wide Goals

A number of area-wide goals have been developed for the West County Action Plan. These goals represent items which are to be monitored by the CCTA when they measure the MTSOs every four years. These are baseline measures; forecasting future-year performance for these goals is not required.

Steps:

None

Source Data for Transit Satisfaction Goal

This area-wide goal is to be measured through the most recent transit operator rider surveys.

Source Data for Pavement Quality Goal

This is to be measured by comparing Agency-monitored Pavement Condition indices for each partner jurisdiction.

Source Data for Drive-Alone Rate

This area-wide goal of 75 percent is to be measured by field observation and/or vehicle occupancy surveys. The measurement is typically taken on Interstate 580 near the Alameda County line.

Source Data for Transit Ridership Increase

This increase of 10 percent between 2007 and 2012 is to be measured by comparing AC Transit, WestCAT and BART boarding data in West County in those two years.

Source Data for Bicycle and Pedestrian Mode Share

The goal of 3 percent is to be monitored by using the American Community Survey responses concerning transportation mode percentages in 2012.

Source Data for Capitol Corridor Daily Ridership

The goal of 3,000 riders a day would be measured by collecting ridership data. The data is based on the number of riders traveling through Contra Costa County between Richmond and Martinez stations in 2012. (NOTE: DKS unable to verify how this is determined.)

Source Data for Ferry Service Daily Ridership

The proposed ferry service for Richmond-San Francisco and Hercules-San Francisco has goals of 500 passengers per day each by 2012. These would be measured by examining weekday boardings for each route in 2012.

Source Data for On-time Bus Transit Performance

This new goal is to be measured by comparing AC Transit, WestCAT and BART data in West County according to the on-time performance definitions of the various systems. The goal is to maintain 2007 on-time performance levels. (DKS note: BART on-time performance is “rail” and not “bus”.)

Average Intersection Stopped Delay

Locations Where Applied

6 Central County Intersections in Concord

Source Data for Current Performance

The MTSO is defined as stopped delay, but the measurement is made through the number of signal cycles needed to clear the intersection. This is determined through the most recent CCTA Monitoring Report for both the AM and PM peak hours.

Process to Develop Projected Performance

Using HCM intersection analysis methods, the cycles needed to clear the intersection would be calculated by replicating the current delay using an HCM-consistent program. The procedures are then guided by the method established in the future year Intersection Level of Service process established by CCTA. Baseline and future-year peak-period (or peak hour) traffic volumes can be extracted from the CCTA Countywide Travel Demand Model for the routes of regional significance and side streets. The increment method should be used to estimate future turning-movement volumes to be used in the HCM intersection analysis, whereby the model-estimated growth in turning-movement volumes is added to counted baseline turning-movement volumes.

Steps:

1. Prepare peak and off-peak transit assignments of the CCTA Countywide Travel Demand Model for the baseline year nearest the year for which the most recent MTSO monitoring data are available.
2. Prepare peak and off-peak transit assignments of the CCTA Countywide Travel Demand Model for the available future year closest to the forecast year and for a network reflecting Action Plan projects.
3. Utilize the CCTA intersection turning movement adjustment method to calculate future traffic volumes.
4. Utilize the intersection LOS determination procedure to determine the average stopped delay.

Appendix C – Traffic Counting Protocol

TRAFFIC COUNTING PROTOCOL

Traffic counts for traffic impact studies, level of service monitoring, and any other application intended to represent prevailing traffic conditions at a given location shall be conducted in accordance with the following provisions:

a. **During Fair Weather** – Counts shall be conducted in fair weather, without rain, flooding, heavy winds, or other adverse weather conditions that could disrupt the flow of traffic;

b. **On Tuesday, Wednesday, or Thursday of a non-holiday week when public schools are in session** – Holidays include New Years Day, Martin Luther King Day, President's Day, Memorial Day, Independence Day, Labor Day, Veteran's Day, Thanksgiving, and Christmas.

c. **Typical School Day** –Counts should be taken on typical school days avoiding half days, late start days and early-dismissal days whenever possible.

d. **No major road closings** – if temporary road closings have occurred that affect traffic flow at the count location, the count should be postponed until the road is re-opened. If the road closing is to be for an extended period, and a count needs to be conducted, the count results should be annotated to reflect the road closure conditions.

e. **No construction activity** – Counts should not be conducted in the presence of construction activity that could disrupt the arrival or departure of traffic at the count location.

f. **No incidents or accidents** – If an incident or accident has occurred in the vicinity of the count location, or if such an event occurs during the count, the count should be discarded, and repeated at a later date.

In the event that a traffic count is conducted specifically to observe conditions under provisions a-f above, the prevalence of such condition(s) should be duly noted in any documents or data that are used to report the count results.

Appendix D – Guidelines for Use of the CCTALOS Methodology

The CCTALOS methodology may be used to evaluate existing levels of service at signalized intersections using actual traffic count data, or future levels of service using forecast traffic projections. The Authority's method is similar to the Circular 212 Planning Method except that through movement capacity has been increased from 1,500 vehicles per hour to 1,800 vehicles per hour. Level of service is calculated by critical movement with lower capacities assumed for turning movements.

Saturation Flow Rates

The saturation flow rate is the basis for determining the capacity of an intersection. It represents the maximum number of vehicles that can pass through an intersection under prevailing traffic conditions. The Authority has modified the Circular 212 Operations and Design Method by assuming a saturation flow rate of 1,800 vehicles per hour (rather than 1,500 vehicles per hour).

Saturation flow rates were measured at four intersections in Contra Costa in February, 1990 to verify the appropriateness of this saturation flow rate. The method for collecting saturation flow rate data described in the 1985 Highway Capacity Manual (HCM) was used. The results are summarized in Table 1. Considerable variation in saturation flow rates were observed at each intersection. The data suggested that the operations and design capacities based on the 1,800 vehicles per hour saturation flow rate are frequently achieved within Contra Costa.

Table 1: Measured PM Peak Hour Saturation Flow Rates Selected Intersections in Contra Costa

Intersection	*Movement*	*Number of Samples*	*Highest Measured (Vehicles Per Hour)*
Treat Boulevard/Clayton Road	Left	4	1,752
	Left/Thru	4	2,054
	Thru	8	2,487
	Thru/Right	4	1,793
Buchanan Road/Somersville Road	Left	8	2,048
	Thru	2	2,014
Alcosta Drive/Crow Canyon Road	Left	3	2,152
	Thru	5	2,261
	Right	1	2,531

Blume Drive/HilltopDrive	Left	4	2,084
	Thru	4	1,807
WEIGHTED AVERAGE	Left	19	2,152
	Left/Thru	4	2,054
	Thru	19	2,487
	Thru/Right	4	1,793
	Right	1	2,531

Source: Patterson Associates, February, 1990

As indicated in Table 1, the saturation flow rates varied by movement type. Exclusive left-turn saturation flow rates were approximately 10 percent less than those for through lanes. Saturation flow rates for shared left and through lanes were 18 percent lower than for through lanes. Sufficient data was not collected to provide statistical accuracy for these averages. They were consistent, however, with the passenger car equivalent (PCE) values adjustments provided in Circular 212.

Optional Capacity Reduction

The effect of vehicle mix, intersection geometrics and other factors on intersection capacity is well documented. These factors, however, are not considered directly in the Circular 212 Planning Methodology. This was why a lower capacity (1,500 vph) was originally selected for use in Circular 212.

The Authority methodology, which uses a higher capacity (1,800 vph), may underestimate existing or future congestion at some locations. The reductions in the capacities provided in Table 2 are therefore optional, provided that measurement of saturation flow rates at those locations justify the lower capacities. Under no circumstances can a signalized intersection capacity above 1,800 vph be used under the Authority methodology. Saturation flow rates must be measured using the technique described in Section 9, Appendix IV of the 1985 *Highway Capacity Manual*.

Table 2: Lane Capacities[1]

Lane Type	*2-Phase*	*3-Phase*	*4+-Phase*
Exclusive Lane	1,800	1,720	1,650
Shared Lane	1,800	1,720	1,650
Dual Turn Lanes[2,3]	1,636	1,564	1,500
Triple Turn Lanes[2,4]	1,565	1,496	1,435

Capacities for a single lane. If multiple lanes are provided, capacity in the table is multiplied by number of lanes to obtain total capacity for movement group.

Can include one shared lane (e.g. one exclusive left, plus one shared through left is considered dual turn lane).

Assumes 45%-55% lane split.

Assumes lane use 15% higher in the most used lane.

The saturation flow rates be adjusted to establish the capacity for the traffic movement considered. Adjustment of the saturation flow rates should be performed as described in equation 9-1 of the 1985 HCM:

$$c_i = s_i \, x \left(\frac{g}{C} \right)_i$$

Where (for lane group or approach *i*):

c_i = capacity in vehicles per hour

s_i = saturation flow rate in vehicles per hour

g =effective green time in seconds

C =intersection cycle length in seconds

Analysis of Delay

Because the Authority's LOS method applies fixed critical lane volumes uniformly throughout the county, the method may underestimate congestion at locations with poor geometrics (older intersections with poor turning radii and small approach widths), or overestimate congestion at locations with excellent geometrics (newer intersections with ideal conditions) and aggressive drivers. The Authority method may not identify locations where severe congestion is limited to a single intersection approach, nor does it reflect significant peaking and congestion within the peak hour.

To address these shortcomings, the following method may be used in lieu of the Authority's method to identify congested locations:

Field measurement of delay on the congested approach or full intersection can be collected using the methodology described in the most recent version of the HCM. The measured delay should be compared with those provided in the most current version of the HCM.

Synchro® or similar software may be used in operations analyses to estimate vehicle delay and LOS based upon delay.

.V/C Level-of-Service Calculation Method

Signalized intersection levels of service may be calculated using the LOS software that is included "free" with this document, or a commercially-available software package that adheres to the Authority's LOS methodology. The software incorporates the following steps. If done manually, the following nine steps should be used to perform the analysis:

Step 1 Lane Geometry

Identify the number and type of lanes for each approach.

Step 2 Intersection Volumes

Identify—by counting (if analyzing existing conditions) or estimating (if analyzing future conditions)—left-turn, through, and right-turn volumes for each approach for the peak (design) hour volumes in vehicles per hour for each peak hour to be analyzed. In most cases, the analysis will assess both the AM and PM weekday peak hour. For projects with peak periods that occur during midday or on weekends, additional time periods should be analyzed.

Step 3 Phasing

Identify the type of phasing (protected left turns, shared, or split) to be used at the intersection.

Step 4 Left-Turn Check

When a traffic signal phase permits left turns against opposing traffic rather than providing an exclusive left-turn phase, a check must be made to determine if sufficient left-turn capacity is provided to meet demand. This check will apply to LOS calculations for both existing, observed conditions and future estimated demand. Determination of the need for an exclusive left-turn phase under existing conditions should also consider actual traffic counts, left-turn delay, observed queuing, and accident history. The left-turn capacity is the combination of left turns made against opposing through movements and left turns made during the amber portion of the phase.

The capacity during the amber portion (V_C)—the maximum number of left turns that can clear in this period—equals two times the number of signal cycles per hour. If the number of cycles per hour is not known, assume that the maximum number of left turns that can clear the intersection in one hour equals 90.

The capacity for left turns during the green cycle (V_L)—the maximum number of left turns that can clear against opposing traffic volumes—is estimated using the following equation:

$$V_L = 1{,}200 \left(\frac{G}{C}\right) - V_O$$

Where:

V_L = left-turn volume, in vehicles per hour, that can clear during the green for opposing through traffic

G = maximum green plus amber time*

C = cycle time for opposing through traffic*

V_O = sum of opposing through and right-turn volumes in vehicles per hour

* If either the maximum green time or the cycle time is not known, use the through and right-turn volumes for the approach divided by the number of lanes.

Add the number of left turns calculated in the change interval V_C to the number calculated in the permitted left for a total number of left turns that can clear without a protected left (V_L). If the number of left turns calculated above (left-turn capacity) is more than those estimated for the project, no protected left-turn phase is needed. If the number of left turns calculated above is less than the left turn demand, operating difficulties and increasing delays will be experienced.

Step 5 Adjust Turning Volumes

Two situations may require adjustment of observed or estimated turning volumes:

Right turns where no separate right-turn lane is provided and significant pedestrian activity exists, and

Left turns where no separate left-turn lane is provided.

The PCE adjustments recommended in Circular 212 should be used. If the Authority's LOS software is used, adjustments to the turn volumes should be made prior to entering into the program.

Step 6 Calculate Volume-to-Capacity Ratio by Movement

The volume-to-capacity ratio of each of the 12 individual movements and any combined movements of the intersection are calculated as follows:

Right-turn volumes on exclusive right-turn lanes are reduced to account for right turns on red. This reduction will equal the non-conflicting left-turn volumes with a minimum reduction of 90 vehicles per hour. (Non-conflicting left turns go concurrently with the right turn. For example, the non-conflicting left turn for the northbound right turn is the westbound left turn.)

Determine the capacity of each movement and each combined movement from Table 2.
Calculate the volume-to-capacity ratio for each movement and combined movement by dividing the adjusted volumes by the capacities. For combined movements, use the combined volumes divided by the combined capacities.

Step 7 Determine Critical Volume-to-Capacity Ratios

Determine the highest total volume-to-capacity ratios for conflicting movements for both the north-south and east-west directions. For a non-split phased direction, the highest total of the right-turn or the through (or through plus right-turn if no exclusive right-turn lane exists) plus the opposing left-turn volume-to-capacity ratios are chosen. For a split phased direction, the highest volume-to-capacity ratio from each of the approaches is chosen. Free right turns are not included in the calculation since they are not under signal control.

Circular 212 does not clearly indicate how the critical movements are to be selected for single lane approaches (that is, when all right, left and thru movements are made from single approach lane). Under the Circular either the approach with the highest volume or both approaches could be designated as the critical movement. As part of the level-of-service method adopted by the Authority, however, both approaches should be considered critical movements.

Step 8 Sum the critical volume-to-capacity ratios for each approach

Step 9 Compare the sum of the critical volume-to-capacity ratio with the ranges in Table 3 to determine the intersection level of service

Table 3: Level of Service Ranges

Level of Service	*Sum of Critical V/C*
A	≤ 0.60
B	0.61 – 0.70
C	0.71 – 0.80
D	0.81 – 0.90
E	0.91 – 1.00
F	> 1.00

OPTIONAL RIGHT-TURN ON RED ADJUSTMENT PROCEDURE

The VCCC method, as implemented in DOS, TransCAD, and other commercial software, internally reduces the input right turn volume, using the right turn lane code and other factors, to establish an "adjusted" volume that accounts for right turns on red (RTOR). The adjusted right-turn volume is then applied in the V/C calculation. This adjustment occurs automatically within the software, and is not directly controlled by the user.

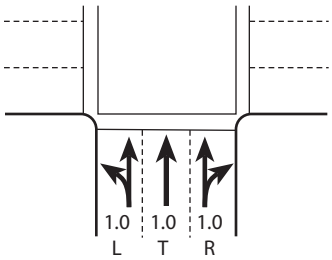
Past experience has proven that, from time to time, the program does not adequately reflect higher levels of RTOR activity that may be occurring in the field. In cases where the program under-estimates the RTOR adjustment, it will also over-estimate the V/C ratio. If, in the analyst's judgment, the RTOR adjustment is being underestimated, then the analyst has the option of conducting a RTOR count and further adjusting the right turn volumes used in the LOS computation based upon observed conditions.

The RTOR count may be conducted after the full turning movement count has been completed. The analyst should determine when the peak hour window occurred within the peak period of the full turning movement count, and should return to the intersection to conduct a spot count during that same peak hour window. The spot count should be for a minimum of one hour, and conducted in accordance with the Traffic Counting Protocol in Appendix B.

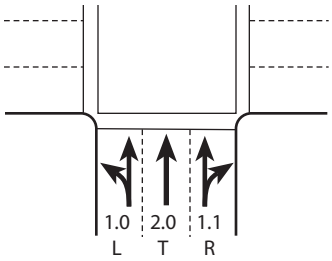
The RTOR adjustment should be made as described below. The key to the input coding convention is found in the VCCC User's Manual, and is reprinted here in Figure 1. For clarity, we have assumed that there is only one right-turn lane involved (hence the coding 1.1, 1.4, etc.). The following guidelines apply, however, to double (and triple) right turns as well (e.g. 2.1, 2.4, or 3.1, 3.4, etc):

Where Right-Turn Lane Code is 1.1 or 1.4 and LOS Calculation is for Existing Conditions: If the right turn lane code is 1.1 or 1.4 (that is, where the right turning vehicle on red must look for gaps in the cross traffic) *and* the analyst is computing LOS for *existing* conditions, then the analyst subtracts the ROTR volume counted in the field from the original right turn volume. (This new result is the "analyst-adjusted volume".) If the resulting analyst's adjusted volume is *lower* than the adjusted volume reported by the software, then the analyst subtracts the difference in these two adjusted volumes from the original right turn volume input for the approach. The VCCC method should then compute an adjusted right turn volume that matches the analyst-adjusted volume.

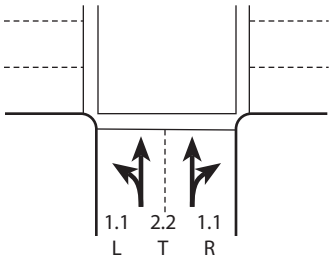
Where Y = 0
The lane is used exclusively for a particular movement (e.g., as an exclusive left-turn lane)



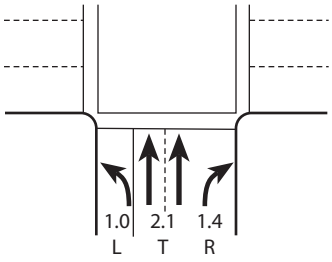
Where Y = 1
The lane is shared, that is, either of two movements can be made from the lane (e.g., a lane shared by through and right-turn traffic)



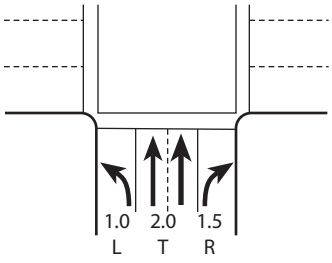
Where Y = 2
Two or more through lanes are shared, one with left-turn traffic and one with right-turn traffic



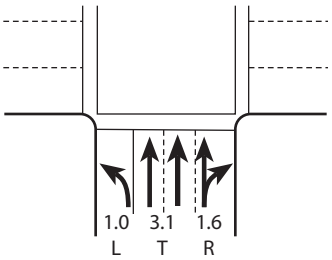
Where Y = 4
Right-turn traffic, using a wide outside lane, can bypass through traffic to make a right turn on red



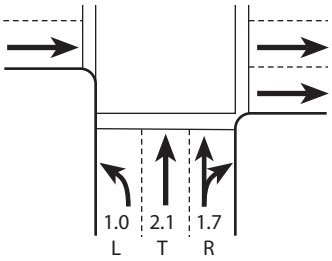
Where Y = 5
Denotes a right-turn movement from an exclusive right-turn lane with a right-turn arrow and prohibition of the conflicting U-turn movement



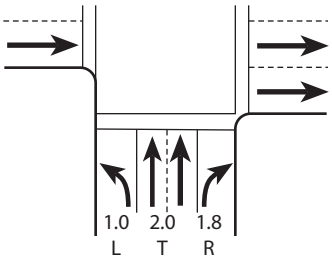
Where Y = 6
Denotes a right-turn movement from a shared lane with a right-turn arrow and prohibition of the conflicting U-turn movement



Where Y = 7
Turn lane that is shared with a through lane or left-turn lane and under signal control, and that has its own lane to turn into. There must be at least two through lanes



Where Y = 8
Denotes an exclusive turn lane that is under signal control and has its own lane to turn into



Where Y = 9
Denotes an exclusive turn lane that is ***not*** under signal control and has its own lane to turn into, often referred to as a "free" turn. Since the volumes of this lane do not conflict with other intersection movements, the v/c ratio of the free right-turn movement is not included in the sum of critical v/c ratios.

