DESTINATION 2030

metropolitan transportation plan

for the central puget sound region

May 24, 2001

Puget Sound Regional Council

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and representing a cross section of the regional community. In total, 301 letters containing 1,378 individual comments were received, including 271 letters and e-mails from individuals. The comments can be grouped into four broad categories:

- Comments that expressed a desire to see a broader and more aggressive mix of transportation improvements — roads, transit, non-motorized, and demand management — than were represented by alternatives analyzed in the DEIS.
- Comments that asked about, supported, or opposed individual transportation projects or activities. This category contained the majority of comments, including comments regarding congestion relief and cost-effectiveness of investments.
- Comments that expressed concern about a wide range of issues arising from transportation demand modeling and data that were used for the document. Comments ranged from issues related to the Endangered Species Act and air quality, to requests for clarification of graphics used in the document.
- Comments that expressed a desire for a strong performance measure monitoring program, as well as increased accountability.

Public comments, along with responses, are reproduced in the *Destination 2030 Final Environmental Impact Statement*, released on March 14, 2000. The Regional Council's Growth Management Policy, Transportation Policy and Executive Boards considered these public comments, as well as the subcommittee input and guidance, in providing direction for the development of *Destination 2030*.

SUMMARY OF LEAST COST ANALYSIS

In the State of Washington, beginning in 2000, Regional Transportation Planning Organizations are required (RCW 47.80.030) to apply least-cost planning analysis to alternative transportation investment strategies. Within Washington Administrative Code (WAC 468-86-030 and WAC 468-86-080) least-cost planning is defined as "a process of comparing direct and indirect costs of demand and supply options to meet transportation goals and/or policies where the intent of the process is to identify the most cost-effective mix of options." Least-cost planning attempts to consider all of the resource costs associated with alternative investments, and to provide information relevant to decisions about investment selection and prioritization. Least-cost planning combines elements of strategic, systems level planning with the accounting framework of benefit-cost analysis.

The Regional Council applied the methods of least-cost planning analysis to the systems level transportation alternatives contained in the *Metropolitan Transportation Plan Alternatives Analysis and Draft Environmental Impact Statement*, published in August 2000. Other analysis might address a broader range of policy and investment questions. This type of analysis is not an exact science, and is subject to the influence of analytical uncertainty. It is not meant to be a substitute for common sense, or political judgement. It is meant to supplement the available information that can aid decision-makers as they face complex choices about alternative investments in future transportation systems. Least-cost analysis provides some insight into the cost effectiveness, and the cost components of different plan alternatives. The following major planning lessons can be drawn from the least-cost analytical exercise:

- Least-cost analysis tells us something about the cost effectiveness of alternative ways of serving a static number of trips but does not fully compare the marginal cost and marginal benefit of the different transportation system alternatives.
- Least-cost analysis of system level transportation alternatives can provide significant information relevant to the decision process.

- Least-cost principles can guide the development of the system elements of a preferred alternative.
- Systems level least-cost analysis of transportation planning alternatives is not a substitute for corridor, project, or program level benefit-cost analysis.

Least-cost analysis is concerned with changes in transportation systems, over the long run. Over time, all transportation costs are variable and are appropriately considered to be influenced by the types of transportation system decisions made. Significant findings from the least-cost analysis of system alternatives include the following:

- When faced with a large increase in the demand for trip-making, regional transportation systems begin to perform poorly if only small actions are taken to directly address additional travel demand.
- Addressing environmental and congestion problems through capital intensive supply side solutions is expensive.
- Programs that manage transportation systems for more efficiency and that offer opportunities to meet travel demand through shorter, higher occupancy, off-peak vehicle trips (or using no motorized vehicle at all) may significantly reduce costs beyond the projects and programs analyzed in the Draft EIS.
- In addition to capital infrastructure costs and congestion costs, one of the most critical variables relating to total transportation system costs (public and private) is the total vehicle miles traveled for all personal travel trips.

SUMMARY OF ENVIRONMENTAL FINDINGS

A decade after Washington State adopted landmark growth management legislation, the central Puget Sound region still struggles with many of the more challenging consequences of vigorous growth and development. There is great uncertainty about how attempts to preserve treasured Puget Sound salmon species, and their habitat, will influence the future shape and character of the region. There is an increasing scarcity of resources that have historically been plentiful in the Pacific Northwest, such as energy, water, farmland and forest resources. Unless properly managed, urban development could eventually compromise the region's most valued asset, the dramatic natural environment that characterizes the Pacific Northwest. Transportation investments contained in *Destination 2030* are designed to directly support the region's long-range growth strategy, which in turn aims to focus growth in a manner that preserves and protects regional environmental quality.

The development of *Destination 2030* involved a broad analysis of potential environmental impacts, as well the identification of strategies to minimize and mitigate these impacts as appropriate. *The Destination 2030* Final Environmental Impact Statement was published under separate cover on May 10, 2001.

ENVIRONMENTAL JUSTICE

Since the 1995 Metropolitan Transportation Plan was adopted, the Federal Highway Administration and the Federal Transit Administration have renewed their commitments to assure that "environmental justice" is carried out in the programs they fund. (See Title VI of the *Civil Rights Act of 1964* and *Executive Order 12898*.) Environmental justice refers to the identification and assessment of disproportionately high and adverse effects of programs, policies or activities on minority and low-income population groups. Within the context of regional transportation planning, environmental justice considers the relative distribution of costs and benefits upon various segments of society from transportation investment strategies and policies.

