United States
Environmental Protection
Agency

Air and Radiation

EPA420-P-99-028
September 1999

Granting Air Quality Credit for Land Use Measures: Policy Options

Report No. SR99-09-01

Granting Air Quality Credit for Land Use Measures: Policy Options

prepared for:

U.S. Environmental Protection Agency
Contract No. 68-C7-0051, Work Assignment No. 1-04

September 8, 1999

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Policy Options

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Executive Summary

Sustainable land use refers to a variety of policies and programs that aim to provide attractive and safe places to live and work, minimize the use of natural resources, and allow for alternatives to automobile travel. A number of studies have shown that sustainable land use activities can reduce vehicle miles traveled and mobile source emissions. This work supports EPA efforts to reduce mobile source air pollution by providing tools to recognize and, where appropriate, credit these types of sustainable land use and transportation practices.

This work builds on Work Assignment 0-09 (WA09), in which the consultant team conducted surveys to determine whether air agencies are currently taking credit in their state implementation plans (SIPs) for control measures that involve land use. The study found that one air agency is taking credit for a land use measure, and several more identify land use measures in air quality plans but do not quantify any emission reductions. This report provides a detailed analysis of the policy options for recognizing and granting credit for sustainable land use activities in light of some specific control measures.

There are three general options for recognizing and providing credit for sustainable land use activities in the air quality planning process: (1) modify procedures for quantifying emissions in the SIP baseline so that the benefits of sustainable land use are better reflected; (2) adopt sustainable land use activities as a SIP control measure; and (3) show emissions reductions from sustainable land use activities to support a transportation conformity determination.

Land Use Measures

In evaluating specific land use measures, it is important to distinguish between the urban form desired as an outcome and the implementing policies and programs that bring about a change in urban form. Implementing mechanisms can range from those at the state and regional level (like state growth control policies, open space protection programs, and development incentives) to local policies (like zoning ordinances, design review guidelines, and local development incentives). Land use measures are typically defined by the urban form they intend to achieve. For this report, land use measures have been grouped into five categories:

- Transit-Oriented Development,

- Infill Development,
- Jobs/Housing Balance,
- Mixed-Use Development, and
- Neotraditional Design Development.

These measures lead to two basic types of urban form change: one is a redistribution of population and employment growth among analysis zones; the other is a change in micro-scale urban design or land use mixing (intra-zonal changes). Land use measures designed to produce transit-oriented development, infill development, or jobs/housing balance will typically result in the first type of urban form change (growth redistribution). Mixed-use development and neotraditional design measures will be more likely to produce the second type of change (micro-scale changes). Many sustainable land use activities will produce both types of changes. However, the distinction is important because it is much easier to monitor and assess the travel impacts of growth redistribution than micro-scale urban form changes.

Note that throughout this document, the term "land use measure" refers broadly to strategies for achieving an emission reduction through land use. This term is not necessarily consistent with the definition of a SIP control measure. The specific legal issues with respect to enforcement that apply to SIP control measures may not apply to land use measures as described in this document. The distinction between these terms will be defined in subsequent policy documents.

Regional Land Use Forecasting

In assessing the options for recognizing sustainable land use, it is important to keep in mind that the process for developing the SIP baseline and making the conformity determination already accounts for some of the effects of land use policies and programs. Mobile source emissions estimates are based on a regional land use forecast developed by the Metropolitan Planning Organization (MPO) or Council of Governments (COG) as part of the regional transportation planning process. This forecast consists of allocating a regional population and employment growth total among zones based on existing factors that can shape development. To the extent that land use policies and programs occurring outside of the air quality planning process impact the allocation of population and employment growth, they will be reflected in this regional land use forecast and therefore in the mobile source emissions estimate.

Land use measures can be used for explicit credit only to the extent that they *are not* reflected in the emissions baseline. One way this might happen is if the standard analytical methodologies used to evaluate land use, travel, and emissions do not reflect the full impact of a land use measure. This is often the case for measures that result in micro-scale land use changes. Alternative methodologies would be needed to allow quantification of the impact of these changes in order to take credit for them. The other possibility is that the regional land use forecast does not include a measure because it is not likely to occur without some future government action. This would be the case for

land use measures initiated by an air agency expressly for air quality purposes. Local governments would commit to sustainable land use activities as part of the regional air quality planning process. The research conducted in WA09 and this project suggests that this scenario is currently unlikely. However, it may become a more attractive option in regions that have trouble controlling mobile source emissions.

Modifying the Baseline Quantification Procedures

One option for recognizing sustainable land use is to modify the baseline quantification procedures to better account for urban form changes. Regional travel demand models can be improved by the addition of pedestrian environmental factors, accessibility variables, or mode choice modules that include non-motorized travel. While these changes can improve the ability of models to reflect land use, the limitations of zone size will always prevent a full accounting of micro-scale urban form changes.

Incorporating in the baseline the impact of land use policies and programs that are not included in the regional land use forecast would be a significant departure from current practice and probably not advisable. Since policies and programs included in the baseline are not subject to the control measure enforceability and documentation requirements, this option could lead to credit for a land use measure that does not get implemented. While in the long run this would cause problems for showing conformity or ROP requirements, credit for activities that are not included in the regional land use forecast should be done using explicit control measures.

The SIP Option

Land use measures not reflected in the baseline could be used to show emission reductions as a SIP control measure. EPA has issued guidance for several types of control measure categories. The guidance for Economic Incentive Programs (EIP) and for Voluntary Mobile Source Emission Reduction Programs (VMEP) can both apply to land use measures. As most land use measures rely on local government implementation rather than direct state control, the VMEP option may be more appropriate for many regions. However, the emissions reduction allowed under VMEP is limited to 3 percent of the inventory for each criteria pollutant.

Adding a land use measure under either the EIP or VMEP option will require the air agency to estimate compliance and programmatic uncertainty. Compliance uncertainty represents the degree to which governments adopt implementing mechanisms in support of sustainable land use. Programmatic uncertainty represents the degree to which urban form, travel, and emissions change as a result of the implementing mechanisms. Due to the nature of the development process, the level of programmatic uncertainty will typically be very high. Land development is strongly influenced by fluctuations in market demand. And most land use policies do not guarantee that any changes will occur, since local officials can choose to ignore the policies.

Since most nonattainment SIPs address only a five- to seven-year horizon, they offer little opportunity to recognize the longer-term benefits of land use. However, areas developing longer-term Maintenance plans may want to consider inclusion of land use measures to help ensure that clean air goals will continue to be met, especially those that are expecting considerable growth. For land use measures initiated expressly for air quality purposes, it may be difficult to use the SIP process as an incentive for local government participation in measure implementation, unless air quality problems are constraining local growth or transportation funding. While local governments in some regions are heavily involved in efforts to reduce pollutants like fugitive dust, in other regions there is little burden placed on local governments to reduce mobile source emissions. Thus, in these regions there may be little opportunity to reduce the burden for those that commit to sustainable land use activities.

Taking credit for land use measures in the SIP process raises the prospect of double-counting benefits already reflected in the baseline. Air agencies typically have a poor understanding of the land use and travel demand forecasts that form the baseline. To ensure that land use measure benefits are surplus, air agencies will need to better document the land use and travel forecasts that make up the baseline. Additional EPA guidance may be needed regarding the form of this documentation. However, it should be recognized that the more requirements are placed on documenting land use activities, the less likely may be the adoption of land use measures.

To adopt, as a control measure, land use policies and programs that are not included in the regional land use forecast, the state would typically need assurances from local governments that the actions would be implemented as expected. The form that this assurance should take is not clear under the existing guidance.

The Conformity Option

Land use measures that are not reflected in the baseline could also be used to show an emissions reduction in the transportation plan conformity determination. The MPO estimates the emissions that will result from the implementation of a long-range transportation plan, and these emissions must be within the mobile source emissions budget established in the SIP.[*] Estimates of emissions can be reduced by factoring in the impact of control measures, thus providing "credit" for the measures.

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[*] It is important to note that mobile source emission budgets are not always fixed at a specific level. Some communities project emission budgets for years beyond the attainment dates established in the Clean Air Act. The purpose of establishing budgets in the "out years" is to allow transportation emission budgets to increase in proportion to reductions occurring in other source categories (i.e., and stay within the emission cap needed to demonstrate attainment.) This eliminates the problem of finding offsets for growth in years beyond the specified attainment date and enhances their ability to demonstrate conformity with the budgets established in the SIP. In this document, the SIP option generally refers only to planning through the attainment year.

This option has several advantages over the SIP process. Most importantly, conformity addresses a longer time period than most SIPs, and thus better matches the time needed to realize the benefits of land use measures. Also, because it is linked to future transportation funding, the conformity determination may offer an opportunity to provide incentives to local governments to adopt land use measures.

The Conformity Rule specifies that emission reductions from projects like TCMs that are not "regionally significant" may be estimated with reasonable professional practice, rather than incorporating them into the regional travel demand model. The Rule defines the type of implementation commitment needed to include a control measure in a conformity analysis. Measures that require regulatory action (i.e., zoning or other growth control mechanisms) generally must be already adopted by the local government, or must be included in the SIP, or the SIP must contain a letter of commitment from the implementing authority.

There are several issues that EPA may wish to address with respect to land use measures in conformity analyses. While the requirements for including control measures in the SIP and conformity determination are essentially the same, at least several air agencies *perceive* that there is less accountability for measures adopted to show conformity than in the SIP. There is also a potential to double-count control measure benefits that are already reflected in the baseline. Currently, it would be difficult for a reviewer to detect this double-counting because there is little requirement for documenting the baseline land use forecast and the policy assumptions that underlie it. As with SIP measures, additional EPA guidance may be needed regarding documentation of the baseline land use assumptions.

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1. Introduction

1.1 Purpose

Across the country, communities are re-thinking the land use policies that have shaped urban form over the last half-century. In many regions, these land use policies have contributed unnecessarily to traffic congestion, air pollution, and the loss of agricultural land and open space, while leaving older, inner-city neighborhoods economically depressed. Local, regional and state governments are now realizing that sustainable land use is vital to preserving quality of life. This means building in ways that provide attractive and safe places to live and work, minimize the use of natural resources, and allow for alternatives to automobile travel. This work supports EPA efforts to reduce mobile source air pollution by providing tools to recognize and, where appropriate, credit these types of sustainable land use and transportation practices.

This work builds on Work Assignment 0-09 (WA09), in which the consultant team conducted surveys to determine whether air agencies are currently taking credit in their state implementation plans (SIPs) for control measures that involve land use. The study found that one air agency is taking credit for a land use measure, and several more identify land use measures in air quality plans but do not quantify any emission reductions. WA09 also discussed some of the barriers that prevent the recognition of the air quality benefits of sustainable land use measures in the air quality planning process.

This report provides a detailed analysis of the policy options for recognizing and granting credit for sustainable land use activities with respect to some specific control measures. Note that throughout this document, the term “land use measure” refers broadly to strategies for achieving an emission reduction through land use. This term is not necessarily consistent with the definition of a SIP control measure. The specific legal issues with respect to enforcement that apply to SIP control measures may not apply to land use measures as described in this document. The distinction between these terms will be defined in subsequent policy documents.

1.2 Methodology

Information for this project was collected primarily through interviews and document review. As part of the evaluation of policy options, interviews were conducted with EPA staff, including Geoff Anderson, Jim Carpenter, Mark Coryell, John Hall and Mark

Wolcott. Other interviews were conducted with staff at selected local, regional and state agencies. These persons are listed in Appendix A.

EPA policy and guidance documents were reviewed as part of this work effort and are listed in the References section. Also listed are a number of documents that were used to evaluate specific land use measures and technical methods. A publication by the California Air Resources Board entitled *Transportation-Related Land Use Strategies to Minimize Motor Vehicle Emissions: An Indirect Source Research Study* was particularly helpful. A number of Internet web sites were also reviewed to gather information about sustainable land use policies and programs. These web sites are listed in Appendix B.