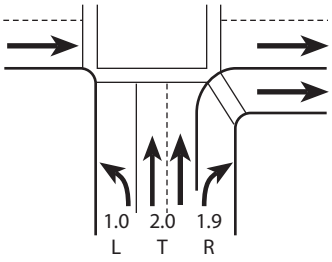


Figure 1

Description of Lane Configuration Input Coding for the CCTALOS Program

Right-Turn Lane Code is 1.1 or 1.4 and LOS Calculation Is for Future Conditions: If the right turn lane code is 1.1 or 1.4 *and* the analyst is computing LOS for *future* conditions, an additional step is required. The analyst measures the right turn on red volume in the field as before. This value, however, is discounted for any future ROTR capacity absorbed by the forecast growth in conflicting cross-street traffic that uses the same lane as the RTOR vehicles are trying to turn into. To calculate this discounted ROTR amount, the growth in conflicting through traffic should be divided by the number of through lanes on the cross street approach and that growth in per lane through volume subtracted from the counted RTOR volume. The reduced RTOR volume is then used as in step 1 above to compute analyst-adjusted right turn volume.

Right-Turn Lane Code is 1.5 or 1.6: If the right turn lane code is 1.5 or 1.6 (right turn arrow and u-turns from the opposing approach prohibited), and RTOR is also allowed (that is, only a green arrow is displayed and there is no red arrow to prohibit RTOR), then the same volume adjustment process is applied as described above under step 1. If a red right turn arrow is displayed, however, then RTORs are prohibited and no RTOR adjustment is appropriate.

Right-Turn Lane Code is 1.7 or 1.8: If the right turn lane code is 1.7 or 1.8 (signal controlled right turns turning into their own receiving lanes on the cross street), then there are no conflicts with cross street through traffic and the same volume adjustment process can be applied as described above under step 1.

Right-Turn Lane Code is 1.9: If the right turn lane code is 1.9 (a free right), no RTOR adjustment should be required. The VCCC method ignores the right turn volume and v/c ratio in the computation of the intersection v/c ratio.

Appendix E – Typical Transportation Analysis Report Outline

Sections for Transportation Impact Analysis Reports

The analyst has discretion to use the most appropriate documentation format depending on the complexity of the analysis, so long as all the required information is provided. Not all information noted below will be appropriate for all studies, and the numbered headings are not meant to imply chapters as some topic areas could be combined into one chapter for brevity and clarity.

1. Introductory Items

- Front Cover/Title Page
- Table of Contents, List of Figures, and List of Tables
- Executive Summary

2. Introduction/Background

- Project description, including special trip generation characteristics (if applicable)
- Type and size of development
- Site plan (include proposed driveways, roadways, traffic control, parking facilities, emergency vehicle access, and internal circulation for vehicles, bicyclists, and pedestrians)
- Location map (include major streets, study intersections, and neighboring zoning and land uses)
- Scope of transportation analysis

3. Project Screening

- Description of whether the project meets General Plan Consistency screening criteria
- Description of whether the project meets VMT screening criteria

4. Existing Conditions

- Description of existing street system within project site and surrounding area
- Location and routes of nearest public transit system serving the project
- Location and routes of nearest pedestrian and bicycle facilities serving the project
- Collision history including vehicle, bicycle, and pedestrian collision data (if available) obtained from a comprehensive data source such as SWITRS, Crossroads, or hospital records

- Figure of study intersections with peak hour turning movement counts, lane geometries, and traffic control (if applicable)
- Map of study area showing average daily traffic of study roadways (if applicable)
- Table of existing peak hour average vehicle delay and LOS (if applicable)
- Definition of standards and objectives (i.e., thresholds of significance)

5. Project Trip Generation and Distribution

- Table of project generated trip estimates
- Figure/map of trip distribution (in percent)

6. Project Site Access and Circulation Evaluation

- Summary of a detailed site review for all modes of travel
- Mobility deficiency analysis for vehicle, transit, bicycle, and pedestrian facilities (under Existing, Background, and Cumulative Conditions)
- Summary of transportation improvements

CEQA Transportation Analysis Report Sections

7. VMT Analysis (For projects not meeting VMT screening criteria)

- Summary of VMT analysis under Baseline Conditions
- Summary of VMT analysis under Cumulative Conditions (if required)
- Identification of significant impacts
- Discussion of mitigation measures
- Evaluation of impacts of mitigation measures

8. Other CEQA Requirements

- Summary of conflicts with a program, plan, ordinance, or policy addressing the circulation system, including transit, roadways, bicycle lanes, and pedestrian paths. Present mitigation measures, as needed.
- Evaluation of hazards due to a geometric design feature (e.g., sharp curves or dangerous intersections) or incompatible uses (e.g., farm equipment). Present mitigation measures, as needed.

- Emergency access evaluation. Present mitigation measures, as needed.

Local Transportation Analysis Report Sections (for Projects Requiring Off-Site Analysis)

9. Existing with Project Conditions

- Map of study area with applicable peak hour turning movements (Project Only and Existing Plus Project Conditions)
- Table of Existing and Existing with Project intersection peak hour average vehicle delay and LOS (or other multimodal performance measure)
- Traffic signal and other warrants
- Changes/Deficiencies to bike, pedestrian, and transit networks
- Findings of project deficiencies
- Improvements for project deficiencies (include a map showing physical improvements)
- Scheduling and implementation responsibility of improvements

10. Background Conditions

- List of approved project(s) and table of trip generation
- Map of study area with applicable peak hour turning movements (Background without Project)
- Table of intersection peak hour average vehicle delay and LOS (or other multimodal performance measure) without and with Project
- Changes/deficiencies to bike, pedestrian, and transit networks
- Traffic signal and other warrants

11. Cumulative Conditions

- Map of study area with Cumulative without Project peak hour turning movements
- Map of study area with Cumulative with Project peak hour turning movements
- Table of Cumulative without Project and Cumulative with Project intersection peak hour average vehicle delay and LOS (or other multimodal performance measure)
- Changes/Deficiencies to bike, pedestrian, and transit networks
- Traffic signal and other warrants
- Findings of project deficiencies

- Improvements for project deficiencies (include a map showing physical improvements)
- Scheduling and implementation responsibility of improvements

Sections that may be Needed Depending on Project Context

12. Construction Impacts

- Trips due to construction workers
- Truck trips and truck access routes

13. Phasing Analysis (For Large Projects)

- Characteristics of each phase
- Trip generation and trip distribution for each phase
- Local transportation analysis for each phase, typically focused on identifying at what phase each major improvement would be needed

14. Appendices

- List of references
- List of authors
- Pedestrian, bicycle, and vehicle counts
- Technical calculations

Appendix F – Procedures for Using ODME and ODME Pilot Test Results

INTRODUCTION

There are a variety of trip table estimation techniques that have been tested and used in the transportation planning field over many years. One such technique, called Origin-Destination Matrix Estimation (ODME), is available through the TransCAD software, and can be used to synthesize trip tables using a small number of traffic counts or to adjust the model assignment output to provide a better match to a larger number of available traffic counts.

The ODME process incrementally adjusts origin-destination pairs in the total vehicle trip matrix, such that the final trip assignment "fits" pre-determined traffic count targets that are selected and input by the model user. The number of iterations and the desired percentage convergence tolerance are pre-selected by the model user as parameters to the ODME procedure. ODME may also be performed on the multi-class vehicle trip matrices (SOV, 2-person carpool, 3+ carpool, and trucks) provided that reliable count data for each vehicle class is available.

The following guidelines are intended for use by model users when implementing the TransCAD ODME procedure:

General: Use of ODME is an *optional* validation tool that may be invoked only after calibration and validation efforts have been conducted to the fullest extent feasible. As a guideline that 90 percent of the screenlines should be within targets before the ODME tool is utilized. Furthermore, ODME should not be used to make up for network and land use inaccuracies that cause poor traffic assignments. Rather, ODME is to be applied only as a refinement after all inputs to the model have been fully reviewed and can no longer be adjusted without deviating from the empirical inputs.

Count Target Coverage: Although ODME can improve the match between model output and actual traffic counts, it is not behaviorally-based. Therefore, ODME should not be applied to undermine the regional assumptions that reside within the overall travel demand model. It is therefore not recommended for implementation at a county-wide or regional level. It can, however, be effectively applied at the subarea and local level to provide a better fit with observed data. Therefore, while the full regional O/D matrix is applied in the ODME process, the coverage of target counts should be limited to at or below the subarea level (e.g. West County, Central County, East County, or the Tri-Valley).

Conflicting Count Targets: In tests performed on regional county-wide targets, it was observed that the benefits of ODME diminished if a large number of count targets are input along a specific route. When the ODME procedure encounters conflicting count data, the validation results tend to degrade, because the ODME process compromises the trip table to meet all of the input targets.

If counts are input along a corridor, check that the counts are balanced and consistent with one another.

Number of Count Targets: The number of count targets input by the model user is flexible. However, based on the ODME tests conducted by DAI, a single target count is not recommended. For gateway constraint applications, a single directional peak hour link volume target should be accompanied by counts/model volume constraints at key parallel strategic locations to preserve model validity. Weighting can be used to prioritize specific count targets over others. Use of selected targets, for example, one or multiple screenline targets can help address a specific validation issue within a specific study area. Alternatively, all available count data within a sub area can be input to improve overall validation. However, inconsistencies in the count data may interfere with achieving convergence. Conflicting count data may be the result of congestion, queuing, or variations in the time of day and/or the season during which adjacent counts were collected. Consequently, juxtaposing conflicting targets will result in fewer of the validation criteria being met, because the ODME matrix balancing process will be unable to achieve convergence for all targets.

Traffic Counting Protocol: All traffic counts used as targets in the ODME process should be collected in accordance with the Traffic Counting Protocol shown in Appendix B. Furthermore, applying ODME on a congested network might artificially lower the volumes to the constrained counts. Therefore, instead of using congested counts, which are generally low, it is recommended to set the target volume at maximum capacity on freeway locations experiencing recurrent congestion. Similarly, congested counts on arterials should be reviewed to take into consideration queuing and compression. Furthermore, counts that are constrained due to metering should be reviewed, and use of a higher count should be considered if the demand at the metering point results in significant queuing and congestion. If the counts appear to be low due to any of the above factors, a higher count that is capacity based should be substituted for the ODME application.

Multi-class Assignment: In the absence of counts for each vehicle classification (SOV, 2-person carpool, 3+ carpool, and trucks), the ODME process setup for the Countywide Model applies matrix adjustments on the combined trip table and uses the original zonal level mode splits on the estimated trip table. If counts are available to the user by vehicle classification, the model user may invoke the "Multi-Class ODME" process, which is available in TransCAD to adjust individual vehicle class trip tables. Use of the multi-class procedure should be implemented in consultation with Authority staff.

Checking the Adjusted O/D Matrix: To preserve the model's integrity, and to maintain consistency with the regional model, the model user should carefully evaluate the effect of ODME on the adjusted O/D trip table before applying the assignment results. O/D pairs that do not cross an ODME target screenline or count location should not be significantly affected by the ODME adjustment process.

Impact on Trip Length: Pre- and post-ODME trip length distributions should be generated by the model user and reviewed to ensure that traffic distribution patterns have not been compromised. Pilot testing of the ODME process indicated a slight increase in the number of shorter trips. A post-

ODME trip length distribution with a greater number of shorter trips (on the order of 5% to 10%) is considered reasonable, and corresponds with the results of the pilot tests conducted by DAI.

Specifying Number of Iterations and Percentage Tolerance: The TransCAD interface will allow the model user to specify the number of iterations and the desired percentage convergence tolerance for the ODME procedure. This will determine running time for the ODME operation. The recommended settings are as follows: inner loop iterations – 50; outer loop iterations – 20; convergence percentage tolerance – 5 percent.

Carrying ODME Adjustments into the Forecast Year: Adjustments to the future trip table should be made after ODME is successfully applied to the base year following the above guidelines. The difference between the original multi-class trip table and the ODME-adjusted trip table by vehicle classification shall be added to the unadjusted future trip table by vehicle class. The adjusted future trip table should be re-assigned using Multi-Class Assignment in TransCAD to obtain the forecast volumes.

Applying ODME to Establish an Interim Horizon Year: The successful application of ODME at the subarea level also suggests that the procedure could be applied successfully to re-calibrate the model to a post-2000 interim horizon year for which traffic counts are available within a particular study area. The procedures to establishing an interim horizon base year and applying ODME to match existing counts is described below.

ESTABLISHING A POST-2010 BASELINE AND REFINING IT WITH ODME

The Authority's model is validated to actual traffic counts on a ten-year cycle (1990, 2000, 2010, etc.). In the interim, model users may wish to use the new 2010 Countywide Model to test existing conditions, and forecast results, based for example upon a post-2010 set of observed data (say 2017) for which traffic counts are available within a particular study area. The ODME procedure could be a useful tool for quickly re-calibrating the year 2010 model run to a post-2010 interim set of counts, provided that overall regional consistency is preserved through a parallel interpolation process for the region-wide trip table or land use data set. To take advantage of this option, the following steps are recommended. These should be carried out consistent with the above ODME guidelines as outlined for conventional (validation-year) applications.

Establishing a Post-2010 Baseline

The new baseline trip table may be developed using the fully validated pre-ODME year 2010 model run, and the corresponding 2020 model run.

The interim-year trip table should be developed by interpolating between the 2010 and 2020 trip tables. Alternatively, if land use analysis is required, the vehicle trip tables for these two horizon years may be developed by interpolation of the land use dataset.

If necessary, create an interim year network that reflects the status of projects for the specific interim-year scenario.

Run the interim base-year model through assignment to establish the pre-ODME interim assignment for (say) 2017.

Check the validation and screenline reports of the pre-ODME interim assignment for reasonableness when compared with 2010 counts and interim observed data.

Using ODME to Improve the Interim Baseline Horizon Year Validation

Once the Interim Baseline Horizon Year model run has been completed and checked, the match between the Interim-year run and the observed data may be improved through the application of ODME as follows:

Assign target volumes for the study area, based upon actual interim-year counts. Counts should be collected in accordance with the Traffic Counting Protocol shown in Appendix B, and consistent with guidelines on ODME count coverage.

Run ODME on the interim horizon year assignment.

Use the post-ODME results as the new interim-base year validation run.

Apply the differences between pre-and post ODME vehicle trip table for the interim year to the forecast year.

CONTRA COSTA TRANSPORTATION AUTHORITY

Technical Memorandum

Date February 1, 2006 (Revised February 15, 2006)

To Technical Modeling Working Group

Through Martin Engelmann

From Neelita Mopati, Dowling Associates, Inc.

RE **ODME Testing and Proposed Methodology for ODME Application**

BACKGROUND

The Authority's travel demand forecasting model was calibrated to the furthest extent possible using puristic techniques. That is, no post-processing adjustments were made to the model to force it to match observed traffic count data. Only the 'pure" input data and the model algorithms were used to generate the baseline outputs. With this approach, and following extensive review by local jurisdictions, 93% of the validation targets in the Authority's *Technical Procedures* were met as of April 2005.

To reach closure on the remaining 7% of the validation targets, there are two options: 1) continue adjusting the model inputs in an attempt to reach closure; or 2) invoke a post processing technique that would automate the adjustment procedure. Option 1 became infeasible for a number of reasons. First, following the extensive local review process, there were really no longer any significant input adjustments left to make. Furthermore, we had no guarantees that the remaining input adjustments that could be identified would help the validation. Clearly, we had reached the point of diminishing returns on this effort. In addition, continued trial-and-error would be costly – well beyond the established budget for this modeling project.

Option 2, on the other hand, could be implemented at a relatively low cost, and held promise to move the model in the right direction to meet the validation

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targets. Consequently, an automated technique called ODME was developed and applied to meet the remaining 7% of the validation targets.

This discussion paper presents test results of the ODME process and a proposed policy for implementation of ODME in practice

Initial testing of the ODME procedure began in TransCAD version 4.6. The procedure in that version, however, was found to adjust all OD pairs, irrespective of whether a particular OD pair was subject to ODME adjustment. In August 2005, Caliper Corporation technical support was notified of this error, and Caliper proceeded to correct it for the next release of TransCAD. Consequently, the 4.8 version of TransCAD – released in December 2005 – had a corrected ODME procedure. All of the tests shown below were performed using a beta-test version of TransCAD 4.8 that became available in October 2005. The tests were subsequently confirmed on the "official" 4.8 release version, and found to be the same as with the beta-test version.

DESCRIPTION OF THE ODME PROCEDURE

The TMWG first discussed the ODME procedure at its April 2005 meeting. At that time, a memo that broadly explained the technique was distributed and is included in Exhibit 1. Following that discussion, much work was conducted to develop and implement an ODME procedure for review by the TMWG in late 2005. Below is a description of the procedure and results as reviewed by TMWG on December 14, 2005.

The technical process, as it occurs in TransCAD 4.8, is illustrated in the flow chart shown in Figures 1 and 2. The approach TransCAD uses is somewhat different than the early approach used with the previous EMME/2 models (see Exhibit 2).

There are two types of matrix estimation methods that are available in TransCAD 4.8 - Single Path and Multiple Path. In the Single Path method, after the assignment, for each O-D pair, the counts along the best single path are compared with the counts and updated accordingly. In the Multiple Path method, for each O-D pair, the counts along a number of best paths are compared and updated. The Multiple Path method is an improvement over the Single Path method, and can yield more accurate results.

In the Multiple Path method, a number of different best paths need to be determined for each O-D pair. This requires a second assignment to be performed within each O-D update iteration. The first assignment is done to calculate the volume. The second assignment is done to calculate the paths. The number of iterations for the first assignment is controlled in the Globals section of the ODME dialog box. The number of iterations used for the second assignment is referred to as the "Inner Iterations" under the O-D Matrix Estimations Settings. The "Outer Iterations" refers to each O-D matrix update. A flow chart of this process is shown in Figure 1. Figure 2 provides the equations governing the origin-destination matrix adjustments.

Because the Multiple Path method is more accurate than the Single Path method, we used the Multiple Path method in all ODME testing described here.

Since ODME can adjust to any given set of counts, we also have explored application of ODME as a method for establishing an interim base-year validation run (say 2007) based upon ground counts available within a study area for that specific time period.

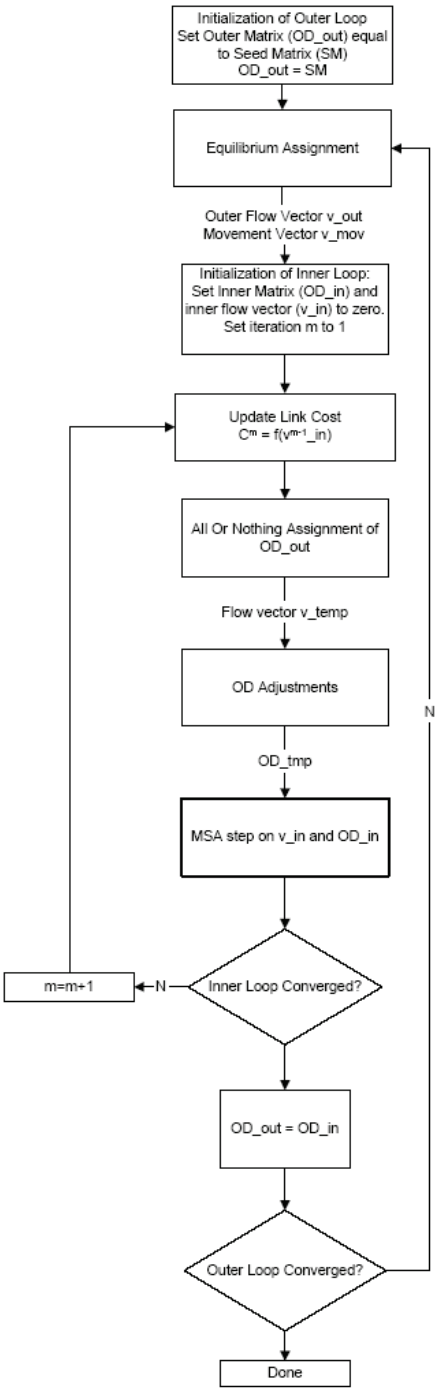
ADJUSTMENT PARAMETERS

Several adjustment parameters are available to the user in the 4.8 ODME procedures:

Normalization: After ODME, the trip table can be adjusted so that the total Origins and Destinations match the original trip table. The adjustment in TransCAD 4.8 restores changes to the specific OD pairs so that total trips of adjusted OD pairs match the original trip table. This process, however, has the unintended consequence of reversing the benefits of the ODME adjustments. An improvisation on this normalization routine would be to be able to keep the zonal level in and out trips the same while modifying only the trip distributions.