The 2001

Least-Cost Planning Analysis

Supplemental Technical Appendix 11

Metropolitan Transportation Plan
Alternatives Analysis and
Draft Environmental Impact Statement

Volume 2 – Appendices

October 26, 2000

Puget Sound Regional Council

Appendix 11.

Least-Cost Planning:

An Analysis of Metropolitan Transportation Plan Alternatives

Contents

I. Summary

What is Least-Cost Planning?

In the State of Washington, beginning July 1, 2000, all regional transportation plans developed by Regional Transportation Planning Organizations in Washington State are required (RCW 47.80.030) to be "based on a least-cost planning methodology that identifies the most cost-effective facilities, services, and programs". Within Washington Administrative Code (WAC 468-86-030 and WAC 468 -86-080) least-cost planning is defined as "a process of comparing direct and indirect costs of demand and supply options to meet transportation goals and/or policies where the intent of the process is to identify the most cost-effective mix of options." Least-cost planning attempts to consider all of the resource costs associated with alternative investments, and to provide information relevant to decisions about investment selection and prioritization. Least-cost planning combines elements of strategic, systems level planning with the accounting framework of benefit-cost analysis. This document describes the application of least-cost analysis to the system level transportation alternatives contained in the *Metropolitan Transportation Plan Alternatives Analysis and Draft Environmental Impact Statement* released August 31, 2000.

Alternatives Analysis

In developing the planning alternatives for the *Metropolitan Transportation Plan Alternatives Analysis and Draft Environmental Impact Statement*, a broad range of investment and management options were narrowed using demand modeling analysis and a review of policy compatibility. Three Metropolitan Transportation Plan (MTP) alternatives were developed to stimulate discussion of wide-ranging transportation choices and options for funding them. Summary descriptions of the alternatives analyzed can be found beginning on *page 14* of this document. Public and agency participation during the fall and winter of 2000 - 2001 will help craft an efficient and fiscally sound "preferred alternative" comprised of the best elements from the alternatives studied. This analysis is designed to provide information relevant to that decision process.

Review and Comment

Least-cost analysis of regional transportation planning alternatives is a new formal analytical requirement, and the analysis contained in this document should be viewed as a first step in addressing this new planning element, as well as incorporating economic evaluation methods more explicitly into the regional plan development process. The Regional Council looks forward to refining these methods over time, based on gained experience and on public comment. The

Conclusions and *Next Steps* sections of this document speak to key points that should help shape the preferred alternative for the *Destination 2030* plan. Least-cost planning principles will play a continued role in further refining the facilities, services and programs contained in *Destination 2030*. The Regional Council is accepting comment on this document through November 27, 2000. A Final Environmental Impact Statement on the 2001 Metropolitan Transportation Plan will address any comments received during this review period.

General Methodology

This least-cost analysis is concerned with changes in transportation systems, over the long run. In the long run, all transportation costs are variable and are appropriately considered to be influenced by the types of transportation system decisions made. Past investment decisions and trip making activity currently satisfied by existing infrastructure are considered a baseline against which future changes must be measured, and therefore, must be excluded from the analysis. This is done by removing costs experienced in the base year from each future years' cost estimates. Base year trips are also removed from future years' trip estimates; current trip activity is a function of the existing population base. What is left are costs and trips, accounted on an annual basis, that are above existing levels, or that are a function of growth. What is then analyzed is alternative means of serving these new trips. Future costs are discounted to their present value and present value costs are factored on a per new trip basis. The cost per new trip is the least-cost measure employed in this analysis. The components of this analytical process are more completely described in *Section III* of this document.

Findings

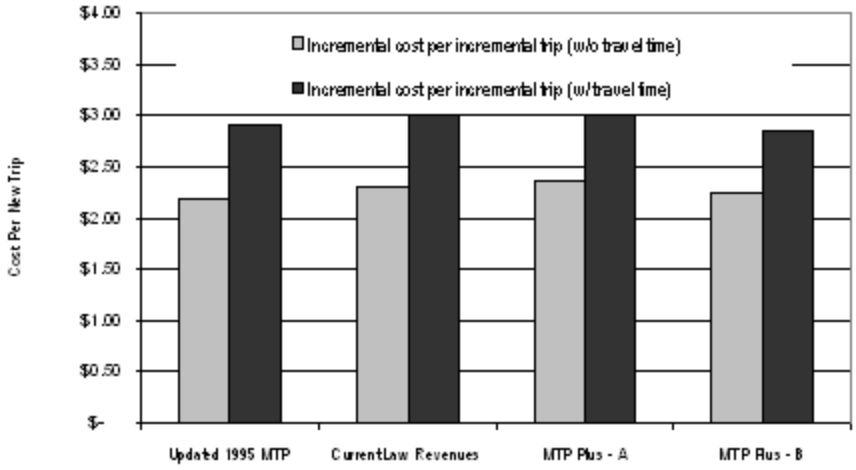
The methods of least-cost planning were utilized to evaluate the cost effectiveness of the MTP alternatives and the findings are described below. This least-cost analysis is interested in the increment of new trips taken each year above the number of trips taken in the year 2000, and the present value of the new costs of serving these additional trips. The person trip is the standard measure of benefit against which all costs are compared. The cost per new trip, for each alternative, both including and excluding the costs of travel time, is summarized in the following table and the graphed below.

