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16. ABSTRACT

This technical report provides a comprehensive overview of the benefit-cost methodology used by the Washington State Department of Transportation (WSDOT) as part of its prioritization of roadway capacity improvements. This report also reviews WSDOT's entire prioritization process, which has been discussed in other previous reports.

This report provides a look into the different types of spreadsheets WSDOT currently uses and details how the benefits and costs are calculated for each type of improvement. It should serve as a reference manual for the benefit-cost calculations of future roadway capacity improvement projects.

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Research Project T9903, Task 53
Mobility Improvements

MOBILITY PROGRAMMING CRITERIA AND EVALUATION PROCEDURES

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CONTENTS

LIST OF FIGURES

LIST OF TABLES

CHAPTER 1: OVERVIEW OF THE MOBILITY PRIORITIZATION PROCESS

INTRODUCTION

The purpose of this report is to summarize the methodology used by the Highway Mobility division of the Washington State Department of Transportation (WSDOT) to rate projects proposed for prioritization. The benefit-cost criteria account for 65 percent of the weight used in determining what projects will be programmed each biennium, and six non-monetary criteria together make up the remaining 35 percent. To fully understand the role the criteria play in prioritization, however, it is first necessary to look briefly at the entire Mobility prioritization process.

Overview of the Mobility Program

Mobility program prioritization is only one of many discrete steps in developing the Washington State biennial budget for state highways. The State Highway Program is divided into four components: Maintenance (M), Transportation System Management (Q), Preservation (P), and Improvements (I). The Mobility Program (denoted as I-1) is one of four programs in the *State Highway Improvement* budget.

The Mobility Program funds the following types of projects:

- general purpose widening
- new alignments
- geometric intersection improvements
- interchanges (new and modified)
- truck climbing, passing, and pace lanes
- two-way left turn lanes and access control
- high-occupancy vehicle lanes and facilities (outside core projects)
- park-and-ride lots
- transportation demand management

- transportation system management (e.g., surveillance control and driver information technologies, ramp metering, and signal timing)
- arterial, frontage road, and ramp improvements
- bridge improvements incidental to capacity improvements.

The goal of the mobility prioritization process is to differentiate among projects enough to choose the group of projects that will produce maximum 'value'[1] and to justify program tradeoffs under budget constraints. Mobility project prioritization is based on the assumption that every project submitted is the best design alternative for each particular site. Therefore, project prioritization is the second-to-last step in the biennial budget development process at Washington State Department of Transportation (WSDOT)

Overview of Budget Development

The biennial budget development process begins with long-range planning and project scoping. The State Transportation Policy Plan defines the broad vision and statewide transportation goals that direct long-range planning; it is an ongoing, joint effort by the Washington State Transportation Commission (WSTC) and the state legislature. The Washington *State Transportation Priority Programming for Highway Development Law*, RCW 47.05, mandates that a priority selection process be applied to all projects that are part of the state's comprehensive, six-year investment program on the basis of needs identified in the state-owned highway component of the multimodal transportation systems plan. Priority programming applies to Washington State Ferries, state highways, state airports, and state-interest public transportation. In part, the statewide multimodal transportation systems plan (hereafter referred to as the "Systems Plan") identifies capacity and operational deficiencies and recommends specific highway improvements and program funding levels to accomplish state transportation policy goals within given financial constraints. WSDOT program management regional staff then conduct project scoping for

[1] The term value, as used here, is meant to encompass all the benefits of a transportation improvement, including those that are not typically assigned a dollar value.

existing deficiencies, which is followed by project prioritization in each budget category. Once projects have been prioritized, the WSTC is responsible for recommending tradeoffs between the budget categories to the state legislature, and on this basis the biennial program is developed. Figure 1 overviews the steps of the budget development process and how Mobility Projects fit into the overall scheme.

Other Technical Reports

Documentation of the Prioritization of Capacity Improvements Study (Reed et al, 1995) provides the original description of the current mobility prioritization process. The report discusses the following topics: the WSDOT's preexisting Category C prioritization formula, state-of-the-art prioritization methods for regional and statewide project programming, state transportation policy, and the ranking methodology for Mobility projects, which was initially implemented for the 1995-1997 biennium programming cycle.

A second report, *Analysis of the Initial Application of the State of Washington Highway Mobility Project Ranking Procedure and Recommended Revisions for the Upcoming Biennium* (Barnes and Rutherford, 1997) reviewed the results of the 1995-1997 Mobility Prioritization and recommended revisions to the process based on that review. These revisions were implemented for 1997-1999 biennium prioritization. This report documents the current process. It also provides a more detailed explanation of the mathematical ranking procedure than was previously available.

OUTLINE OF THE MOBILITY PRIORITIZATION PROCESS

Each biennium, highway mobility projects are submitted for prioritization by each of the six regions in the State of Washington. The prioritization methodology consists of three primary components: (1) screening criteria, (2) evaluation criteria, and (3) a mathematical ranking algorithm. WSDOT regional staff are responsible for evaluating every project before its submission to the statewide prioritization process. Headquarters' staff serve primarily as technical support during the evaluation process and review calculations for accuracy. They also perform the mathematical ranking of projects.

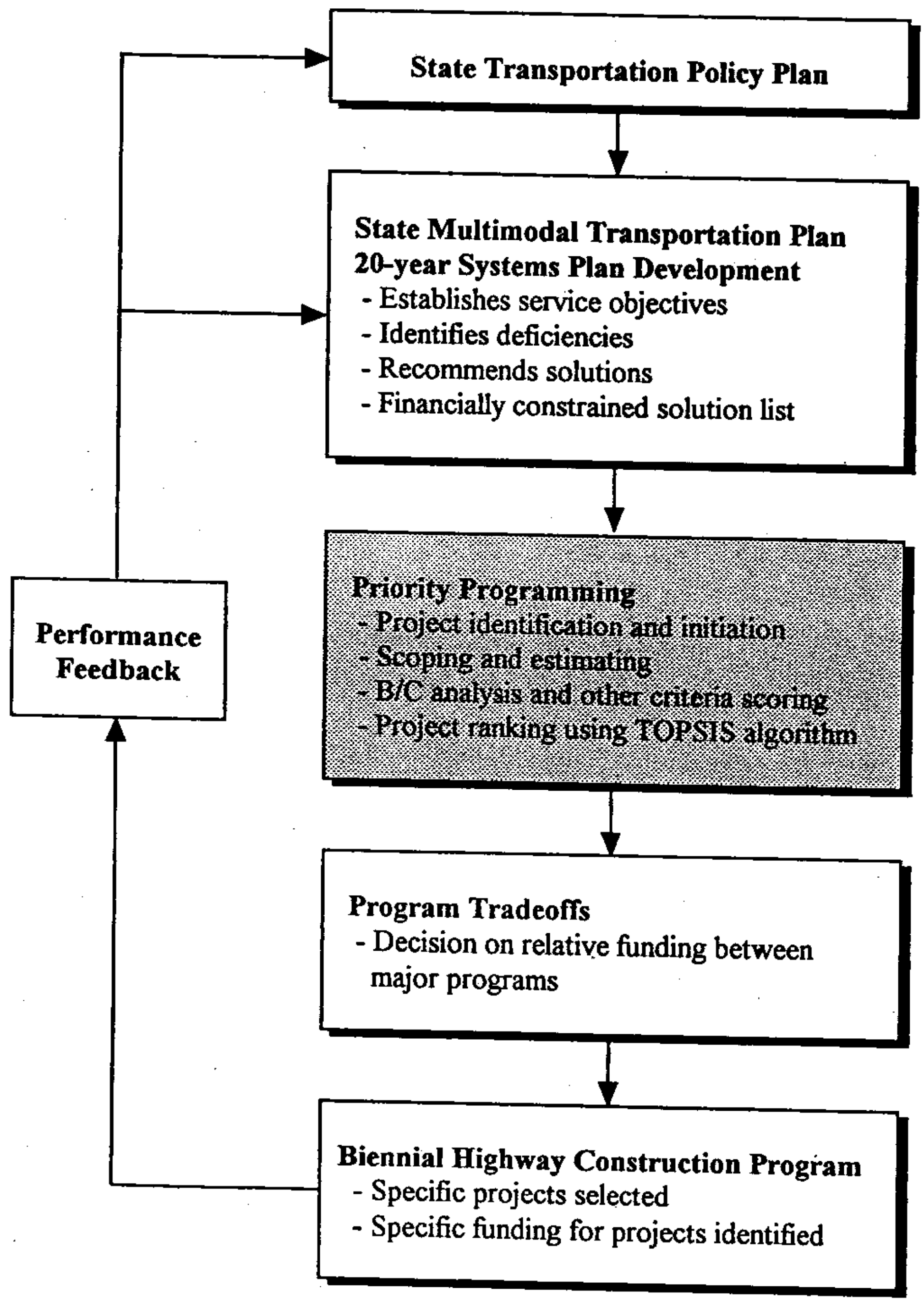

Figure 1. Budget Development Process for Transportation Mobility Projects, State of Washington (WSDOT, 1995)

Screening Criteria

The Systems Plan, with its defined financial constraints for highway improvements, functions as the first screening criterion. Project requests not contained in the Systems Plan are ineligible for further prioritization. Because the state highway systems plan must guarantee conformity to air quality requirements, any proposal that would worsen air quality in a non-attainment area would also fail the initial screening. A further expectation for the 1995-1997 programming cycle was that project submittals would focus only on existing deficiencies, except as otherwise requested by outside agencies such as metropolitan planning or regional transportation planning organizations.

Evaluation Criteria

Table 1 shows the seven criteria that are used for Mobility project evaluation, along with their relative weights. The criteria categories, scoring procedures, and weights were established with extensive input from state transportation officials and WSDOT personnel.