The work also included a review of several recent and ongoing federal work efforts that complement this project. A description of these projects is included in Appendix C.

1.3 Report Organization

The remainder of this report is organized into three chapters, as described below.

Chapter 2 describes the policy options in detail. Three general options are considered. Under the first option, the benefits of sustainable land use measures would be incorporated into the baseline of the SIP or conformity process. The procedures for developing this baseline are reviewed. Under the second option, land use policies or programs would be adopted as a SIP control measure. EPA guidance with respect to several categories of control measures is reviewed, including the Economic Incentive Program (EIP) and the Voluntary Mobile Source Emission Reduction Program (VMEP). Under the third option, land use policies or programs would be used to reduce mobile source emissions to support a transportation conformity determination. This process and its applicable rules are reviewed.

Chapter 3 describes specific land use measures and evaluates their potential to be used for emission reduction credit. The chapter begins with a brief overview of the land use, transportation, and air quality planning process and the responsibilities of different public agencies in that process. Implementing mechanisms are then reviewed. These are the policies and programs that are used to bring about a change in urban form, and they have been grouped into seven broad categories. Chapter 3 then describes the following basic categories of land use measures, defined by the type of urban form they attempt to achieve:

- Transit-Oriented Development,
- Infill Development,
- Jobs/Housing Balance,
- Mixed-Use Development, and
- Neotraditional Design Development.

The last part of Chapter 3 evaluates the potential for these land use measures to be used for air quality credit. Here the focus is on quantifying the impact of policies and programs on urban form, and quantifying the impact of urban form change on travel and emissions.

Chapter 4 provides conclusions by tying together the issues raised in Chapters 2 and 3. The potential for recognizing sustainable land use activities under each of the three general policy options is evaluated in terms of the specific land use measure categories and implementing mechanisms. The chapter identifies some issues that may be relevant for EPA.

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2. Policy Options

The Clean Air Act Amendments (CAAA) of 1990 require states with areas that do not meet National Ambient Air Quality Standards (NAAQS) to submit to EPA a State Implementation Plan (SIP) that documents how the area(s) will achieve NAAQS within the required time frame. States consider a wide array of control measures in the development of SIPs. A land use measure would be a policy or program that changes the urban form in a way that leads to fewer vehicle emissions.

Control measures have been classified by EPA based on source category and operational mechanism. *Transportation Control Measures* (TCMs) refer to measures designed to reduce emissions from transportation sources through a reduction in vehicle use or changes in traffic conditions. Section 108(f) of the CAAA lists 16 examples of TCMs, including several that could rely on land use or urban design changes. *Economic Incentive Programs* (EIPs) are control measures that rely on market-based incentives to reduce emissions and increase compliance flexibility. *Voluntary Mobile Source Emission Reduction Programs* (VMEPs) refer to measures that rely on the voluntary actions of individuals or businesses to reduce emissions. Each of these classes of measures could include certain types of sustainable land use policies and programs.

2.1 General SIP Requirements

Under the CAAA, all SIP measures must be consistent with SIP attainment and Rate of Progress (ROP) requirements. They must result in emission reductions that are quantifiable, enforceable, and permanent. Quantifiable means that the emission reduction can be measured reliably and replicably. Enforceable means that the actions required to achieve emission reductions are independently verifiable, program violations are defined, those liable can be identified, and penalties can be applied where applicable. Permanent means that the emission reduction occurs throughout the life of the measure, and for as long as it is relied upon in the SIP. While these principles apply to all SIP measures, EPA has provided guidance that clarifies how the principles can be interpreted for some of the specific classes of measures.

The required date for reaching attainment depends on the pollutant and the severity of air pollution levels. For carbon monoxide, those areas remaining out of attainment (i.e., those "bumped up" to serious) must demonstrate attainment by December 31, 2000. For the one-hour ozone standard, the attainment dates range, depending on their nonattainment classification, between 1999 and 2010. For the eight-hour ozone standard,

the draft planning guidance indicates that attainment dates will range between 2005 and 2010. For PM_{10}, those areas remaining out of attainment (again, those bumped-up to "serious") must demonstrate attainment between 2001 and 2006 (the latter for those areas that comply with the "most stringent measure" requirements). Under the revised PM_{10} standard, the draft planning guidance indicates that attainment dates will range between 2006 and 2010. For $PM_{2.5}$, draft planning guidance indicates that the attainment dates will also range between 2006 and 2010.

These attainment dates are particularly significant for land use measures. Unlike some other types of control measures, those involving land use often require a decade or more before having any significant impact on mobile source emissions. For example, one land use strategy is to use urban growth boundaries and other forms of open space protection to increase pressure for infill development. Under this strategy, however, significant infill can only be expected to occur if the region is growing and if new greenfield sites are effectively unavailable for development. Changing the urban form using this strategy would not be likely to have a significant impact on regional travel within the SIP timeframe in all but the most extreme nonattainment areas.

Since the decision-making authority for land use rests almost exclusively with local governments, it is important to consider how the policy options can create incentives for local governments to participate in sustainable land use activities. If a state wants to create an incentive through the SIP process for local governments to adopt land use measures, the state could pass on the reduced emission control burden to the local governments in some way. This could happen in the form of reducing the burden of other control measures that require local implementation. As discussed later, granting credit through the conformity analyses may provide better opportunities for offering incentives to local governments through transportation funding decisions.

2.2 The SIP Baseline

Some land use policies and programs are implicitly factored into all SIPs through the development of the baseline. To develop the SIP baseline, the state produces an emissions inventory that reflects current and expected emission levels from each source, for each criteria pollutant. In developing the mobile source emission inventory, the state typically relies on the forecasts of future vehicle activity that are made by the regional MPO. These travel demand forecasts make certain assumptions about the future distribution of population and employment that are based, in part, on existing land use policies and programs. While EPA has provided considerable guidance on procedures to be followed in developing the travel forecasts (e.g. Section 187 VMT Forecasting and Tracking Guidance, etc.), little guidance has been provided on how to consider issues related to land use.

2.2.1 The Regional Land Use Forecast

In most regions, the MPO or COG adopts an "official" land use forecast that then serves as the basis for all of its transportation forecasts. The processes for developing this forecast vary – some regions rely heavily on land use models while others use more of a negotiating process with local governments. All regional land use forecasts reflect, to some extent, the policies and programs that influence land use in the region. The MPO or COG considers all the local, regional and state policies that can affect the land use forecast together with past trends and the realities of the real estate market.

The only policies and programs that could explicitly be used for air quality credit as control measures are those that are somehow not reflected in the baseline. There are two reasons why this might occur. One possibility is that the analytical methodologies used to evaluate land use, travel, and emissions do not reflect the full impact of a land use measure – a measure that is already in place or an expected future measure. In this case, alternative methodologies would be needed to allow quantification of the impact of the land use measure. The other possibility is that a policy or program is not expected to occur without some future government action (adoption, implementation, enforcement, etc.), and therefore was not included in the baseline. In this case, the government agency would have to commit to performing the action that will bring about the land use change, and that commitment would be identified as a control measure.

Actions being initiated outside of the air quality planning process

The limited ability of existing analysis methodologies to quantify sustainable land use activities can obscure the benefits of those programs that are occurring as part of the regional planning process. Sustainable land use policies and programs are being considered in almost every metropolitan area in the country for such reasons as to reduce traffic congestion, promote economic vitality, preserve recreational open space and agricultural lands, protect threatened species, and use infrastructure funds more efficiently. While many communities recognize the potential air quality benefits of these activities, air quality is not the driving factor in their implementation. The regional land use forecasting process generally includes these policies to the extent that they are having an impact on population and employment growth. It may still be possible to take explicit credit for these policies if the emissions baseline does not reflect their full impact. As discussed further in Chapter 3, the technical methodologies used to forecast travel and emissions often do not detect changes in urban design and land use mixing that can reduce vehicle travel. In addition, land use forecasting techniques differ widely between regions, and some areas may not fully capture the effects (both positive and negative) of local land use policies.

Actions initiated by the air agency

Because of the nature of the regional land use forecasting process, sustainable land use activities that are occurring as part of a larger planning agenda will be included in the regional land use forecast to the extent that they change population and employment growth. One example of an activity that clearly would not be included in the regional land use forecast would be one initiated expressly for air quality purposes. Based on the interviews conducted as part of WA09 and this project, we feel this possibility is unlikely.

However, it is possible that an air agency could initiate sustainable land use activities that would otherwise not occur, and these measures might therefore not be reflected in the baseline.

2.2.2 Modifying the Baseline Quantification Process

One way to recognize sustainable land use activities would be to modify the procedures for developing the baseline to better account for land use measures. By improving land use and travel demand models, it may be possible to better reflect in the baseline emission reductions that result from land use measures that are in place. Some of these improvements are discussed in Chapter 3. Of course, modifying these tools could also improve the quantification of explicit land use measures in the SIP or as part of a conformity determination. However, the current modeling tools will always be somewhat limited in their ability to show the impact of land use on travel.

Baseline emissions could also be reduced by incorporating the impact of land use policies and programs that are not included in the regional land use forecast (i.e., new policies and programs). This would be a significant departure from current practice and not advisable. That is because explicit revisions to land use policies would constitute a control measure. If states are to take emission reduction credit for these revisions, the measures must be fully enforceable and tracked as any other control measure commitments established under a SIP.

2.3 Economic Incentive Program

Economic Incentive Programs (EIPs) are strategies that encourage emissions reductions through market-based incentives. EPA has issued guidance for these measures in the form of the 1994 EIP Rule, and is currently in the process of comprehensively updating this guidance for discretionary EIPs.[*]

2.3.1 Description

There are four general types of EIPs:

- Emission Trading Programs,
- Financial Mechanism EIPs,
- Clean Air Investment Funds, and
- Public Information EIPs.

[*] *Economic Incentive Program Rules,* US Environmental Protection Agency, 40 CFR Part 51, 1994.

Emission trading programs create transferable emission reductions that authorize sources to emit a unit of emissions. Emission trading programs are typically used for stationary sources, though it might be possible to develop a trading program that applied to mobile sources through land use. For example, if a particular development project could show a reduction in mobile source emissions through land use, that reduction could be traded to allow some other source to emit more. While this sort of trading would not reduce overall emissions levels, it would add flexibility to a reduction strategy. However, most development projects would not create an emission reduction large enough to be used as a tradable credit.

Financial Mechanism EIPs include fees, taxes, or subsidies targeted at promoting pollution-reducing activities or products. This type of EIP also includes time-saving mechanisms. Most land use measures that rely on economic incentives would likely be of this type. For example, programs that attempt to influence the behavior of developers through taxes or subsidies would fall under this category. A Financial Mechanism EIP could also attempt to influence developers by saving time and effort through a streamlined permitting process.

Clean Air Investment Funds are state-run mechanisms to provide a way to lower costs for sources facing high control costs and invest in technology innovation to improve long term air quality. This type of EIP would not typically apply to land use.

Public Information EIPs include product certifications or public information campaigns that attempt to influence public behavior in a way that reduces emission-producing activities. Some land use measures might be included in the Public Information category. For example, some regions have considered an outreach program that would use analytical models to show developers how infill projects can save them costs.

Like all SIP measures, EIPs must be consistent with SIP attainment and Rate of Progress requirements, and the emission reductions from EIPs must be quantifiable, enforceable, and permanent. In addition, EIPs emission reductions must be *surplus*, meaning that the reductions are not relied upon in the SIP as part of another control strategy. Like other SIP measures, EIPs would be enforced by the state or the state's designate. The enforcing agency would be responsible for ensuring that the EIP is creating the expected behavioral response. However, unlike traditional command and control measures, the state may not have direct control over the emissions source under an EIP. Rather, the state would have direct control over the incentive being offered.