Factor Limits: The user may specify limits to the adjustments factors that ODME will apply to the OD matrix. For example, a maximum factor of 0.75 to 1.5 could be established as the limits on changes to any origin or destination cell. After ODME, the change in trips for each cell is calculated and adjusted back to reflect a maximum change in trips by the factor specified. By applying factor limits, the model user may contain the potential loss of integrity that the trip table could otherwise suffer if the factors are left unbounded.

Figure 1: ODME Methodology used by TransCAD

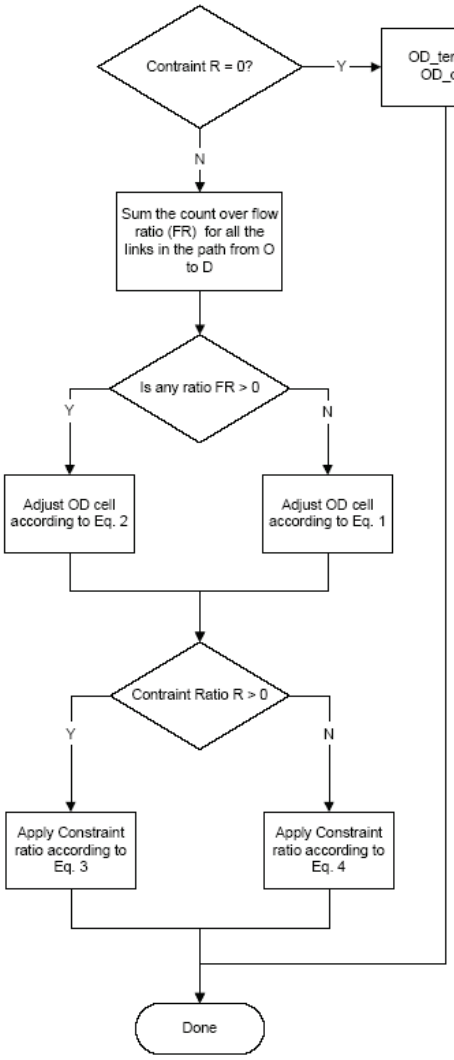


$$\lambda = \frac{1}{m}$$

$$v_{in}^{m} = (1-\lambda)v_{in}^{m-1} + \lambda v_{temp}^{m-1}$$

$$OD_{in}^{m} = (1-\lambda)OD_{in}^{m-1} + \lambda OD_{temp}^{m-1}$$

Figure 2: Origin-Destination adjustment logic for each OD pair



Eq. 1

$$OD_{ij}^{temp} = \frac{\sum_j OD_{ij}^{in} + \sum_i OD_{ij}^{in}}{\sum_j OD_{ij}^{out} + \sum_i OD_{ij}^{out}} OD^{in}$$

Eq. 2

$$OD_{ij}^{temp} = \frac{1}{\sum_{a \in A_{ij}} W_a} \sum_{a \in A_{ij}} \left(\frac{x_a}{v_a^{out}} W_a OD_{ij}^{out} \right) + \frac{1}{|B_{ij}|} \sum_{b \in B_{ij}}$$

Eq. 3

$$OD_{ij}^{temp} = OD_{ij}^{out} \min\left(\frac{OD_{ij}^{temp}}{OD_{ij}^{out}}, 1 + R_{ij} \right)$$

Eq. 4

$$OD_{ij}^{temp} = OD_{ij}^{out} \max\left(\frac{OD_{ij}^{temp}}{OD_{ij}^{out}}, 1 + R_{ij} \right)$$

Where:

W_a	Weight of count on link a
A_{ij}	Set of links along path ij
B_{ij}	Set of turning movements along path ij
x_a	Count on link a
y_b	Count on turning movement b

Weighting: A further useful parameter is weighting. All counts/targets can be weighted to establish a structure for prioritizing one targets over another in order of importance. For example, weighting may be used to set gateway/cordon line constraints as a high priority target, with adjacent screenline targets set at a lower priority. The gateway constraint becomes, in effect, a non-negotiable target, while the screenlines will receive some, but not all of the ODME adjustments.

Subarea ODME: This option allows the user to specify a subarea (selection of zones) around the study area and run the ODME only on the subarea. This permits the user to control the OD pairs to adjust and also be consistent with the adopted

model. Further control of the subarea cordon volumes is possible by the use of weighting.

PILOT TESTING OF THE ODME PROCESS

To demonstrate the affects of ODME, DA ran several pilot tests in 4.8. Beginning with the first example, which shows the results of one target, we progress to using one screenline, to several screenlines, and finally, to application of all available screenlines.

Initial runs of the full 2,700-zone Countywide Model took more than 24 hours to run for one time period. For the purposes of testing the ODME model, the West County subarea was segmented from the model and used to analyze ODME. Using just the West County portion of the model for assignment purposes, this 308 zone model took only 1.5 hours to run. Following the subarea tests, the full model was used to perform tests using all screenlines.

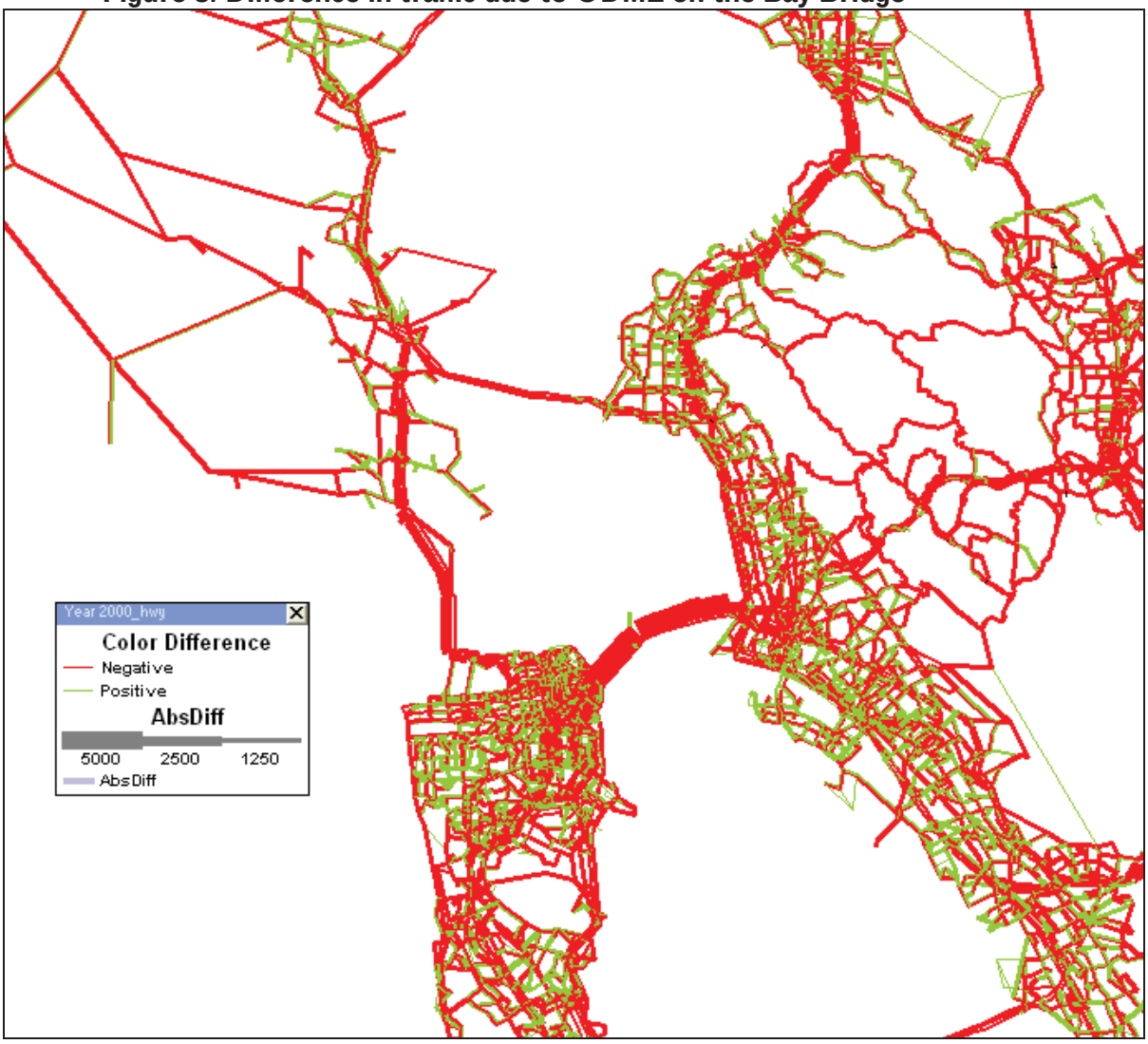
Single Target Test

As an initial test for ODME, a single target test was conducted on the Bay Bridge using I-80 Westbound in the a.m. peak. The Authority's Countywide Model is designed to allow this link to be over assigned in the 2000 validation run to compensate from upstream queuing at the Bay Bridge Toll Plaza. The single target test set this volume at the actual count of 10,000, while the initial assignment for 2000 is 15,229. A weighting of 1000 was selected.

Results:

- *Impact on Target Area:* The final assigned volume on the Westbound Bay Bridge after applying ODME was 9,773 in the AM Peak Hour;
- *Impact on surrounding area:* A difference plot of traffic assignment with and without ODME for the Bay Bridge is shown in Figure 3. ODME does not conserve trips; hence in order to match the lower Bay Bridge count, all the trips using the Bay Bridge are decreased.

Figure 3: Difference in traffic due to ODME on the Bay Bridge

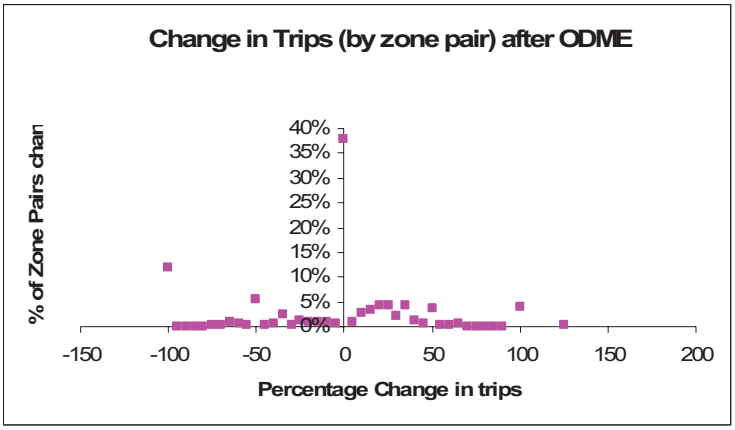


- *Changes to the OD matrix:* The range of change by total origin and destination trips of all affected OD pairs is as follows:

Percent Change	Origins Zones	Destination Zones	% Origins	% Destinations
No Change	259	300	10%	12%
Below 10%	1487	1249	58%	50%
10-25%	616	708	24%	28%
25-50%	100	122	4%	5%
50-100%	72	104	3%	4%
100-200%	13	15	1%	1%

Percent Change	Origins Zones	Destination Zones	% Origins	% Destinations
Above 200%	14	21	1%	1%

- *Change by zone pair:* A histogram of the change in AM Peak Hour trips by percent of zone pair in each range is shown in the chart below. About 40% of the trips do not change and 15% of the cells decrease by 100%.



- *Changes in County to County Trips:* The difference in County to County trips due to trip adjustments of the Bay Bridge ODME is summarized below. It is interesting to note that the even trips between counties that should not be affected by the Bay Bridge ODME like San Mateo to Santa Clara, which are slightly affected by 4%. Also Sonoma to Napa – OD pairs that presumably would not use the bridge – decreases 19%. On the other hand, trips from Alameda to Contra Costa do not change at all. One reason for this might be the adjustments made to OD trips not passing through target counts as shown in Equation 1 of the ODME methodology in Figure 2.

			Destination County							
Origin County	*San Francisco*	*San Mateo*	*Santa Clara*	*Alameda*	*Contra Costa*	*Solano*	*Napa*	*Sonoma*	*Marin*	*TOTAL*
San Francisco	14%	-5%	-21%	-8%	-22%	-21%	-20%	-25%	-19%	6%
San Mateo	-10%	8%	-4%	-9%	-24%	-19%	-20%	-23%	-11%	3%
Santa Clara	-20%	5%	4%	1%	-9%	-5%	9%	11%	15%	4%
Alameda	-50%	-18%	-19%	8%	0%	-23%	-15%	-10%	-6%	2%
Contra Costa	-54%	-31%	-24%	-3%	0%	-1%	-10%	10%	0%	-3%
Solano	-40%	-45%	-14%	-5%	-4%	18%	22%	15%	15%	11%
Napa	-45%	-37%	-10%	-27%	-18%	4%	11%	3%	-3%	8%

	Destination County									
Origin County	*San Francisco*	*San Mateo*	*Santa Clara*	*Alameda*	*Contra Costa*	*Solano*	*Napa*	*Sonoma*	*Marin*	*TOTAL*
Sonoma	-48%	-51%	-17%	-36%	-27%	-20%	-19%	10%	-14%	5%
Marin	-24%	-29%	-27%	-17%	-20%	-13%	-13%	15%	9%	1%
TOTAL BAY AREA	-6%	3%	2%	2%	-1%	12%	8%	10%	4%	3%

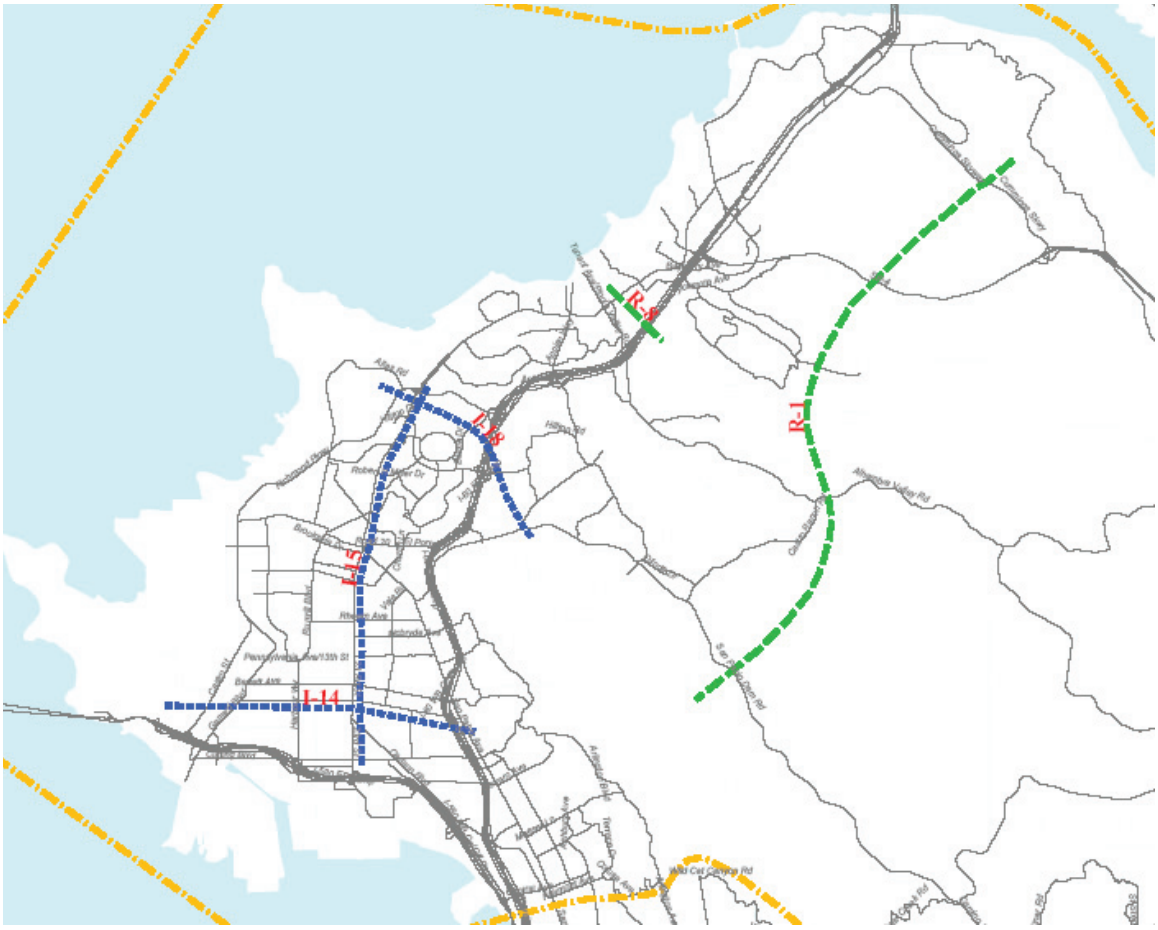
Single Screenline Tests

I-15: Richmond San Pablo: The only screenline not within 15% of validation counts is I-15 in the PM Peak Hour. So, this screenline was selected for testing the ODME process for a single screenline. Further, to reduce the time taken to run ODME, a subarea of all West County zones was created and the ODME process was tested on the subarea. Figure 4 shows the screenlines in West County. Screenline I-15 runs north to south, parallel and to the west of I-80.

The following ODME scenarios were tested for Screenline I-15 on the West County Subarea:

1) Use only the I-15 counts as targets
2) Use the I-15 counts as targets, plus use the model volumes as subarea externals (from the complete model) with heavy weighting. This enables a user to modify a subarea and still be consistent with the model outside the subarea.
3) ODME on I-15 using actual counts (R1 and Cordon) as subarea externals with heavy weighting.
4) ODME on I-15 using actual counts (R1 and cordon) as subarea externals with heavy weighting and a maximum factoring or 10%
5) ODME on I-15 using actual counts (R1 and cordon) as subarea externals with heavy weighting and a maximum factoring or 50%
6) ODME on I-15 using actual counts (R1 and cordon) as subarea externals with heavy weighting and a maximum factoring or 100%
7) ODME on I-15 using actual counts (R1 and cordon) as subarea externals with heavy weighting and a maximum factoring or 200%

Figure 4: Internal and Regional Screenlines in West County



Results:

- *Impact on target area and surrounding area*: A comparison of ODME I-15 is shown in the table below:

Screenline										
No.	Name	2000 PM Count	I-15 2000 Validation	I-15 ODME No Externals	I-15 ODME with External Model Volumes	I-15 ODME with External Counts	I-15 ODME with External Counts (Max Change 10%)	I-15 ODME with External Counts (Max Change 50%)	I-15 ODME with External Counts (Max Change 100%)	I-15 ODME with External Counts (Max Change 200%)
I14	Richmond	21,520	4%	-12%	1%	-1%	-16%	-12%	-7%	-1%
I15	Rich/Sanpb	13,039	-16%	5%	0%	-1%	-30%	-18%	-13%	-1%
I18	Pinole/County	21,193	9%	-4%	8%	0%	-11%	-7%	-3%	0%
Cordon	Cordon Line	23,446	-3%	-22%	-5%	0%	-20%	-15%	-9%	0%
R1	West/Central	6,090	-2%	-17%	-4%	-1%	-19%	-11%	-9%	-1%
R8	S.C West	17,711	1%	-16%	-4%	-13%	-19%	-16%	-13%	-13%

All Screenlines in West County

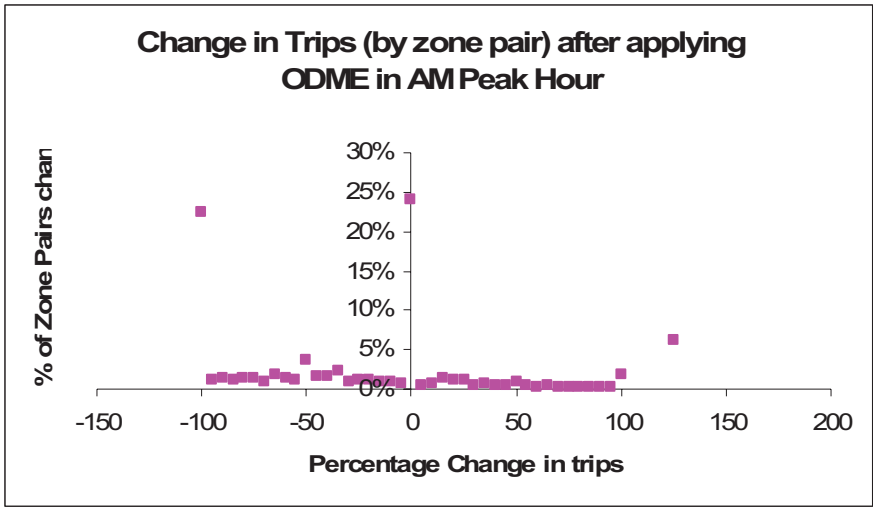
The ODME process was tested for all counts in West County using R1 and Cordon counts in West County with heavy weighting.