Table 1. Criteria and Weights for the 1995-1997 Biennium

CATEGORY	*WEIGHT*
1. Cost-efficiency	65 %
2. Community Support	14 %
Environment	8 %
3. Wetlands	
4. Water Quality and Permitting	
5. Noise	
6. Mode Integration	7 %
7. Land Use	6 %
TOTAL	*100 %*

Each of the seven criteria is briefly described below. The calculation of the benefit-cost ratio for cost-efficiency is detailed in Chapter 2. Because of the debate over their value and appropriateness, community support, wetlands, water qualtiy and permitting, noise, mode integration, and land use are not monetized (and many are unquantifiable).

However, they are included in the mobility prioritization framework to ensure that these important impact areas are taken into account. Chapter 3 discusses the scoring of the six non-monetary criteria.

1. Benefit-Cost Ratio (B/C)

The cost-efficiency of a project is measured by the B/C, which is the present value of the monetized project benefits divided by the project costs. Monetary benefits and costs projected over a 20-year period are converted into present value (today's dollars) using a discount rate of 4 percent.

The benefit categories consist of

- travel time savings for passenger and freight movement
- user operating savings
- accident reduction.

The cost categories consist of

- construction
- environmental retrofit
- preliminary engineering
- annual operating and maintenance.

In this category, projects with higher scores are more favorable.

2. Community Support

The community support category consists primarily of yes/no questions that assess financial participation, endorsement, and opposition by local governments, local organizations, and private groups or individuals. This criterion also addresses potential disruption of neighborhoods and displacement of homes, businesses, or farm land. In this category, projects with lower scores are more favorable.

3. Wetlands Assessment

This category assesses the intrusion of proposed projects upon classified wetlands and associated buffer areas in accordance with federal, state, and local regulations. Since mitigation costs are already included in the construction cost estimate, this category seeks to reflect the magnitude of public resistance to wetland impacts (Niemeier et al., 1996). It considers the acreage of any wetlands within 300 feet of proposed projects and assigns penalty points weighted according to the classification of the encroached wetlands. In this category, projects with lower scores are more favorable.

4. Water Quality and Permitting

This category assesses potential impacts on the acreage of impervious surface area within 2000 feet of any body of water. Analysis consists of yes/no questions primarily regarding the number and nature of permitting requirements for a proposed project. The subtotal score reflects the magnitude of permitting requirements and is divided in half if no foreseeable permitting conflicts exist. In this category, projects with lower scores are more favorable.

5. Noise Assessment

This category assesses the potential noise impacts for a proposed project. Points are accrued on the basis of a calculated "risk factor," which is based on the number of lanes of the proposed project, as well as the number of noise receptors and their proximity to that project. Risk factor points are weighed twice as heavily for new projects as they are for improvements to existing projects. In this category, projects with lower scores are more favorable.

6. Modal Integration

The purpose of this criterion is to assess the level of modal integration supported by a proposed project in accordance with Washington State policy goals. This category consists of yes/no questions concerning efficient use of existing capacity, connectivity between existing systems, integration of alternative modes such as bicycling and walking, and "multimodally" packaged projects. In this category, projects with lower scores are more favorable.

7. Land Use

This category assesses the support that proposed projects provide for Washington State mobility and land-use management objectives. Land-use criteria consist of yes/no questions concerning coordination between WSDOT engineers and planners, provision of convenient accessibility to transit, connectivity between urban activity centers, and consistency with regional and local comprehensive and/or transportation plans. In this category, projects with higher scores are more favorable.

Ranking Algorithm

Once proposed projects have been screened, evaluated, and scored in the seven criteria categories, they are ranked with a mathematical ranking procedure. The projects are compiled into an evaluation matrix in which the rows define the different projects to be ranked and the columns contain the seven criteria categories. The algorithm used to rank projects is called TOPSIS because it is based on the methodology of the same name (Hwang and Yoon, 1981). This method allows elements with disparate units (in this case, projects with disparate criteria) to be easily evaluated.

The premise of TOPSIS is that it

1. normalizes the scores in an evaluation matrix into dimensionless units
2. multiplies each of the scores by their relative assigned weights
3. formulates a theoretical "ideal-best" project and a theoretical "ideal-worst" project
4. prioritizes proposed projects by calculating their relative distances between the ideal solutions.

The theoretical "ideal-best" project is determined by combining all of the best scores in each of the criteria categories. The "ideal-worst" project is determined by combining all of the worst scores in each of the separate criteria categories. TOPSIS is based on the concept that the chosen alternative should be closest to the ideal-best solution and farthest from the ideal-worst solution.

Currently, the WSDOT Mobility prioritization process is utilizing the version TOPSIS-8. For a mathematical explanation of the steps of TOPSIS, a less technical summary of the steps of TOPSIS, or a comparison of TOPSIS-8 to previous versions, refer to the "Recommended Revisions" report (Barnes and Rutherford, 1997).

ADVANTAGES OF THE MOBILITY PRIORITIZATION PROCESS

The mobility prioritization process has several advantages. First, the framework is flexible enough to accommodate changes in state policy with each biennium. Second, the process introduces the ability to evaluate and rank multimodal mobility projects in direct response to transportation policy and service objectives. Third, the process is well suited to inform budget trade-offs at the program level.

MOBILITY PROJECT INPUT DATABASE

The Mobility Project Input Program was created by the WSDOT Traffic Data Office. This program contains a series of environmental and cost estimate worksheets. The program stores the information in a database as the information is input into the various worksheets. When all of the worksheets are completed, the program creates the Topsis 8 input file. (See Appendix D for graphic representations of these worksheets.)

REPORT ORGANIZATION

The next section of this report contains a detailed explanation of the benefit-cost procedures for different project types. Benefit-cost analysis is the most involved of the seven project criteria, and with a 65 percent weight, it also has the most influence over a project's final ranking. Thus, the benefit-cost section makes up the bulk of this document. The next section contains scoring procedures for the six non-monetary criteria that make up the other 35 percent of the prioritization weight.

CHAPTER 2. BENEFIT-COST CALCULATION

This section documents the benefit-cost analysis process and serves as reference for future analysis. The structure of this manual is based on the existing cost-efficiency worksheet, *Benefit-Cost Analysis for Safe Movement of People and Goods*. This worksheet is used to calculate a proposed improvement's benefit-cost ratio. The basic equation is

$$B/C = \frac{PV_b}{PV_c}$$

where $B/C =$ benefit-cost ratio

$PV_B =$ present value of the project's benefits

$PV_C =$ present value of the project's costs

The various methods for calculating project costs and benefits will be addressed as each step of the procedure is documented. The cost-efficiency worksheet is included in this report in Appendix A.

ASSUMPTIONS AND DEFAULT VALUES

The following basic standard assumptions are integral to the outcome of the benefit-cost analysis:

- discount rate
- project life cycle
- base roadway capacities
- value of time
- operating costs
- average vehicle occupancy
- overall user benefit cost parameter.

These are each discussed in the following sections.

Discount Rate

The prioritization process' benefit-cost methodology utilizes the "constant dollar" approach to estimate future benefits and costs. The reason for using this approach, as opposed to the current dollar approach, is that it eliminates speculation about future inflation. It does this by using a discount rate that reflects only the real cost of capital. The standard discount rate, or opportunity cost of capital, for the constant dollar approach (the rate at which the money to be used in a given project could be alternatively invested) is 4 percent. This is the rate used in the following analysis. For further information on this subject, refer to Appendix B, a Memorandum from a WSDOT economist explaining the rationale behind the choice of the discount rate.

Project Life Cycle

In addition to the discount rate, project default values must be considered. The traditional project life cycle, the length of time generally used in planning and forecasting transportation projects, is 20 years. This is the default value unless another length of time is determined to be more appropriate. The AASHTO "Red Book" (1977) is helpful in determining alternative analysis periods based on the type of project proposed. WSDOT has determined that some projects do benefit from a shorter period of analysis but that the majority of projects are well suited to the 20-year time frame. For projects that require a longer period of analysis, a residual value is used to determine the benefits and costs beyond 20 years.

All of the benefit/cost ratios are adjusted to account for the effect of a project's residual value at the end of the 20-year analysis period. This adjustment takes into account the value of the improvement remaining after 20 years.

The methodology for adjusting the benefit/cost ratio to account for an improvement's **residual value** is based on work done for AASHTO by the Texas Transportation Institute. Cambridge Systematics has reviewed this methodology and agrees with the concept and approach. It is done by applying the following factors to the project estimate:

•	Right-of-way	0.55
•	Grading and Drainage	0.60
•	Structures	0.57
•	All other costs (including PE)	1.00

For cases in which the estimate is not broken out by the four groupings, a region may approximate how much of the project cost is in the right-of-way, grading, drainage, and structures and use a factor of 0.59. All other costs will use a factor of 1.00. (Refer to Appendix B for Residual Value memorandum.)

Base Roadway Capacities

The base roadway capacities used are those given by the Highway Capacity Manual (HCM) (1985) and Charles Fuhs' 1990 High Occupancy Vehicle (HOV) design manual. These base capacities are not dependent on site design factors and are as follows:

Urban multilane highway or freeway	2200 vphpl†
Rural/small urban freeway	2000 vphpl
2-lane highway	1400 vphpl
Arterial	1600 vphpl
HOV lane	1500 vphpl

† vehicles per hour per lane

Value of Time

The value of in-vehicle travel time is an average value obtained by taking one-third of the mean annual wage per household in the state. For Washington, that rate was determined to be $6.12 per hour in 1992 dollars. This is consistent with comparisons around the country in which estimates range from $4 to $11 per hour. The value of commercial in-vehicle travel time was determined to be $20.22 per hour, given consultation with the Teamsters Union. The national range for commercial vehicle travel time is from

$12 to just under $20 an hour, plus a benefits package that is approximately equal to $4 in wages per hour. So, again, the commercial in-vehicle travel time is consistent with national averages. See Appendix B for a memorandum that provides further justification for these values.