The quantification of emission reductions under an EIP must reflect the uncertainties inherent in the program. EPA guidance specifically identifies two types of uncertainty:

- *Compliance uncertainty*, which is the extent to which the responsible party will fully implement the VMEP program; and

- *Programmatic uncertainty*, which is the extent to which voluntary responses actually occur and/or the inherent uncertainties of program design.

Land use measures would have multiple levels of uncertainty. Consider, for example, a regional growth management strategy adopted by the MPO that relies on voluntary implementation by local governments. Compliance uncertainty could refer to the extent to which local governments modify their policies in support of the regional strategy. Programmatic uncertainty could refer to the extent to which new development adheres to the local government policies, and the extent to which new development patterns influence travel and emissions. Since the factors that affect development can vary so widely, these levels of uncertainty probably need to be estimated on a case-by-case basis.

2.3.2 Application to Land Use Measures

Typically, an EIP land use measure would offer some type of monetary reward to builders of sustainable development. This could be in many forms, including tax breaks, grants, or a fee structure. These monetary rewards could be offered by local, regional, state or federal government agencies, or perhaps even by non-governmental agencies. An EIP land use measure could also work by offering non-monetary incentives, such as density bonuses, relief from impact mitigation, or a streamlined permitting process for sustainable development.

Most non-monetary incentives, and some monetary incentives, would be incorporated into local government land use policy, and thus would be implemented at the local level. This raises some questions as to how EIP land use measures would be enforced. For monetary incentives over which the state has direct control, a land use measure would be fairly similar to other EIP measures, and could be developed using existing guidance. The state would be responsible for ensuring that the incentive is offered as planned, and would need to monitor its effect on behavior to ensure that the measure was having its expected impact.

For incentive programs operated by regional or local governments, adopting the measure as a SIP EIP might require additional guidance. Since the state would not be directly implementing the incentive program, it would have to receive some sort of enforceable commitment from the local or regional agency. If state law required that the local governments offer the incentive, this would probably be sufficient assurance. If not, the state would need assurances that the local or regional agency would adopt the program (if it was not yet in place) and would implement the program as expected. The form that these assurances would take is not made clear in existing guidance. One possibility would be some form of a Memorandum of Understanding (MOU) between the state and local/regional agency.

2.4 Voluntary Measures

Another type of SIP measure is known as the Voluntary Mobile Source Emission Reduction Program (VMEPs). VMEPs rely on the voluntary actions of individuals or businesses to achieve emission reductions. EPA released guidance on incorporating

VMEPs into SIPs in 1997.[*] The guidance offers more flexibility for the adoption of voluntary measures, recognizing that the standard SIP requirements can be overly burdensome for voluntary measures that typically offer only small emission reductions. However, since states have only limited experience in measuring the effectiveness of voluntary programs, EPA has limited the emission reduction allowed under VMEP to 3% of the inventory for each criteria pollutant.

2.4.1 Description

Like other SIP measures, voluntary measures must be consistent with SIP attainment and Rate of Progress requirements, and the emission reductions must be quantifiable, enforceable, permanent, and surplus. Voluntary measures differ from other SIP measures in that EPA does not require direct state authority over the program. This may make the VMEP program particularly attractive as an option for land use measures. A VMEP program can be implemented by a local or regional government, or by a private entity, without the kind of state authority required of EIPs or other SIP measures. The state is, however, required to monitor, assess, and report on the implementation of the VMEP, and must make up any shortfall in emission reductions. As with EIP measures, the quantification of emission reduction under a voluntary measure must reflect both compliance uncertainty and programmatic uncertainty.

2.4.2 Application to Land Use Measures

Most types of land use measures fit the criteria to be adopted as a VMEP. Many sustainable land use programs will not be directly operated by the state, for example. Nearly all land use measures rely on "voluntary" action in the sense that they cannot directly force action by private developers nor by the travelers who are affected by land use. In addition, the VMEP guidance specifically accounts for the fact that states have only limited experience in quantifying the emission reductions under these programs. This type of guidance will be needed for many land use measures, where the uncertainties in quantifying the impact of land use on emissions may make it difficult to adopt them as EIPs or TCMs.

As with EIPs, the state would need some type of assurance that local governments would implement a land use measure that was not yet in place. It is not clear from the guidance what form this assurance should take.

States might not want to adopt a land use measure as a VMEP because of the 3% limit. This limit applies to the combined reduction from all voluntary measures. So, for example, a state that was taking credit for mobile source emission reductions under an

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[*] *Guidance on Incorporating Voluntary Mobile Source Emission Reduction Programs in State Implementation Plans (SIPs),* Memorandum from Richard D. Wilson, October 24, 1997.

Ozone Action Day program and an employer-based trip reduction program might not have much room left under the 3% cap. In this case, the state might want to adopt the land use measure as an EIP or TCM. Doing so would require that the state have more authority over the program operation and more certain methods for quantifying emission reductions.

2.5 Maintenance Planning

Under the CAAA, the state prepares a maintenance plan for areas that achieve attainment of NAAQS. The maintenance plan must show that air quality standards can be maintained for ten years after redesignation from nonattainment to attainment. Eight years after redesignation, a subsequent maintenance plan must be submitted that demonstrates how NAAQS will be maintained for an additional ten-year period. Maintenance plans must account for future increases in emissions, and therefore may require the adoption of new control measures. The maintenance plan must also identify contingency measures that will take effect should the region experience future violations of NAAQS.

Because the maintenance plan addresses a longer time frame than most control strategy SIPs, it may provide an opportunity to take air quality credit for land use measures. Some sustainable land use strategies may not produce travel and emission benefits for ten years or more. So some regions may have policies and programs that do not result in quantifiable benefits within the SIP attainment horizon, but do produce quantifiable benefits beyond that during the maintenance period.

Of course, many maintenance regions will not be in need of additional mobile source control measures, and will be unlikely to commit to them. However, areas where expected regional growth could result in significant increases in VMT may want to examine the impacts of land use measures to ensure maintenance of the standard. Furthermore, if the benefits of a sustainable land use policy or program could be quantified fairly easily, and the measure could reduce emissions in a less expensive manner than alternatives, then the region may wish to adopt a new land use measure to allow it to drop other control measures. Interest in sustainable land use polices may also be stimulated if, in the later years of a maintenance plan, VMT growth outweighs vehicle technology improvements.

The requirements for maintenance plan control measures are the same as for measures submitted in a nonattainment SIP. Emission reductions must be quantifiable, enforceable, and permanent. Land use measures submitted in a maintenance plan would be subject to the same rules and guidance as described above for TCMs, EIPs, and VMEPs.

2.6 Transportation Conformity

The CAAA of 1990 requires that transportation plans and programs are consistent with efforts to attain air quality standards. Nonattainment areas must demonstrate that their transportation plans and programs are in conformity with the area's SIP, and areas that cannot make this demonstration may be ineligible for federal transportation funds. EPA has released rules for making conformity determinations, most recently in 1997.

2.6.1 Description

Federal law requires that metropolitan areas (those with a population over 200,000) prepare a long-range transportation plan, and update this plan at least every five years. Typically, these plans are prepared for a 20-year horizon. Metropolitan areas also prepare a Transportation Improvement Program (TIP), typically a 3- to 5-year document that identifies specific project funding. Both of these documents, as well as any significant projects not identified in the plan or the TIP, are subject to the conformity determination. Conformity of transportation plans must be determined at least every three years.

The requirement for making a conformity determination rests with the MPO, the Federal Highway Administration (FHWA), and the Federal Transit Administration (FTA). This is done in consultation with EPA, the air agency, the state department of transportation, and other relevant agencies. The MPO must show that the emissions that will result from the projects identified in the 20-year plan are within those allowed by the SIP mobile source emission budget.[*] Incorporating the impact of control measures would be one way to reduce the transportation plan emissions. In this way, it would be possible to "take credit" for land use measures in the conformity process. As in the SIP process, it would be possible to take credit for land use measures in the conformity process *implicitly* (by enhancing models to better account for land use impacts) or *explicitly* (by identifying the policy or program as a control measure and quantifying its impacts outside of the standard network analysis).

2.6.2 Application to Land Use Measures

As with the SIP baseline, all conformity determinations inherently reflect some land use policies and programs. EPA guidance requires that "land use, population, employment, and other travel model assumptions must be documented and based on the best available

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[*] It is important to note that mobile source emission budgets are not always fixed at a specific level. Some communities project emission budgets for years beyond the attainment dates established in the Clean Air Act. The purpose of establishing budgets in the "out years" is to allow transportation emission budgets to increase in proportion to reductions occurring in other source categories (i.e., and stay within the emission cap needed to demonstrate attainment). This eliminates the problem of finding offsets for growth in years beyond the specified attainment date and enhances their ability to demonstrate conformity with the budgets established in the SIP. In this document, the SIP option generally refers only to planning through the attainment year.

information." This means that the transportation plan update must account for any revisions to the regional land use forecast. Any sustainable land use measure could be used for explicit conformity credit only to the extent that it is not included in the official regional forecast, or is not measured because of modeling limitations.

The Transportation Conformity Rule, Section 122(a), provides some guidance on how emission reduction measures should be included in the conformity analysis.[*] All expected projects that are "regionally significant" must be included in the emissions analysis. Nonattainment areas classified as serious for CO and areas classified as serious, severe, or extreme for ozone are required to use network modeling (as specified in the rule) to analyze emissions. Projects that are not regionally significant, including TCMs, do not necessarily need to be analyzed using network modeling, but can be analyzed off-model in accordance with "reasonable professional practice." Following this logic, the benefits of land use measures could be quantified using similar procedures if they are interpreted to be TCMs. Given the complexity of land use analysis, EPA should carefully consider whether communities should be allowed to assess the impact of land use policies outside of the travel demand modeling process.

The Conformity Rule includes some requirements on the type of authority needed for a control measure in order to take credit for the measure in the conformity determination. It states that emission reduction activities that require regulatory action for implementation can only be included if:

1. the action is already adopted by the enforcing jurisdiction, or
2. the activity is included in the SIP, or
3. the SIP contains a written commitment to implement the activity from the authorized agency, or
4. the action has been approved by EPA, or is required under the CAAA without the need for state action.

Many land use measures, like zoning ordinances or subdivision regulations, do require regulatory actions, and would be subject to the rules above. So a land use measure like local zoning changes that was not yet adopted nor identified in the SIP could not be used for conformity credit, according to the rule. Some other land use measures would not require regulatory action, such as some incentive programs. The rule states that if these are not included in the transportation plan or TIP, then the MPO must obtain written implementation commitments from the appropriate entities in order to include them in the conformity emissions analysis. Including the incentive program in the plan or TIP would serve as assurance that the program would receive funding and would be implemented in a timely manner.

[*] *Transportation Conformity Rule Amendments: Flexibility and Streamlining; Final Rule*, US Environmental Protection Agency, 40 CFR Parts 51 and 93, August 15, 1997.

2.6.3 Time frame

Transportation plans typically cover a period that extends beyond the attainment year addressed by the SIP. To determine conformity in these years, the plan's emissions are compared with the mobile source emission budget established in the SIP. For example, in a severe ozone nonattainment area that adopts a 20-year transportation plan, the emissions resulting from the plan in 2020 must be shown to be less than the SIP mobile source budget for the attainment year of 2005 (or 2007), unless future year emission budgets have been developed. In those communities that are projecting rapid growth, it may be difficult to demonstrate conformity with the budget in later years of the plan (e.g., 10 years after the attainment year). Under this circumstance, sustainable land use policies may prove to be an attractive control measure option.

The longer time frame is one of the primary benefits of using the conformity process for land use credit. Many land use measures cannot be expected to produce significant emission reductions within ten years, which effectively makes them irrelevant for attainment-year SIP planning. However, land use is more likely to have an impact within a 20-year horizon. Some metropolitan areas may be in need of additional control measures at the 15-year or 20-year point. In many regions, technological improvements to vehicles can more than compensate for expected increases in VMT over the next decade or so. But the benefits of current technological improvements will reach a limit over time, when fleet turnover has replaced most older technology vehicles. At that point, the expected rise in VMT will require additional reductions in mobile source emissions, and land use measures could serve this role.