Cost Per New Trip by Planning Alternative

	Updated 1995 MTP	Current Law Revenues	MTP Plus - A	MTP Plus - B
Cost Per New Trip w/o Travel Time	$ 2.18	$ 2.31	$ 2.36	$ 2.24
Cost Per New Trip with Travel Time	$ 2.91	$ 3.01	$ 3.01	$ 2.86

The *MTP Plus* alternative (System Management model run B) has the lowest cost per new trip ($2.86), while the *Current Law Revenue* alternative, as well as the *MTP Plus* (Infrastructure Emphasis model run A), have the highest cost per new trip ($3.01). The per trip cost variation between alternatives appears modest, but is significant considering the many billions of person trips taken over the thirty years of the plan. The effect of all trips taken over thirty years reveals a net present value cost differential, between the highest and lowest cost alternatives, of nearly $3 billion.

Present Value of the Total Costs of Alternatives Per New Trip



Additional findings include the following:

- When faced with a large increase in the demand for trip-making, regional transportation systems begin to perform poorly if only small actions are taken to directly address additional travel demand.

- Addressing environmental and congestion problems through capital intensive supply side solutions is expensive.

- Programs that manage transportation systems to achieve greater efficiency and offer more opportunities to meet travel demand through shorter, higher occupancy, off-peak vehicle trips (or using no motorized vehicle at all) may significantly reduce costs beyond the projects and programs analyzed in this document.

Sensitivity Analysis

Many of the analytical parameters of least-cost analysis are subject to uncertainty. For example, reasonable people will disagree about the correct discount rate to use in the analysis. Cost estimates for environmental damages can vary considerably. Estimates of the costs of implementing major capital projects are just that, estimates. All of these factors lead to uncertainty in the analytical findings. It is reasonable to build into the analysis the ability to capture key elements of uncertainty, this is known as sensitivity analysis. A range of estimates for key variables, about which there is uncertainty, were introduced, thus allowing analysts to understand the degree to which varying the values of key variables affects the outcome of the analysis. Sensitivity testing did not change the alternative that was the least-cost alternative on a cost per new trip comparison.

Conclusions

The analysis contained in this document represents a first cut at applying least-cost analysis to Metropolitan Transportation Plan alternatives within the central Puget Sound region. This analysis provides useful insight into the total cost picture of the planning alternatives. Significantly, the least-cost approach changes the nature of the cost discussion to include all relevant costs, not merely the public sector cost which are typically the focus of financial and cost discussions.

This analysis evaluates the three planning alternatives (including two options for the *MTP Plus* alternative) presented in the *Metropolitan Transportation Plan Alternatives Analysis and Draft Environmental Impact Statement*. Other analysis might address a broader range of policy and investment questions. It is important to remember that this type of analysis is not an exact science, and is subject to the influence of analytical uncertainty. It is not meant to be a substitute for common sense, or political judgement. Least-cost analysis does not require decision-makers to select a least-cost alternative. Instead, it is meant to supplement the available information that can aid decision-makers as they face complex choices about alternative investments in future transportation systems. Recognizing its limitations, this application of a least-cost analysis provides some insight into the cost effectiveness, and the separate components of the total costs, associated with different plan alternatives. The following major points can be drawn from this least-cost analytical exercise:

- ***Least-cost planning tells us something about the cost effectiveness of alternative ways of serving a static number of trips but does not fully compare the marginal cost and marginal benefit of the different transportation system alternatives.*** For example, this least-cost analysis does not assess the consequences of different methods of financing transportation facility investments. There is strong evidence that the manner by which investments are financed can have dramatic effects upon how facilities are used and how they perform, and, ultimately, upon the environmental and social costs associated with travel activity.

- ***Least-cost analysis of system level transportation alternatives can provide significant information relevant to the decision process.*** Relying solely on information relating to public sector costs leads to incomplete findings. Additional cost factors, such as private costs, environmental costs, and other non-market costs can easily overshadow the public sector costs of investments. These cost factors should be part of any serious economic analysis of transportation alternatives.

- ***The alternatives analyzed in this document represent "book-ends" on the investment spectrum.*** On the one hand, the *Current Law Revenue* alternative represents minimal public investment in transportation systems. Capital costs are low, but other costs (environmental, congestion, and private auto ownership) are high. On the other hand, the two variations of the *MTP Plus* alternative represents two distinct approaches to achieve major system expansion. Capital costs are high, in each approach, while environmental and congestion costs are lower than the *Current Law Revenue* alternative. Cost differences between the two approaches to *MTP Plus* are noteworthy; as they suggest that lower total costs are realized through a combined program of investments that reduce travel delay and pollution, while also reducing dependency upon the automobile for personal travel.

- ***Least-cost principles can guide the development of the system elements of a preferred Metropolitan Transportation Plan alternative.*** It is likely that further analysis could refine a strategic mix of public investments in transportation supply and programs designed to manage existing systems better, to further reduce capital costs while reducing environmental, congestion, and private vehicle ownership costs. A focus on efficiently managing existing infrastructure first is an example of a cost effective strategy for serving travel demand.

- ***System level least-cost analysis of transportation planning alternatives is not a substitute for corridor, project, or program level benefit-cost analysis.*** This systems analysis suggests that it can be very expensive to build our way out of our transportation problems. Great care should be taken when selecting projects and programs that fulfill regional transportation goals and policies. A system level blueprint for regional investment does not eliminate the need for rigorous project level analysis of benefits and costs. An efficient investment framework includes (1) establishing a pricing policy to broadly guide pricing and investment decisions, (2) system level benefit-cost analysis to establish a strategic investment program, (3) project, or corridor, level benefit-cost analysis to establish the best projects and initiatives to implement the strategic investment program.