Operating Costs

Operating costs for the state of Washington are based on an average system running speed of 50 mph (the generally accepted range is between 40 and 60 mph). This value was not differentiated on the basis of congestion, as the added precision was determined to be insufficient with respect to the increased complexity of analysis required for such calculations. The mean operating cost was determined to be $0.0749 per mile, or $3.74 per hour, based on the system running speed of 50 mph. This value is consistent with older, more conservative estimates that were determined by the project's Technical Advisory Committee to be more appropriate than more recent federal figures. The operating cost used for commercial vehicles is $0.657 per mile.

Average Vehicle Occupancy

The WSDOT prioritization process uses the concept of person trips rather than vehicle trips for estimation of both travel time savings and user operating cost savings. Therefore, to estimate user benefits, average vehicle occupancies (AVO) are used as multipliers in a combined procedure. The Technical Advisory Committee determined AVO default values for the state of Washington after consulting data from the U.S. Census Bureau, the National Personal Transportation Survey, Puget Sound Regional Council travel surveys, and HOV monitoring studies. The AVO values, shown in Table 2, are broken down by region, vehicle, and lane type.

Note that in time, when traffic management systems become operational, the occupancy parameter will be computed on the basis of observed values.

Table 2. Average Vehicle Occupancy Default Values

General purpose traffic within federally designated urbanized areas (populations >200,000)	1.30
General Purpose traffic-statewide other	1.10
Trucks statewide (assuming one professional paid driver)	1.0
HOV lane/facility traffic	requires site specific data

Overall User Benefit Cost Parameter

Travel time savings and user cost savings estimates are calculated as one value by a procedure based on volume to capacity ratios over 20 years. The user benefit-cost parameter for autos has been set at $10 per vehicle hour and at $50 per vehicle hour for trucks. The values are adjusted for person-hours with the default AVO parameters. Note that in time, when traffic management systems become operational, the occupancy parameter will be computed on the basis of observed values.

CALCULATION OF ESTIMATED PROJECT COSTS

The calculation of estimated project costs is fairly standard. The main categories of project costs are

1. construction (C)
2. environmental retrofit (E_R)
3. preliminary engineering (S_P)
4. annual operating and maintenance (O_PM_A).

These are summed together to estimate the present value of project costs (PV_C). The equation for the present value of costs is as follows:

$$PV_C = (C) + (E_R) + (S_P) + O_PM_A\left[\frac{(i+1)^n - 1}{i(1+i)^n}\right]$$

where i is the discount rate (4 percent) and n is the number of years in the study period.

The construction, environmental retrofit, and preliminary engineering costs are one-time costs that occur at the beginning of a project, so they are automatically calculated as present values. The costs for annual operating and maintenance, however, are continuous costs that occur throughout the life of the project. Therefore, operating and maintenance costs are multiplied by the present value formula, which yields an estimate for all costs accrued during the study period. Thus, the formula uses the discount rate to project the present value of operating costs for the entire length of the study period.

Construction Costs

All costs of construction are aggregated in this category with the exception of costs accrued in the remaining three categories. Within the construction cost category, the researchers assume that environmental analysis, mitigation costs, and right-of-way expenditures are included.

Environmental Retrofit

The WSDOT has singled out environmental *retrofit* costs to indicate proposals that must address pre-existing environmental impacts. A separate environmental retrofit program is intended to fund this type of work; therefore, these costs should not be part of the cost efficiency calculation. When possible, funds to pay for environmental retrofitting should be transferred to the Mobility program so that project rank is not negatively affected.

Costs in this category are those that are attributable to pre-existing conditions, that is, costs that are incurred to ensure the project in question meets the necessary environmental standards. Such costs include, but are not limited to, noise barriers, water quality treatment, and fish barrier removal. Some of these costs may be exempt.

Preliminary Engineering Costs

Costs included under this category are those that are incurred in the development of the project, such as (but not limited to) legislative studies and route/design studies. These may include origin/destination surveys, traffic counts, evaluation and analysis of traffic soils, and land-use, environmental and b/c analysis.

Annual Operating and Maintenance Costs

This category includes all costs required annually for the operation and maintenance of a given project. These costs are estimated by the submitting district and should be based on the historical data of rates in areas with similar proposed geometries. Costs of the following are not included in the above figure: snow and ice removal, structures and ferries, rest area management, and public damage repair.

As stated above, the costs accrued under the first three categories are discrete or one-time costs. They are incurred at the beginning of the project only. Therefore, the value for these categories is simply an aggregation of specific costs. The annual operating and maintenance costs are continuous over the life of the project, or at least for the duration of the study period. To account for this, the annual operating costs must be multiplied by the present value formula.

Note that the estimation of these costs is fairly standard practice. The ambiguity usually lies in the calculation of benefits.

CALCULATION OF ESTIMATED PROJECT BENEFITS

The calculation of project benefits falls into two broad categories: the present value of user benefits and the present value of safety benefits. Summing the values in each of these categories gives the estimated present value of total benefits. However, unlike the estimation of costs, in which the calculations are simple accounting steps, the calculation of the benefits is less straightforward. The following sections discuss the benefits calculation procedure, based on the worksheets for Additional General Purpose Lane User Benefits and Safety Benefits. The worksheets can be found in Appendix A of this report. Differences between the Additional General Purpose Lane worksheets and the other worksheets are noted.

Present Value of User Benefits

The calculation of user benefits includes both travel time savings and user operator savings. These are both determined with the User Benefits Worksheet. Different worksheets are used to calculate user benefits, depending on the type of project proposed. The project types for which worksheets exist are

- additional general purpose lanes/freeway daily benefits
- intersection capacity improvement projects
- grade intersection improvements
- two-way left turn lane improvements
- park and ride lots
- HOV lanes
- truck climbing lanes
- New Interchange at a new access point.

On each worksheet, the calculations are performed for the first and 20th years of the project as well as for the "No-Build" option. Once the user benefits for each year have been calculated, the ratio of year 20 benefits to year 1 benefits is calculated. This value is then used in the final step to determine the present value of user benefits. Below is a detailed discussion of the "Additional General Purpose Lane" user benefits worksheet. The other Capacity Improvement worksheets are addressed following this example to the extent that they differ from the Additional GP Lane worksheet.

Note: The benefits worksheet for truck climbing lanes is still under review, so it is subject to change. Please verify the correct version of this form before making calculations.

General Guidelines

Where volumes and/or the adjacent land uses vary along the length of the proposed project, the benefit calculations must be segmented appropriately. Caution must be exercised to avoid segmenting the roadway data excessively. The intent is to assess the potentially dramatic benefits that might affect the most congested section (i.e., with the least current capacity) but that would be obscured if averaged over the entire project distance.

In some cases, improved traffic flow (i.e., user benefits) may extend outside of the project limits. For instance, building an interchange to replace an at-grade intersection may improve the flow of traffic to the next intersection or interchange on each side of the project and the parallel arterials. However, these benefits may only be attributed to the proposed improvements IF they can be reasonably documented with a traffic model that will assess before and after conditions.

USER OPERATOR AND TRAVEL TIME SAVINGS

Additional General Purpose Lane

Step One: Roadway Characteristics

In this step, the proposed changes of the project are examined, and the purpose of the project, the type of improvement it will accomplish (this determines which worksheet is used), and the traffic data available for the project are determined. Count data for this step are necessary. Traffic count data may be collected by the individual regions, as this may be easiest, or in some cases they may be obtained from the TDO Travel Analysis Section of the WSDOT.

By applying current growth rates in the area, the Year 1 ADTs are estimated from present year data with a straight line growth method. Growth rate information is available from the TDO. Future rates (or current rates in some rural areas) may be applied to calculate year 20 projections. However, the estimated year 20 ADTs may also be available from a previously submitted traffic analysis. Other sources include MPO long-range forecasts, route corridor plans, developer impact documents, and others. The actual source of traffic data should be cited on the data source list.

If the data source list is a previously submitted traffic analysis and the design year is not compatible with the year 20 for this biennium, the data must be adjusted. If the design year is within a few years of the current tear 20, ADTs can be estimated with reasonable accuracy by applying the same growth rate to the base year as the growth rate used in the original analysis. This may be done by using the peak hour reduction factors shown in Table 3. (See Appendix C for memorandum.) These factors will lower the design hour volume (DHV) taken from design reports. K30 (DHV) is the average weekday peak hour percentage of ADT (working peak hour volume) to be used for the mobility project calculations.

Table 3. Peak Hour Reduction Factors

Category	K30 Reduction Factor	Average Weekday Peak hour Percent of ADT
Large Urban Areas	0.90	8.34
Other Urban Commuter	0.88	9.89
Combination-commuter & social recreational	0.83	9.12
Rural	0.75	8.98
Social-Recreational	0.60	9.04
Mountain Passes	0.45	9.35

Note 1: The design hour volumes for highly used social-recreational routes are typically the 100th highest hour of the year instead of the 30th hour. Therefore, a working peak hour volume of not less than 9 percent of the ADT should be used for social-recreational volumes.

Note 2: Specific projects may be located close to permanent traffic recorders maintained by the Transportation Data office. For these locations, specific factors can possibly be provided on request.

Future public/private capital developments that will significantly affect the project area's volumes, growth rates, traffic patterns, and/or land use should be accounted for in the analysis. Additionally, this section requires the percentage of trucks in the ADT.

Step Two: Capacity

The first step is to determine the capacity for the subject section with and without the proposed improvement. The procedures for this calculation are from the Highway Capacity Manual and use the default values stated previously. When the Working Peak Hour Volume is determined, the following formulas should be used: [ADT*K] or [DHV* peak adjusted %] in conjunction with the default values for working peak hour volumes given previously. It may also be necessary to determine the percentage of HOV traffic, as well as the percentage of truck traffic. If an HOV percentage is used, it is also necessary to include the AVO on the worksheet in the space provided. The source of this information and the procedures used in developing the raw data must be cited at this point.

The WSDOT acknowledges that in general, the peak hour percentage of ADT (K) will decline over time as the roadways become more congested and peak period spreading occurs. However, working peak hour volumes were for cost-benefit analysis in the 1995-97 biennium.