2.6.4 Other Benefits of Using the Conformity Process

In addition to the longer time frame, there are several other issues that may make the conformity process more attractive for land use credit than the SIP process. The conformity requirements for interagency consultation bring together all relevant local, regional, and state agencies in a frequent and regular forum. (While interagency consultation often occurs in SIP process as well, it is not explicitly required.) Any difficulty in showing conformity will focus the participants specifically on strategies to reduce mobile source emissions. Since this process is being conducted in conjunction with a new regional land use forecast and transportation plan, it provides a good opportunity to consider the impact of land use. The conformity process may also provide a better means to offer incentives for local government participation. The inability to demonstrate conformity can mean an interruption in federal transportation funds, and this can mean that transportation projects are delayed or canceled. To local governments that fear losing a desired project, this may offer an incentive to adopt sustainable land use policies and programs.

2.6.5 EPA's Role in Conformity Determinations

There may be some question as to what EPA would need to do to better facilitate taking credit for land use measures in the conformity process. EPA does not make conformity determinations itself, and nothing currently prevents an MPO from including land use measures in its conformity determination (aside from the requirements previously discussed). However, EPA does play a role in the process, and EPA promulgates the conformity rules. Additional guidance may be needed if EPA wishes to promote the use of effective sustainable land use measures.

2.7 Policy Options Not Chosen for Further Evaluation

One policy option that was considered but not chosen for further evaluation is the promotion of sustainable land use through the environmental review process. One example of this option is the Clean Air Communities Program proposed by the South Coast Air Quality Management District and described in the WA-09 report.[*] In California, environmental review is performed under the state's California Environmental Quality Act, or CEQA. The SCAQMD has produced a CEQA Handbook that contains guidance for conducting air quality impact studies. As part of a review of this Handbook, the SCAQMD had proposed a modification of the environmental review process that would reward new development employing sustainable land use practices. This proposal has since been dropped by SCAQMD, and inquiries revealed no similar efforts in other areas of the country. While this policy option remains an attractive tool for the promotion of sustainable land use, the issues associated with state and federal environmental review are complex and beyond the scope of this work assignment.

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[*] This program came out of the EPA's Clean Air Communities Initiative. See *Clean Air Communities*, Clean Air Act Advisory Committee, US EPA, August 7, 1997.

3. Land Use Measures

3.1 General Land Use and Transportation Issues

The transportation and air quality planning process involves some complex interrelationships between different public agencies at the local, regional, state, and federal government levels. It is useful to review the responsibilities and authority of these agencies with respect to land use, transportation, and air quality.

Local governments have most of the power to control land use within their borders. They issue permits for development, and control where and how development occurs. They also have some responsibility for the local transportation infrastructure, including the local street system and bicycle and pedestrian facilities. Local governments possess their land use authority at the will of the state. In a few cases, states have placed some restrictions on local government land use powers by requiring compliance with state regulations or by granting land use powers to a regional agency.

The Council of Governments (COG) serves the local governments and the state by preparing the land use forecasts used in transportation and air quality planning. COGs use a variety of procedures to develop a land use forecast. Nearly all, however, begin with a fixed amount of regional population and employment growth, often determined by the state. The forecasting process involves allocating this growth total to the cities and counties of the region, and then down to the level of transportation analysis zones, or TAZs. Some metropolitan areas employ land use allocation models like DRAM/EMPAL to perform their land use forecasts, with post-model adjustments. Others rely completely on past trends, local plans, and negotiations between the MPO/COG and local governments. In either case, local governments have some input in developing the forecast. The forecasts thus reflect to some extent the policies and programs in place that shape land use.

The Metropolitan Planning Organization (MPO) is responsible for regional transportation planning and for distributing state and federal transportation funds. The MPO prepares the long-range regional transportation plan and the short-term Transportation Improvement Program, and is responsible for ensuring that these documents do not violate air quality plans. Sometimes the MPO and the COG are the same agency. In most cases, neither the MPO nor the COG has any real power to control land use decisions.

The air agency is designated by the state and is responsible for developing the air quality plans for the metropolitan area and enforcing certain rules and regulations related to air quality. The air agency itself has no power to control land use decisions, and relies on the forecasts of the COG and MPO to develop air quality plans. However, in some cases the MPO is also the local air quality agency charged with developing air quality plans. These areas have a unique opportunity to develop transportation and air quality plans that have coordinated goals and analytical consistency.

The phrase "land use" may be used in different ways by these agencies. To city planners, land use refers to the type of activity conducted on a site – industrial, retail, low-density residential, parks, etc. Land use is also sometimes used more broadly to encompass some elements of urban design, such as building setback and height, pedestrian paths, and landscaping. In travel demand forecasting, land use typically means simply demographic and employment figures at the level of transportation analysis zone (TAZ). Typically, TAZs are the size of one or several census tracts, which can be a half-mile to several miles across. For residential areas, a standard land use forecast consists of the population, number of households, and some characteristics of the households like auto ownership, income, number of workers, etc., for each zone in the region. For non-residential areas, land use is typically defined as retail and non-retail employment by zone, student enrollment, and perhaps a measure of retail or office floor space. These population and employment figures then become the basis for the trip generation, trip distribution, and mode choice travel demand modeling steps.

3.2 Implementing Mechanisms

Before discussing land use measures, it is important to identify the specific policies and programs that are used to achieve a desired urban form. Usually these will be policies and programs adopted or operated by a government agency, though a non-government agency could also offer a development incentive program. Implementing mechanisms differ across levels of government and authority. For example, in order to facilitate transit-oriented development (TOD), a local government could amend its general plan, modify its zoning ordinance or design review guidelines, adopt an incentive program to encourage development in focused areas, or make necessary capital improvements. In reality, the local government would probably adopt several of these policies and others. A state or regional body like an air agency or MPO/COG could also promote TOD, though in a more indirect way. Its program might include providing educational materials to developers on the benefits to them of building near transit, encouraging local governments to amend their policies in support of TOD and providing model ordinances for them, or facilitating cooperation between the transit agency (who might own land around rail transit stations), local governments, and developers.

There are numerous implementing mechanisms for sustainable land use measures. For this report, implementing mechanisms have been grouped into the following seven categories:

- Regional/state growth controls;

- Regional/state/federal development incentives;
- Regional/state/federal education and facilitation programs;
- Local government growth controls;
- Local government design controls;
- Local government incentives; and
- Private developer actions, without specific government policies or programs.

These categories attempt to distinguish between mechanisms that primarily affect *where* building occurs (growth controls and some incentives) from those that primarily affect *how* building occurs (design controls and some incentives).

3.2.1 Regional/State Growth Controls

Regional/state growth controls refer to non-local government programs to restrict the location and intensity of new development. Often, these are programs or policies primarily intended to protect open space (for agricultural use, recreational use, habitat conservation, runoff prevention, etc.), not to reduce VMT. Some of the programs can work directly by providing funding for the purchase of open space land. Other programs prevent the use of state infrastructure funds in certain areas, or attempt to preserve the agricultural use of lands. They can also work indirectly by forcing local government actions, such as requiring local governments to designate growth areas or to accept new housing. Nearly all examples of these programs are at the state level. One exception is the Portland, Oregon area, where a regional government agency has been granted some land use powers by the state.

Because most state growth controls are designed primarily to protect open space, they generally have limited ability to achieve the urban form changes needed to reduce vehicle emissions. For example, without proper controls, a state program to protect open space within a metropolitan area could push new development farther out and increase regional VMT. Programs such as Washington's Growth Management Act and Maryland's Smart Growth Initiative require that local governments designate growth areas, and discourage use of state infrastructure funding outside of these areas. While these programs may result in more orderly development patterns, and discourage development that is unwanted by local governments, they do not require local governments to build more compact, mixed use, or transit-oriented development that could reduce vehicle use.

3.2.2 Regional/State/Federal Development Incentives

Regional/state/federal development incentive programs attempt to lure new development to desired areas. They can work through monetary incentives, like grants, tax breaks or fee reductions, or through non-monetary incentives like a transfer of development rights (TDR). An example is the Transit Village Program in New Jersey, which provides resources and technical assistance to local governments to promote development around passenger rail stations. The aim of most of these programs is usually to protect open

space or spur economic revitalization, not to reduce vehicle use. For example, New Jersey also has a state TDR program to protect open space. Landowners in areas desired for open space are given development rights in exchange for maintaining the low density character of their land. These rights can be sold to developers and used to build at higher densities in existing urban areas. While this program may work well to protect open space, it could actually result in more development and higher emissions in the nonattainment area than would otherwise occur.

3.2.3 Regional/State/Federal Education and Facilitation Programs

Education and facilitation programs attempt to encourage sustainable development through publicity, education, technical assistance, intergovernmental cooperation, or similar efforts. These are programs that do not offer significant development incentives nor restrict growth through controls. They can be implemented at any level of government, though most significant programs are at the regional, state, or federal level.

One example is the San Francisco Bay Area Air Quality Management District's measures focused on TOD and pedestrian travel. These measures are intended to serve as a catalyst for local governments to take actions in support of sustainable development. In particular, the Air District, along with the region's MPO and COG, has committed to the following:

- Encourage local governments to revise general plans and zoning ordinances to encourage transit-oriented development and pedestrian improvements;
- Develop planning pilot projects;
- Provide technical assistance to local government agencies;
- Publicize noteworthy examples of clean air plans, policies and programs; and
- Encourage pedestrian improvements in capital improvement programs.

Because the air agency and other regional agencies do not have any authority over land use decisions, they can rely only on local government implementation.

Other regions have tried to encourage sustainable land use through non-binding long-range plans or "visions." Again, since these regional agencies lack the authority to control development, they must rely on voluntary participation by local governments. For example, the Denver region's *Metro Vision 2020 Plan* calls for future development to occur in a more compact fashion than current development trends. The Plan identifies a flexible urban growth boundary, and relies on voluntary local government implementation to enforce the boundary.

3.2.4 Local Government Growth Controls

Local government growth controls include city and county policies to restrict the location and intensity of new development. These policies include zoning ordinances and general

plans, and they often work in conjunction with local government design controls and incentive programs.

Zoning regulates the type and intensity of new development. In most cities, all land is covered by zoning regulations to some degree. Since zoning can work only by restricting certain development, its impact depends on the market demand to build. On the urban edge, zoning that requires very low densities can effectively preserve land as open space. In infill areas, raising zoning densities can facilitate higher density development than previously allowed. Zoning can also encourage (or prevent) land use mixing. In most states, zoning works in conjunction with general plans and specific plans. The general plan lays out the vision for development in the municipality, and the zoning ordinance incorporates that vision into city code.

Zoning is one tool used to implement an urban growth boundary (UGB). A UGB is a line drawn around an urban area, beyond which new urban development cannot occur. This is accomplished by zoning the land beyond the UGB for very low density, adopting policies that prevent the extension of city services to new development beyond the boundary, and facilitating more development within the UGB. Zoning can also be used to encourage mixed use development. Traditionally, zoning was used to segregate different land uses thought to be incompatible, and this prevented office and retail facilities from locating within walking distance of residential areas. If these restrictions are lifted, mixed use development can occur in places where developers find it profitable to do so. One variation on this is mixed-use overlay zoning – a second layer of zoning is added to an area that is predominantly single-use. Overlay zoning could be used to allow, for example, small commercial development in residential areas or housing development in commercial areas. Similar policies can encourage second units in areas dominated by single-family detached homes, which can effectively increase residential densities.