Next Steps - Role of Least-Cost Planning in Destination 2030

This least-cost planning analysis is for discussion and key input to the development of the preferred plan and program implementation strategies for the final Destination 2030 Plan. As

noted previously, this is the very first effort to conduct such analysis for a regional transportation plan in the state of Washington. While this analysis should provide a useful focus to help shape the broad policy directions and implementation strategies to be incorporated in Destination 2030, it should be seen as only the beginning of a new way to look at optimizing cost effectiveness information for making major investment and policy decisions in regional transportation plans. The adopted Destination 2030 Plan could incorporate a policy commitment to further refine the regional plan using the least-cost planning approach as a key input to determining which major facilities, services, or program strategies and investments warrant policy action to change from *Candidate* to *Approved* status in the adopted plan. The process of designating major regional system components as *Candidate* or *Approved* was adopted in the 1995 Metropolitan Transportation Plan. This process was designed to allow incorporation and further analysis of proposed, and as yet unfunded, major public system investments intended to address major regional transportation problems but which require a formal public environmental process to determine an appropriate preferred regional solution.

Including a further policy commitment to utilize least-cost planning analysis in Destination 2030 would direct and enable the Regional Council to use such analysis to better discriminate among the differences in character and scope of major proposed future modal and system investments and policy and program strategies that may be included as *Candidate* projects or programs in the final adopted Destination 2030 Plan.

II. Introduction

What is Least-Cost Planning?

In the State of Washington, beginning in 2000, Regional Transportation Planning Organizations are required (RCW 47.80.030) to apply least-cost planning analysis to alternative transportation investment strategies. Least-cost planning is a modified form of benefit-cost analysis, which was developed within the electric utility industry as a means to select cost-effective approaches to meeting projections of increased demand for services. Least-cost planning places all alternatives (investments in transportation facilities and programs to reduce demand for capital intensive investments) on an equivalent analytical footing through the application of the principles of benefit/cost analysis.

Within Washington Administrative Code (WAC 468-86-030 and WAC 468 -86-080) least-cost planning is defined as "a process of comparing direct and indirect costs of demand and supply options to meet transportation goals and/or policies where the intent of the process is to identify the most cost-effective mix of options." The least-cost methodology is outlined as follows: "The methodology shall consider direct and indirect costs and benefits for all reasonable options to meet planning goals and objectives. The methodology shall treat demand and supply resources on a consistent and integrated basis." A number of other documents prepared by the Regional Council, the Federal Highway Administration, and transportation professionals were consulted during the development of this analysis. These documents are listed in the attached resource bibliography.

Least-cost planning attempts to consider all of the resource costs associated with alternative investments, and to provide information relevant to decisions about investment selection and prioritization. Least-cost planning combines elements of strategic, systems level planning with the accounting framework of benefit-cost analysis. There are two major components to a least-cost planning process. The first step is the identification of alternative transportation scenarios or investment packages. This is essentially a strategic planning exercise. The second is the estimation and comparison of costs and benefits associated with these different alternatives. This is essentially a simplified benefit-cost analysis modified to assist the evaluation of transportation planning alternatives.

Least-Cost Analysis and the Metropolitan Transportation Plan

The Metropolitan Transportation Plan for the central Puget Sound region must be updated regularly to comply with state and federal requirements. This ensures that new information, such as revised population and employment forecasts, demand modeling improvements, and the newest sources of planning data are incorporated into the overall planning process. The

collaborative decision-making and information sharing structure of the Regional Council ensures broad participation from member jurisdictions, their staffs and constituencies, as well as state and other governmental agencies.

Least-cost analysis is one approach to aid in understanding the full policy and resource implications of planning alternatives. Often, during the development of a long range strategic plan, questions are asked such as; what are the economic consequences of choosing one alternative over another, or what are the relative benefits gained or lost when a particular set of investments are chosen? While no predictive analysis can answer these questions without some level of uncertainty, least-cost analysis does represent a structured and formal method for considering broad questions of costs and benefits. Least-cost analysis can contribute to the dialogue that leads to the selection of a preferred planning alternative. Least-cost analysis, however, cannot answer all questions and must be considered within a proper policy and political context.

Strategic System Planning

As noted above, least-cost planning is both strategic planning and a cost accounting framework. The strategic planning component of least-cost planning ensures that a broad array of alternative transportation investment options are considered during evaluation, and that the evaluation process is orderly and focused on problem solving. The formal analytical process outlined under SEPA guidance, and further refined for the 2001 MTP Update effort, is completely consistent with the strategic planning principles that are traditionally part of a least-cost planning exercise. A Federal Highway Administration publication, *Evaluation of Transportation Alternatives: Least-Cost Planning: Principles, Applications, and Issues*, describes these principles as follows:

- *Application of benefit-cost analysis in the evaluation of alternative transportation systems and projects;*
- *Consideration of policies and investments to reduce demand for transportation facilities on equal footing with those that increase their supply;*
- *Evaluation of the uncertainties in forecasts of future travel demand and the performance of different alternatives;*
- *Involvement of the public in the development of alternatives and their evaluation;*
- *Coordination among different agencies and jurisdictions of a system-wide planning effort that regularly updates plans to reflect new information about those measures that are cost effective.*

Policy Guidance

The process used during the development of the 2001 MTP began with the adopted regional policies contained in VISION 2020 and the 1995 MTP as the organizing framework. These

policies provided the guidance for identifying a range of alternative transportation investment and management packages. Historically, the MTP for the central Puget Sound region has been a bottoms-up plan. The current plan development process has not deviated from this approach. Local jurisdictions, public interest groups, transit providers, and the state Department of Transportation, who constitute the Regional Council's membership, provide the starting point for project and program identification. Under guidance from the Regional Council's policy boards and standing committees, these projects and programs are then organized into program areas in order to establish a framework for beginning to define plan alternatives.