Recent traffic counts in the project area are the best source of data for identifying the working peak. Where reasonable counts are not available, the following methods may be used:

- The TRIPS "peak hour percentage of ADT" may be applied if it is representative of an annual average weekday peak hour
- Directional design hour volumes (DDHV, typically the 30th highest hour of the year) that are adjusted to reflect an average weekday peak hour may be used. The directional split shown in the TRIPS traffic report is generally weekday information and will adequately convert to DDHV.
- Peak hour truck percentages for an average weekday peak hour are available in the TRIPS History File for most projects. This truck percentage may also be used for year 20 unless more detailed truck traffic projections are available.
- The Transportation Systems Plan traffic data file (V/C spreadsheet) prepared by Loyd Fergestrom should be used ONLY as a data source of last resort.

Step Three: Volume/Capacity

Once the capacity has been determined in step two, the volume to capacity ratio (V/C) should be calculated with and without the proposed improvement for the first year and the twentieth year. This is done with the volume and capacity values obtained above.

Step Four: Travel Time

The fourth step is the determination of travel time hours (TT). The method for doing this depends on the V/C ratio from step three. If the V/C is >1, the formula used to determine travel time is as follows:

((Volume-Capacity)/2 x Distance) + (Volume x distance/ 30) = Travel Time (hrs)

If the V/C is <1, then the method is different. Using charts from the Traffic Engineering Handbook (second edition), (figures 16.1, 8, 13 or 14), the operating speeds for both years with and without improvements are input into the worksheet. The travel time in these cases is automatically calculated from the operating speeds and the length of the section in question using the formula

Volume x Distance/ speed = TT

Step Five: Travel Time Savings

The fifth step is to calculate the travel time savings (TTS). This is done by calculating the absolute value of the difference between the travel time saved by implementing the project and the no-build option for both years 1 and 20.

$TT_{BUILD} - TT_{NO\text{-}BUILD} = / TTS_{Year\ 1\ or\ 20} /$

The next component of calculating TTS has to do with the HOV percentage. If the percentage of HOV traffic is known, then the Travel Time Savings calculated above can be converted into TTS for SOV, HOV and trucks. This is accomplished by multiplying the TTS from above by the percentage of traffic for each group. If HOV traffic is 10 percent and trucks are 10 percent, then necessarily SOV traffic is 80 percent (must total to 100 percent). To determine travel time savings for SOV traffic for a given year, TTS for that year are multiplied by the percentage of traffic for SOVs, and the absolute value is taken:

$TTS_{Year\ 1} * 0.80 = / TTS_{Year\ 1}$ for SOV traffic/

This can be done for all modes for all years.

If the percentage of HOV traffic is not known, then only the breakdown for trucks and general purpose lanes is available, since it is not possible to determine the ratio of SOV to HOV (which, again, must total 100 percent). Using the TTS calculated above for the first year and the twentieth year and multiplying by the percentage of trucks and the percentage of general purpose traffic yields the travel time savings for GP lanes and trucks.

Step Six: Conversion of Delay Estimates into User Benefits

The next step is to translate the delay estimates calculated above into user benefits by using the following formulae. Again, it is important to note that there is a distinction between calculations depending on whether the HOV percentage is known.

If the HOV percentage is known, the following formula is used:

$$\text{User Benefits Year 1 or 20} = (TTS_{SOV} * CP_{SOV} * 260) + (TTS_{HOV} * CP_{HOV} * 260) + (TTS_{T} * CP_{T} * 260)$$

If the HOV percentage is not known, this formula is used:

$$\text{User Benefits Year 1 or 20} = (TTS_{GP} * CP_{GP} * 260) + (TTS_{T} * CP_{T} * 260)$$

where the variables are

TTS_{SOV} = Time Savings (hrs) for SOV

TTS_{HOV} = Time Savings (hrs) for HOV

TTS_{T} = Time Savings (hrs) for Trucks

TTS = Time Savings (hrs) for GP traffic

and the cost parameters (including operating costs) are

CP_{GP} = $10.00 * 1.35 [AVO]

CP_{SOV} = $10.00 * 1.21 [AVO]

CP_{HOV} = $10.00 * AVO_{HOV}

CP_{T} = $50.00 * 1.0 [AVO]

Vehicle occupancy is calculated as 1.3 in urbanized areas and 1.1 elsewhere.

Once the user benefits for the first and twentieth years have been calculated, these are then used in the final step to determine the Present Value of User Benefits (PV_B).

Step Seven: Present Value Factor

The final step uses the value of user benefits determined above to calculate the Present Value Factor, based on Figure 5 from the AASHTO Red Book (1977).

The PVF is calculated by first finding the ratio of year twenty to year one user benefits, as determined in step five. This is signified by (α). The PVF is then given by the following:

$$\mathrm{PVF} = \frac{(e^{(r-i)n} - 1)}{(r - i)}$$

where:	$Y =$	period of estimate (20 years)
	$r =$	$\ln(\alpha)/Y$ [annual growth rate]
	$i =$	Discount rate (4%)
	$n =$	Analysis Period (20 years)

Year 1 user benefits are then multiplied by the PVF to determine both the present value of user travel time (and operating) savings benefits (PV_B). This value is then recorded on the Cost Efficiency Worksheet.

Two-Way Left Turn Worksheet (TWLT)

Two-way left turn delay reduction estimates can be determined from the table from the report *Effective Utilization of Street Width* (March 1990), prepared for the National Cooperative Highway Research Program by the Midwest Research Institute.

This worksheet is the same as the one used to measure benefits from an additional general purpose lane. The only difference is in calculating the volume to capacity ratio. On this worksheet, the V/C for "with improvement" is assumed to be

$$V/C = V/C_{\text{without improvement}} - 0.5$$

Intersection Improvement Worksheets

The following improvements can be assessed with the Intersection Capacity Improvement Worksheet.

Widening at Signalized Intersections

To calculate intersection delay reduction, a capacity analysis must be performed. This requires the use of the multi-hour delay analysis program. This analysis predicts total intersection delay on an hourly basis for an entire 24-hour period. After the total delay has been determined for the build and no-build scenarios, the program calculated the benefit of the proposed improvement. It also invokes a peak spreading formula for situations in which hourly volumes are projected to exceed capacity. This requires the input of hourly approach volumes for the intersection. All 24 hours are required for analysis. Year 1 no-build and Year 1 build peak hour capacity analyses are also required. The analysis method must provide the average delay, critical intersection V/C and V/C for all through movements. Also required are truck percentage, growth rate (straight line), occupancy, user costs, and volume reduction percentages.

The volume reduction percentages address the reduction of vehicles at an intersection caused by the proposed project. For example, if a project adds an interchange at location A, it could result reduce the volumes at signals 1 and 2. Intersections 1 and 2 are where the volume reduction percentages would be applied.

The diagram sheet for the subject intersection should be completed with the improvement, and all supporting data should be attached to confirm that the results are reasonable.

The rest of the worksheet is the same as the Additional GP Lane example given above.

Unsignalized to Signalized Intersection Improvement

Projects in this category should be treated as two-phased signalized intersections, and the calculation of benefits should follow the same procedure as above.

Truck Climbing Worksheet

When this manual was being developed, the Truck Climbing Benefits worksheet was still under development. Before the benefits of Truck Climbing projects are calculated, analysts should confirm that the most up-to-date form is being used. What follows is a discussion of a draft of the truck climbing worksheet, not the finalized version of the form.

To begin this worksheet, the current and future year roadway characteristics must be determined. Some of the criteria can be found in HCM tables 8-6 and 7-3.

Step 1

The first step is to determine the capacity for the subject section with and without the improvement using the procedures outlined in the Highway Capacity Manual. All relevant factors (i.e., heavy vehicles, grades, lane width, shoulder width, etc.) must be accounted for. The base capacities given on the worksheet and in the HCM can be referenced, and any additional calculations should be attached.

Truck climbing lanes may be evaluated with calculation 6 for three-lane rural highways from the 1985 Highway Capacity Manual, Chapter 7, multilane highways. The procedure recommends a 10 to 15 percent reduction in service volumes for three-lane computations. Use a 15 percent reduction.

For example, where the current roadway is a two-lane highway and the proposed improvements is a truck climbing lane, analysis is confined to the upgrade lane, and the following equations apply:

$$\text{Capacity}_{\text{No-Build}} = (\text{Base Capacity})(F_D)(F_W)(F_G)(F_{HV})$$
$$= (2800)(F_D)(F_W)(F_G)(F_{HV})$$

where F_{De} and F_W are obtained from HCM tables 8-4, 8-5 and 8-8, and F_G and F_{HV} are obtained with equations 8-4, 8-6, or Table 7-9.

$$\text{Capacity}_{\text{Build}} = (\text{Base Capacity})(\#\text{ of lanes})\ (FW)(FHV)(FE)(FP)$$
$$= (1700)(2)(FW)(FHV)(FE)(FP)$$

$$= (3400)(FW)(FHV)(0.95)(0.90)$$

where $F_{VH} = 1/[1+T(E_T-1)]$ or Table 7-9, and F_W is from 1985 HCM Table 7-2 (calculation 6).

Specific project procedures must be cited as they are used (e.g., choice of analysis year, DDHV if asymmetrical improvement, capacity methodology).

Step Two

Step two determines the V/C ratio with and without the improvement. The working peak hour volumes should be used wherever volumes are required in the remainder of the analysis.

Step Three

Step Three is the same as in the previous example. The appropriate table from the HCM must be used: tables 8-7, 7-1, and 7-12.

The remainder of the worksheet is the same as in the example above.

Additional HOV Lane Worksheet

Step One

Additional HOV lane projects begin with a breakdown of traffic composition. The results from this step are the final HOV volumes and the assigned HOV designation. Most of the data required for this step can be obtained from the Puget Sound Regional Council and the Washington State Transportation Center. The analysis period may have to be divided if the HOV designation changes from 2+ to 3+. For analysis purposes, the change should occur the first year that 2+ volumes exceed capacity of the lane (1500). The information is then entered into the subsequent table to determine the Pool Volume at 3+ minimum. If the 3+ volumes exceed the 1500 capacity, then the constrained pool AVO (1500) should be used.