Zoning ordinances and general plans are probably the strongest tools that governments have to affect land use. However, zoning is only as strong as the locally elected officials want it to be. Low density zoning does not prevent building on urban fringe lands because local officials can grant zoning variances. Higher density zoning near transit or other infill sites will have no impact if local officials make the approval process too difficult or too risky for developers, or if there is no market demand. Zoning works only in the negative – it can shape urban form through restriction, but it does not create demand. Therefore, zoning needs to be carefully structured to shape development in sustainable patterns. For example, an urban growth boundary that does not include enough land for new development and does not facilitate infill, will merely push growth into other jurisdictions farther out.

3.2.5 Local Government Design Controls

Local governments can exercise control over site design through the design review process. New projects come before the local government design review board, which can require architectural or design changes in order to approve a project. The board may use design review guidelines to standardize its decisions. Design review guidelines might

require that in certain areas, a project must be mixed use, or can require features related to bike and pedestrian facilities (paths, racks, showers, etc.), landscaping, building and parking placement, etc.

Subdivision regulations offer another opportunity for local governments to affect design on developing land. Subdivision regulations can require that a new subdivision include sidewalks, bicycle paths, transit lines, bridges, easements for access to schools, etc. They also can set street standards.

Like zoning ordinances, the effectiveness of design controls depends on local officials. In many cities, design review guidelines are only advisory and may be ignored as planning boards see fit. Getting developers to modify a project design depends greatly on local market forces. In areas without high demand, the ability and will of local government planners to exact design concessions from developers can be quite limited.

3.2.6 Local Government Incentives

Incentive programs offer monetary or non-monetary rewards to developers who build in desired locations or who include certain design features in new projects. At the local level, these programs can work in a variety of ways, such as offering grant money or tax abatements, modifying an impact fee structure, allowing higher density development through density bonuses or TDRs, or reducing the time to obtain necessary permits.

Local governments can require that new development pay an impact fee to cover infrastructure improvements, or make improvements in-kind as an exaction. These fees or exactions can be structured to encourage development that reduces vehicle use. For example, development impact fees or parking requirements can be reduced for mixed-use or transit-oriented development, or for developments that make improvements to the pedestrian and bicycle infrastructure. Some local governments have attempted to extend impact fees to require traffic and air quality mitigation measures from all new development as part of an indirect source review (ISR) program. These types of programs were first introduced in the 1970's but have been less common in recent years. Under such a program, new development can be required to include specific design and land use features in order to reduce the vehicle emissions associated with the site, or pay a fee instead. Sacramento County is considering this type of program.

Density bonuses allow new development to be built at a higher density than would be allowed under zoning regulations, in exchange for including certain desirable features in the development. For example, an office project that includes child care or housing near transit could be allowed to build a taller building. Incentives can also work by saving time. For example, the local government permit process can be streamlined to encourage sustainable development projects. In many cities, the permitting process for new development is often easier for single-use, auto-oriented development than for mixed-use projects. Local policies can be revised to make the approval of certain types of projects easier, which can reduce the time and cost for developers building mixed-use projects.

Local governments can provide tax incentives for infill development by establishing enterprise zones. An enterprise zone is typically created for an economically depressed part of the city as a way to create jobs and spur revitalization. Developers are offered reduced taxes and fees for building in the zone. Or local governments can reduce the cost of building in certain desired locations by making infrastructure improvements.

The ability of incentive programs to have a significant impact on new development depends to a large degree on the nature of the existing development fees and risks. Offering a reduction in a traffic impact fee or parking requirement that is already minimal will have little impact on developer behavior. Development incentives will have to be fairly large to have a significant impact on a developer's choice of building location, and many local governments will not have the resources to offer these types of incentives over a long period of time. It may also be difficult to determine how much impact an incentive program is actually having, given that there are so many factors that affect the cost and risk associated with development.

3.2.7 Private Developer Actions, without Specific Government Policies or Programs

Of course, sustainable development can occur without a specific government policy or program. Every city can experience new development even if it does not modify its development controls or adopt incentive programs. Once built, this development will be reflected in any update of the regional land use forecast. However, the emissions baseline may not fully reflect the beneficial impact of the project.

In most cases, a single development would have to be quite large to have a regional emissions impact. There are several mixed-use, infill projects in the planning stages that might meet this criterion, such as the Playa Vista development in Los Angeles, the Stapleton development near Denver, and the Atlantic Steel development in Atlanta. All of these projects are planned to incorporate features to reduce vehicle use, such as housing, retail and office mixed use, pedestrian and bicycle connections, and high transit access. Assessing the extent to which these projects are included in a baseline forecast would have to be done on a case-by-case basis.

3.3 Land Use Measure Categories

Land use measures are typically thought of in terms of how they change urban form. While some land use measures might be defined in terms of the implementing mechanism itself, most will take credit for a change in urban form. Techniques for monitoring the change in urban form and measuring its impact can vary. For purposes of this project, land use measures have been grouped into the following five categories based on urban form types:

- Transit-Oriented Development,
- Infill Development,
- Jobs/Housing Balance,

- Mixed-Use Development, and
- Neotraditional Design Development.

Transit-oriented development (TOD) refers to moderate to high density development along a regional transit system. Most TOD programs are focused around rail transit stations, though the concept can be applied to a bus corridor or ferry terminals. Ideally, TOD consists of housing and complementary retail, office, and public service development, though some TOD programs have focused on only a single land use. TOD can reduce mobile source emissions by increasing transit mode share.

Infill development refers to any type of new development that occurs within existing built-up urban areas. Infill development occurs on a vacant or under-developed site, and is the opposite of greenfield development, which occurs at the urban edge on land that has never been developed. Brownfield development is a specific type of infill development that occurs on sites with real or perceived environmental contamination due to a previous use. Infill development can reduce vehicle emissions by increasing transit mode share, increasing walk and bike mode shares, and reducing vehicle trip lengths.

Jobs/Housing balance refers to reducing the disparity between the number of residences and employment in a sub-region. In all metropolitan areas, some sub-regions have more jobs than housing, while others have more housing than jobs. This disparity is thought to contribute to longer commute trips. By achieving a more even balance of jobs and housing within subregions, trip lengths and regional VMT may be reduced.

Mixed-use development typically refers to development that locates complementary land uses such as housing, retail, office, services, and public facilities within walking distance of each other. Mixed-use development can occur as part of a large new development project, such as an entire housing subdivision. Or it can occur in built-out neighborhoods, by adding neighborhood-scale retail and services in areas that are used exclusively for housing or offices, for example, or by adding housing to commercial areas. Mixed use development can reduce vehicle emissions by increasing walking and bicycling mode share, and by reducing vehicle trip lengths.

Neotraditional neighborhood development refers to a set of land use and urban design elements that are designed to replicate pedestrian-oriented neighborhoods built before automobiles became the dominant travel mode. While this term is often applied loosely to a wide variety of development, it usually includes some land use mixing that allows walking from housing to retail and/or office development. Neotraditional development also encompasses numerous design features that encourage walking. These include design improvements to public spaces such as the addition of pedestrian-scale signs, benches, landscaping and small parks, and infrastructure improvements like sidewalks, bicycle facilities, narrow streets and greater street connectivity. Commercial development is typically oriented to sidewalks, with office space ideally over ground floor retail. Parking is minimized and located behind buildings away from the street frontage. Neotraditional neighborhood development can be located on new greenfield

sites or on infill sites. It can reduce vehicle emissions by increasing walking and bicycling mode shares.

Obviously there is considerable overlap between these categories. A typical transit-oriented development, for example, can occur on an infill site that features mixed land uses and incorporates neotraditional design features. In fact, most of the land use measures that could be considered for air quality credit will promote more than one of these types of urban form. They are distinguished in this report because they may vary in their implementation mechanisms, their ability to reduce emissions, and in the methods needed to quantify their impact.

There are also a number of measures that are typically considered part of sustainable development, but do not strictly involve land use. These include improved bicycle and pedestrian facilities, traffic calming and street design, and parking strategies like cash-out programs, parking pricing, and reduced parking standards. These strategies can all play a role in reducing vehicle use and often work in conjunction with the land use measures listed above. They are not considered further in this paper, however.

3.4 Impact of Land Use Policies and Programs on Urban Form

The effect of land use policies and programs on urban form, travel and emissions is complex. Our understanding of these relationships is incomplete, and the technical methods used to represent them have inherent uncertainties. While developing a specific methodology for quantifying the impact of land use measures is beyond the scope of this work effort, it is important to raise some of the quantification issues that affect the policy options available for emissions credit. It is useful to represent these relationships as follows:

Policies/Programs ➞ Changes in Urban Form ➞ Changes in Travel ➞ Changes in Emissions

The quantification effort will require estimating how the policies or programs will affect urban form, how the urban form change will affect travel, and how the travel change will affect emissions. We will focus here primarily on the first two relationships: the impact of land use policies and programs on urban form, and the impact of urban form changes on travel. Most of the issues with respect to the impact of travel on emissions are not specific to land use and are well-documented elsewhere.

Evaluating the impact of policies and program on urban form requires a system to measure the urban form and monitor its change. In general terms, there are two types of urban form change: one is a redistribution of regional population or employment growth between zones; the other is a change in urban design or small-scale land use mixing. While in reality most land use measures could produce both types of urban form change, it is useful to consider them separately.

3.4.1 Redistribution of growth between zones

A shift in growth between analysis zones would be the likely impact of an effective measure to promote infill, jobs/housing balance, or TOD. This type of urban form change will be relatively easy to measure and monitor. The zonal population or employment figures can simply be compared to those in the baseline.

Infill Development

To monitor the progress of a control measure designed to increase infill development, the agency would need to define a set of zones as infill target areas. These would likely be areas in the central city or inner-ring suburbs that have significant amounts of vacant or underutilized land. To measure infill progress, the population or employment in these target zones should increase more than in an uncontrolled baseline scenario, while growth in non-infill zones should occur at a rate slower than in a baseline.

Jobs/Housing Balance

Measures designed to increase jobs/housing balance can be monitored using available land use data, though more sophisticated metrics may be needed. At the simplest level, sub-regions could be defined as sets of analysis zones and the ratio of population to employment could be tracked over time. This would not account for the variances in employment needs across education and skill levels, however. Some studies have developed more sophisticated indices of employment accessibility that account for the differences between high-skill, white collar jobs and lower-skilled blue collar and service jobs.

Transit-Oriented Development

Comparing zonal growth figures would also work to some extent to monitor transit-oriented development. Zones containing, or near, regional transit stations should experience a population or employment increase above a baseline forecast, at the expense of non-transit-oriented zones. The ability to accurately measure transit-oriented development will depend on zone size, however. Most studies indicate that the maximum distance travelers will walk to a transit station is a quarter- to half-mile. If the objective of the TOD measure is to reduce vehicle starts, then population or employment densities must increase within this distance from a transit station. Analysis zones that are several miles across will not be able to discern clustering around a transit station from a general increase in zone density.

3.4.2 Micro-Scale Urban Form Changes

Micro-scale changes in urban form, such as site- or neighborhood-level land use mixing and urban design factors, will be more difficult to measure and monitor. These types of changes would be the likely outcome of an effective mixed use or neotraditional design measure.

Land Use Mixing

Measuring land use mixing or urban design features may require some analysis tools that are not currently available to most regional agencies. Land use mixing at the site or neighborhood level cannot typically be measured using population and employment figures unless very small zones are used. These types of changes will probably need to be measured on a project-by-project basis. For example, if a control measure was intended to increase the mixing of office facilities with retail and services (such as restaurants, convenience stores, dry cleaning, day care, etc.), progress could be monitored by tracking the portion of new office developments that incorporate these features. There will be no way to compare this to a standard land use baseline forecast, so some assumptions will have to be made regarding the amount of mixing of "uncontrolled" development patterns. Another option would be to define mixed use target areas and then monitor the number of retail, office, and service facilities using business registration data. The monitoring agency would need to define the objectives of a mixed use strategy. For example, in areas dominated by office use, a goal would be to increase the ratio of retail floor area to office floor area.