Often, a sketch planning approach is used to narrow the range of alternatives to those which appear to be most effective in addressing transportation problems. Again, the Federal Highway Administration publication, *Evaluation of Transportation Alternatives: Least-Cost Planning: Principles, Applications, and Issues*, summarizes initial steps involved in conducting a least-cost planning exercise:

- *Identify and screen alternative programs and facilities to eliminate obviously inferior ones;*
- *Bundle resources (investments) into competing portfolios;*
- *Estimate the costs of all resources in comparable terms (cost per unit of output);*
- *Compare, rank, and select the portfolio that minimizes cost given the uncertainty in demand and cost estimates.*

Analytical Test Packages of Options

In developing the planning alternatives for the *Metropolitan Transportation Plan Alternatives Analysis and Draft Environmental Impact Statement*, a broad range of investment and management options were narrowed using demand modeling analysis and a review of policy compatibility. The three alternatives developed for SEPA review reflect various levels, and combinations, of transportation investments originally examined during sketch planning. The process that resulted in a definition of three MTP alternatives began in August 1999, and was formalized in December 1999 when the Regional Council's Transportation and Growth Management Policy Boards approved the *Scope of the Environmental Review for the 2001 Update of the Metropolitan Transportation Plan*. This scoping document, a result of extensive public outreach, set in motion an analysis structure that, over the past six months, examined a number of "test packages" and used what was learned to help define three MTP alternatives. The analytical packages did not represent "plan alternatives," but were designed to test the effects of specific investment and management approaches on the region's growth, transportation, environmental, and financial goals and objectives. For more complete descriptions of the assumptions and analysis of the analytical test packages conducted by the Regional Council, see Appendix 3 and Appendix 4 contained in Volume 2 of the *Metropolitan Transportation Plan Alternatives Analysis and Draft Environmental Impact Statement*. Major findings of the test packages include:

- Current levels of investment in transportation projects and programs result in continued deterioration of transportation system performance.

- Significant investments in roadway expansion reduce future congestion problems, but also result in increased vehicle miles traveled, and great difficulty in meeting air quality conformity requirements.

- Significant investments in local transit service reduce future congestion problems, and help to decrease the growth of vehicle miles traveled. These investments also result in a more balanced multimodal transportation system that offers choices between single occupancy vehicles, carpools, and transit.

- Paying for transportation through user fees and charges can significantly reduce congestion on roadway facilities.

- Compact land development patterns have a significant and positive effect upon transportation system performance.

Three SEPA Alternatives

Results from analyzing the test packages helped regional leaders to craft three alternatives that addressed the full range of choices for environmental and policy analysis. Three MTP alternatives were developed, in compliance with the State Environmental Policy Act, to stimulate discussion of wide-ranging transportation choices and options for funding them. Public and agency participation during the fall and winter of 2000 will help craft an efficient and fiscally sound "preferred alternative" comprised of the best elements from the alternatives studied. Within the agreed-upon environmental scope, the alternatives provide a focus for environmental and technical analysis of a comprehensive set of choices that range from taking no action (the current law revenue option), extending the currently adopted MTP to 2030, to expanding roadway and/or transit capacity and/or emphasizing better management of transportation systems. Each of the three MTP/State Environmental Policy Act (SEPA) alternatives is briefly discussed below.[1]

> ***Updated 1995 MTP.*** The Updated 1995 MTP alternative contains policies, programs and projects identified in the 1995 MTP, with the addition of projects completed or underway since 1995, extended to year 2030. The plan calls for the development of a region-wide multi-modal transportation system that links urban centers with transit-oriented investments and serves compact communities. The system envisioned in the plan

[1] For a more detailed description of the plan alternatives or the plan development process please refer to the DEIS document.....

emphasizes accessibility, includes a variety of mobility options, and enables the efficient movement of people, goods, freight, and information. Increased capacity is reflected by the addition of 290 general purpose freeway lane miles, 950 arterial lane miles, 308 freeway HOV lane miles, and 95 arterial HOV lane miles. The Updated MTP alternative also assumes full build-out of the Sound Transit Long-Range Vision Plan, with light rail extensions fully connecting north-south from Everett to Tacoma and east-west from Seattle across Lake Washington on I-90 to Issaquah and Redmond. State intercity rail service from Vancouver, Canada to Portland, Oregon is also improved.

Current Law Revenues. The Current Law Revenue alternative is limited to those elements of the 1995 MTP with committed or identified funding sources, extended to year 2030. Projects, programs, and levels of service reflect revenue reductions resulting from Initiative-695, which eliminated the state motor vehicle excise tax (MVET). Increased capacity is added to the current Metropolitan Transportation System in the form of an additional 68 freeway, 83 arterial, and 72 high occupancy vehicle (HOV) lane miles. These additional lane miles all represent a reduction from the extent of facilities planned in the Updated 1995 MTP alternative. Very little ferry service is assumed after year 2010, and only Phase I of the Sound Transit Sound Move plan is completed. The alternative assumes no changes in taxes, tax rates, or the system of allocating tax revenues to various transportation uses.