Step Two

The next step is to calculate the travel time with and without the improvement. The "without improvement" calculation is the same as for the additional GP lane worksheet. For the "with improvement" section, the same table should be used as that for the "without" condition to estimate the appropriate capacity and operating speeds for the section. When travel time savings are calculated with the improvement, GP traffic is calculated separately from HOV traffic. GP-build travel time savings are calculated, and both the build and no-build travel time savings are calculated for HOV traffic. Travel time savings are then converted into user benefits, as before:

User benefits = (TT savings non-trucks * cost parameter non-trucks*260) +
(TT savings HOV * cost parameter HOV * 260) +
(TT savings trucks * cost parameter trucks *260)

where

cost parameter non-trucks = $10.00 x AVO non-trucks
cost parameter HOV = $10.00 x AVO HOV
cost parameter trucks = $50.00 x AVO trucks

All of this is then aggregated to determine total user benefits, which are then converted into the present value of user benefits at the end of the study period.

Note: There may be some adjustment in the AVO parameters and accrual of benefits for the general purpose lanes at the time of the project review process. In each case, the AVO for the actual HOV lane should be set by local/regional data. A discussion of this determination and the minimum occupancy of the added lane should be attached.

Park and Ride Project Worksheet

Park and ride projects should assess the reduction in VMT on the mainline. The Transportation Data Office should be consulted for assistance.

Interchange Projects

When interchange proposals are analyzed, there are several different base scenarios. These may be independent or in combination and may primarily improve traffic flow outside of the project limits in some cases. Therefore, no one standard method can be used in every case. Many will require professional judgment on a case-by-case basis.

The basic principle to keep in mind is that who is stopping and where (i.e., which movements) should be analyzed, and then the delay (sec/veh or total hours) before and after the proposed improvement should be estimated. The focus is the improvements to the mainline traffic and turning movements ONLY, unless the scenario/improvement is supported by a modeling effort.

The Traffic Data Office-Special Studies team recommends the following guidelines for varying BEFORE improvement conditions (see Appendix C for memorandum regarding this subject):

<u>Existing At-Grade Intersection</u>

- Calculate the intersection delay in the same manner as outlined in the User Benefit worksheet for the appropriate type of intersection.
- Calculate the mainline flow rate with the interchange using the HCM mainline freeway capacity calculation. (**Assume a 0.05 reduction in V/C if the calculations do not reflect any improvements.)

<u>Existing At-Grade Intersection with Restrictions</u> (i.e. blocked movements —generally median barrier, etc.)[2]

- Calculate the distance saved for blocked movement routing (check the V/C on the mainline; an interchange may increase the capacity of the remaining movements).[3]
- Calculate the intersection delay.

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[2] On capacity of movements—Blockages and delays of some movements are caused by the configuration of local connections at at-grade intersections. The interchange will remove the blockage, but this may not show up on a delay calculation because it is configuration delay rather than intersection delay. (That is, people cannot turn left across the median if there are cars in the median waiting to make the <u>reverse</u>~~revers~~ movement and blocking the median space. Obvious types are median barricades that cause rerouting for the left turn.)

[3] The theoretical capacity is calculated in some cases as a signalized or unsignalized intersection. Some of the barricaded movements are more realistic because the actual left turn delay due to time, space, and gapping is many times more than the calculation would show. Engineering judgment must be relied upon.

- Calculate the mainline flow rate with the interchange using the HCM mainline freeway capacity calculation. (**Assume a 0.05 reduction in V/C ratio if the calculations do not reflect any improvements).

New Interchange—No Previous Connection[4]

- Because most known projects are also related to new developments, this type of project generally requires some type of backup data for analysis. Any rerouting calculations should be documented and any new development traffic should be identified. Therefore, it may be necessary to evaluate some projects with a model of the development scenario with and without a particular capital improvement.
- Some projects may be intended to reduce congestion at nearby interchanges by providing a connection that did not previously exist. In these cases, a modeling effort will be required to estimate delay reduction at the effected locations.
- Trip lengths may be reduced in some cases, and because there are models to support those effects, VMT data may have to be analyzed to accurately estimate delay.[5]

It is important to keep the generated traffic data well noted for these projects. Detailed discussion of the source of the data for all interchange projects should be submitted.

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[4] For most of the significant new interchanges, studies have been conducted over the last several years. Most produced model based data. This is an area in which a trained analyst is needed.

[5] Reduced VMT has been dealt with before, butin this year's work only travel time savings are being dealth with. In the past, distance savings have been calculated for these projects. However, VMT savings can be approximated by recalculating any VMT reduction as a reduction in travel time.

SAFETY BENEFITS WORKSHEET

This worksheet calculates the safety benefits for all project types on the basis of accident savings. (See Appendix A for worksheet.)

Step One

Step one is a statement of what safety improvements will be made.

Step Two

This step requires the site's most recent 3-year or 36-month accident history, which can be obtained from the mainframe TRIPS (Transportation Information Planning and Support) database. TRIPS contains accident data from January 1, 1993, to today.

First, the milepost limits of the project and the applicable data range must be determined. (Unless otherwise directed, this data range should only include the 36 months before any improvements at the site.) Then, it must be ascertained whether the site is on the mainline, a spur, a couplet, a reversible lane, an alternative route, an on- or off-ramp, a collector-distributor, an interchange crossroads, or a frontage road.

If the site is on anything but a mainline route, the related roadway type (RRT) and related roadway qualifier (RRQ) must be known to select accident data from the TRIPS database. RRTs and RRQs for spurs, couplets, reversible lanes, and alternative routes can be obtained from the State Highway Log; for ramps, collector-distributors, interchange crossroads, or frontage roads, the interchange drawings, which are available in each Region's Traffic Office, can be referenced. (If any of these items is not locatable, contact the Accident Data Section at 360-753-2935 or 753-3211 for assistance. In addition, if accident data before 1993 are required, contact these numbers for further information.)

The appropriate mileposts, dates, RRT, and RRQ (if appropriate) for each study location should be entered in TRIPS. To make analysis easier, the accident history that sorts by collision type should be chosen.

Step Three

This step involves analyzing the accident history generated in TRIPS (see above) to identify applicable accidents. Certain types of accidents are normally excluded from analysis because proposed improvements would have little or no effect on them. These include

- vehicles striking road machinery
- rocks or trees falling on vehicles
- vehicles hitting animals
- ice or snow accidents (see below for exceptions*)
- pedestrian accidents (unless the project has specific pedestrian improvements).

*Ice or snow accidents involving overturns or off-road impacts may be included in the analysis if the proposed improvement involves flattening side slopes or similar roadside modifications.

It is also recommended that accidents involving vehicles entering at an angle be excluded for projects that involve adding through lanes.

Ultimately, the determination of which accidents are applicable depends on the following question: "Will this improvement affect or help to prevent this type of accident?" If the answer is no, then the accident should be excluded from consideration.

The remaining accidents should be summed by accident severity. Accident severity is divided into the following categories: fatality, disabling injury, evident injury, possible injury, and property damage only (no injury) (PDO).

Next, the appropriate accident reduction factor(s) for the project must be selected. Accident reduction factors are an estimate of the percentage of reduction in accidents anticipated because of the introduction of one or more improvements to the study location. They can be found in the Safety Countermeasures Reference Summary, prepared by the Olympia Service Center's Traffic Office (360-705-7289). A less extensive list of factors is contained in Appendix C of the Informational Guide for Highway Safety Improvements, 1978. These reduction factors vary depending on rural versus urban areas, number of lanes, and severity category, so it is important to use the correct accident reduction factors for the given location.

To use the reduction factors, the number of accidents in each severity category is multiplied by the appropriate reduction factor(s). Three types of accident reduction analyses can be performed: single improvement, independent multiple improvements, and combined multiple improvements. Examples of each are discussed below.

Single Improvement

This is the easiest type of analysis to perform, as it involves only one type of improvement and thus only one type of accident reduction. Suppose the proposed improvement is to add a left turn lane at a rural, two-lane intersection, and analysts wish to calculate the expected accident reduction based on the previous three years' experience. After excluding non-applicable accidents from the history, twelve PDO accidents, nine injury accidents, and one fatal accident are left. Consulting the table of accident reduction factors shows that adding a left turn lane at this type of location yields an 80 percent reduction in fatal and injury accidents and a 20 percent reduction in PDO accidents. To determine the reduction in the annual number of accidents expected to be caused by the improvement, the numbers of applicable PDO, injury, and fatal accidents are multiplied by their respective factor, and then this is divided by the number of years in the study period. For simplicity, the following examples represent only three of the five possible accident types. Please note that these methodologies can be applied to all five accident types.

(12 PDO accidents x .20)/ 3 years = 0.8 PDO accidents reduced per year

(9 injury accidents x .80)/ 3 years = 2.4 injury accidents reduced per year

(1 fatal accident x .80)/ 3 years = 0.3 fatal accidents reduced per year

Independent Multiple Improvements

This kind of analysis involves two or more types of improvements, which must be evaluated independently of each other. Suppose the proposed improvement is to flatten side slopes on a 2.5-mile-long section of rural two-lane highway and to install flashing warning signals at two intersections within the project limits. Analysts wish to determine the expected accident reduction benefits of the project based on the previous three years' experience. While both of these improvements will reduce accidents, they are acting independently of each other, and thus the accident reductions must be done separately. To evaluate the side slope improvement, the number of applicable off-road or overturn accidents for each severity category should be totaled. For this example, assume there were 14 PDO accidents, 22 injury accidents, and three fatal accidents. Consulting the table of accident reduction factors shows that flattening side slopes for this type of highway yields a 20 percent reduction in fatal and injury accidents and a 20 percent reduction in PDO accidents. To determine the reduction in the annual number of accidents expected to be caused by this improvement, the numbers of applicable PDO, injury, and fatal accidents are multiplied by their respective factor, and then this is divided by the number of years in the study period.