Neotraditional Design

Changes in urban design may also require some alternative measurement techniques. One simple option would be to track improvements to the pedestrian and bicycle infrastructure that result from a control measure, such as the addition of pedestrian paths, sidewalks, street crossings, bicycle lanes, bicycle racks, etc. Some studies have developed other simple measurements of the pedestrian environment, such as blocks per square mile or street widths, but this would not work well to measure change in neighborhoods that are already built-out. There have been a number of recent efforts to develop composite measurements of the pedestrian environment in order to test its influence on travel behavior. In the Portland region, for example, every analysis zone was assigned a Pedestrian Environmental Factor (PEF) from 4 to 12 by rating four attributes: street connectivity, sidewalk continuity, ease of street crossing on principal arterials, and topographic constraints to pedestrian mobility.[*] These rating systems are somewhat arbitrary, however, and it might be difficult to use them to track changes in the pedestrian environment due to a control measure.

3.4.3 Quantifying the Impact of Policies and Programs

There are no standard procedures for quantifying the impact of land use policies and programs on urban form. If we consider only the sustainable land use activities that are occurring as part of the larger regional planning process, then the existing procedures for developing the regional land use forecast account to some extent for all local, regional, and state land use policies. Typically, the COG will produce an initial land use forecast, and then negotiate with local governments over the details. The COG must weigh the desires of local governments with past trends and the realities of market forces. General plans, zoning ordinances, development incentives, etc., do not guarantee that any change

[*] *LUTRAQ Volume 4a: The Pedestrian Environment*, 1000 Friends of Oregon, 1993.

will occur. The process of developing the regional land use forecast typically accounts for all the factors that can shape the distribution of growth, and their inherent uncertainties; thus, generally, it would be difficult to identify growth redistribution impacts from land use measures that are not reflected in the regional land use forecast.

If it is felt that there are growth distribution impacts not reflected in the baseline, or in the case of a land use measure initiated expressly for air quality purposes, quantifying the impact of the control measure would need to be done on a case-by-case basis by knowledgeable local and regional planners. In a few regions that employ formal land use models like TRANUS or MEPLAN to aid in the forecasting process, the models can be used to some extent to forecast the impact of some policies and programs. However, the most widely used land use model, DRAM/EMPAL, cannot generally be used to forecast the impact of most land use policies, such as zoning or development incentives. All regional land use models could be used only to show the redistribution of regional growth; micro-scale urban form changes are generally not recognized in zone-based models.[*]

The impacts of policies and programs on micro-scale urban form changes are not accounted for in developing the regional land use forecast because they are not typically measured. Quantifying these impacts will require expertise by local and regional planners. For example, the effectiveness of incentive programs that encourage developers to include certain design or land mixing elements into projects will depend greatly on the type of incentive and the market forces in that city at that time. Local planners will be in the best position to credibly estimate the impact of these types of programs on urban form.

One issue that could complicate efforts to quantify the impact of land use policies and programs on growth distribution is the impact on regional growth totals. Currently, nearly all MPOs assume a fixed amount of population and employment growth for the region. States often determine these figures and require MPOs to use them. Under the assumption of fixed regional growth totals, growth controls and development incentives simply rearrange new jobs and housing within the region. However, it is possible that some land use policies and programs could actually change regional growth totals from the state's official forecast. For example, very strict growth controls could limit the regional population in-migration, or strong infill incentives could lure additional growth to a region. In the latter case, emission reduction benefits from sustainable development might be offset by a greater increase in the region's population and VMT. Trying to account for changes in regional growth totals would probably be difficult both politically and technically. If land use measures were thought to be causing a change in regional growth totals, it would raise questions about whether other cities in the state were gaining or losing growth as a result. Given these difficulties, it is likely that metropolitan areas will continue to assume fixed regional growth totals.

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[*] For a full discussion of these issues, see *Evaluation of Modeling Tools for Assessing Land Use Policies and Strategies*, 1997. See also Abraham and Hunt, 1998.

3.4.4 Time Frame for Change

It is very difficult to draw any conclusions about the length of time that will be needed for sustainable land use policies and programs to have an impact. As mentioned earlier, the most commonly used land use models are not very sensitive to land use policy changes, so they cannot be employed to estimate the impact of land use measures over time. The effectiveness of specific implementing mechanisms will depend heavily on local market conditions. In general, those interviewed as part of this work assignment and WA09 felt that policies such as urban growth boundaries that attempt to promote infill by restricting new development on the urban edge may not have any impact until available greenfields land becomes scarce. Direct incentives to build on infill sites or near transit stations may have an impact more quickly.

A number of regions have used travel and emissions models to show how alternative future land use scenarios could reduce emissions, including the MPOs in Denver, Portland (Oregon), Boston, and San Diego. But these scenarios are typically developed to illustrate the full range of possibility and bear little relation to actual land use policies. Most of the interviewees we asked about this issue felt that a realistic land use measure would not show a significant emissions benefit for at least a decade and possibly two or three. But clearly more research is needed to understand how sustainable land use policies can shape urban form over time.

3.5 Measuring the Impact of Urban Form Change on Travel and Emissions

Once the impact of a land use measure on urban form has been quantified, the next step is to quantify the impact of the urban form change on travel and emissions. As described earlier, the existing process is to use the official regional land use forecast as input to a standard four-step regional travel demand model. The model produces a forecast of VMT, vehicle starts, and average speeds that is used in an emissions model.

Quantifying the travel and emissions impact of a land use measure can be done in several ways. Although there will also be many uncertainties involved in this calculation, there is a large body of research and some existing analytical tools to rely upon. The complexity of these tools and the cost and effort needed to use them can vary considerably.

In general, there are three ways in which land use can affect the travel and mobile source emissions in the modeling process.

1. By shifting trips to non-automobile modes, land use can reduce regional VMT and reduce vehicle starts. This can be accomplished by locating housing, employment, or retail in areas more accessible to transit, or in closer proximity to each other to facilitate walking or bicycling. Infrastructure and urban design changes can also increase the non-automobile mode share by making transit, walking, or bicycling more attractive options.

2. By bringing trip origins and destinations in closer proximity, land use can reduce vehicle trip lengths and hence regional VMT. This can be accomplished by locating housing, retail, and employment in closer proximity to reduce the distance of automobile trips. However, since this does not affect the number of vehicle starts, it generally has less impact on emissions than diverting trips to alternative modes.

3. Land use can affect congestion levels and vehicle speeds. The impact of vehicle speed on emissions depends on the pollutant. In general, emissions per mile are greatest at low speeds and high speeds, and lowest at moderate speeds.

It will generally be more difficult to quantify a travel and emissions benefit from micro-scale urban form changes than from growth redistribution. Most empirical studies of the land use/transportation relationship have focused on the impact of density and transit access. Because higher densities often occur in conjunction with greater land use mixing, and pedestrian-friendly urban design, it is difficult to separate the impacts of each of these factors. Some studies have succeeded in isolating the impact of land use mixing. Urban design is more difficult to study in isolation, and very few studies have been able to credibly quantify its impacts on travel.

3.5.1 Using Regional Travel Demand Models to Quantify Land Use Benefits

One option for quantifying the impacts of urban form change would be to use the regional travel demand model. This is the standard four-step model (possibly with other steps added as enhancements), typically created and run by the MPO. While running a full metropolitan travel demand model requires extensive time and effort for data collection, model calibration, and validation, it may be relatively easy for an MPO to test alternative land use scenarios in conjunction with the evaluation of a regional transportation plan or a major investment study. A typical regional travel demand model could be used to quantify at least some of the impact of a redistribution of population or employment growth.

Metropolitan travel demand models can vary considerably in their sophistication and their ability to forecast the travel impact of urban form changes. For example, if population growth is shifted to TAZs that are located in areas with higher transit service, one would expect the travel demand model to forecast an increase in transit use. The extent to which the model does this depends on how the mode choice module is structured. Less sophisticated mode choice modules might capture TOD benefits only through a slight reduction in total transit travel time. A more sophisticated model might show lower transit walking access time, higher densities around transit stations, and lower vehicle

ownership levels as a result of TOD.[*] Similarly, shifting some of the retail or office employment growth to TAZs that are located closer to residential areas, or to TAZs with better transit access, should reduce vehicle use in the forecast. More sophisticated models include walking and bicycling options in the mode choice module, and these mode shares should increase if more destinations are accessible by foot or bike. In simpler models that generate only vehicle trips, a higher density of local shopping destinations would reduce only the vehicle trip generation rates. [**]

A number of metropolitan areas have used regional travel demand models to evaluate the transportation and air quality impacts of alternative land use scenarios. For example, studies in Baltimore, Seattle, and Portland have used regional models to show a reduction in VMT from more compact growth patterns.[***] The most comprehensive studies, done in Portland, show significant congestion and emissions reductions resulting from more compact and transit-oriented growth. However, the scenarios being evaluated in many regions represent the extremes of future urban form, and assume full regional participation. Modeling more realistic land use changes, or changes that occur only in portions of the region, may show more ambiguous results.

The distinct advantage of using a single regional travel demand model for measuring the impact of land use is that the model usually covers a geographic area roughly consistent with the nonattainment area. Emissions are measured across the entire nonattainment area. A local impact in urban form can have secondary impacts in other parts of a region, such as affecting congestion levels; only a regional model can account for these impacts.

The limitations of these models are well known. Because they are based on a system of analysis zones that are typically no smaller than census tracts, they cannot account for micro-scale changes in land use, such as land use mixing at the site or block level. And because they are designed primarily for evaluating large highway and transit infrastructure improvements, they typically do not accurately reflect bicycle and pedestrian travel. Therefore, in order to quantify the impact of micro-scale land use changes, some alternative tools must be employed.

3.5.2 Improving Models to Better Capture Land Use Benefits

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[*] Purvis, Charles, L., *Incorporating Land Use and Accessibility Variables in Travel Demand Models*, Presentation at the ASCE Specialty Conference on Transportation, Land Use and Air Quality, May 1998.

[**] Harvey, Greig and Elizabeth Deakin, *A Manual or Regional Transportation Modeling Practice for Air Quality Analysis*, prepared for the National Association of Regional Councils, July 1993.

[***] *The Effects of Urban Form on Travel and Emissions: A Review and Synthesis of the Literature, Draft Report*, 1998.

The ability of a standard regional travel demand model to capture the benefits of sustainable land use can be enhanced by increasing the model complexity, employing additional model variables, or supplementing the model with other software packages.

Pedestrian Environmental Factors

One option is to enhance the standard travel demand model with some measure of the pedestrian environment at the zonal level. The Portland, Sacramento, and Montgomery County areas have incorporated a "pedestrian environmental factor" into their models. This factor has been shown to improve the mode choice and auto ownership elements of the models.

However, it is unlikely that this type of model enhancement would be able to fully capture the micro-scale benefits of land use. Since the factor is a composite rating for the entire zone, it may not be useful for changes that occur in only a small part of a zone. Also, because all models are designed to forecast trips between zones and not within zones, many short walking and bicycling trips are never captured in a travel demand model even with measurements of the pedestrian environment.

INDEX Model

Another alternative is to use some form of spreadsheet-based analysis tool to enhance a regional travel demand model. As described in Appendix C, a related EPA project has been attempting to measure the benefits of infill development using the INDEX model. This model combines GIS mapping capabilities with spreadsheet analysis and some assumptions about the land use/transportation relationship from empirical studies. A proposed development can be described in detail with INDEX, including such factors as block length, land use mixing, parking, pedestrian features, and transit accessability. The INDEX model, combined with a regional travel demand model, produces estimates of the traffic, energy use, and emissions that result from the development.[*]

This process of combining a regional travel demand model with a tool like INDEX requires considerable effort, and it would probably not be feasible to repeat it on a case-by-case basis. If the EPA-sponsored efforts could develop some general estimates of the emissions benefits of particular urban form changes, then it might be possible to apply these results to other control measures. The work currently being done is testing the sensitivity of the INDEX model to variations in the size, location, and type of land use mixing in a project. This may be an important tool to distinguish between the benefits of growth distribution and micro-scale urban form changes.