Results:

- *Impact on targets* : A comparison of ODME results for all west county screenlines is shown in the table below.

Screenline				
No.	Name	2000 PM Count	2000 Validation % Diff	ODME All West County Screenlines
I14	Richmond	21,520	4%	1%
I15	Rich/Sanpb	13,039	-16%	-2%
I18	Pinole/County	21,193	9%	-5%
Cordon Line	Cordon Line	23,446	-3%	-1%
R1	West/Central	6,090	-2%	-7%
R8	S.C West	17,711	1%	-5%

- *Change by zone pair:* A histogram of the change in AM Peak Hour trips by percent of zone pair in each range is shown in the chart below. About 25% of the cells do not change at all and 22% of the OD trips are reduced to zero.



All Screenlines in Contra Costa County

Following tests for the subarea level, the full model was run using all screenline counts as targets in the AM Peak Hour, with no factoring and no normalization.

Results:

- *Impact on targets*: The ODME process produced good results for all the screenlines in the AM peak hour. The screenline comparison report is shown in below.

Internal Screenlines

Screenline		AM PEAK HOUR				
No.	Name	2000 AM Count	2000 AM ODME	2000 AM Model	ODME % Diff	Validation % Diff
I1	SR 4	23,967	23,490	26112	-2%	9%
I2	Concord	29,027	28,551	30312	-2%	4%
I3	Orinda	16,523	15,668	17171	-5%	4%
I4	I-680	39,372	40,021	36460	2%	-7%
I5	Treat	34,701	33,828	36244	-3%	4%
I6	Ygnacio	29,072	28,142	29641	-3%	2%
I7	SR24	5,356	5,141	4873	-4%	-9%
I8	Walnut Creek	27,465	27,083	30318	-1%	10%
I9	San Ramon	14,779	14,261	14907	-4%	1%

Screenline		AM PEAK HOUR				
No.	Name	2000 AM Count	2000 AM ODME	2000 AM Model	ODME % Diff	Validation % Diff
I10	Danville(NB / SB)	7,002	6,790	7118	-3%	2%
I11	Danville (EB / WB)	7,564	7,438	6955	-2%	-8%
I12	Antioch/Brentwood	6,727	6,699	6555	0%	-3%
I13	Oakley/Brentwood	6,412	6,443	6951	0%	8%
I14	Richmond	21,176	21,268	21785	0%	3%
I15	Rich/Sanpb	16,118	16,232	14890	1%	-8%
I16	I-580	23,939	23,262	22394	-3%	-6%
I17	West Livermore	20,486	19,962	20713	-3%	1%
I18	Pinole/County	20,701	19,296	22568	-7%	9%
TOTAL – Internal		18 of the 18 Screenlines meet target				18 of 18 Meet Target
		350,387	343,575	355967	-2%	2%

Regional Screenlines

Screenline		AM PEAK HOUR				
No.	Name	2000 AM Count	2000 AM ODME	2000 AM Model	ODME % Diff	Validation % Diff
Cordon Line	Cordon Line	86,122	83,057	82390	-4%	-4%
R1	West/Central	5,743	5,734	6166	0%	7%
R2	Lamorinda	21,069	19,132	19652	-9%	-7%
R3	TriValley	16,823	15,984	19670	-5%	17%
R4	Central/East	16,872	15,866	18483	-6%	10%
R5	S.C Central	6,627	6,374	7171	-4%	8%
R6	S.C East	12,553	12,442	14246	-1%	13%
R7	S.C Tri Valley	14,486	13,705	14671	-5%	1%
R8	S.C West	16,359	15,201	18005	-7%	10%
R9	Alameda County	21,661	21,657	21617	0%	0%
R10	Sunol	9,450	9,506	10243	1%	8%
R11	Greenville	10,641	10,574	10809	-1%	2%
TOTAL – Regional		12 of the 12 Screenlines meet target				10 of 12 Meet Target

Screenline		AM PEAK HOUR				
No.	Name	2000 AM Count	2000 AM ODME	2000 AM Model	ODME % Diff	Validation % Diff
		238,406	229,232	243123	-4%	2%
GRAND TOTAL		588,793	572,807	599090	-3%	2%

All Available Counts

Following tests for just the screenline counts, the full model was run using all available screenline and intersection counts as targets, with no factoring and no normalization. Since the main concern was to hit all screenline targets using ODME, screenline counts were weighted higher than intersection counts.

Results:

- *Impact on targets*: The ODME process produced very good link level validation results for all screenline and intersection counts. The screenline report and the validation are shown below.

Comparison of Screenline Report with and without ODME

Internal Screenlines

Screenline		AM PEAK HOUR					PM PEAK HOUR				
No.	Name	2000 AM Count	2000 AM ODME	2000 AM Model	ODME % Diff	Validation % Diff	2000 PM Count	2000 PM ODME	2000 PM Model	ODME % Diff	Validation % Diff
I1	SR 4	23,967	26,330	26112	10%	9%	25,623	28,274	27876	10%	9%
I2	Concord	29,027	29,440	30312	1%	4%	31,414	31,990	31692	2%	1%
I3	Orinda	16,523	18,023	17171	9%	4%	15,887	16,667	17229	5%	8%
I4	I-680	39,372	41,863	36460	6%	-7%	43,621	41,648	39581	-5%	-9%
I5	Treat	34,701	36,009	36244	4%	4%	36,840	37,527	38556	2%	5%
I6	Ygnacio	29,072	28,491	29641	-2%	2%	30,089	30,640	31594	2%	5%
I7	SR24	5,356	5,508	4873	3%	-9%	5,717	5,428	5709	-5%	0%
I8	Walnut Creek	27,465	28,568	30318	4%	10%	29,867	32,953	33122	10%	11%
I9	San Ramon	14,779	14,232	14907	-4%	1%	15,943	15,888	16317	0%	2%
I10	Danville(NB / SB)	7,002	7,535	7118	8%	2%	7,241	7,678	7006	6%	-3%
I11	Danville (EB / WB)	7,564	7,928	6955	5%	-8%	7,667	7,892	8039	3%	5%
I12	Antioch/Brentwood	6,727	7,301	6555	9%	-3%	7,918	8,173	7877	3%	-1%
I13	Oakley/Brentwood	6,412	6,888	6951	7%	8%	7,539	7,932	7858	5%	4%
I14	Richmond	21,176	23,335	21785	10%	3%	21,520	23,762	22378	10%	4%
I15	Rich/Sanpb	16,118	15,968	14890	-1%	-8%	18,589	19,228	15672	3%	-16%
I16	I-580	23,939	25,721	22394	7%	-6%	26,507	25,420	24304	-4%	-8%
I17	West Livermore	20,486	18,877	20713	-8%	1%	21,015	20,258	22956	-4%	9%
I18	Pinole/County	20,701	22,100	22568	7%	9%	21,193	23,084	23067	9%	9%
TOTAL - Internal		**18 of the 18 Screenlines meet target**				**18 of 18 Meet Target**	**18 of the 18 Screenlines meet target**				**16 of 18 Meet Target**
		350,387	**364,117**	**355967**	**4%**	**2%**	**374,190**	**384,442**	**380833**	**3%**	**2%**

Regional Screenlines

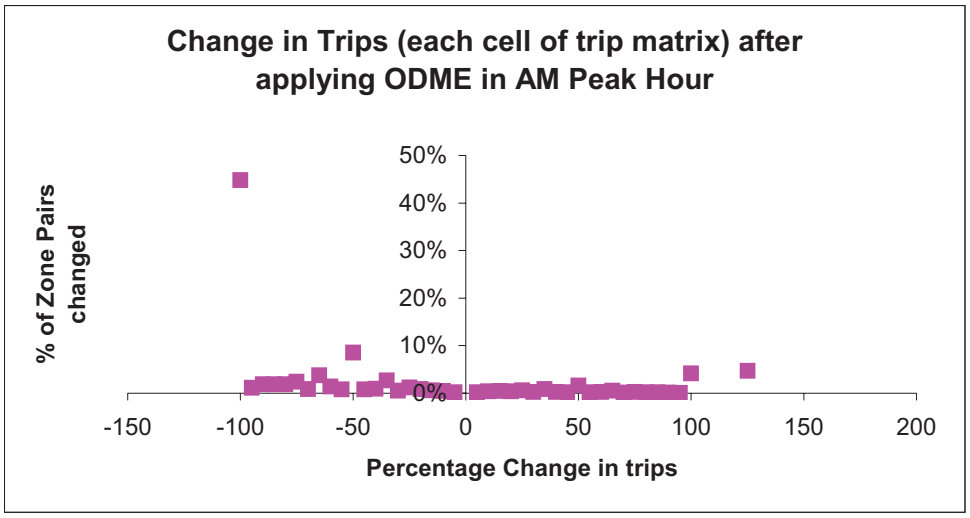
Screenline		AM PEAK HOUR					PM PEAK HOUR				
No.	Name	2000 AM Count	2000 AM ODME	2000 AM Model	ODME % Diff	Validation % Diff	2000 PM Count	2000 PM ODME	2000 PM Model	ODME % Diff	Validation % Diff
Cordon	Cordon Line	86,122	82,801	82390	-4%	-4%	90,766	87,980	88141	-3%	-3%
R1	West/Central	5,743	5,668	6166	-1%	7%	6,090	5,618	5969	-8%	-2%
R2	Lamorinda	21,069	19,789	19652	-6%	-7%	20,174	20,419	21372	1%	6%
R3	TriValley	16,823	16,149	19670	-4%	17%	17,989	16,669	19386	-7%	8%
R4	Central/East	16,872	16,208	18483	-4%	10%	17,268	16,921	18579	-2%	8%
R5	S.C Central	6,627	7,243	7171	9%	8%	7,408	7,688	8136	4%	10%
R6	S.C East	12,553	13,952	14246	11%	13%	14,355	14,817	15846	3%	10%
R7	S.C Tri Valley	14,486	13,134	14671	-9%	1%	15,147	13,947	15535	-8%	3%
R8	S.C West	16,359	17,238	18005	5%	10%	17,711	17,706	17967	0%	1%
R9	Alameda County	21,661	20,105	21617	-7%	0%	18,731	18,005	18553	-4%	-1%
R10	Sunol	9,450	9,570	10243	1%	8%	11,894	11,634	12917	-2%	9%
R11	Greenville	10,641	11,300	10809	6%	2%	11,587	12,033	11959	4%	3%
TOTAL - Regional		**11 of the 12 Screenlines meet target, 1 is +/-15%**				**10 of 12 Meet Target**	**12 of the 12 Screenlines meet target**				**12 of 12 Meet Target**
		238,406	**233,157**	**243123**	**-2%**	**2%**	**249,120**	**243,437**	**254360**	**-2%**	**2%**
GRAND TOTAL (Regional + Internal)		**588,793**	**597,274**	**599090**	**1%**	**2%**	**623,310**	**627,879**	**635193**	**1%**	**2%**

Link Based Validation Report with and without ODME

Facility Type and Criteria	Number of Counts	Links Meeting Target	% of links within target with ODME	% of links within target (validation)	Validation Target
AM PEAK HOUR					
Freeway Links within 20%	75	72	96%	95%	75%
Freeway Links within 10%	75	70	93%	75%	50%
Arterials with 10,000+ ADT within 30%	86	81	94%	67%	75%
Arterials with 10,000+ ADT within 15%	86	67	78%	37%	50%
Intersections with 1000+ Vehicles per hr within 20%	609	514	84%	87%	50%
Intersections with 500-1000 Vehicles per hr within 20%	197	157	80%	82%	30%
All Intersections within 30% of Counts	893	807	90%	89%	75%
All Intersections within 15% of Counts	893	639	72%	76%	50%
80% of Freeway Counts below the Curve	61	48	79%	89%	80%
80% of Ramp Counts below the Curve	450	422	94%	78%	80%
Freeways and ramps	511	470	92%	79%	80%
PM PEAK HOUR					
Freeway Links within 20%	75	73	97%	81%	75%
Freeway Links within 10%	75	67	89%	68%	50%
Arterials with 10,000+ vehicles within 30%	86	84	98%	74%	75%
Arterials with 10,000+ vehicles within 15%	86	68	79%	44%	50%
Intersections with 1000+ Vehicles per hr within 20%	663	551	83%	86%	50%
Intersections with 500-1000 Vehicles per hr within 20%	164	125	76%	71%	30%
All Intersections within 30% of Counts	907	793	87%	53%	75%
All Intersections within 15% of Counts	907	617	68%	29%	50%
80% of Freeway Counts below the Curve	61	53	87%	82%	80%
80% of Ramp Counts below the Curve	450	412	92%	77%	80%
Freeways and ramps	511	465	91%	78%	80%

Three of the validation targets get worse using the ODME process: Intersections with 1000+ Vehicles per hr within 20%, Intersections with 500-1000 Vehicles per hr within 20%, and 80% of Freeway Counts below the Curve. All of these except the freeways below curve are still within the target criteria. This might be because of inconsistent screenline and intersection counts.

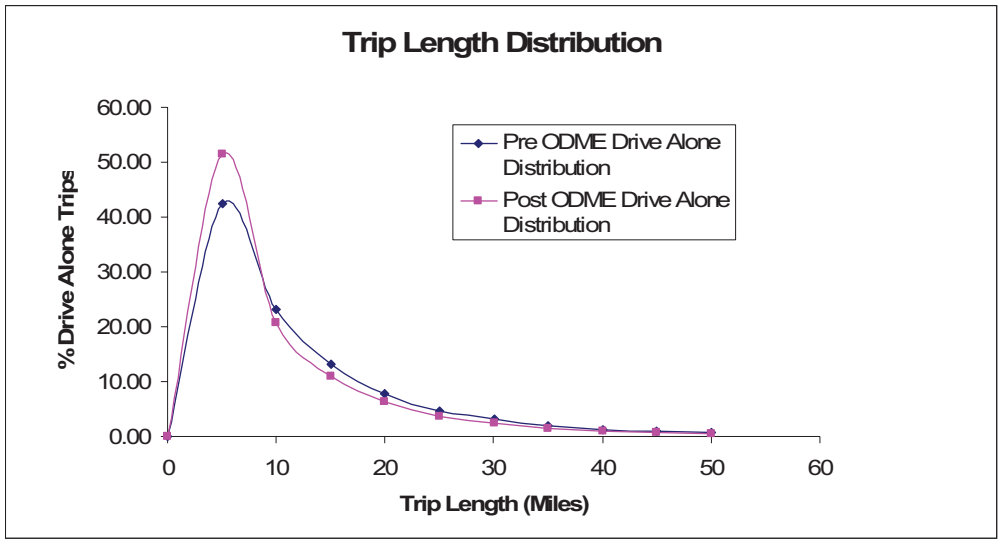
Change by zone pair: A histogram of the change in AM Peak Hour trips by percent of zone pair in each range is shown below. About 45% of trips by zone pair decrease by 100%.

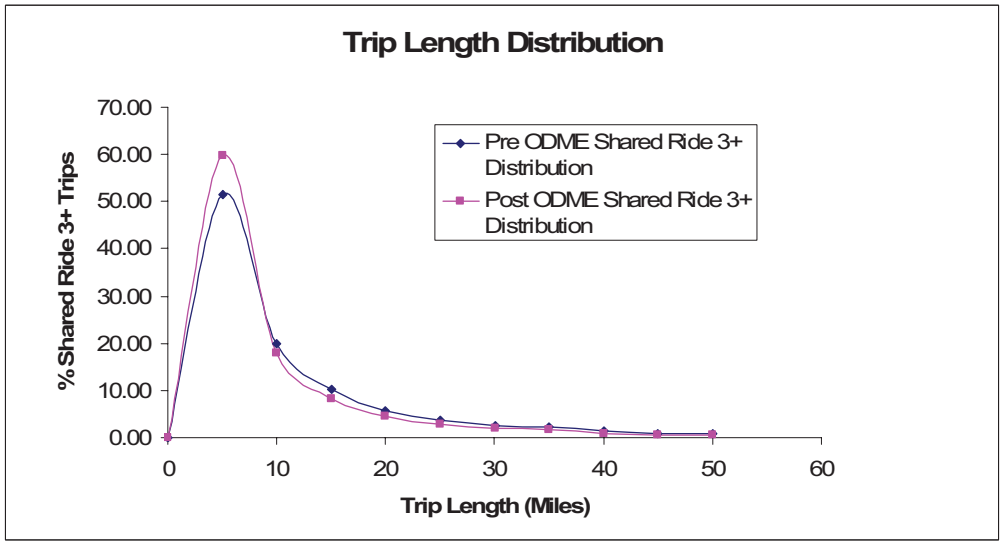


- *Changes to the OD matrix:* The range of change by total origin and destination trips of all affected OD pairs is as follows:

	AM Peak Hour				PM Peak Hour			
Percent Change	Origins Zones	Destination Zones	% Origins	% Destinations	Origins Zones	Destination Zones	% Origins	% Destinations
No Change	266	201	10%	8%	78	95	3%	4%
Below 10%	834	850	33%	34%	1038	1009	40%	39%
10-25%	204	171	8%	7%	185	268	7%	10%
25-50%	290	202	11%	8%	283	328	11%	13%
50-100%	320	276	12%	11%	362	363	14%	14%
100-200%	275	367	11%	15%	306	261	12%	10%
Above 200%	372	452	15%	18%	322	280	13%	11%

- Changes to the trip length distribution: At the December 14, 2005 TMWG meeting, a concern was raised regarding the impact of ODME on the trip length distribution. In response to this concern, DA developed the figures below to determine whether the trip-length distribution by mode was adversely affected by the ODME procedure. Shown below is a comparison of the pre- and post-ODME trip distribution for the ODME run with all available counts by Drive Alone and Shared Ride 3+ modes. The Matrix Estimation process seems to create more short length trips for both the Drive Alone and Shared Ride classes when compared to the distribution before adjustment. The effect is greater for the drive alone trips since they make up about 85% of all trips. This suggests that adjustments are made to closer O-D pairs contributing to a count rather than farther O-D pairs. However, the overall affect appears insignificant.





SUMMARY OF RESULTS

Overall, the ODME process in TransCAD 4.8 was able to match target counts very well. The pilot testing produced consistent results for all test cases. The ODME test using all screenline and intersection counts proves that it is a useful tool that can help reach closure on the remaining 7% of the validation targets as well as produce good link level validation results.

Some of the ODME adjustment parameters like normalization and factoring available in TransCAD 4.8 neither help in matching target counts nor maintain trip table consistency. In fact, these parameters as currently applied serve to reverse the benefits of the ODME adjustments. While both of these parameters serve as useful tools for other applications of TransCAD, they did not help toward achieving the specific ODME objectives we are pursuing here. To add utility for the CCTA application, both adjustment parameters would need to be applied during the matrix estimation process instead of after it. For example, if a maximum change factor of 50% is applied within ODME, the adjustment process will try to hit counts while making sure that no cell in the trip table goes over 1.5 times its value. The same factor, when applied after completion of the ODME procedure, restores all ODME-adjusted pairs to the 1.5 factor limit, without re-checking the assignment against the target value. As seen in the test cases for screenline I-15 in Richmond, the benefits attributable to ODME are reversed through this technique, consequently, use of factoring is not recommended. Similarly, normalization is not recommended for implementation in the CCTA method.