(14 PDO accidents x .20)/ 3 years = 0.9 PDO accidents reduced per year

(22 injury accidents x .20)/ 3 years = 5.9 injury accidents reduced per year

(3 fatal accidents x .20)/ 3 years = 0.8 fatal accidents reduced per year

Next, the number of applicable intersection accidents at the two locations where flashing warning signals will be installed must be determined. For this example, assume there were nine PDO, sixteen injury, and zero fatal accidents at the two intersections. Consulting the table of accident reduction factors shows that installing flashing warning signals at a rural, two-lane highway intersection yields a 30 percent reduction in fatal and injury accidents and a 50 percent reduction in PDO accidents. To determine the reduction in the annual number of accidents expected to be caused by the improvement, the numbers of applicable PDO, injury, and fatal accidents are multiplied by their respective factor, and then this is divided by the number of years in the study period.

(9 PDO accidents x .50)/ 3 years = 1.5 PDO accidents reduced per year

(16 injury accidents x .30)/ 3 years = 1.6 injury accidents reduced per year

(0 fatal accidents x .30)/ 3 years = 0 fatal accidents reduced per year

Finally, to get the total reduction in the number of accidents expected to be caused by the whole project, the numbers of PDO, injury, and fatal accidents reduced by each portion of the project are added together.

0.9 PDO + 1.5 PDO = 2.4 PDO accidents reduced per year

5.10 injury + 1.6 injury = 7.5 injury accidents reduced per year

0.11 fatal + 0 fatal = 0.8 fatal accidents reduced per year

When this type of evaluation is done, the separate accident reduction totals must be shown for each component of the project, along with the accident reduction totals for the entire project.

Combined Multiple Improvements

This type of analysis involves two or more types of improvements that act in combination with each other. Therefore, the accident reduction factors must be combined before they are applied to the applicable accidents. Suppose the proposed improvement involves adding an additional lane in each direction along with a center, two-way left turn lane to an existing section of two-lane urban highway. Consulting the table of accident reduction factors shows that adding through lanes yields a 35 percent reduction in all types of accidents, while adding a two-way left turn lane reduces all types of accidents by 50 percent. To combine the factors, the following formula is used:

$$R = r1 + (1 - r1)\, r2$$

where R = the combined reduction factor

$r1$ = the largest reduction factor of any improvement

$r2$ = the second largest reduction factor of any improvement

For the example above, the combined reduction factors for PDO, injury, and fatal accidents would be calculated as follows:

$$\text{Reduction} = .50 + (1 - .50) \times .35 = .67$$

After the combined reduction factors have been calculated, the number of applicable PDO, injury and fatal accidents is totaled for the projects. For this example, assume there were 28 PDO, 19 injury, and two fatal accidents during a three-year period. To determine the reduction in the annual number of accidents expected to be caused by this project, the numbers of applicable PDO, injury, and fatal accidents are multiplied by their respective factor, and then this is divided by the number of years in the study period.

(28 PDO accidents x .70)/ 3 years = 0.9 PDO accidents reduced per year

(19 injury accidents x .65)/ 3 years = 5.9 injury accidents reduced per year

(2 fatal accidents x .65)/ 3 year = 0.8 fatal accidents reduced per year

Note, if the project involves three different types of improvements, the following formula is used to calculate the combined reduction factors:

$$R = r1 + (1-r1)r2 + (1-r1)(1-r2)r3$$

where R= the combined reduction factor

$r1$= largest reduction factor of any improvement

$r2$= second largest reduction factor of any improvement

$r3$= third largest reduction factor of any improvement

Step Four

Step four involves calculating the annual safety benefits by sing the WSDOT recommended societal costs per severity type:

$700,000 per fatal collision

$700,000 per disabling injury collision

$57,000 per evident injury collision

$30,000 per possible injury collision

$5,300 per property damage only collision

The cost per collision is multiplied by the annual reduction rate to determine the annual benefits.

Step Five

The last step on the Safety Benefits worksheet is to calculate the present value of the annual benefits. This is similar to the final step in the User Benefits worksheet. Using the generalized present value equation for a series of uniform annual end-of-period payments, the series present value factor is found. The discount rate is again 4 percent, and the analysis period is usually 20 years unless otherwise specified (and definitely no longer than 20 years). (Note: always use the same time period as is used for the corresponding mobility project.) Using the same formula as before, the present value factor (PVF_s) is calculated. Then the TOTAL annual benefits is multiplied by the PVFs to determine the present value of the accident reduction savings. This value is recorded on the Cost Efficiency worksheet.

Step Six

The final step is to sum the total benefits from the User Benefits worksheets and the Safety Benefits worksheet to determine the overall present value of total estimated benefits (PV_B). This value is then used as the numerator in determining the benefit-cost ratio of the proposed project.

CHAPTER 3: NON-MONETARY CRITERIA

This section contains a detailed description of the scoring guidelines for the six non-monetary criteria. Each category of criteria is described, followed by the scoring guidelines for the criteria, as contained in the PCIS report (Reed et al., 1995). The worksheets for each category can be found in Appendix C.

COMMUNITY SUPPORT

The purpose of this category of criteria is to assess the degree of community support for or opposition to and potential local impacts associated with the proposed system improvement.[6] The community support criteria are primarily categorical (yes/no) questions regarding public and private participation, endorsements or opposition, disruption of cohesive neighborhoods, and physical displacement that are supplemented and scaled by qualitative assessments. Projects that exhibit the strongest community support and have the least physical impact receive lower scores than do projects that are insensitive to local sentiment and conditions. The total score is minimized in the final ranking algorithm.

Scoring

- #3. Score the scale of opposition referenced by common extremes: minimal = one to two individuals or a group without substantial support; significant = mobilized opposition substantial enough to seriously threaten the success of the project.
- #5. Score only the scale of displacement by the number of homes/farms/businesses displaced. Acreage estimation is additional information in the scoping process.
- #5a. No score is assigned. The question serves as a procedural checklist for completing the project cost estimate.
- Total Score = sum each score entered in the column to the right.

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[6] The land-use criterion further evaluates the degree of interjurisdictional coordination.

Definitions

- Divide identifiable neighborhoods, schools, business service areas—Subject to local plans/existing conditions, this may become an affirmative response in the case of substantial widening projects, access restrictions, or barrier separated facilities. Refer to historical local response and community plans where available.

WETLANDS

The purpose of this category of criteria is to assess the proposed project's potential encroachment upon classified wetlands and associated buffers in accordance with federal, state, and local regulations. Quantification of the estimated acreage is only required where wetlands are identified within 300 feet of either project edge; otherwise, the total score equals zero. Points are accrued on the basis of the actual acreage likely to be affected by project construction and a multiplier that directly reflects the Washington State Department of Ecology wetland replacement ratios. The total score is minimized in the final ranking algorithm so that projects with minimum or no net impacts (and therefore low scores) will rank favorably in comparison to projects with greater wetlands impacts.

This worksheet is intended to prompt a paper inventory of wetland resources for each project area. The values are based on the body of federal, state, and local regulations related to wetland preservation. Most notably, concurrent with WSDOT [EPM3 2-1A] and other state agency procedures, the "Washington State Four-Tier Rating System, September 1, 1990" is used as the worksheet framework and the replacement ratios for compensatory mitigation outlined in *The Model Wetlands Protection Ordinance*, Washington State Department of Ecology, are applied. The required band of analysis (300 ft.) is also based on the body of literature and adopted ordinances that establish wetland buffers ranging from 25 to 300 ft. statewide. These buffers are also subject to a 1:1 replacement ratio in RCW 36.70.

Refer to the *District Resource List* for local inventory information and see the enclosed outline of the "Washington State Four-Tier Rating System, September 1, 1990".

Scoring

- Evaluate the acreage of the footprint of proposed construction encroachment into an inventoried wetland area and/or the associated buffers only.
- When the equivalent four-tier category of a wetland is unknown, use the "Category 2 Forested" replacement ratio.
- Total Score = sum each score entered in the column to the right.
- If ANY wetlands may be affected as defined above, the minimum Total Score = 0.5 acres, regardless of the area of encroachment. If NO wetlands or buffer areas will be affected as defined above, the Total Score = 0.0 acres.

Definitions

- Wetlands—Lands that are either permanently or seasonally "inundated by surface or ground water with a frequency sufficient to support and under normal circumstances does or would support a prevalence of vegetative or aquatic life that requires saturated or seasonally saturated soil conditions for growth and reproduction." (Presidential Executive Order 11990). (Environmental Procedures Manual, 1993)

WATER QUALITY AND PERMITTING

The purpose of this category of criteria is to assess the proposed project's potential watershed impact and to quantify the risk and staff time associated with resource-related permitting requirements. The evaluation criteria consist of categorical questions regarding the proximity of the project to sensitive areas, federally designated floodways or sole source aquifer areas, managed heritage or resource lands, and the associated permits. The total impervious surface area of the project is measured and scored. The total score, equaling the sum of points accrued in this category of criteria, may be divided in half if all permitting agencies have been contacted and there are no foreseeable conflicts or disagreements. If a required permit has already been obtained for the expected duration of need, then no points are accrued in that topic area, and the issuance date is recorded instead. The total score is minimized in the final ranking algorithm because projects that avoid watershed impacts and that have preliminary environmental agency approval receive lower scores than those with greater impact or uncertain permit approval.

Scoring

- Refer to the WSDOT Environmental Procedures Manual 6.0-6.9, March 1990, to evaluate permit requirements for the proposed project.
- Total Score = subtotal of each score entered in the column to the right, subject to the final operation as noted on the worksheet.