Metropolitan Transportation Plan "Plus". The MTP Plus alternative has been divided for technical analysis purposes into two versions. One - 3A - focuses on improved system performance by adding infrastructure capacity beyond that called for in the current MTP. The second - 3B - emphasizes improved system performance through system management, transit service, and growth management provisions in addition to roadway capacity. Both represent the same alternative of providing additional transportation capacity, but by different means.

- The MTP Plus alternative (Infrastructure Emphasis model run A) includes all of the elements of the 1995 MTP, with the addition of projects completed or underway since 1995, extended to year 2030. In addition, increased capacity is added to the 1995 MTP in the form of an additional 396 freeway lane miles, 245 arterial, and 53 high occupancy vehicle (HOV) lane miles. Roadway capacity is also extended through HOV system operation enhancements and ferry system improvements. Commuter rail service miles and hours are the same as in the Updated 1995 MTP. The MTP Plus alternative assumes full build-out of the Sound Transit's Long-Range Vision Plan, as in the Updated 1995 MTP alternative.

- The MTP Plus alternative (System Management model run B) also includes all of the elements of the 1995 MTP, with the addition of projects completed or underway since 1995, extended to year 2030. Increased capacity is added to the 1995 MTP in the form of an additional 52 general purpose freeway, and 157 high occupancy vehicle

(HOV) lane miles. In addition, increased capacity is added to the MTP through System Management (including Intelligent Transportation Systems and Smart Travel programs), and through transit system improvements beyond those identified in the 1995 MTP. This model run also assumes full build-out of the Sound Transit's Long-Range Vision Plan. In addition to current levels of bus transit service, bus transit routes (service miles) and service hours are substantially increased beyond those in the 1995 MTP, by 55 percent and 52 percent, respectively. Ferry service miles and service hours are increased by 65 percent and 47 percent, respectively. Commuter rail service miles and hours are slightly higher than in the Updated 1995 MTP. The HOV system is completed, expanded, and operationally enhanced. Concentration of housing, population and jobs in centers, station areas and activity areas is more aggressively pursued, market mechanisms increasingly manage parking in the most intensively developed areas, and the ferry system is expanded and improved.

Full-Cost Analysis

The Regional Council has been a regional leader in system level strategic planning for years. Least-cost planning simply brings an additional set of analytical steps into the mix of planning analysis conducted by the Regional Council. Least-cost planning requires that planning alternatives be evaluated from a full resource cost perspective. This means that least-cost planning attempts to help understand which alternative investments or policies will realize the greatest net benefits to society.[2]

It should be noted, however, that estimating and evaluating the full costs of transportation investment and policy alternatives is conceptually and practically difficult for a number of reasons. First, there is a great deal of uncertainty concerning long-term planning forecasts. One example would be the forecasted land use assumptions that both influence, and are influenced by, alternative future transportation system scenarios. Second, reliance upon traditional modeling techniques may inadequately estimate the system effects from non-traditional investments or policies. Travel demand models rely upon observed traveler responses to changes in various supply assumptions, innovative policies may push the useful limits of existing data underlying the demand and supply relationships in the models. Third, the transportation system is a bundle of services, and variations in benefits between service are not easily isolated or assigned a monetary value. Fourth, discounting future costs and benefits may systematically undervalue the costs and benefits resulting from enduring changes associated with particular investments that significantly influence future generations of residents.

The first two limitations described above are inherent to any modeling analysis. The other areas

[2] Net benefits are the value of benefits of a particular investment or policy minus the costs of implementation and the costs that result from the investment or policy.

of uncertainty can be explicitly addressed through testing the sensitivity of the results to more than one set of assumptions. With these concerns in mind, a least-cost planning framework can introduce a great deal more information into the planning process than has been historically available. The results of any such analysis must be considered within a broader decision process, which evaluates other factors not easily incorporated in the least-cost planning framework. Once analysis is completed, it should be understood that decisions are appropriately made according to community values, with the results of least-cost planning analysis merely providing information that may prove useful in aiding decisions.

While strategic planning is the broad organizational framework for least-cost planning, the principles of benefit-cost analysis are the analytical accounting framework for evaluating cost-effectiveness of alternative transportation investments and policies. In its simplest form, benefit-cost analysis involves (1) estimating all costs of a project or policy, (2) estimating all benefits of a project or policy, and (3) comparing costs with benefits in a manner that directly accounts for the time value of money. Least-cost planning, on the other hand, asks the question: what is the cost of alternative transportation proposals per unit of system output? The mechanics of this least-cost measure are explained, in detail, in the sections that follow.

Least-Cost Analysis. What it Can and Can't Tell Us.

As stated previously, least-cost planning attempts to answer the following question.

> *Which alternative investments or policies will realize the greatest net benefits to society (net benefits are the value of benefits of a particular investment or policy minus the costs of implementation and the costs that result from the investment or policy)?*

A final benefit-cost calculation provides information about the relative resource intensity of the different transportation alternatives being analyzed. Analysis that considers all appropriate costs and benefits helps to answer the question of which alternative will provide people with the most value, or, under which scenario is society better off than it would be under the other alternatives considered. It is important to remember that this type of analysis is not an exact science, and is subject to the influence of analytical uncertainty. It is not meant to be a substitute for common sense, or political judgement. Least-cost analysis does not in any way require decision-makers to select a least-cost alternative. Rather, it is meant to supplement the available information that can aid decision-makers as they face complex choices about alternative investments in future transportation systems.