Use of the subarea windowing feature in TransCAD coupled with the ODME process proves to be a useful way to reduce run time for local validation applications, while maintaining consistency with the regional model. The dramatic decrease in the ODME run-time will be especially useful when numerous trial-and-error runs are required.

Weighting is another valuable parameter than can be used to prioritize target counts for ODME. Subarea ODME for West County using high weights for the cordon lines and lower weights for I-15 was within target not only for I-15 but also for other screenlines in West County, showing that the matrix adjustments were moving in the right direction.

Changes to the demand trip table during the ODME process are of particular concern. With a high number of target counts as the test case using all screenline and intersection counts, about 50% of the OD pair trips are zeroed out during

ODME. On the other hand, with a single target like the Bay Bridge, 40% of the cells are unchanged while 15% are zeroed out. However, at the zonal level, the in and out trips for a zone change by only 10% for more than half the zones. On the county level, depending on how regional the target count is, county-to-county trips may be affected as well, and should be monitored accordingly.

A further area of concern is the effect of ODME on the integrity of the trip-length distribution table. Based upon the above analysis, it appears that changes to the trip-length distribution are minimal. This suggests that ODME can be successfully implemented without disturbing the trip-length results, provided the model user implements ODME under conditions similar to those tested above, and consistent with established guidelines.

ODME IMPLEMENTATION GUIDELINES

Based upon the above investigation, the following guidelines are proposed for incorporation into the Authority's Technical Procedures, subject to review and approval by the TMWG and TCC:

- Use of ODME is an *optional* validation tool that may be invoked only after calibration and validation efforts have been conducted to the fullest extent feasible. *[We propose, as a guideline that90% of the screenlines should be within targets before the ODME tool is utilized.]* ODME should not be used to compensate for network and land use inaccuracies that cause poor traffic assignments. Rather, ODME is to be applied only as a refinement after all inputs to the model have been fully reviewed and can no longer be adjusted without deviating from the empirical inputs.
- The ODME process can provide a better match to traffic counts, but is not behaviorally-based and so is not recommended for implementation at a county-wide level. It can, however, be effectively applied at the subarea and local levelto provide a better fit with observed data. In tests performed on regional county-wide targets, it was observed that the benefits of ODME diminished as the number of targets increased. When the ODME procedure encounters large number of conflicting count data, the validation results tend to degrade, because the ODME process compromises the trip table to meet <u>all</u> of the input targets.
- The successful application of ODME at the subarea level also suggests that the procedure could be applied successfully to re-calibrate the model to a post-2000

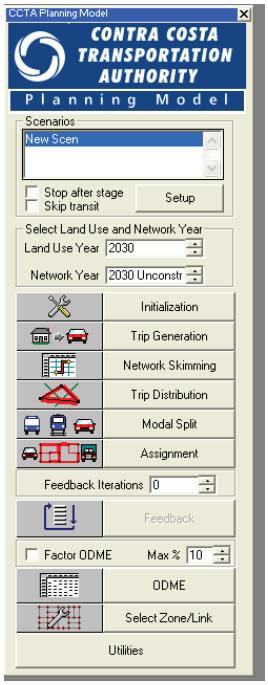
interim horizon year for which traffic counts are available within a particular study area.

- "Windowing" can be used to apply ODME to local areas. Subarea ODME helps in maintaining consistency with the regional model while improving local validation. This also reduces the run time dramatically because of a much smaller analysis data set. Because of consistency issues with the regional model, however, use of windowing was not supported by the TMWG.
- The number of count targets input by the model user is flexible. However, based on ODME tests conducted, a single target count,is not recommended For gateway constraint applications, a single directional peak hour link volume target should be accompanied by counts/model volume constraints at key strategic locations to preserve model validity. Weighting can be used to prioritize specific count targets over others. Use of selected targets, for example, one or multiple screenline targets can help address a specific validation issue within a specific study area. Alternatively, all available count data within a subarea can be input to improve overall validation. However, inconsistencies in the count data may interfere with achieving convergence. Conflicting count data may be the result of congestion, queuing, or variations in the time of day and/or the season during which adjacent counts were collected. Consequently, juxtaposing conflicting targets will result in fewer of the validation criteria being met, because the ODME matrix balancing process will be unable to achieve convergence for all targets.
- Applying ODME on a congested network might artificially lower the volumes to the constrained counts. Therefore, instead of using congested counts, which are generally low, it is recommended to set the target volume at maximum capacity on freeway locations experiencing recurrent congestion.
- In the absence of counts by mode, the ODME process setup for the CCTA Model applies matrix adjustments on the combined trip table and uses the original zonal level mode splits on the estimated trip table. If counts are available to the user by mode, it is advisable to use the 'Multi-Class ODME" process available in TransCAD to better assign multi-modal volumes on the network.
- To preserve the model's integrity, and to maintain consistency with the regional model, the model user should carefully evaluate the effect of ODME on the adjusted O/D trip table before applying the assignment results. O/D pairs that do not cross an ODME target screenline or count location should not be significantly affected by the ODME adjustment process. In addition, trip length distributions should be compared before and after ODME to ensure that traffic distribution patterns have not been compromised.

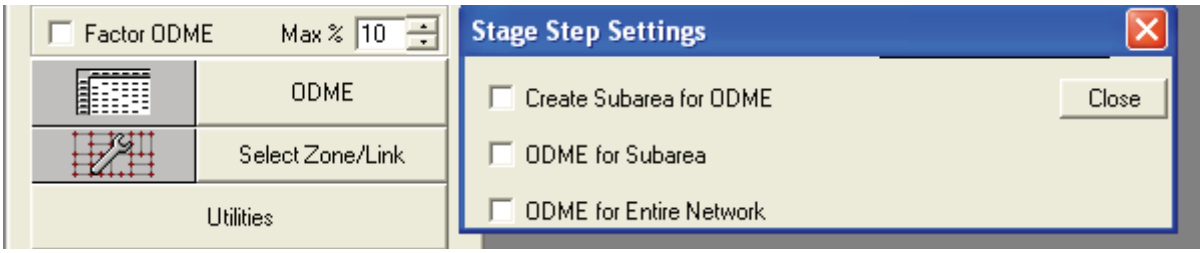
- The TransCAD interface will allow the model user to specify the number of iterations and the desired percentage convergence tolerance for the ODME procedure. This will determine running time for the ODME operation. *[Based on tests and discussions with Caliper Corporation, the recommended inner loop iterations are 50 and outer loop iterations are 20. A convergence percentage tolerance of 5% is sufficient.]*
- Adjustments to the future trip table should be made after ODME is successfully applied to the base year following the above guidelines. The difference between the original multi-modal trip table and the estimated trip table by mode shall be added to the unadjusted future trip table by mode. The adjusted future trip table should be re-assigned using Multi-Class Assignment in TransCAD to obtain the forecast volumes.

PROCEDURE FOR APPLYING ODME

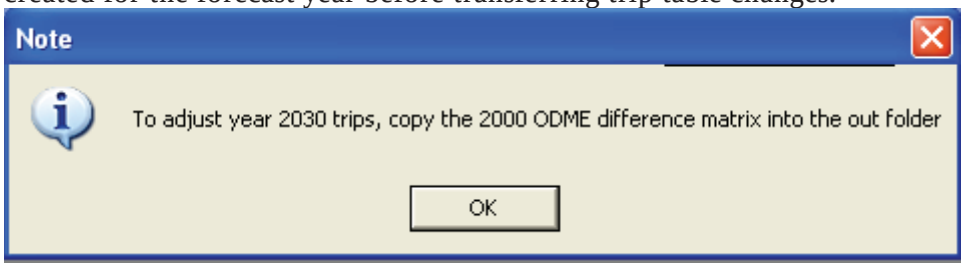
The following procedures will be included in the Model User's Guide as directions to run ODME:



- Run the "puristic" model validation for the base year (year 2000) from Initialization to Assignment. Any changes to the land use or model network should be made prior to running the model. Changes made after running the model and before running ODME will be ignored.
- Generate screenline report and validation report. Instructions to generate screenline reports are included in the User's Guide. Reproduce and check the results of the validation run against the Authority's model documentation. In case of changes to the model or local revalidation, 90% of the screenlines should be within targets.
- Input count targets and "weights" for counts by time period in a separate database by network link ID. A sample count table used for ODME is provided as part of the model files. If the user has count information by mode, then additional columns should be added to the database to include these counts.
- Using the user-interface, select and run the ODME process on the entire network or a subarea. If running ODME on a subarea, the "Create Subarea for ODME" process as shown below should be run earlier to the ODME step.



- Compute trip table differences before and after ODME. Create 9 county summaries if using the entire network. Compare tables and check for reasonableness.
- Check assignment differences for rationality of results and validation to count targets;
- Apply differences to forecast by running the same ODME step for the future year. The ODME difference trip table should be copied into the future year model run folder. In the absence of such a file, the process will provide the message below and hang. If running the Subarea ODME, a Subarea needs to be created for the forecast year before transferring trip table changes.



- Check forecast ODME assignment for reasonableness.

USING ODME TO ESTABLISH AN INTERIM BASELINE HORIZON YEAR

The Authority's model is validated to year 2000 traffic counts. The next decennial model update will involve a re-validation to 2010 traffic data. In the interim, model users may wish to use the model to test existing conditions, and forecast results, based upon post-2000 interim horizon year (say 2007) for which traffic counts are available within the study area. The ODME procedure could be a useful tool for quickly re-calibrating the year 2000 model run to a post-2000 interim set of counts, provided that overall regional consistency is preserved through a parallel interpolation process for the regionwide land use data set. To take advantage of this option, the following steps are recommended. These should be carried out consistent with the above ODME guidelines as outlined for conventional (Year 2000) applications.:

- The interim year model run should be developed using the fully validated pre-ODME year 2000 model run, and the corresponding 2010 model run.
- An interim-year land use data base should be developed by interpolating between 2000 and 2010. Alternatively, if land use analysis is not required, the vehicle trip tables for these two horizon years may be used as a basis for interpolation to a new base year.
- Run the interim base-year model through assignment to establish the pre-ODME interim assignment for (say) 2007.
- Assign target volumes for the study area, based upon actual counts.
- Run ODME on the interim horizon year assignment.
- Use the post-ODME results as the new interim-base year validation run.
- Apply the differences between pre-and post ODME vehicle trip table for the interim year to the forecast year.

EXHIBIT 1

Memorandum

TO: Martin Engelmann, CCTA

FROM: Maren Outwater and Vamsee Modugula, CS

DATE: April 12, 2005

RE: Application of Trip Table Estimation Techniques for the Contra Costa Countywide Travel Model

The objective of the calibration of the Contra Costa Countywide Travel Model was to capture travel behavior within Contra Costa County and match observed traffic and transit counts within the county, as well as to provide overall consistency with the MTC regional travel model. The validation standards established at an aggregate and screenline level all serve to achieve this objective. Additional objectives to have the model provide accurate link and turn-level volumes for subarea, corridor or site studies can be met by refining the model in these locations and further by implementing trip table estimation procedures to adjust model outputs to more closely match traffic counts. These trip table estimation procedures can provide a better match to traffic counts, but are not behaviorally-based so are not recommended at a county-wide level. Nonetheless, they can be applied and used for local area studies to provide a better fit with observed data.

There are a variety of trip table estimation techniques that have been tested and used in the transportation planning field over many years. One demonstration of this is discussed in a paper by Alan Horowitz[1]. Caliper Corporation has incorporated one of these techniques into the TransCAD software package, called Origin-Destination Matrix Estimation (ODME). TransCAD documentation presents a summary of the process, as follows:

> The O-D Matrix Estimation procedure in TransCAD is based on the work of Nielsen (1993), who independently developed it as a procedure for TransCAD 2.1. The method was re-implemented by Caliper Corporation. This method has the advantages of treating counts as stochastic variables, as well as working with any traffic assignment method. It therefore is attractive for use with the Stochastic User Equilibrium Assignment method, as well as with User Equilibrium Assignment. Nielsen's method is an iterative (or bi-level) process that switches back and forth between a traffic assignment stage and a matrix estimation stage. The procedure requires an initial estimate of the O-D matrix. This can be a default, be a prior estimate based upon survey measurements, or be synthetically generated (e.g., from a doubly-constrained trip distribution model). The success of this method is based upon use of a realistic traffic assignment model. Otherwise, a biased trip table will be produced. In practice, Nielsen's method appears to work quite well, and many users have reported good results with its use.

The TransCAD model documentation documents the process to implement this trip table estimation procedure in detail, and can be used to refine the model volumes for a corridor, small area, or traffic impact study by local jurisdictions. It was purposely not used to validate the countywide model, given the lack of behavioral realism in the procedure, but this is not considered to be a problem at a local level.

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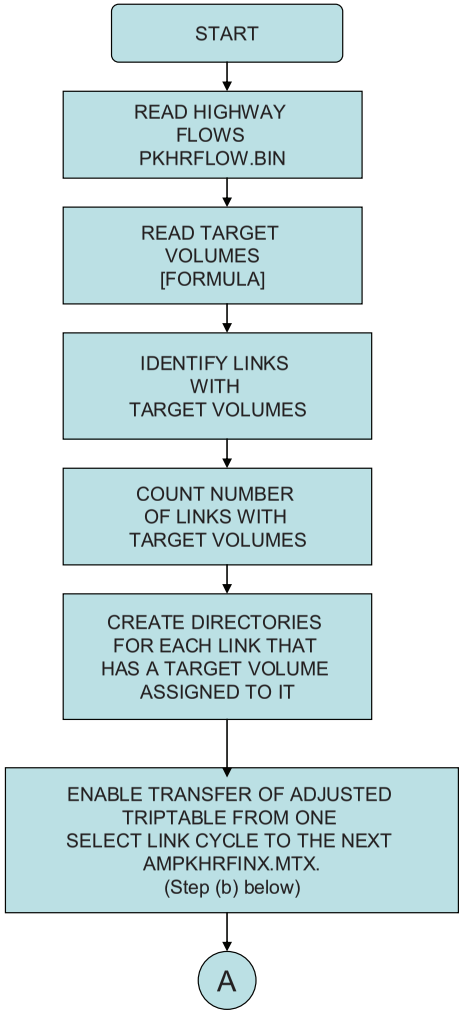
[1] Alan Horowitz, Tests of a Family of Trip Table Refinements for Long-Range, Quick-Response Travel Forecasting, Center for Urban Transportation Studies, University of Wisconsin – Milwaukee, http://www.uwm.edu/~horowitz/ODTableRefinement.pdf.

EXHIBIT 2

PROPOSED ODME PROCEDURE FOR CONTRA COSTA INCORPORATING THE GRADIENT APPROACH

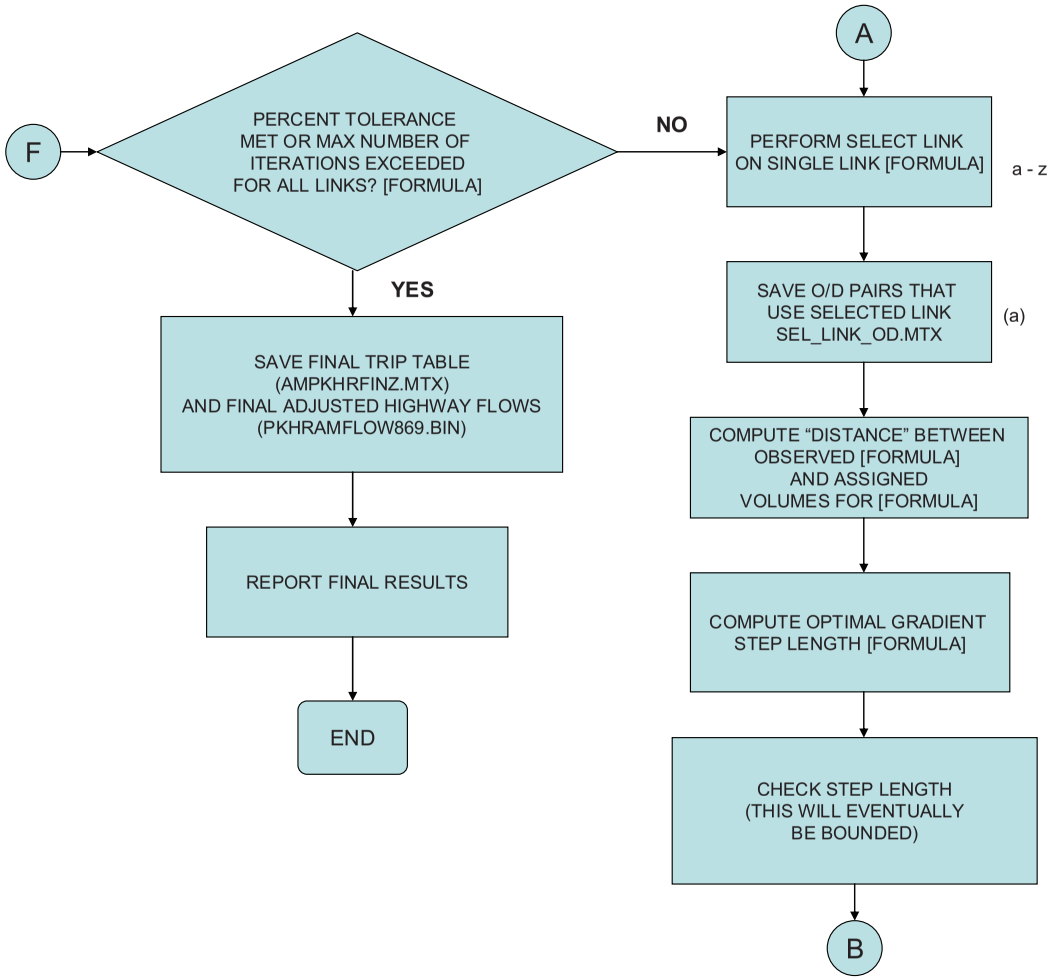


ASSIGNED VOLUMES = [FORMULA]

TARGET VOLUMES ARE THE OBSERVED VOLUMES [FORMULA]

[FORMULA]

HOW THE PROGRAM CYCLES THROUGH MULTIPLE SELECT LINKS IS TO BE DETERMINED: USE THE MOST EFFICIENT APPROACH -- EITHER 1) PERFORM ONE ITERATION ON EACH TARGET IN SERIES, OR 2) PERFORM MULTIPLE ITERATIONS ON A SINGLE TARGET TO CONVERGENCE.