Definitions

- Body of water—All inter/intrastate waters within the ordinary high water line, such as lakes, rivers, streams (including intermittent streams), mud flats, sandflats, wetlands, sloughs, prairie pot-holes, wet meadows, playa lakes, or natural ponds, including all waters that are subject to the ebb and flow of the tide (ending where the rise and fall of the water surface can no longer be practically measured in a predictable rhythm because of masking by hydrologic, wind, or other effects).
- Total impervious surface area—The total surface area of the roadway upon completion of the proposed project (i.e., width including the improvements* length of the roadway segment within 2000' of any water body).
- Hydraulic project—Construction or other work that will use, divert, obstruct, or change the natural flow or bed of any river or stream, or that will utilize any of the salt or fresh waters of the state, or materials from the stream beds (WAC 220-110-020(16)).
- Fish passage problem— Any migration barrier condition that exists when adult and/or juvenile fish are either delayed or denied passage beyond a point in a stream system or marine shallow water habitats during the normal course of their migration for spawning or rearing purposes. If fish are delayed from reaching suitable spawning areas, mass spawning or spawning in unsuitable substrate can occur,

resulting in a decrease in survival. [WDF/WDW/WSDOT MOU (GC9058), and WDF/WSDOT State Interagency Agreement for Fish Passage Inventory and Barrier Removal (GC9392).]

- Shoreline of statewide significance—Water areas of the state, including reservoirs, and their associated wetlands, including lands within 200 feet of the high-water mark, including associated marshes, bogs, swamps, floodways, river deltas, and flood plains for which there is a special interest in preserving the natural characteristics and in encouraging and increasing public access to enjoy the physical and aesthetic qualities of the natural shoreline with the overall best interest of the state and people generally being considered. The restriction for development is greater because the master plan must meet the requirements of RCW 90.58.020 (see RCW 90.58.030 for list).
- New roadway—Project construction along a new alignment.
- Sensitive/critical—Designation subject to definition by the local governing authorities under State Environmental Protection Act, Growth Management Act, or zoning code implementation.
- Governing jurisdiction—The public agency, political unit, or apparatus with administrative powers to command, determine, judge, or otherwise enforce the laws, public policy, and affairs within the proposed project area.
- Regulatory floodway—The area regulated by federal, state or local requirements to provide for the discharge of the base flood (the flood that has a 1 percent chance of being equaled or exceeded in any given year, also known as the 100-year flood plain) so the cumulative increase in water surface elevation is no more than a designated amount (not to exceed 1 foot). The "Zone A" designation on the *Flood Insurance Rate Maps* by the Federal Emergency Management Agency indicates the 100-year flood plain, or minimum level to be used by a community in its flood plain management regulations. (44 CFR Ch.I 9.4)

- Sole source aquifer area—Area designated by the EPA as the sole or principal source of drinking water for a given aquifer service area; that is, an aquifer that is needed to supply 50 percent or more of the drinking water for that area and for which there are no reasonably available alternative sources should the aquifer become contaminated. (Section 1424(e) of Safe Drinking Water Act, 1974)
- Forest land—All land that is capable of supporting a merchantable stand of timber (a stand of trees that will yield logs and/or fiber suitable in size and quality for the production of lumber, plywood, pulp, or other forest products and of sufficient value at least to cover all the cost of harvest and transportation to available markets) and is not being actively used for a purpose that is incompatible with timber growing. (RCW 76.09.020, WAC 222)
- Other jurisdictions/resource lands of regional significance—Areas including, but not limited to, tribal governments, reservation lands, regulatory commissions (e.g., Columbia River Gorge Commission), significant/endangered wildlife corridors, prime/unique farmlands, archaeological/historical sites, National Park lands, other recreation land, and wild and scenic rivers that have been identified in the planning process as outlined in the Environmental Procedures Manual 3.0-3.12, March 1990.

NOISE IMPACT

The purpose of this category of criteria is to assess the proposed project's potential noise impact and associated risk in terms of project implementation. The noise level risk factor is a multiplier based on the number and proximity of receptors per type of improvement (new or existing roadways). Changes in distance from a residence or other receptor to the roadway is the only acoustical factor quantified by the noise criteria. The total score is minimized in the final ranking algorithm because projects that avoid expansion of the roadway and that maintain the existing distance from local residences, businesses, or schools receive lower scores than projects likely to result in increased speed and traffic volumes.

This worksheet is intended to be completed in-house using aerial photographs of the right-of-way and the table provided on the worksheet.

Scoring

- Determine whether there are existing noise impacts over 67dBA level that would require mitigation where feasible and reasonable (see definition below). The cost of mitigation measures MUST be included in the cost estimate EXCEPT where mitigation has been previously determined "unfeasible" or "unreasonable" by WSDOT procedures. This determination must be referenced on the worksheet in the space provided and is the only justifiable reason for not including these potential costs in the estimate.
- If the proposed project is on a *new alignment*, evaluate the number of receptors within 400' of the edge of the existing roadway.
- If the proposed project will **widen** the roadway along the *existing alignment*, evaluate the number of receptors within 200' of the edge of the existing roadway.
- Working with aerial photographs of the area, group the number of receptors with respect to distance from the edge of proposed roadway as categorized on the worksheet chart: if new, <100 ft., 101-200 ft., 201-400 ft.; if existing, <100 ft., 101-200 ft. ONLY).
- Using the Noise Level Risk Factors in question #4, compute the subtotals as follows: Divide the number of lanes that will be added/constructed by 2. *This result will be the same for each receptor category.* Multiply the result by the number of receptors in each distance category and by the appropriate risk factor. Apply only *one* risk factor to each receptor category from either the new *or* existing alignment column in the worksheet chart.

- Add the subtotals in the right-hand column of the worksheet chart and log the Total Score in the blank provided.

Definitions

- Existing noise impacts—Noise priority sites as established by WSDOT Directive D 22-22, November 2, 1987. Guidelines are detailed for conducting a noise inventory for existing state highways. The priority listing was developed on the basis of an inventory of noise sensitive developments which existed, or for which a building permit had been approved, before May 14, 1976, and is current as of August 19, 1986 in Appendix A. As new sites must be investigated, because of citizen complaints or public officials' concerns, the procedures in this Directive will be used to prioritize the new sites. More comprehensive or up-dated inventories may have been conducted by individual districts; check with environmental noise specialists. (WSDOT EPM 3.1, March 1990)
- Feasible mitigation—Noise mitigation that has no overwhelmingly significant physical constraints to construction and will provide significant noise abatement for *some* of the impacted receptors. Refer to WSDOT Headquarters Environmental division for specific parameters.
- Reasonable mitigation—Noise mitigation that will cost < $10,500/residence, not withstanding scenic views, desirability, and other consideration. Refer to WSDOT Headquarters Environmental division.

MODE INTEGRATION

The purpose of this category of criteria is to encourage multimodal characteristics in every proposed mobility project. The criteria consist of categorical questions designed to score multimodal design attributes such as the following: intermodal freight transfer points, non-motorized facilities, high-occupancy vehicle lane system extensions, links or extensions to the system of alternatives to single-occupant vehicles (e.g., park-and-ride lots), and preservation of existing capacity with transportation systems or transportation demand management measures rather than construction of an additional lane. The total score is minimized in the final ranking algorithm because projects that optimize existing capacity and that improve alternative mode integration are scored lower than mobility improvements aimed exclusively at single-occupancy travel modes.

Scoring

- Total Score = Sum of each score entered in the column to the right.

Definitions

- Improve or facilitate linkage for movement of goods through port or terminal facilities—The proposed project must facilitate the movement of goods along a roadway with high truck traffic (for roadway classifications by truck percentage, Refer to "Task B: Freight and Goods Transportation System; Cost Responsibility Study- Phase I", Final Report for the State of Washington Legislative Transportation Committee, January 1993.) and be within a 10-mile radius from the terminal facility.
- Increased mobility—Used here to indicate conditions of greater movement of people and/or goods along the main roadway than presently supported by the facility.
- Bikeway—Includes all four bikeway classes described by WSDOT Design Manual Standards.

LAND USE

The purpose of this category of criteria is to encourage coordination among WSDOT engineers and local planners; convenient access for transit; connectivity between urban activity centers; and consistent transportation planning. Points are awarded to projects designed for existing or planned transit thoroughfares and/or designed to connect areas of mixed-use or high intensity commercial use. Points are also accrued whenever the WSDOT region has completed a land-use checklist for every jurisdiction through which the project passes. Improvements that are not identified on state or regional transportation plans are, by definition, fatally flawed (although assigned a score in this category); thus, the screening criteria exclude them from prioritization, as previously described. The total score is maximized in the final ranking algorithm because projects that better integrate land use and transportation improvements will receive higher scores than projects designed without regard to such goals.

Scoring

- Total Score = Sum of each score entered in the column to the right.

Definitions

- Local governments having an interest—Counties/cities through whose respective jurisdictional boundaries the proposed project passes.
- *Land Use Policy and Implementation* file—Reference to a DOT region specific library of up-to-date documents, long-range transportation policies, and implementation measures for each city or county government encompassed by the region planning area. Each file must contain the following elements to enter a score of 5 points: *Land Use Checklist*, Comprehensive Plan, Transportation Plan, Zoning Code, Road/Design Standards, Critical Areas/Sensitive Areas Code/Ordinance, and other supporting inter-local, regional, and city/county-wide policy documents.
- *Land Use Checklist*—Form used to facilitate distillation of the governing jurisdiction's codes and policies. Intended for use as a procedural checklist, only categorical completion of this form (yes/no) is scored. See blank form attached.
- Designated growth center—An area designated by regional or local planning agencies to receive a major share of the regional employment growth in the future.