This least-cost analysis does not assess the consequences of different methods of financing transportation facility investments. There is an assumption that, for each alternative, all planned investments will be made, but there is no determination of how they will be financed, or the effects of financing upon travel behavior. There is strong evidence that the manner by which investments are financed can have dramatic effects upon how facilities are used and how they

perform, and ultimately upon the environmental and social costs associated with travel activity. This point is important to remember when drawing conclusions from this least-cost analysis. The Nobel Prize winning economist William Vickrey cautions, in the following passage, that an optimal decision making sequence does not disregard issues of finance or price structure.

> The efficient pattern of decision making consists of first establishing a pricing policy to be followed in the future (as distinct from the application of that policy to produce a specific set of prices), then planning adjustments to fixed capital installations according to a cost-benefit analysis based on the predicted demand patterns and predicted application of the pricing policy, subject to whatever financial constraints may be applicable...[3]

Since pricing policy is not assessed, and the absolute utility of travel activities (trips) are not estimated, this least-cost analysis does not answer all questions that might be addressed in a fully specified benefit-cost analysis of transportation alternatives. Future trip making activity is effectively fixed in this analysis. Individual trips are assumed to be utility maximizing, but are subject to the assumption that they will be taken no matter what the specific cost of the lowest cost solution. So least-cost planning tells us something about the cost effectiveness of alternative ways of serving a static number of trips but does not fully compare the marginal cost and marginal benefit of the different transportation system alternatives.

[3] Vickrey, William.

III. Analytical Approach

General Methodology

This least-cost analysis is concerned with changes in transportation systems over the long run. In the long run, all costs are variable and are appropriately considered to be influenced by the types of transportation system investment decisions made. Past investment decisions, however, and trip making activity currently satisfied by existing infrastructure, must be excluded from the analysis. This is done by netting out costs experienced in the base year from each future years' cost estimates. Base year trips are also netted out from future years' trip estimates, current trip activity is a function of the existing population base. What is left are costs and trips, accounted on an annual basis, that are above existing levels, or that are a function of growth. What is then analyzed is alternative means of serving these new trips. Future costs are discounted to their present value and present value costs are factored on a per new trip basis. The cost per new trip is the least-cost measure employed in this analysis. The remainder of this section describes individual pieces of this analytical process in greater detail.

Benefit Calculation (Step 1)

Starting with Demand Modeling

In transportation analysis, a simple evaluation of cost per unit of output is not usually a robust benefit-cost measure since benefits to users associated with a non-standardized unit of output (person trip) are not explicitly treated. However, within the limits of the models employed, travel demand modeling allows user benefit calculations to be implicitly treated. Not all person trips are the same, yet it is reasonable to standardize benefits to a person trip unit. Demand models assign trips to different modes (auto, transit), on different transportation facilities, based on observed survey data reflecting the travel choices of the residents of the region, and on the relative utility of the different travel alternatives. This, in effect, is a calculation which takes into account the variable user benefits associated with different types of person trips.

Measuring Benefits

When assessing the economic benefits from transportation investments, it is best to evaluate the final economic results from the investment, tracing economic interactions through the economy and avoiding the double counting of benefits in the process. Yet, tracing the economic benefits and costs of transportation investments through their many transformations and exchanges, can become nearly impossible to fully outline or describe. A second best approach is to quantify initial benefits (travel time benefits to users) and only assess secondary benefits when economic

theory and evidence indicates that the magnitude of the final economic benefits will differ from the initial assessment. The question here is, are there likely to be additional (external) benefits beyond those realized by individuals engaged in travel activity? Benefits, or negative costs, realized by individuals engaged in travel activity are captured in this analysis, but external benefits are not. External benefits of transportation investments might be present under a number of possible conditions, three of which are discussed below.

- If markets that are transportation dependent, or intensive, are competitive, benefits to users may be efficiently capitalized in the economy. However, a region with a significant lack of competition between firms may realize specific benefits from transportation investments in addition to those realized directly by the users of the transportation system, as a result of market efficiencies realized through increased competition. Adequate competition between firms suggests no additional benefits are likely to be realized. The latter is the norm within U.S. regions.

- A region with transportation prices higher than the full marginal costs of travel may realize specific benefits from transportation investments in addition to those realized directly by the users of the transportation system. In cases where prices are lower than marginal costs final benefits may actually be lower than the total of benefits that accrue to users. The latter is the norm within U.S. regions.

- A region with an immature system of transportation infrastructure may realize large additional benefits under the previous two scenarios. Regions with relatively mature infrastructure, as compared to newly developing regions, will realize comparatively small returns on marginal investments in transportation. Evidence from the USDOT analysis suggests that within the U.S. economic returns on highway investments have been decreasing over time. Most U.S. regions have fairly mature transportation systems.

The Person Trip as Benefit

In other words, travel time reductions (initial benefits) will equal, in magnitude, the final economic benefits from transportation investments, if: (1) perfect competition exists in all major regional markets (2) if the price of travel is equal to the marginal social costs of travel (all external social costs have been internalized into markets). If these conditions are not satisfied, then the final benefits from investment may be either greater or lesser than the initial benefits indicate. If travel time reductions are the primary measure of benefit from transportation investments, then accounting for total travel time as a cost, while person trips are held relatively constant across alternatives, will provide the same result. So, given the above arguments and the realization that the travel demand model is essentially a benefit calculation which maximizes benefits on a trip by trip basis, for the purposes of least-cost analysis of the 2001 MTP Update alternatives, the person trip is the standard measure of benefit against which costs are compared.