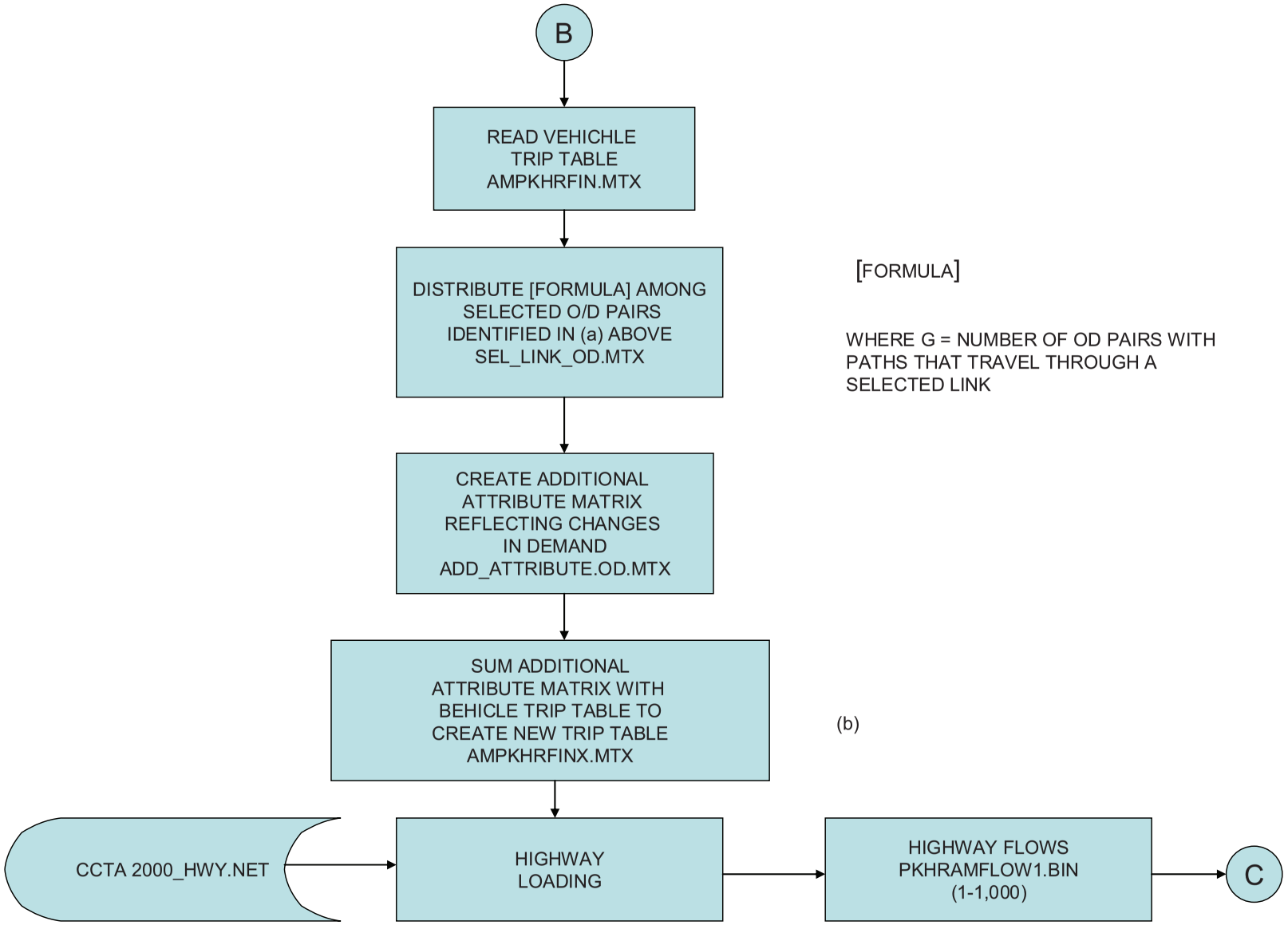
OBJECTIVE: MINIMIZE DISTANCE BETWEEN OBSERVED AND ASSIGNED VOLUMES

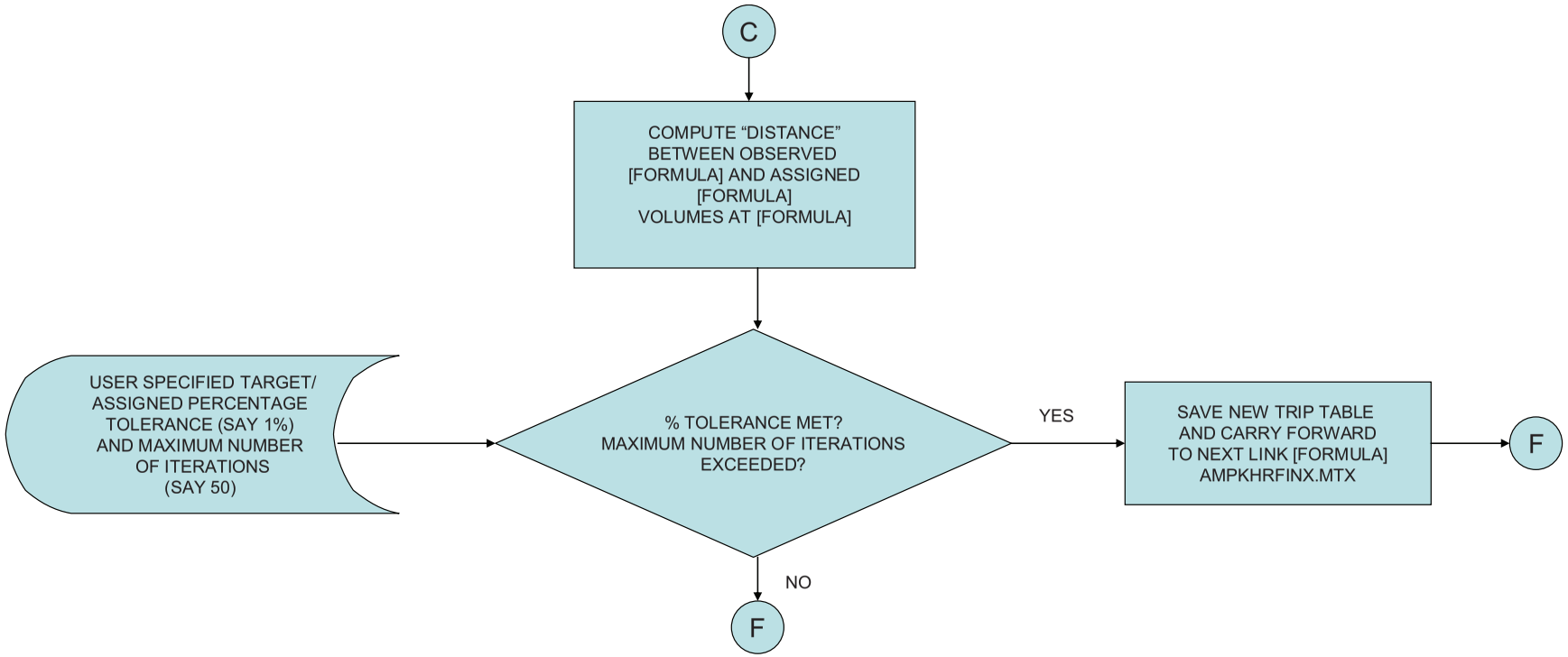
[FORMULA 1] (1)

[FORMULA 2] (2)

[FORMULA 16] (16)

[FORMULA 13] (13)


B
READ VEHICHLE TRIP TABLE AMPKHRFIN.MTX
DISTRIBUTE [FORMULA] AMONG SELECTED O/D PAIRS IDENTIFIED IN (a) ABOVE SEL_LINK_OD.MTX
[FORMULA]
WHERE G = NUMBER OF OD PAIRS WITH PATHS THAT TRAVEL THROUGH A SELECTED LINK
CREATE ADDITIONAL ATTRIBUTE MATRIX REFLECTING CHANGES IN DEMAND ADD_ATTRIBUTE.OD.MTX
SUM ADDITIONAL ATTRIBUTE MATRIX WITH BEHICLE TRIP TABLE TO CREATE NEW TRIP TABLE AMPKHRFINX.MTX
(b)
CCTA 2000_HWY.NET
HIGHWAY LOADING
HIGHWAY FLOWS PKHRAMFLOW1.BIN (1-1,000)
C


C
COMPUTE "DISTANCE" BETWEEN OBSERVED [FORMULA] AND ASSIGNED [FORMULA] VOLUMES AT [FORMULA]
USER SPECIFIED TARGET/ ASSIGNED PERCENTAGE TOLERANCE (SAY 1%) AND MAXIMUM NUMBER OF ITERATIONS (SAY 50)
% TOLERANCE MET? MAXIMUM NUMBER OF ITERATIONS EXCEEDED?
YES
SAVE NEW TRIP TABLE AND CARRY FORWARD TO NEXT LINK [FORMULA] AMPKHRFINX.MTX
F
NO
F

Appendix G – Guidelines for Application of Gateway Capacity Constraint Methodology

Appendix G
GATEWAY CAPACITY CONSTRAINT METHODOLOGY

Introduction

The methodology described in this section is an update of one developed during 1994 for the Authority by a technical working group comprised of both public and private sector transportation professionals. The group was charged with responding to a situation that commonly arises when using peak-hour travel forecasting demand models in high-growth "traffic sheds". Any of the available travel demand forecasting modeling software packages—TransCAD, CUBE, EMME/3, VISUM—can give projected peak-hour traffic volumes that significantly exceed estimated peak hour capacity on major freeway corridors. This phenomenon occurs even though these models use capacity-constraining algorithms when assigning traffic to a congested roadway network.

Where travel forecasting models predict that peak-hour volumes will exceed capacity, transportation planners have a good indication that congestion may occur at those locations. But it also raises a concern that the model has assigned too many trips to the highway network during the peak hour. In actual operations, a roadway cannot carry more vehicles than its capacity allows. Drivers must choose to wait in upstream queues, change their time of travel, shift modes, or elect not to travel. This section of the *Technical Procedures* presents a methodology for working with model output where projected volumes exceed capacity, and for constraining the model output in the framework of the travel demand forecasting model.

The Gateway Capacity Constraint Methodology (GCCM) provides a technique for adjusting model output downward where projected peak-hour volumes significantly exceed capacity on major corridors (or "gateways") serving a study area. Travel forecasting models generally assign peak-hour vehicle trips to the fastest, most direct route between origin and destination. Once those routes have become congested, the model assigns traffic to alternative, less convenient routes. As demand approaches capacity on all possible alternate routes, the model may continue to assign traffic to the congested routes, even when the demand exceeds capacity.

Where peak-hour volume model outputs exceed capacity, the model is predicting unrealistically high traffic levels and is failing to take into account the physical constraints at the study area "gateways". For example, in the Tri-Valley, the travel model results for future years may show forecasts of 12,000 vehicles per hour entering the Tri-Valley study area on I-580 over the Altamont Pass in the AM peak hour. I-580 is an eight-lane freeway at Altamont Pass (four-lanes each way) with a capacity of roughly 8,000 vehicles per hour in each direction. In this case the model results are 50 percent beyond the corridor's capacity. The model is simulating how trips converge on a congested gateway, then disperse to downstream facilities. It follows that if projected traffic at any point on the network is unrealistically high, then traffic levels assigned to downstream facilities would also be unrealistically high.

This methodology allows the analyst to specify "not to exceed" peak hour flows at gateways where clear future capacity limitations have been identified. To further constrain only specifically identified gateway links of the highway network, it is necessary to trace the path of each trip from the gateway onto downstream facilities, including freeways, ramps, arterials, and collector and local streets to its final destination. Because doing this by hand would be overly time consuming, this methodology is executed within the framework of the TransCAD modeling software.

Description of Methodology

TransCAD features an *ODME (Origin-Destination Matrix Estimation) procedure* that allows the user to constrain the peak hour vehicle trip OD table to the capacity of selected road links in the network. The ODME procedure is described in Section 8 of these procedures and in the Model Users Guide. The following steps describe how to implement the GCCM using ODME:

Step 1 A normal multi-class (SOV, HOV2, HOV3+) auto assignment is executed using the peak hour vehicle trip table (referred to below as the original O/D matrix). If this assignment results in raw output volumes that significantly exceed roadway capacity at study area gateways, the GCCM may be implemented.

Step 2 The user defines *target volumes* not to be exceeded on each gateway facility where overassignment has occurred.

Step 3 TransCAD ODME is used to reduce the original OD matrix so that the gateway volumes do not exceed the constraints. The resulting reduced OD tables (SOV, HOV2, HOV3+) are called the constrained OD tables

Step 4 The analyst performs a matrix comparison (Original minus Constrained) and totals the number of vehicles that could not be assigned during the peak hour. To the extent that the vehicles remain on the system, the number of unassigned vehicles is multiplied by one-hour to obtain total vehicle-hours of delay (VHD) to be added to the reported results for the constrained peak hour assignment.

Step 5 The analyst also compares the two peak hour assignments (Original minus Constrained) and reports the "unserved" peak hour demand by link.

Note: To apply the GCCM methodology to the base-year, and carry the results forward into the forecast year, please refer to the section on ODME contained in Section 8.

Criteria for Defining Gateways

THE STUDY AREA

The GCCM methodology should be applied only to relatively large traffic sheds. The suggested minimum size for a study area corresponds with the size of the five regional transportation planning areas established in Contra Costa: West County, Central County, East County, Lamorinda, and the Tri-Valley.

IDENTIFYING GATEWAYS

Application of the methodology should be restricted to locations where there is a clear limitation on the number of pathways and alternative routes into the study area. Gateway locations should be clearly defined. If commuters have an option of avoiding or bypassing a gateway by choosing an alternate route into the study

area, then the gateway should be defined to include both the main roadway and that alternative, albeit circuitous path. The methodology should not be applied to situations where the gateway screenline is physically broad and numerous alternate routes may be used to enter or leave the study area through the gateway.

Some of the well-defined gateways located in Contra Costa and Alameda Counties that meet these restrictions are listed below:

I-580 Altamont Pass
The Carquinez Straits (the gateway should include both the Carquinez and the Benicia-Martinez Bridges)
I-680 at Scotts Corner (south of State Route 84)
I-680 in Walnut Creek at Rudgear Road
The Caldecott Tunnel

Application of this methodology should be made in consultation with RTPC and Authority staff.

ELIGIBLE GATEWAY TRIP REDUCTIONS

This methodology is intended to reflect the physical limitations on the number of vehicles that can enter or leave a study area through a gateway in a given peak hour. Due to inherent capacity constraints at the gateway, some peak hour trips that originate outside of the study area physically cannot reach their destination within the study area. Using the TransCAD® modeling software, these trips are "stripped" from the network by removing them from the O/D matrix vehicle trip tables. On the other hand, trips with origins inside the study area are not physically restricted from entering the network and attempting to reach destinations outside of the study area via the gateway. Therefore, corresponding reverse-peak-hour trips that originate within the study area are treated differently than trips that originate outside of the study area.

The GCCM may be applied to trips that originate outside of the study area as follows:

- AM peak hour home-based work trips to employment centers within the study area
- PM peak hour home-based work trips to residences within the study area

The GCCM also applies to the following trips that originate within the study area:

- AM peak hour home-based work trips destined to jobs located outside the study area
- PM peak hour home-based work trips destined to households outside the study area

Setting a Target Volume for Gateway Capacity

Application of this methodology requires that the total capacity of freeways and parallel arterials serving the gateway corridor be assessed. In the assignment procedure, the model may have overassigned traffic onto the freeway, but underassigned it to parallel arterials. A *target volume* is calculated for the main facility, taking into account unused capacity on parallel arterials. Target volumes are calculated differently depending on whether traffic is entering or exiting through the gateway.

SETTING TARGET VOLUMES FOR TRIPS THAT ORIGINATE OUTSIDE OF THE STUDY AREA

For trips that originate outside of the Study Area, the *target volume* should be calculated using the following formula:

$$G = (1.05)C_f + (C_a - A_a)$$

Where:

- G = The *target volume* specified as peak hour capacity of the gateway's primary facility in vehicles per hour. A factor of 1.05 is applied to reflect LOS F at the gateway.
- C_f = Capacity of the primary facility (usually a freeway) calculated using the *Highway Capacity Manual* or observed volumes if higher.
- C_a = Capacity of parallel arterials
- A_a = Forecast volume on parallel arterials

The $(C_a - A_a)$ function accounts for the possibility that at the gateway the model may have overassigned trips to the freeway, and underassigned trips to parallel arterials. Planners have the option of rerunning the assignment in an attempt to achieve balanced saturation on all links at the gateway. The $(C_a – A_a)$ function reduces the need for this by quantifying remaining gateway capacity and including it in the calculation of peak-hour gateway capacity.

Because the specified *target volume* exceeds capacity, the resulting assigned volumes will also exceed capacity, but to a far lesser extent than before capacity constraints were imposed. The remaining excess demand on the primary facility is intended to reflect a LOS F condition at the gateway.

SETTING TARGET VOLUMES FOR TRIPS THAT ORIGINATE WITHIN THE STUDY AREA

Although the GCCM may be applied to trips that originate within the study area, the process of setting Target Volumes is different from the process for trips that originate outside of the study area. The following principles are used to select the appropriate target volume:

- It is assumed, based upon available surveys conducted in the Bay Area, that commuters will endure a maximum of 20 minutes of delay at the gateway. The delay may be incurred at the freeway ramps or on the freeway proper in proximity to the gateway. Additional delay may be incurred either prior to entering the freeway, or after leaving the study area. The additional delay is not included as part of the 20-minute delay experienced at the gateway.
- Calculation of the target volume that results in a 20-minute delay depends upon the degree to which the vehicle arrival rate at the gateway exceeds the gateway capacity and the duration of time that the condition exists.

METHODOLOGY

Develop 24-hour profiles for existing conditions at the gateway location.

Develop a projected 24-hour profile by raising the existing profile based upon the percentage increase in peak hour traffic as forecast by the model for the future year scenario. By raising the profile, the duration of time for which demand exceeds capacity will increase.

For the forecast year, determine the duration of time during which volume exceeds capacity based upon the projected 24-hour profile.

Estimate the average v/c for that period (i.e. keep the duration of time for which v/c exceeds 1.0 constant, and calculate the average v/c that equates to the volume of traffic that exceeds capacity for a fixed duration.) The area of the profile that exceeds v/c of 1.0 must be transformed from a triangular shape to a rectangle, as shown in Figure 10.

Use the formula below to estimate "G", the target volume. In the formula, "v/c" varies depending upon the duration of time that volume exceeds capacity. Use either Table 1 or Figures 1 and 2 to estimate the value of v/c that equates to a 20-minute delay at the gateway:

$G = (v/c)C_f + (C_a - A_a)$

Where:

G = The *target volume* specified as peak hour capacity of the gateway's primary facility in vehicles per hour.

v/c= The average volume-to-capacity ratio required to cause a 20-minute delay, based upon the duration of congestion as determined from Table 1 below.