3.5.3 Off-Model Calculations

[*] *The Transportation and Environmental Impacts of Infill versus Greenfield Development: A Comparative Case Study Analysis, Review Draft*, 1997.

The other option is to estimate the impact of urban changes outside of the regional modeling process. Using some professional judgement and empirical research, the forecast of regional VMT or trips would be adjusted to account for a control measure. For example, the air agency for the San Francisco Bay Area estimated the emissions benefits of its program to promote more transit-oriented development. They assumed 200 additional housing units at each of the region's 75 rail transit stations. Based on the regional household travel survey, each of these households was estimated to contribute 0.5 fewer trips per day than if the household were not located near a transit station. After calculating the total emissions reduction, the agency took credit for only 20% of the benefit to account for the uncertainties involved.

Several regional air agencies in California use a software tool known as URBEMIS7G to estimate the emissions impact of particular projects. The software is primarily used as part of an environmental review. It incorporates standard trip generation rates and some assumptions about the vehicle fleet, average speed, etc. The latest version of the software also allows the user to account for specific land use and urban design features that can reduce travel and emissions, based on empirical studies of the land use/transportation relationship.[*] While the emission reduction from any individual project would be quite small, this type of tool could possibly be used to estimate the impacts of land use and design features that were incorporated into a group of projects.

The danger in calculating travel and emission impacts off-model is that there may be secondary impacts of a local land use change that are not captured. For example, it's possible that a mixed-use development on an infill site could increase walking mode shares locally, but because the site becomes a popular regional attraction, it would cause shoppers to drive farther than they currently do. Or the development could increase local congestion levels to the point where they negate the emission reduction due to increased walking. These secondary effects are difficult to measure without a region-wide model.

The nature of land use measures can also make them difficult to evaluate in isolation. Some regions feel that individual control measures have little impact in isolation, but the synergistic effects of a combination of measures is greater than the sum of the parts. In other cases, the benefits of several individual measures might overlap, and the cumulative impact is less than the sum of the parts. The only way to consistently treat these interactions would be to evaluate all measures under a single modeling framework.

3.6 Summary

Table 1 summarizes some of the points made in this chapter. It is important to keep in mind that the conclusions drawn here reflect some simplifying generalizations about policies, urban form, travel behavior, and technical methods.

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[*] *URBEMIS7G Computer Program User's Guide*, Version 3.1, prepared for San Joaquin Valley Unified Air Pollution Control District by Jones & Stokes Associates, August 1998.

Table 1
Land Use Measures Summary Points

Land Use Measure	Implementing Mechanisms	Effect on Urban Form	Effect on Travel	Reflected in Baseline?	Ability to Quantify Benefits
TOD	State Development Incentives Local Growth Controls Local Incentives	Mostly Growth Redistribution Some Micro-scale Impacts	Mode Shift to Transit	Somewhat likely	Less difficult
Infill	State Growth Controls State Development Incentives Local Growth Controls Local Incentives	Mostly Growth Redistribution Some Micro-scale Impacts	Mode Shift to Transit/ Walk/Bike Shorter Trip Lengths	Somewhat likely	Less difficult
Jobs/Housing Balance	State Growth Controls State Development Incentives Local Growth Controls Local Incentives	Growth Redistribution	Shorter Trip Lengths	Likely	Less difficult
Land Use Mixing	Local Growth Controls Local Design Controls Local Incentives	Mostly Micro-scale Impacts	Mode Shift to Walk/Bike Shorter Trip Lengths	Somewhat unlikely	More difficult
Neotraditional Design	Local Growth Controls Local Design Controls Local Incentives	Mostly Micro-scale Impacts	Mode Shift to Walk/Bike	Unlikely	More difficult

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4. Conclusions

Land use measures can provide an effective strategy to reduce mobile source emissions. However, in order to better recognize sustainable land use practices in the air quality planning process, a number of technical, institutional, and regulatory issues need to be addressed. As discussed in Chapter 2, there are three general options for recognizing the emissions benefits of sustainable land use: include the measure in the SIP baseline, adopt the measure as some type of SIP control measure, or show an emissions reduction from the measure to support a conformity determination. A critical factor in assessing these options is the extent to which the measure is already reflected in the regional land use forecast.

The interest in sustainable land use results primarily from efforts to reduce traffic congestion, promote economic vitality, preserve recreational open space and agricultural lands, protect threatened species, and use infrastructure funds more efficiently. Sustainable land use activities may have a beneficial impact on air quality, but that is rarely their primary intent. Thus, most sustainable land use activities are being considered as part of a local and regional planning process, and are included in the regional land forecast. These measures could still be used for explicit emissions credit if the baseline does not completely reflect their impact.

It is also possible that land use measures could be initiated by air agencies expressly for air quality purposes. The research conducted under WA09 and this project suggests that this is rare. However, if such a measure were implemented, it might not be reflected in the baseline and could potentially serve as a SIP control measure.

4.1 The Baseline Option

A forecast of regional emissions may be reduced by improving the procedures for quantifying land use impacts in the baseline scenario. It is important to keep in mind that the process for developing the SIP baseline and conformity analyses already accounts for some of the effects of land use policies and programs. Emissions benefits from land use measures that are reflected in a baseline cannot be used for explicit credit, neither in the SIP nor as a conformity determination control measure. With this in mind, there may be ways to better incorporate some land use measures into the baseline that are not normally reflected in the baseline.

What is typically reflected in the baseline?

The benefits of a land use measure are likely to be reflected in the baseline if (1) the land use forecast includes the urban form change caused by the measure and (2) the travel modeling captures the benefits of the urban form change. As discussed in Chapter 3, this is likely to be the case for measures that result in a redistribution of regional growth between zones. Thus, measures that simply cause growth redistribution are generally not good candidates for explicit emissions control measures.

The types of measures that would typically produce growth redistribution include infill development, transit-oriented development (TOD), and jobs/housing balance measures. The implementing mechanisms that produce these types of changes include state and regional growth controls and local growth controls. In general, the more likely it is that a policy will affect actual growth distribution, the more likely it will be reflected in the baseline. For example, in regions affected by state-mandated growth control policies, the regional land use forecast that underlies the baseline will almost certainly reflect any impact of the policy on growth distribution.

What is typically not reflected in the baseline?

The baseline land use forecast will probably not reflect micro-scale urban form changes like urban design and land use mixing. Nor is it likely that most travel and emissions models capture the full impact of these types of changes. So land use measures that produce micro-scale urban form changes are better candidates for explicit credit. In addition, the baseline might not reflect a measure that was initiated expressly for air quality purposes by the air agency.

The types of measures that would typically produce micro-scale changes include mixed-use development and neotraditional design measures. Some infill and TOD measures could also produce micro-scale urban form changes as a secondary impact. The implementing mechanisms that can produce these types of changes include local government incentives and design controls. Many transportation modelers have indicated that the emissions benefits from micro-scale urban form changes will typically be very small and difficult to quantify.

In reality, many land use measures will produce *both* larger-scale growth redistribution and micro-scale urban form changes. This could lead to a scenario in which some of the benefits of a measure were accounted for in the baseline, and other benefits were not. In such a case, the only way to take credit for the change as an explicit control measure would be to separate the impact of the two types of urban form changes. This may be difficult to do and would probably require a high level of approximation.

Can land use be better incorporated into the baseline?

It may be possible to modify the baseline forecasting process to account for land use measures that would not otherwise be reflected in the baseline. For example, there are a

number of improvements that can be made to regional travel demand models so that they better account for micro-scale factors like the pedestrian environment.

Incorporating in the baseline the impact of land use policies and programs that are not included in the regional land use forecast would be a significant departure from current practice and probably not advisable. Since policies and programs included in the baseline are not subject to the control measure enforceability and documentation requirements, this option could lead to credit for a land use measure that does not get implemented. While in the long run this would cause problems for showing conformity or ROP requirements, credit for activities that are not included in the regional land use forecast should be done using explicit control measures.

Issues for EPA

The advantage of taking "implicit credit" for land use measures in the baseline is that it would be relatively easy for air agencies or MPOs to do. Taking emissions credit by improving the existing regional travel demand model would also minimize the possibility of double-counting benefits. Because of the limitations of the current models, however, this option will probably not provide much emissions credit.

4.2 The SIP Option

Land use measures not reflected in the baseline could be used to show emission reductions as a SIP control measure. As described in Chapter 2, the existing EPA guidance for both EIP and VMEP programs can apply to land use measures. As most land use measures rely on local government implementation rather than direct state control, the VMEP option may be more attractive to many regions. However, the emissions reduction allowed under VMEP is limited to 3 percent of the inventory for each criteria pollutant.

Existing Requirements

Adding a land use measure under either the EIP or VMEP option will require the air agency to estimate compliance and programmatic uncertainty. Compliance uncertainty addresses the degree to which governments adopt implementing mechanisms in support of sustainable land use. Programmatic uncertainty addresses the degree to which urban form, travel, and emissions change as a result of the implementing mechanisms. Due to the nature of the development process, the level of programmatic uncertainty will typically be very high. Land development is strongly influenced by fluctuations in market demand. And most land use policies do not guarantee that any changes will occur, since local officials can choose to ignore the policies.

Disadvantages of the SIP Process

Since most nonattainment SIPs address only a five- to seven-year horizon at the most, they offer little opportunity to recognize the longer-term benefits of land use unless

measures are included in a Maintenance Plan. In addition, for land use measures initiated expressly for air quality purposes, it may be difficult to use the SIP process as an incentive for local governments to participate in measure implementation. While local governments in some regions are heavily involved in efforts to reduce pollutants like fugitive dust, in other regions there is little burden placed on local governments to reduce mobile source emissions. Thus, there may be little opportunity to reduce the burden for those that commit to sustainable land use activities.

Issues for EPA

Taking credit for land use measures in the SIP process raises the prospect of double-counting benefits already reflected in the baseline. Air agencies typically have a poor understanding of the land use and travel demand forecasts that form the baseline. To ensure that land use measure benefits are surplus, air agencies will need to better document the land use and travel forecasts that make up the baseline. Additional EPA guidance may be needed regarding the form of this documentation. However, it should be recognized that any new requirements may make the adoption of land use measures a less attractive option.

To adopt, as a control measure, land use policies and programs that are not included in the regional land use forecast, the state would typically need assurances from local governments that the actions would be implemented as expected. The form that this assurance should take is not clear under the existing guidance.

4.3 The Conformity Option

Land use measures that are not reflected in the baseline could be used to show an emissions reduction in support of a transportation conformity determination. The MPO estimates the emissions that will result from the implementation of a long-range transportation plan, and these emissions must be within the mobile source emissions budget established in the SIP. Estimates of emissions can be reduced by factoring in the impact of control measures, thus providing "credit" for the measures.

Advantages over the SIP Process

As described in Chapter 2, the conformity option has several advantages over the SIP process. Most importantly, conformity addresses a longer time period than the SIP, and thus better matches the time needed to realize the benefits of land use measures. The conformity requirements for interagency consultation bring together all relevant local, regional, and state agencies in a frequent and regular forum. Any difficulty in showing conformity will focus the participants specifically on strategies to reduce mobile source emissions. Since this process is being conducted in conjunction with a new regional land use forecast and transportation plan, it provides a good opportunity to consider the impact of land use. Finally, because it is linked to future transportation funding, the conformity process may offer an opportunity to provide incentives to local governments to adopt land use measures.

Existing Requirements

The Conformity Rule specifies that emission reductions from projects like TCMs that are not "regionally significant" may be estimated with reasonable professional practice, rather than incorporating them into the regional travel demand model. The Rule defines the type of implementation commitment needed to include a control measure in the conformity determination. Measures that require regulatory action (i.e., zoning or other growth control mechanisms) generally must be already adopted by the local government, or must be included in the SIP, or the SIP must contain a letter of commitment from the implementing authority.