Cost Assessment (Step 2)

Estimating Cost Factors

The full resource costs of an investment or policy are not limited to just the capital costs of construction, and the ongoing costs of keeping an investment operational. Transportation costs include all resources dedicated to, or depleted by, the investment or policy. These costs include the environmental costs associated with vehicle emissions, water pollution from roadway run-off, the time delay costs of congestion, the private costs of auto ownership and operation, and user time associated with travel. All of these costs represent real resources that could be dedicated to some alternative use. In other words, these costs could be avoided if the policy or investment was not selected. The full costs of surface transportation has been the subject of extensive previous analysis by the Regional Council.[4]

Many of these costs are not easily quantified or represented in a monetary manner. Although quantifying costs is often difficult, a wide body of research is available that estimates many of these values. Where cost estimates vary widely, a range can be included in the analysis to test the sensitivity of policy alternatives to the key areas of cost uncertainty. All costs which are identified as being relevant should be estimated, since otherwise these costs are assigned a zero value by default, which can significantly skew the analysis.

Avoid Double Counting

In addition to ensuring that all significant costs and benefits are counted it is important to make sure that costs are counted only once. An example illustrates this point. If travel delay due to congestion is estimated and valued in the analysis, and if total travel time is also estimated, then the portion of travel time that is delay will be counted twice. Accurate accounting avoids double counting of costs or benefits. As demonstrated through the above discussion of counting benefits of transportation investments, this is a significant issue that is not always intuitively resolved, but rather requires careful thought and analysis based upon accepted economic theory.

The Present Value of Annual Cash Flows (Step 3)

Any benefit-cost calculation attempts to account for temporal variations in benefits and costs. This concept is simple in principle. If Joe receives $100 today it is worth more to Joe than if he

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[4] See *The Costs of Transportation: Expenditures on Surface Transportation in the Central Puget Souns Region for 1995.* Puget Sound Regional Council; Transportation Pricing Task Force. Published 1996.

receives the $100 next year. This can be demonstrated quite simply. If Joe were to take the $100 he receives today and invest it in a growing business, next year it might be worth $112, $112 is clearly worth more than $100, even after accounting for inflation. The point in time which a cost or benefit is realized makes a difference in economic analysis because of the time value of money. In order to develop a more robust picture of the economic consequences of the planning alternatives analyzed in this document, all relevant transportation data and cash flows (costs) were estimated on an annual basis. The transportation modeling began with a base year analysis for 1998 and ended with a planning horizon analysis for the future year 2030. Data for the years between 1998 and 2030 were estimated by interpolating between these boundary data points, a unique constant growth factor was assumed for each variable to simplify the analysis. The Metropolitan Transportation Plan is scheduled for adoption in 2001, so the first two years of data were discarded leaving 2000 as the base year with 2001 being the first year of change.

Analyze Marginal Changes

A least-cost analysis is interested in changes from today in transportation system investments and performance. According to transportation models, in the year 2000 people in the central Puget Sound region will make over 10 million trips each day. By 2030 daily person trips will increase to over 16 million, reflecting the increase in population and employment that is expected. The least-cost analysis is interested in the increment of new trips taken each year above the number of trips taken in the year 2000. Each year, and for each plan alternative analyzed, this increment is slightly larger than the previous year's increment of growth. The same is true when considering the costs of serving these person trips. This means that our analysis includes a stream of cost data, by cost category, for each year between 2000 and 2030 for each plan alternative, and assumes a steady phased investment in transportation systems over that same time period. These cost streams are the added new costs of serving additional trips.

Discount Values

Once these cost streams are estimated, costs must be discounted to present values. Discounting costs and benefits is a method of standardizing values to account for the time value of money. Benefits received at some point in the future are worth less than they would be if received today. Future values need to be discounted to a present value using a discount rate that reflects the opportunity cost of alternative uses of resources. If a young entrepreneur went into a bank to ask for capital to invest in a new business start she would expect to pay interest on the loan. The interest rate reflects inflation, risk, and the opportunity costs of loaning the money to the entrepreneur rather than some alternative investment strategy. In this analysis inflation is not factored since all cost estimates are in year 2000 dollars, but a real discount rate is applied to future cost streams to account for the other components of the time value of money. A base real discount rate of 6 percent is assumed for this analysis, but other discount rates are applied to test the sensitivity of the results to changes in discount rate assumptions.

Cost Per New Trip (Step 4)

For each alternative, the present value of all costs are summed over the 30 year life of the plan. Least-cost planning, however, is concerned with the cost it takes to serve the travel needs of the region. It has already been established that trip utility maximization is a characteristic of travel demand modeling, so the model serves as a surrogate for a true benefit calculation. It is then possible to measure the present value of all costs on a per new trip basis. The result is a cost per average trip. This reveals something about the resource efficiency of alternative investment proposals that serve travel activity demand. This analysis does not reveal cost information about individual trips that will be taken by individual people, but rather an average trip that has the averaged aggregate characteristics of actual trip activity as predicted by the travel demand model. In this way, the measure provides information about which alternative investments or policies will realize the greatest net benefits to society.

The Role of Sensitivity Analysis

Many of the analytical parameters of least-cost analysis are subject to uncertainty. Reasonable people will disagree about the correct discount rate to use in the analysis. Cost estimates for environmental damages can vary considerably. Estimates of the costs of implementing major capital projects are just that, estimates. All of these factors lead to uncertainty in the analytical findings. It is reasonable to build into the analysis the ability to capture key elements of uncertainty; this is known as sensitivity analysis. A range of estimates for key variables, about which there is uncertainty, are introduced. This allows analysts to understand the degree to which varying the values of key variables effects the outcome of the analysis.