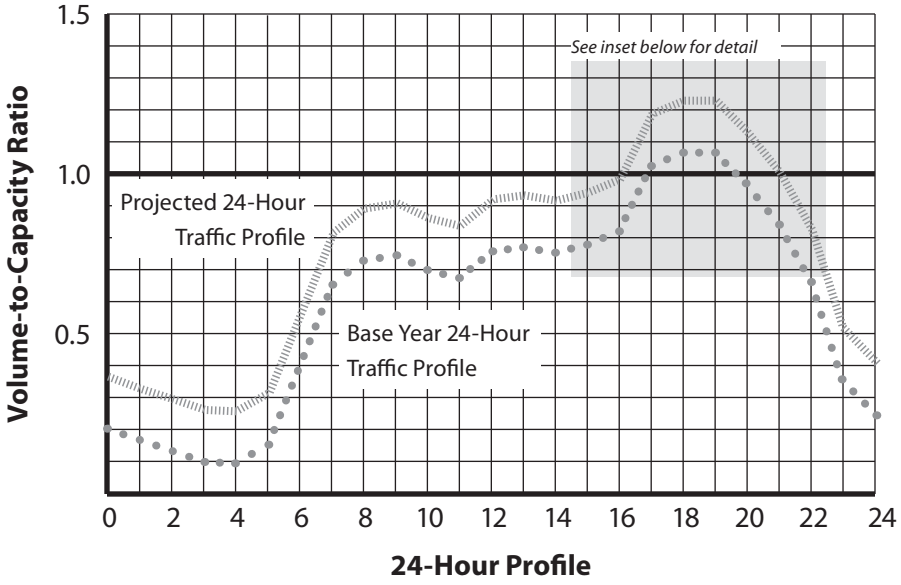
C_f = Capacity of the primary facility (usually a freeway)

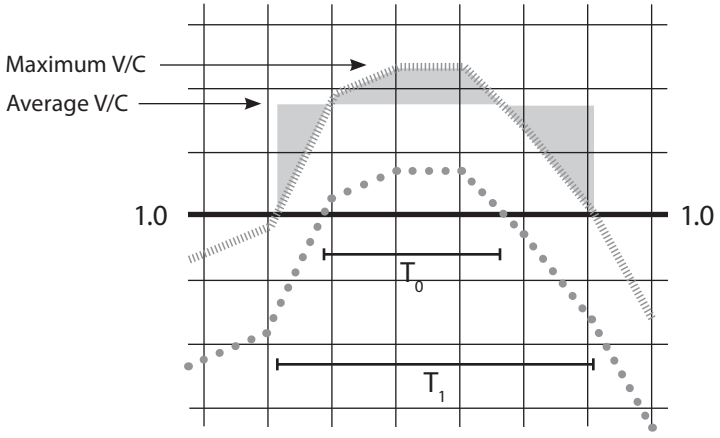
C_a = Capacity of parallel arterials

A_a = Forecast volume on parallel arterials

Table 1: Estimation of V/C for Use in Determining the Target Volume for Gateway Constraint

Duration of time v/c > 1.0	*Average v/c*
1 hour	1.33
2 hours	1.17
3 hours	1.11
4 hours	1.08
5 hours	1.05





T_0 = Duration of time that demand exceeds capacity in the base year

T_1 = Duration of time that demand exceeds capacity in the projected year

Figure 1

Estimating Average V/C During Time that Demand Exceeds Capacity

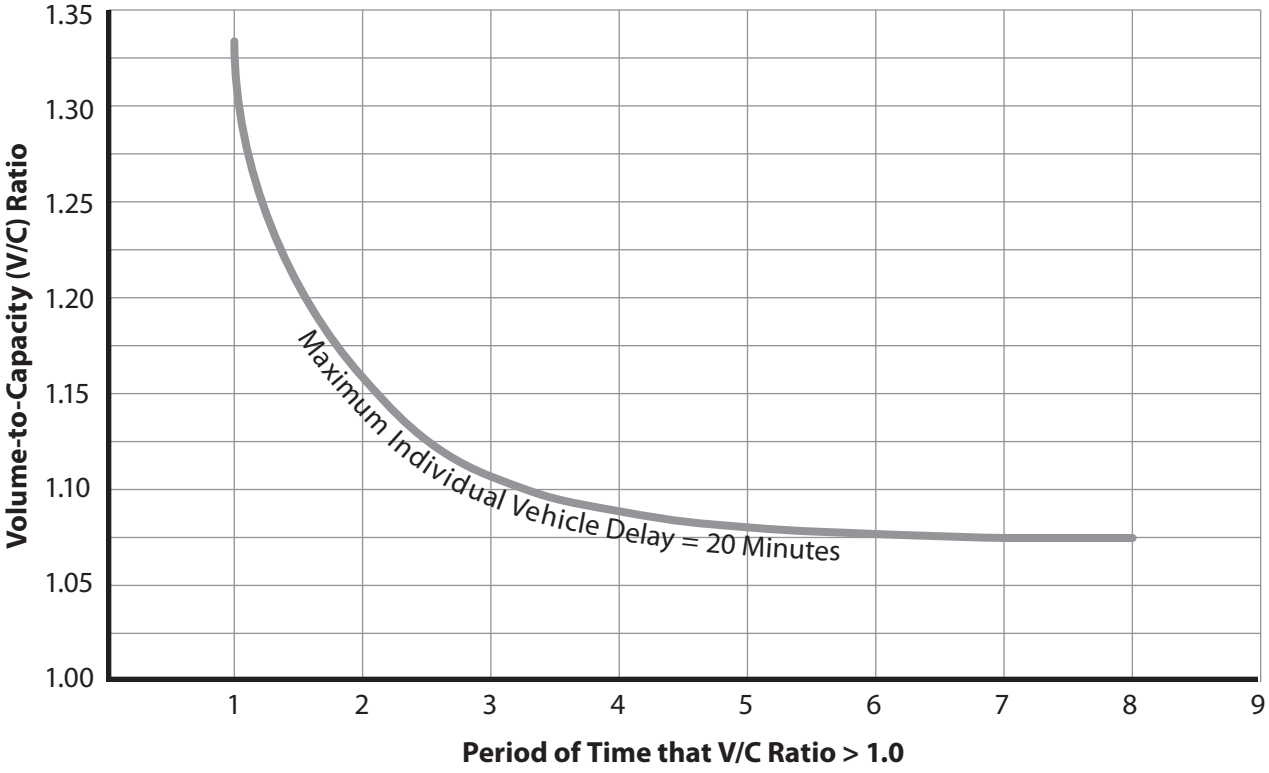


Figure 2

Correlating a 20-Minute Delay to an Estimated Volume-to-Capacity Ratio

EXAMPLES:

If, according to the projected 24-hour profile, v/c exceeds 1.00 for one hour, then the GCCM may only be applied if the *average v/c* during that hour is greater than 1.33. In this case the *target volume* should be set at 1.33 times the capacity at the gateway. If the v/c is less than 1.33, then the GCCM should not be applied.

If v/c exceeds 1.00 for two hours, then the GCCM may only be applied if the *average v/c* for that two-hour period is greater than 1.17. If the average v/c is less than 1.17, then the GCCM does not apply.

If, according to the projected 24-hour profile, v/c exceeds 1.00 for three hours, then the GCCM may only be applied if the *average v/c* during that three-hour period is greater than 1.11. In this case the *target volume* should be set at 1.11 times the capacity at the gateway. If the average v/c for the three-hour period is below 1.11, then the GCCM should not be applied.

If, according to the projected 24-hour profile, the duration of time for which v/c exceeds 1.00 is four hours, then the GCCM may only be applied if the *average v/c* during that four-hour period is greater than 1.08. In this case the *target volume* should be set at 1.08 times the capacity at the gateway. If the average v/c for the four-hour period during which v/c exceeds 1.00 is below 1.08, then the GCCM should not be applied.

If the projected 24-hour profile indicates that v/c will exceed 1.00 for five hours or longer, then the following formula should be used. This is the same formula specified for determining the *target volume* for trips that originate outside of the study area:

$$G = (1.05)C_f + (C_a - A_a)$$

FEEDBACK LOOPS

Application of the gateway constraint methodology inevitably raises the question: "What happens to trips that are removed from the peak hour forecast?" The methodology gives planners some latitude to the number of trips that will be removed, and these guidelines do not establish, either in percentage or actual terms, limits on gateway reductions. It is therefore imperative that, concurrent with the use of this methodology, possible effects the gateway constraint phenomenon might have "feedback" into the planning process. Suggested feedback loops that should be addressed are listed below:

Peak hour spreading and duration of congestion. The initial peak hour percentage and assumptions about the duration of congestion based upon the original O/D assignment should be documented and compared with the final peak hour percentage and duration of congestion resulting from the GCCM. If the ratio of peak hour volumes to average daily traffic has dropped below currently observed nationwide data, the future conditions scenario should be reevaluated. Peak-hour percentages can range from six to 12 percent. A 4.2 percent peak hour factor reflects a 24-hour duration of congestion, which is unlikely to occur.

Trip distribution. If the peak hour demand predicted by the model at the gateways is vastly greater than the gateway capacity, then the trip distribution model should be checked to determine why it is pairing origins and destinations that are separated by a high impedance network. Consistency with the Metropolitan Planning Organization's (MPO) trip distribution should be verified.

Queuing. It could be assumed that some or all of the vehicles that have been constrained from the assignment are in queue outside of the study area upstream of the gateway location. The length and duration of the queue should be analyzed and documented. Comparisons to the queues that resulted from the initial O/D assignment should be provided.

Modal shifts. The model should account for any modal shifts to carpools, vanpools, or transit. Treatment of modal split for trips external to the study area should be checked.

In addition, decision makers should be informed of the consequences that gateway constraints may have on land use development potential. Reduced accessibility and lack of mobility could change long-range market trends in land use development. These trends need to be identified and communicated to the appropriate policy forum. If planned development results in congestion at the study area gateways, longer duration of congestion, periods of delay exceeding 20 minutes, then the extent and nature of the planned development may be altered.

Appendix H – Regional and Internal Screenline Comparisons

CCTA Model Validation Table 1. Year 2000 Peak Hour Screenlines

2000 CCTA Peak Hour Screenlines

Internal Screenlines

Screenline		AM PEAK HOUR			PM PEAK HOUR		
No.	Name	2000 AM Count	2000 AM Model	% Diff	2000 PM Count	2000 PM Model	% Diff
I1	SR 4	24,726	26,681	8%	27,350	29,498	8%
I2	Concord	29,027	30,831	6%	31,414	34,054	8%
I3	Orinda	16,523	17,201	4%	15,887	17,185	8%
I4	I-680	39,372	42,612	8%	43,621	46,943	8%
I5	Treat	34,701	32,463	-6%	36,840	37,120	1%
I6	Ygnacio	29,072	25,233	-13%	30,089	28,717	-5%
I7	SR24	5,356	5,907	10%	6,250	6,826	9%
I8	Walnut Creek	27,465	27,624	1%	29,867	31,211	4%
I9	San Ramon	14,779	13,868	-6%	15,943	14,790	-7%
I10	Danville(NB / SB)	7,002	7,505	7%	7,241	7,016	-3%
I11	Danville (EB / WB)	7,564	7,927	5%	8,142	7,628	-6%
I12	Antioch/Brentwood	5,404	5,352	-1%	6,611	6,469	-2%
I13	Oakley/Brentwood	6,412	7,352	15%	7,539	7,383	-2%
I14	Richmond	19,990	19,889	-1%	21,129	21,716	3%
I15	Rich/Sanpb	16,118	16,705	4%	18,589	16,923	-9%
I16	I-580	23,939	22,971	-4%	26,507	24,557	-7%
I17	West Livermore	20,486	18,723	-9%	21,015	19,457	-7%
I18	Pinole/County	20,701	21,487	4%	21,193	21,953	4%
TOTAL - Internal		**16 of the 18 Screenlines meet targets; 2 within +/-15%**			**18 of the 18 Screenlines meet targets**		
		348,637	**350,331**	**0%**	**375,227**	**379,446**	**1%**

Regional Screenlines

Screenline		AM PEAK HOUR			PM PEAK HOUR		
No.	**Name**	2000 AM Count	2000 AM Model	**% Diff**	2000 PM Count	2000 PM Model	**% Diff**
Cordon Line	Cordon Line	86,122	81,591	-5%	89,105	82,222	-8%
R1	West/Central	5,743	6,208	8%	6,090	6,375	5%
R2	Lamorinda	21,069	20,597	-2%	21,431	22,423	5%
R3	TriValley	16,823	18,023	7%	17,989	18,025	0%
R4	Central/East	16,872	15,376	-9%	17,268	15,753	-9%
R5	S.C Central	6,627	6,358	-4%	7,408	7,151	-3%
R6	S.C East	13,603	15,030	10%	14,727	16,261	10%
R7	S.C Tri Valley	14,486	13,642	-6%	15,147	14,703	-3%
R8	S.C West	16,359	16,582	1%	16,328	15,842	-3%
R9	Alameda County	21,070	19,938	-5%	18,731	17,297	-8%
R10	Sunol	9,450	10,442	10%	11,894	12,619	6%
R11	Greenville	10,641	10,446	-2%	11,587	11,700	1%
TOTAL - Regional		**12 of the 12 Screenlines meet targets**			**12 of the 12 Screenlines meet targets**		
		238,865	**234,233**	**-2%**	**247,704**	**240,371**	**-3%**
GRAND TOTAL (Regional +		**587,501**	**584,564**	**0%**	**622,931**	**619,817**	**0%**

CCTA Model Validation Table 2. Year 2000 Peak Period and Daily Screenlines

2000 CCTA 4-Hour Peak Period and Daily Screenlines

Internal Screenlines

Screenline		AM PEAK PERIOD			PM PEAK PERIOD			DAILY ADT		
No.	**Name**	2000 AM Count	2000 AM Model	% Diff	2000 PM Count	2000 PM Model	% Diff	2000 Daily Count	2000 Daily Model	% Diff
I1	SR 4	78,142	87,363	12%	94,346	101,944	8%	342,425	331,611	-3%
I2	Concord	93,450	96,592	3%	110,895	114,234	3%	357,052	349,803	-2%
I3	Orinda	54,210	59,144	9%	58,449	61,713	6%	212,515	214,991	1%
I4	I-680	127,609	136,052	7%	151,220	158,300	5%	513,032	481,147	-6%
I5	Treat	109,006	106,128	-3%	132,325	124,467	-6%	462,630	390,802	-16%
I6	Ygnacio	90,074	80,679	-10%	110,765	95,090	-14%	390,740	315,684	-19%
I7	SR24	16,179	20,508	27%	20,025	23,355	17%	69,529	71,993	4%
I8	Walnut Creek	89,068	88,866	0%	107,452	106,303	-1%	386,465	345,511	-11%
I9	San Ramon	46,981	43,211	-8%	55,626	53,651	-4%	190,784	181,153	-5%
I10	Danville(NB / SB)	19,243	22,875	19%	25,205	26,896	7%	83,278	85,190	2%
I11	Danville (EB / WB)	20,995	25,218	20%	24,537	31,496	28%	82,543	94,140	14%
I12	Antioch/Brentwood	21,302	14,777	-31%	26,817	20,152	-25%	90,263	47,986	-47%
I13	Oakley/Brentwood	23,268	23,847	2%	27,450	26,590	-3%	96,039	80,529	-16%
I14	Richmond	66,148	65,092	-2%	78,332	75,474	-4%	294,870	276,972	-6%
I15	Rich/Sanpb	52,328	51,334	-2%	70,509	55,484	-21%	254,326	168,740	-34%
I16	I-580	76,410	67,635	-11%	91,773	80,537	-12%	317,681	255,820	-19%
I17	West Livermore	64,555	59,646	-8%	76,064	67,682	-11%	269,526	235,625	-13%
I18	Pinole/County	71,451	68,849	-4%	87,346	74,794	-14%	295,305	274,170	-7%
		14 of 18 Screenlines within +/-15%			**14 of 18 Screenlines within +/-15%**			**12 of 18 Screenlines within +/-15%**		
	TOTAL	**1,120,419**	**1,117,816**	**0%**	**1,349,136**	**1,298,162**	**-4%**	**4,709,003**	**4,201,867**	**-11%**

Regional Screenlines

Screenline		AM PEAK PERIOD			PM PEAK PERIOD			DAILY ADT		
No.	**Name**	2000 AM Count	2000 AM Model	% Diff	2000 PM Count	2000 PM Model	% Diff	2000 Daily Count	2000 Daily Model	% Diff
Cordon Line	Cordon Line	278,471	269,589	-3%	224,740	204,717	-9%	793,027	734,197	-7%
R1	West/Central	17,124	16,226	-5%	19,639	16,161	-18%	62,278	43,658	-30%
R2	Lamorinda	68,161	69,187	2%	73,389	77,754	6%	248,112	201,982	-19%
R3	TriValley	53,276	55,430	4%	64,054	64,715	1%	222,623	213,801	-4%
R4	Central/East	53,006	56,047	6%	60,600	58,497	-3%	214,753	209,497	-2%
R5	S.C Central	20,048	19,775	-1%	25,180	22,519	-11%	85,374	63,613	-25%
R6	S.C East	39,746	51,247	29%	51,652	57,374	11%	179,129	180,684	1%
R7	S.C Tri Valley	44,877	44,770	0%	54,724	53,669	-2%	191,529	181,169	-5%
R8	S.C West	51,147	54,579	7%	61,766	56,213	-9%	192,193	215,426	12%
R9	Alameda County	73,343	61,640	-16%	67,849	61,304	-10%	264,964	217,473	-18%
R10	Sunol	32,584	37,645	16%	42,526	45,889	8%	147,511	182,728	24%
R11	Greenville	34,976	34,156	-2%	41,957	41,792	0%	144,736	156,949	8%
	TOTAL	766,759	770,291	0%	788,076	760,604	-3%	2,746,229	2,601,177	-5%
		10 of 12 Screenlines within +/-15%			**10 of 12 Screenlines within +/-15%**			**7 of 12 Screenlines within +/-15%**		
GRAND TOTAL (Regional + Internal)		**1,887,178**	**1,888,107**	**0%**	**2,137,212**	**2,058,766**	**-4%**	**7,455,232**	**6,803,044**	**-9%**

CCTA Model Validation Table 3a. Year 2000 and 2010 AM Peak Hour Screenline Comparisons

CCTA Model 2000 and 2010 AM Peak Hour Screenline Comparison

AM Internal Screenlines

Screenline		AM Peak Hour						
		2000	2010	% Growth	2000	% Diff	2010	% Diff
No.	Name	Counts	Counts	2000-2010	Model	2000 Model	Model	2010 Model
I1	SR 4	24,726	27,994	12%	26,681	8%	28,162	1%
I2	Concord	29,027	28,893	0%	30,831	6%	31,426	9%
I3	Orinda	16,523	15,840	-4%	17,201	4%	15,947	1%
I4	I-680	39,372	39,221	0%	42,612	8%	40,351	3%
I5	Treat	34,701	34,409	-1%	32,463	-6%	31,954	-7%
I6	Ygnacio	29,072	26,661	-9%	25,233	-13%	26,129	-2%
I7	SR24	5,356	6,897	22%	5,907	10%	5,375	-22%
I8	Walnut Creek	27,465	24,603	-12%	27,624	1%	22,740	-8%
I9	San Ramon	14,779	15,078	2%	13,868	-6%	13,883	-8%
I10	Danville(NB / SB)	7,002	6,229	-12%	7,505	7%	7,045	13%
I11	Danville (EB / WB)	7,564	8,688	13%	7,927	5%	8,100	-7%
I12	Antioch/Brentwood	5,404	13,674	60%	5,352	-1%	12,642	-8%
I13	Oakley/Brentwood	6,412	10,533	39%	7,352	15%	9,645	-8%
I14	Richmond	19,990	17,237	-16%	19,889	-1%	20,207	17%
I15	Rich/Sanpb	16,118	17,113	6%	16,705	4%	16,903	-1%
I16	I-580	23,939	23,631	-1%	22,971	-4%	23,953	1%
I17	West Livermore	20,486	16,569	-24%	18,723	-9%	18,613	12%
I18	Pinole/County	20,701	19,557	-6%	21,487	4%	22,349	14%
TOTAL - Internal		348,637	352,827	1%	350,331	0%	355,424	1%
		Screenlines within 10% of target counts				**16 / 18**		**13 / 18**
		Screenlines within 15% of target counts				**18 / 18**		**16 / 18**

AM Regional Screenlines

Screenline		AM Peak Hour						
		2000	2010	% Growth	2000	% Diff	2010	% Diff
No.	**Name**	Counts	Counts	2000-2010	Model	2000 Model	Model	2010 Model
Cordon Line	Cordon Line	86,122	74,634	-15%	81,591	-5%	83,791	12%
R1	West/Central	5,743	5,796	1%	6,208	8%	5,601	-3%
R2	Lamorinda	21,069	18,793	-12%	20,597	-2%	19,635	4%
R3	TriValley	16,823	15,918	-6%	18,023	7%	17,961	13%
R4	Central/East	16,872	16,239	-4%	15,376	-9%	17,165	6%
R5	S.C Central	6,627	5,580	-19%	6,358	-4%	6,459	16%
R6	S.C East	13,603	13,663	0%	15,030	10%	15,879	16%
R7	S.C Tri Valley	14,486	13,504	-7%	13,642	-6%	14,062	4%
R8	S.C West	16,359	14,829	-10%	16,582	1%	17,733	20%
R9	Alameda County	21,070	15,981	-32%	19,938	-5%	18,348	15%
R10	Sunol	9,450	11,482	18%	10,442	10%	11,215	-2%
R11	Greenville	10,641	11,229	5%	10,446	-2%	10,523	-6%
TOTAL - Regional		238,865	217,648	-10%	234,233	-2%	238,372	10%
GRAND TOTAL (Regional + Internal)		**587,501**	**570,475**	**-3%**	**584,564**	**0%**	**593,796**	**4%**
		Screenlines within 10% of target counts				**12 / 12**		**6 / 12**
		Screenlines within 15% of target counts				**12 / 12**		**10 / 12**

CCTA Model Validation Table 3b. Year 2000 and 2010 PM Peak Hour Screenline Comparisons