Issues for EPA

There are several issues that EPA may wish to address with respect to land use measures in the conformity determination. While the requirements for including control measures in the SIP and conformity determination are essentially the same, at least several air agencies *perceive* that there is less accountability for measures adopted to show conformity than in the SIP. There is also a potential to double-count control measure benefits that are already reflected in the baseline. Currently, it would be difficult for a reviewer to detect this double-counting because there is little requirement for documenting the baseline land use forecast and the policy assumptions that underlie it. As with SIP measures, additional EPA guidance may be needed regarding documentation of the baseline land use assumptions.

4.4 Summary

In summary, the first critical issue with respect to policy options for land use measure credit is whether the regional land use forecast includes the control measure. Nearly all examples of current sustainable land use activities are occurring primarily for reasons other than air quality, and these are likely to be included in the regional land use forecast to the extent that they are having an impact. Then the issue becomes the extent to which the emissions benefits of the measure are reflected in the output of travel and emissions models. Many of the micro-scale changes may not be reflected, and could be used for additional emissions credit. Care must be taken to avoid double-counting benefits that are already reflected in the baseline.

For control measures that are not reflected in the regional land use forecast, the key issue with respect to credit is obtaining the commitment needed to assure that the land use measure will be implemented. If these commitments exist, then the important issues relate to evaluating the inherent uncertainties of urban form change and quantifying the travel and emissions benefits. Again, care must be taken to avoid double-counting benefits that are already reflected in the baseline. Table 2 presents a summary of these issues.

Table 2: Sustainable Land Use Policies and Programs			
Process for Adoption	Adopted Outside the Air Quality Planning Process		Initiated Expressly for Air Quality Purposes
Included in Regional Land Use Forecast?	Likely		Unlikely
Land Use Measure	TOD Infill Jobs/Housing Balance	Mixed-Use Neotraditional Design	TOD Infill Jobs/Housing Balance Mixed-Use Neotraditional Design
Urban Form Impacts	Mostly Growth Redistribution	Mostly Micro-Scale Changes	Growth Redistribution & Micro-Scale Changes
Models Reflect Travel and Emissions Benefits?	Likely	Unlikely	No (if not in regional land use forecast)
Candidate for Additional Control Measure?	Probably Not	Possibly	Possibly
Issues for EPA	How to prevent double-counting of benefits already reflected in baseline?	How can models be improved to better account for emissions benefits of measure? How to prevent double-counting of benefits already reflected in baseline?	Appropriate commitment is needed from local gov't to assure measure implementation. How to estimate the uncertainty of urban form change? How can models be improved to better account for emissions benefits of measure? How to prevent double-counting of benefits already reflected in baseline?

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Tools for Reducing Vehicle Trips Through Land Use Design, San Diego Air Pollution Control District, January 1998.

URBEMIS7G Computer Program User's Guide, Version 3.1, prepared for San Joaquin Valley Unified Air Pollution Control District by Jones & Stokes Associates, August 1998.

Ventura County 1994 Air Quality Management Plan, Appendix R-94: Transportation Control Measure Documentation, Ventura County Air Pollution Control District, 1994.

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Appendix A Interviewees

Charles Baber, Baltimore Metropolitan Council
Ben Cacatian, Ventura County Air Pollution Control District
Dennis Canavan, Montgomery County, Maryland
Diane Franks, Maryland Department of the Environment
Andy Hamilton, San Diego Air Pollution Control District
Paul Kavanaugh, San Diego Association of Governments
Dave Mitchell, San Joaquin Valley Unified Air Pollution Control District
Brian O'Sullivan, Puget Sound Air Pollution Control District
Steve Smith, South Coast Air Quality Management District
Bob Stern, New Jersey Department of Environmental Protection
Steve Tracy, Local Government Commission, Sacramento, California
Tim Trahimovich, City of Redmond, Washington
Mike Winter, Sacramento County, California

Appendix B Sustainable Land Use Internet Web Sites

Smart Growth Network
http://www.smartgrowth.org

Transportation Action Network
http://www.transact.org

Sustainable Communities Network
http://www.sustainable.org

Growth Management Institute
http://www.gmionline.org

U.S. Department of Energy, Center of Excellence for Sustainable Development
http://www.sustainable.doe.gov

The U.S. Conference of Mayors, Joint Center for Sustainable Communities
http://www.usmayors.org/uscm/sustainable/sj-7.htm

National Governors Association, Center for Best Practices
http://www.nga.org/Center/Activities/SmartGrowth.asp

Presidents Council on Sustainable Development
http://www.whitehouse.gov/PCSD/

National Trust for Historic Preservation
http://www.nthp.org

Planners Web: Sprawl Resource Guide
http://www.plannersweb.com/sprawl.html

Center for Neighborhood Technology
http://www.cnt.org

Oregon Transportation and Growth Management Program
http://www.lcd.state.or.us/issues/tgmweb/about/index.htm

BUILDER Online, July 1998 special report on Sprawl
http://builder.hw.net/monthly/1998/jul/covstory/sprawl4.htx

City of Austin, Smart Growth Initiative
http://www.ci.austin.tx.us/doorstep/98/10/smartgrow.htm#anchor1055467

New Jersey Pinelands Comprehensive Management Plan
http://www.state.nj.us/pinelands/cmp.htm

Smart Growth in Maryland
http://www.op.state.md.us/smartgrowth/

Appendix C Related Work Efforts

A Methodology to Establish SIP Creditability of Infill Development

This is an ongoing contract with Apogee/Hagler Bailly and Criterion under EPA's Office of Policy (OP). Preliminary work performed is described in a draft report entitled *The Transportation and Environmental Impacts of Infill versus Greenfield Development: A Comparative Case Study Analysis*. This study uses regional travel demand modeling to compare the travel and emissions impacts between a hypothetical development located on an infill site and on a greenfield site. Models were run for three case studies, in San Diego, California; Montgomery County, Maryland; and West Palm Beach, Florida. Each case study consisted of modeling a hypothetical large development as if it were located on an actual infill site, and then modeling the same development as if it were on an actual greenfield site. The development size remains the same in both locations, but the density and street patterns are consistent with the surrounding urban form at each location. In each case, the MPO travel demand model was used to simulate the travel impacts of the development. Environmental impacts (including NOx and CO_2 emissions) and energy use were estimated using a GIS-based model called INDEX.

All three case studies show that locating the development on the infill site results in lower vehicle use and lower vehicle emissions. VMT per capita at the infill sites was roughly half that at the greenfield sites. NOx emissions were 27 percent to 42 percent lower at the infill sites, even though congestion at one infill site was higher than the greenfield site. It should be noted that the INDEX model uses simplified per-mile and per-trip emissions factors, not the standard vehicle emissions models. Further work is continuing under this contract. The same simulation methodology will be used in different cities (Baltimore, Dallas, and Chicago) to explore the sensitivity of the earlier results to changes in project scale, land use type, land use mix, location, transit accessibility, etc.

Transportation Impacts of Micro Scale Urban Design Elements: Data Collection and Modeling Needs

This 1998 joint DOT (FHWA)/EPA (OMS and OP) funded project will bring together current knowledge and recent research concerning the ability to appropriately reflect the transportation impacts of various micro-scale urban design elements (e.g., sidewalk width, building setback, street grid type, etc.). A report from the contractor conducting the study, Parsons Brinckerhoff, should be available in late 1999. The report will explain procedures to estimate how land use development strategies and site design elements affect travel behavior and will give examples from selected MPO experience. Particularly useful for MPOs will be a product that will relate specific urban design changes to auto ownership, trip generation (or tour or activity generation), and mode choice for use in current travel demand models.

Air Quality Impacts of Regional Land Use Policies

This 1998 joint OP/OMS-funded grant to Robert Johnston at the University of California, Davis will produce a document for policy makers at the national, state, and metropolitan levels that illustrates the air quality benefits or deficits of regional policy scenarios that affect land use development patterns. Policies that affect land use directly, such as removing density caps on zoning around rail stations, and indirectly, such as travel pricing or transit investment, will be simulated. A suite of models is under development that utilizes earlier work done in the Sacramento metropolitan area. Numerous scenarios will be evaluated and compared to the expected baseline out to the year 2015. Scenarios having strong effects on region-wide accessibility and affecting demand for travel or land significantly (e.g., new road capacity, major region-wide transit capacity expansion, or strong travel and parking pricing policies) will be evaluated. In addition, plans call for evaluation of scenarios that include land market pricing corrections, such as incentives for infill development, and land development fees for raw land projects at the urban edge and beyond.

The simulations of land use, transit, and travel pricing scenarios for the Sacramento region using the regional MPO's travel demand model are complete. Part two of the project is underway. This will evaluate the best two or three scenarios, using two urban models that represent land development and travel, MEPLAN and an improved TRANUS. These results will give differences that take into account land use pricing and give indications of the magnitude of land use price differentials for the various outcomes. Results will be compared to the less resource intensive modeling technique previously used.

The Effects of Urban Form on Travel and Emissions: A Review and Synthesis of the Literature

This is an ongoing contract with Apogee/Hagler Bailly under EPA's Office of Policy (OP). The draft report offers a thorough summary of recent research on the effect of land use on travel behavior. Studies fall into two general categories. Empirical studies compare data collected from actual communities and try to distinguish how various land use factors lead to different travel patterns. Simulation studies use computer models to examine the impact of hypothetical land use patterns on travel and emissions.

The report concludes that changes in land use can reduce region-wide vehicle use and emissions over a period of several decades. Using simulation models, several studies have convincingly shown that modifying future development patterns in ways that make them less dependent on automobile use will reduce VMT and emissions. The reduction in emissions comes from shorter trip lengths and shifts to transit, bicycling, and walking modes. While computer modeling has improved greatly in recent years, it is still subject to some serious limitations. Zonal size generally precludes modeling the impact of micro-scale design features, for example.

The report documents how numerous empirical studies have shown relationships between specific land use factors and components of travel demand. For example, compact

clusters of mixed-use development are correlated with reduced trip lengths. Similarly, higher density communities of mixed land use are associated with higher shares of travel by transit, bicycling and walking. The report acknowledges the methodological flaws that limit the conclusions that can be drawn from empirical studies. Some, for example, do not control for factors like income when comparing neighborhoods. A more fundamental flaw is the fact that cross-sectional studies, by nature, cannot establish causality.

Evaluation of Modeling Tools for Assessing Land Use Policies and Strategies

This complementary effort was done for the EPA Transportation and Market Incentives Group by Systems Application International (SAI). Its final report was issued in August 1997. The work was intended to assess how regional land use forecasting models are able to incorporate specific land use policies. The report evaluates three commercial land use models: DRAM/EMPAL, MEPLAN, and TRANUS. Each model was evaluated in terms of how well it could account for policies designed to (1) increase development densities, (2) increase land use mixing, and (3) modify design elements and infrastructure to encourage alternative travel modes. The specific policies used to achieve these goals were summarized as zoning, monetary incentives (such as subsidies to developers to build in targeted areas), and non-monetary incentives (such as reduced parking requirements).

The study concludes that DRAM/EMPAL, because it does not easily represent costs, cannot model the impact of any of the three types of policies. MEPLAN and TRANUS do include representations of development costs, and therefore can at least partially model zoning policies as well as monetary and non-monetary incentives. The report points out that all the models are seriously constrained by zonal size, however. They are usually run using zones the size of several census tracts, or a single census tract at the smallest. As a typical urban census tract is roughly one square mile, a model built on zones of this size could possibly detect an increase in density within a half-mile of a transit station or transit corridor; it could not detect smaller-scale land use changes. If the zonal system uses aggregations of census tracts, even transit station-area densities could not be resolved.