CCTA Model 2000 and 2010 PM Peak Hour Screenline Comparison

PM Internal Screenlines

Screenline		PM Peak Hour						
		2000	2010	% Growth	2000	% Diff	2010	% Diff
No.	Name	Counts	Counts	2000-2010	Model	2000 Model	Model	2010 Model
I1	SR 4	27,350	28,608	4%	29,498	8%	31,226	9%
I2	Concord	31,414	32,250	3%	34,054	8%	35,260	9%
I3	Orinda	15,887	15,911	0%	17,185	8%	16,306	2%
I4	I-680	43,621	40,360	-8%	46,943	8%	45,964	14%
I5	Treat	36,840	36,158	-2%	37,120	1%	37,326	3%
I6	Ygnacio	30,089	28,025	-7%	28,717	-5%	29,418	5%
I7	SR24	6,250	7,209	13%	6,826	9%	6,316	-12%
I8	Walnut Creek	29,867	27,701	-8%	31,211	4%	27,130	-2%
I9	San Ramon	15,943	15,885	0%	14,790	-7%	15,209	-4%
I10	Danville(NB / SB)	7,241	6,731	-8%	7,016	-3%	7,010	4%
I11	Danville (EB / WB)	8,142	9,762	17%	7,628	-6%	8,312	-15%
I12	Antioch/Brentwood	6,611	14,444	54%	6,469	-2%	14,559	1%
I13	Oakley/Brentwood	7,539	11,023	32%	7,383	-2%	10,987	0%
I14	Richmond	21,129	19,011	-11%	21,716	3%	22,394	18%
I15	Rich/Sanpb	18,589	18,856	1%	16,923	-9%	17,971	-5%
I16	I-580	26,507	26,660	1%	24,557	-7%	26,844	1%
I17	West Livermore	21,015	19,866	-6%	19,457	-7%	20,346	2%
I18	Pinole/County	21,193	19,981	-6%	21,953	4%	23,304	17%
TOTAL - Internal		375,227	378,441	1%	379,446	1%	395,882	5%
		Screenlines within 10% of target counts				**18 / 18**		**13 / 18**
		Screenlines within 15% of target counts				**18 / 18**		**16 / 18**

PM Regional Screenlines

Screenline		PM Peak Hour						
		2000	2010	% Growth	2000	% Diff	2010	% Diff
No.	**Name**	Counts	Counts	**2000-2010**	Model	**2000 Model**	Model	**2010 Model**
Cordon Line	Cordon Line	89,105	78,245	-14%	82,222	-8%	84,849	8%
R1	West/Central	6,090	5,779	-5%	6,375	5%	5,898	2%
R2	Lamorinda	21,431	19,999	-7%	22,423	5%	22,030	10%
R3	TriValley	17,989	16,028	-12%	18,025	0%	18,412	15%
R4	Central/East	17,268	14,895	-16%	15,753	-9%	18,088	21%
R5	S.C Central	7,408	6,598	-12%	7,151	-3%	7,313	11%
R6	S.C East	14,727	14,901	1%	16,261	10%	17,798	19%
R7	S.C Tri Valley	15,147	14,036	-8%	14,703	-3%	15,231	9%
R8	S.C West	16,328	15,485	-5%	15,842	-3%	17,359	12%
R9	Alameda County	18,731	15,870	-18%	17,297	-8%	16,315	3%
R10	Sunol	11,894	12,502	5%	12,619	6%	12,773	2%
R11	Greenville	11,587	11,080	-5%	11,700	1%	11,740	6%
TOTAL - Regional		624,931	605,868	-3%	621,817	0%	645,698	7%
GRAND TOTAL	**(Regional + Internal)**	**1,000,158**	**984,309**	**-2%**	**1,001,263**	**0%**	**1,041,580**	**6%**
		Screenlines within 10% of target counts				**12 / 12**		**6 / 12**
		Screenlines within 15% of target counts				**12 / 12**		**10 / 12**

CCTA Model Validation Table 4. Peak Hour Screenline Growth 2010-2040

Growth in CCTA Peak Hour Screenlines (2010 to 2040)

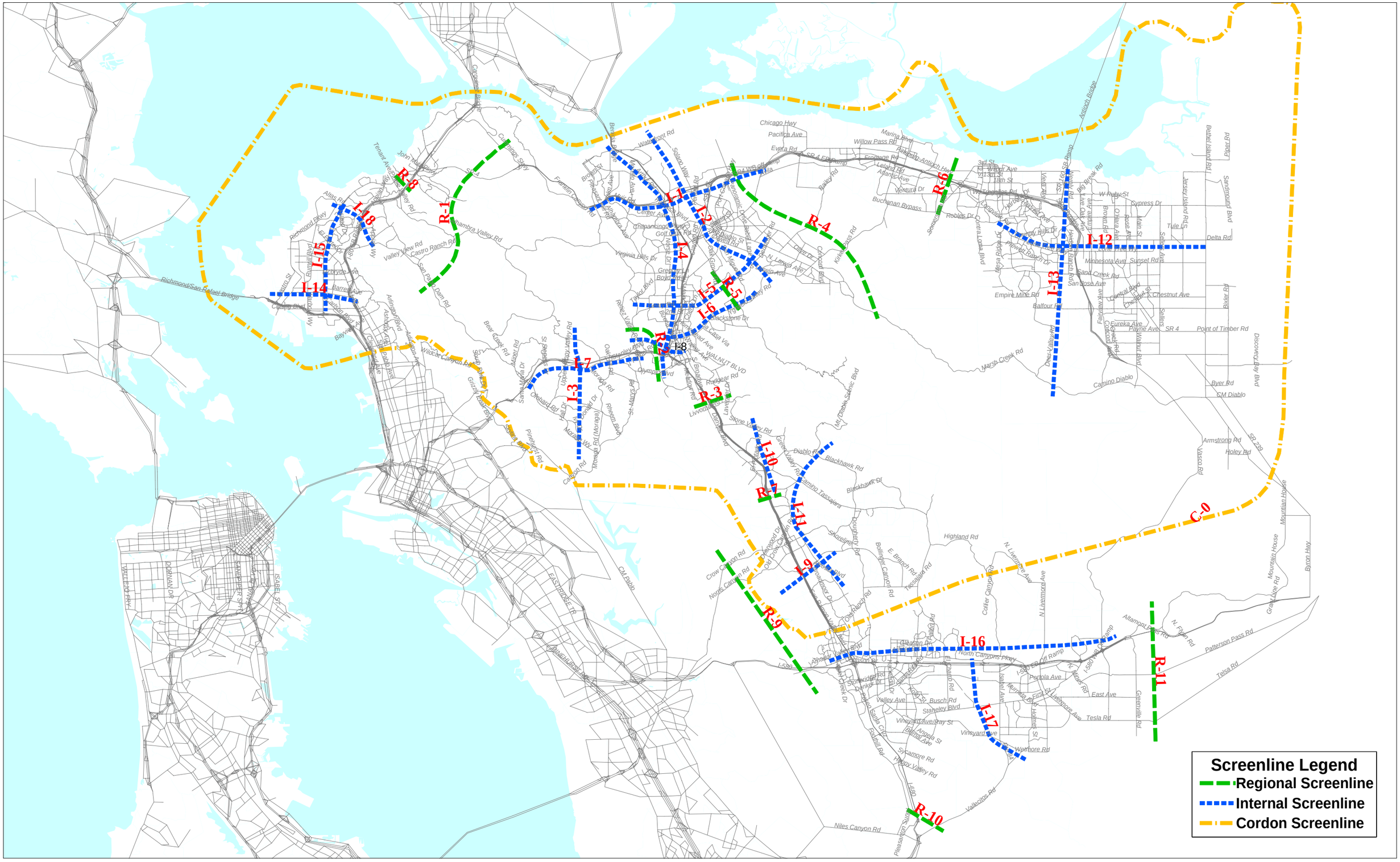
Internal Screenlines

Screenline		AM PEAK HOUR					PM PEAK HOUR				
No.	Name	2010 AM Count	2010 AM Model	% Diff	2040 AM Model	Model AM Growth%	2010 PM Count	2010 PM Model	% Diff	2040 PM Model	2040 Model PM Growth%
I1	SR 4	27,994	28,162	1%	41,490	47%	28,608	31,226	9%	44,390	42%
I2	Concord	28,893	31,426	9%	42,947	37%	32,250	35,260	9%	46,150	31%
I3	Orinda	15,840	15,947	1%	22,433	41%	15,911	16,306	2%	23,319	43%
I4	I-680	39,221	40,351	3%	53,321	32%	40,360	45,964	14%	59,249	29%
I5	Treat	34,409	31,954	-7%	40,752	28%	36,158	37,326	3%	45,722	22%
I6	Ygnacio	26,661	26,129	-2%	34,038	30%	28,025	29,418	5%	38,394	31%
I7	SR24	6,897	5,375	-22%	6,649	24%	7,209	6,316	-12%	7,817	24%
I8	Walnut Creek	24,603	22,740	-8%	38,380	69%	27,701	27,130	-2%	42,757	58%
I9	San Ramon	15,078	13,883	-8%	19,164	38%	15,885	15,209	-4%	19,666	29%
I10	Danville(NB / SB)	6,229	7,045	13%	9,799	39%	6,731	7,010	4%	9,727	39%
I11	Danville (EB / WB)	8,688	8,100	-7%	12,489	54%	9,762	8,312	-15%	13,381	61%
I12	Antioch/Brentwood	13,674	12,642	-8%	18,991	50%	14,444	14,559	1%	22,968	58%
I13	Oakley/Brentwood	10,533	9,645	-8%	15,488	61%	11,023	10,987	0%	18,771	71%
I14	Richmond	17,237	20,207	17%	26,847	33%	19,011	22,394	18%	30,045	34%
I15	Rich/Sanpb	17,113	16,903	-1%	25,176	49%	18,856	17,971	-5%	26,862	49%
I16	I-580	23,631	23,953	1%	38,455	61%	26,660	26,844	1%	42,005	56%
I17	West Livermore	16,569	18,613	12%	28,734	54%	19,866	20,346	2%	33,823	66%
I18	Pinole/County	19,557	22,349	14%	30,147	35%	19,981	23,304	17%	31,564	35%
TOTAL - Internals		**352,827**	**355,424**	**1%**	**505,300**	**42%**	**378,441**	**395,882**	**5%**	**556,610**	**41%**

Regional Screenlines

Screenline		AM PEAK HOUR					PM PEAK HOUR				
No.	**Name**	2010 AM Count	2010 AM Model	**% Diff**	2040 AM Model	Model AM Growth%	2010 PM Count	2010 PM Model	**% Diff**	2040 PM Model	2040 Model PM Growth%
Cordon Line	Cordon Line	74,634	83,791	12%	111,584	33%	78,245	84,849	8%	112,039	32%
R1	West/Central	5,796	5,601	-3%	8,981	60%	5,779	5,898	2%	9,785	66%
R2	Lamorinda	18,793	19,635	4%	27,226	39%	20,174	22,030	9%	28,950	31%
R3	TriValley	15,918	17,961	13%	23,274	30%	16,028	18,412	15%	23,473	27%
R4	Central/East	16,239	17,165	6%	29,703	73%	14,895	18,088	21%	29,461	63%
R5	S.C Central	5,580	6,459	16%	8,192	27%	6,598	7,313	11%	8,780	20%
R6	S.C East	13,663	15,879	16%	22,405	41%	14,901	17,798	19%	24,615	38%
R7	S.C Tri Valley	13,504	14,062	4%	15,446	10%	14,036	15,231	9%	15,566	2%
R8	S.C West	14,829	17,733	20%	22,198	25%	15,485	17,359	12%	22,070	27%
R9	Alameda County	15,981	18,348	15%	25,703	40%	15,870	16,315	3%	23,723	45%
R10	Sunol	11,482	11,215	-2%	15,074	34%	12,502	12,773	2%	15,786	24%
R11	Greenville	11,229	10,523	-6%	15,562	48%	11,080	11,740	6%	19,387	65%
TOTAL - Regionals		**217,648**	**238,372**	**10%**	**325,348**	**36%**	**225,592**	**247,806**	**10%**	**333,635**	**35%**
GRAND TOTAL (Regional + Internal)		**570,475**	**593,796**	**4%**	**830,648**	**40%**	**604,033**	**643,688**	**7%**	**890,245**	**38%**

CCTA Model Validation Cordonline and Screenlines



Appendix I – Standard Agreement Regarding Use of the Authority's Travel Demand Forecasting Models and Databases

CONTRA COSTA TRANSPORTATION AUTHORITY

AGREEMENT TDFM XX-XX
FOR USE OF THE
CONTRA COSTA TRANSPORTATION AUTHORITY
TRAVEL DEMAND FORECASTING MODEL AND GIS

CONTRA COSTA TRANSPORTATION AUTHORITY ("CCTA") and XXXX ("USER") as of the date set forth below, do hereby agree as follows:

1. CCTA agrees to provide USER a personal, non-transferable and non-exclusive license to use and adapt data files from its Transportation Demand Forecasting Model and Countywide GIS, or portions thereof, including all input and output files (electronic or otherwise) and any data, including but not limited to traffic count, land use, and network data, needed to run the EMME/2, TransCAD®, TP+, or ArcView or any similar software for the purpose set forth in Paragraph 2.b. below, including the West, Central, East, Tri-Valley, CMP and Countywide models, inclusively, the "MODEL."

2. USER agrees:

   a. to only install, operate and use the MODEL on a computer system owned, leased or otherwise controlled by USER in its own facilities;

   b. to use and execute all portions of the MODEL on such computer systems for the limited purpose of miscellaneous traffic impact studies for new development proposals, associated environmental impact analyses, fee impact studies, transportation project analysis, and the evaluation of proposed transportation strategies and plans;

   c. to only make such number of copies of the MODEL as necessary for the foregoing purposes, and a further reasonable number of copies solely for nonproductive back-up purposes in accordance with its standard procedures, provided that it accounts for such copies;

   d. to use the MODEL in accordance with the most current published version of CCTA's *Technical Procedures*;

   e. prior to using the model or data, to notify CCTA in writing of each specific study or project User expects to undertake;

   f. to provide CCTA with written documentation of any revisions to the MODEL.

3. Any use, copying, distribution, adaptation or public display of the MODEL by USER not authorized by this Agreement shall automatically terminate USER's rights hereunder. Use of the MODEL on processors accessible through communications networks through terminals and devices not on premises owned or controlled by USER is prohibited unless otherwise agreed in writing by CCTA. USER shall promptly notify CCTA and make available to it all modifications, additions, or updates USER makes to the MODEL and shall grant CCTA a perpetual, royalty-free license to use, reproduce, sublicense, and to otherwise make available to third parties the MODEL as modified, and to modify such modifications, additions, or updates.

4. Title to the MODEL, including all modifications, additions, deletions, input and output file additions and modifications, updates, copies and derivative works thereof by USER, shall be in and remain with CCTA. User hereby assigns to CCTA ownership of all such modifications, additions, deletions, input and output file additions and modifications, updates, copies and derivative works, including output from operations models (ex. FREQ, Paramics, VISSIM) which rely on MODEL data as input.

5. CCTA, ITS AFFILIATES, SUBCONTRACTORS AND REPRESENTATIVES MAKE NO WARRANTIES, EXPRESS OR IMPLIED, AND SPECIFICALLY DISCLAIM ANY WARRANTIES INCLUDING, WITHOUT LIMITATION, ANY WARRANTY OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE OF THE MODEL. USER AGREES THAT ITS SOLE REMEDY AGAINST CCTA, ITS AFFILIATES, SUBCONTRACTORS AND REPRESENTATIVES FOR LOSS OR DAMAGE CAUSED BY ANY DEFECT OR FAILURE OF THE MODEL, REGARDLESS OF THE FORM OF ACTION, WHETHER IN CONTRACT, TORT, INCLUDING NEGLIGENCE, STRICT LIABILITY OR OTHERWISE, SHALL, TO THE EXTENT FEASIBLE (AS DETERMINED SOLELY BY CCTA) BE THE REPAIR OR REPLACEMENT OF THE MODEL. IN NO EVENT SHALL CCTA, ITS AFFILIATES, SUBCONTRACTORS OR REPRESENTATIVES BE LIABLE FOR INCIDENTAL, INDIRECT, SPECIAL OR CONSEQUENTIAL DAMAGES, OR FOR LOST PROFITS, SAVINGS, OR REVENUES OF ANY KIND, OR FOR LOST DATA OR DOWNTIME, WHETHER OR NOT CCTA, ITS AFFILIATES, SUBCONTRACTORS OR REPRESENTATIVES HAVE BEEN ADVISED OF THE POSSIBILITY OF SUCH DAMAGES.

6. This Agreement shall be effective as of the date set forth below and, unless terminated in accordance with Section 3 above or extended by written amendment to this Agreement, shall terminate on the earlier of the date that USER is not making use of the MODEL or **Month XX, 201X**. Upon termination, or upon immediate request by CCTA, USER shall return all copies, and submit any modifications or derivative works and accompanying documentation of revisions to

CCTA. Thereafter, the provisions of Sections 3, 4, 5 and 8 shall continue to apply in accordance with their terms, notwithstanding the termination of this Agreement. The medium for submittals of electronic data files to CCTA shall be arranged by USER in consultation with CCTA. Writeable CD is an acceptable medium for submittal of electronic files.

7. This Agreement shall inure to the benefit of, and shall be binding on, USER and CCTA and their respective successors and assigns, provided that USER shall not assign this Agreement or any right to use of the MODEL as provided herein, except to a successor to all or substantially all of the business and properties of USER, without the express prior written consent of CCTA.

8. This Agreement and the rights and obligations of the parties with respect to the MODEL shall be governed by California law, as it applies to a contract negotiated, executed and performed in that state.

USER ACKNOWLEDGES THAT IT HAS READ THIS AGREEMENT AND UNDERSTANDS IT, AND THAT BY ENTERING INTO THE AGREEMENT, INSTALLING AND EXECUTING THE MODEL, OR MAKING ANY OTHER USE OF IT, USER AGREES TO BE BOUND BY THE TERMS AND CONDITIONS HEREOF. THE PARTIES FURTHER AGREE THAT, EXCEPT FOR SEPARATE WRITTEN AGREEMENTS BETWEEN CCTA AND USER, THIS AGREEMENT IS THE COMPLETE AND EXCLUSIVE STATEMENT OF THE RIGHTS AND LIABILITIES OF THE PARTIES.

This Agreement is made as of Month XX, 201X.

CCTA	**USER**
Contra Costa Transportation Authority 2999 Oak Road, Suite 100 Walnut Creek, CA 94597	Agency/Consultancy Name Address City, CA 9XXXX
By:_____ Martin R. Engelmann, P.E. Deputy Executive Director, Planning	By:_____ Agency/Consultant Designee Title

Appendix J – Glossary of Acronyms

ABAG Association of Bay Area Governments

CAPCOA California Air Pollution Control Officers Association

CCTA Contra Costa Transportation Authority

CCTALOS CCTA's LOS methodology

CEQA California Environmental Quality Act

CHTS California Statewide Household Travel Survey

HCMA Congestion Management Agency

CMP Congestion Management Program

CO Carbon Monoxide

CTP Countywide Transportation Plan

CTPL Comprehensive Transportation Project List

GC Government Code

GHG Greenhouse Gases

GME Growth Management Element

GMP Growth Management Program

GP General Plan

HBW Home-Based Work

HOV High Occupancy Vehicle

ITE Institute of Transportation Engineers

LOS Level of Service

LPMC Lamorinda Program Management Committee

LUIS Land Use Information System

MTC Metropolitan Transportation Commission

MTSO Multi-Modal Transportation Service Objective

NOx Oxides of Nitrogen

ODME Origin-Destination Matrix Estimation

OPR Office of Planning and Research

PCE Passenger Car Equivalent

PDA Priority Development Area

PM Particulate Matter

ROG Reactive Organic Gases

RTO Regional Transportation Objective

RTP Regional Transportation Plan

RTPC Regional Transportation Planning Committee

SB Senate Bill

STIP State Transportation Improvement Plan

SWAT Southwest Area Transportation Committee (Lamorinda and San Ramon Valley)

TAZ Traffic Analysis Zone

TCC Technical Coordinating Committee

TDM Transportation Demand Management

TMWG Technical Modeling Working Group

TOD Transit-Oriented Development

TPA Transit Priority Area

TransPAC Transportation Partnership and Cooperation (Central Contra Costa)

TransPLAN Transportation Planning Committee (Eastern Contra Costa County)

TRB Transportation Research Board

TVTC Tri-Valley Transportation Council

V/C Volume-To-Capacity

VHT Vehicle Hours Traveled

VMT Vehicle Miles Traveled

WCCTAC West Contra Costa Transportation Advisory Committee