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Appendix A

Examples of Worksheets

Included in this appendix:

- Cost Efficiency Worksheet-Benefit-Cost Analysis for Safe Movement of People and Goods
    - Benefit-Cost- TOPSIS Data
    - Quantity Calculations for Cost Estimate
- Additional General Purpose Lane Worksheet
- Two Way Left Turn Worksheet
- Intersection Capacity Improvement Worksheet
- Additional HOV Lane Worksheet-A
- Additional HOV Lane Worksheet-B
- Truck Climbing Lane Worksheet
- Park-n-Ride Lot Worksheet
- User Benefit for a New Interchange at a New Access Point Worksheet
- Grade Intersection Removal Worksheet
- Safety Benefits Worksheet: Safety Improvement with Collision Records

COST EFFICIENCY WORKSHEET -
BENEFIT-COST ANALYSIS FOR SAFE MOVEMENT OF PEOPLE AND GOODS

The purpose of this worksheet is to summarize project costs and benefits. Detailed calculations should **be included for each project and attached on a separate page. Benefits and costs should be expressed as present values using the following parameters:**

Discount Rate (i) = 0.04
Study Period (n) = 20 years

(may vary on some projects, yet MUST be consistent with the time period used to calculate Project Benefits in any case. See accompanying outlines as detailed below.)

Project Cost Estimate: **199_ $'s**

Construction ______ (C)
(Sum ALL relevant line items including: environmental mitigation, and right-of-way; and excepting the following:)

Environmental Retrofit ______ (E_R)
(costs incurred due to a pre-existing condition, e.g. noise barriers, water quality treatment, and fish barrier removal. Some may be exempt.)

Preliminary Engineering ______ (S_P)

Annual Operating and Maintenance ______ (OpM_A)
(based on historical rates in similar area with proposed geometrics, except the following: Snow and Ice Removal, Structures & Ferries, Rest Area Management, and Public Damage Repair)

Calculate the Present Value of Project Costs (PV_C):

$$PV_C = (C) + (E_R) + (S_P) + \left\{ OpM_A \left[\frac{(1+i)^n - 1}{i(1+i)^n} \right] \right\}$$

Total Est. Costs (PV_C) = ______

Project Benefit Estimate:

Present Value of User Benefits ______
(includes both Travel Time Savings & User Operating Savings. Calculate as outlined in accompanying "User Benefits Worksheets")

Present Value of Safety Benefits ______
(Calculate as outlined in accompanying "Safety Benefits Worksheets")

Total Est. Benefits (PV_B) = ______

Calculate the BENEFIT-COST RATIO of Proposed Project:

$$B/C = (PV_B)/(PV_C) = \_\_\_\_\_\_\_\_$$

BENEFIT COST - TOPSIS DATA

SR	0						
Project Title:				**Posted Speed:**			
Subject Section:		**MP**	0	**to**	**MP**	0	
Length of Subject Section:			0	**Miles**			
Number of Lanes:		**No - Build**	0	**Build**	0		
Terrain for this project (L for Level, R for Rolling, M for Mountainous):						L	

PRELIMINARY ENGINEERING		$0		1	$0
ENVIRONMENTAL RETROFIT		$0		1	$0
RIGHT OF WAY		$0		0.55	$0
CONSTRUCTION COST	$0				
GRADE/DRAIN		$0		0.6	$0
STRUCTURES		$0		0.57	$0
OTHER		$0		1	$0
TOTAL COST OF PROJECT		$0			
COST SHARE BY NON-WSDOT		$0			
WSDOT COST OF PROJECT		$0			
WSDOT RESIDUAL COST					$0
ANNUAL OPERATION & MAINTENANCE		$0			$0
TOTAL PRESENT VALUE COST (PVc)					$0

	GPlane	Intersection
PVub	$0	$0

PVub	PVs	PVb	PVc	NPV	B/C
$0	$0	$0	$0	$0	####

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QUANTITY CALCULATIONS FOR COST ESTIMATE

SR	0				
Project Title:			**Posted Speed:**		
Subject Section:	**MP**	0	**to**	**MP**	0
Length of Subject Section:		0	**Miles**		
Number of Lanes:	**No - Build**	0	**Build**	0	
Terrain for this project (*L* for Level, *R* for Rolling, *M* for Mountainous):					L

General Cost per Mile Estimate:

	# of Lanes	Mile	Cost per lane mile	R/U*	Cost
Arterial Lane Addition	0	0	$1.6M to $3.5M		$0
Add Climbing/Passing Lane	0	0	$1.3M to $7.0M		$0
Freeway Lane Addition	0	0	$2.5M to $7.5M		$0
Channelize Intersection	0	0	$0.15M to $0.60M		$0
Realignment	0	0	$1.3M to $6.0M		$0
Widen Shoulders	0	0	$0.5M to $3.0M		$0
	Structure Width	Structure Length	Cost per SF		Cost
New Bridge	0	0	$100		$0
New Urban I/C	0	0	$425		$0
New Diamond I/C	0	0	$475		$0
GENERAL COST ESTIMATE					
Enter **R for Rural, **U** for Urban*			**$0**	**to**	**$0**

Detailed Planning Cost Estimate:

		Quantity	Unit	Unit Cost	Other	Cost
Bridge		0	SF	$100		$0
Walls	Retaining	0	SF	$25		$0
	Noise	0	LF	$260		$0
Guardrail (# of Anchors in Other)		0	LF	$15	0	$0
Concrete Barrier		0	LF	$25		$0
Signals		0	EA	$250,000		$0
Illumination		0	EA	$8,000		$0
Signing/Striping		0	LF	$10		$0
Sidewalks, Curb, & Gutter		0	LF	$35		$0
Surface/Paving		0	LF	$50		$0
Drainage	Ditch	0	LF	$5		$0
	Enclosed System	0	LF	$50		$0
Earthwork		0	LF	$30		$0
Clear/Grub	Shrubs/Grass	0	Acre	$1,000		$0
	Light Woods	0	Acre	$3,000		$0
	Heavy Forest	0	Acre	$5,000		$0
Wetland Mitigation		0	Acre	$100,000		$0
Roadside Development		0	Mile	$5,000		$0
Traffic Control (5% of Total)				5%		$0
Removal Items (5% of Total)				5%		$0
Mobilization @ 8%				8%		$0
Contingencies @ 5%				5%		$0
Right of Way		0	SF	$0		$0
Preliminary Engineering @ 15%				15%		$0
Construction Engineering @ 20%				20%		$0
Sales Tax @ 7.6%				7.60%		$0
DETAILED COST ESTIMATE USED FOR B/C						**$0**

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DAILY BENEFIT WORKSHEET FOR ADDING GP LANES

		No - Build	Build
SR	539		
Posted Speed		50	50
Project Title	HORTOON RD. TO LAUREL RD.		
Subject Section:	MP. 1.73	to	MP. 5
Length of Subject Section:	3.27	Miles	
Number of lanes	No - Build 2	Build	4
Direction of facility	NB	SB	

Traffic Data

	Year 1	Year 20	Year 20
ADT	19221		38442
Peak Hour Volume			
K factor			
Truck %	8%		8%
Grade	0		
Length of grade	0		
Growth Rate	5.00%		

Traffic Volume Distribution Curve

Curve Number	3
Peak Period AVO	1.1

Capacity

Roadway Type	Base	Base	Section Type No Build	Section Type Build
Urban Multilane Highway or Freeway	2200	vphpl		
Rural/Small Urban Freeway	2000	vphpl		
2 Lane Highway	1300	vphpl	X	
Arterial	1600	vphpl		X

Capacity without improvement	***1204***
Capacity with improvement	***2963***

DAILY BENEFIT WORKSHEET FOR ADDING GP LANES

			No - Build	Build
SR	539	**Posted Speed**	50	50
Project Title	HORTOON RD. TO LAUREL RD.			
Subject Section:	**MP.**	1.73	to **MP.**	5
Length of Subject Section:		3.27	**Miles**	
Number of lanes	**No - Build**	2	**Build**	4
Direction of facility	NB	SB		

User Benefits

Hour	NB or WB	SB or EB	Total
1	$2,098	$2,061	$4,159
2	$1,469	$1,942	$3,411
3	$1,469	$1,903	$3,371
4	$0	$1,506	$1,506
5	$1,595	$2,140	$3,735
6	$5,556	$6,686	$12,242
7	$8,441	$222,023	$230,464
8	$168,439	$2,489,475	$2,657,913
9	$67,709	$2,462,267	$2,529,976
10	$241,348	$2,187,678	$2,429,026
11	$648,617	$2,684,121	$3,332,738
12	$1,460,351	$2,673,582	$4,133,933
13	$1,835,297	$1,995,321	$3,830,618
14	$2,329,160	$1,931,231	$4,260,391
15	$3,224,849	$1,549,760	$4,774,609
16	$4,228,577	$1,758,218	$5,986,794
17	$4,699,283	$1,945,348	$6,644,631
18	$3,852,465	$1,312,303	$5,164,768
19	$1,483,130	$822,819	$2,305,949
20	$537,598	$63,442	$601,040
21	$242,608	$29,838	$272,446
22	$168,439	$7,641	$176,080
23	$21,101	$2,282	$23,383
24	$2,565	$5,805	$8,370

Total Present Value of User Benefits

$49,391,554

ADDGPLN VER 1

Addgpln.xls
TDO Nov. 1997

TWO WAY LEFT TURN LANE

USER BENEFIT WORKSHEET

Capacity Improvement (TWLT Lane)

Fill in red boxes as needed. Blue boxes will be calculated automatically

SR ____ Posted Speed ____

Project Title ____

Subject Section: ____

Length of Subject Section: ____ Miles Proposed ____ Miles

Number of Lanes ____ # of Lanes (w/improvement) 0

Evaluated by: ________

*Note: Use (ADT*K) or (DHV*peak adjust %) for the Working Peak Hour Volumes below.*

Roadway Characteristics

Year 1 = 1995			**Year 20 = 2015**		
Working Pk hr. Vol.			Working Pk hr. Vols.		
% HOV			% HOV		
% Trucks			% Trucks		

***Attach Data Source citation list, and detail procedures for developing ALL raw data.*

If an HOV % is used input the Average Vehicle Occupancy (AVO) ____

Capacity

Roadway Type	Base	Section Type With " X " No Build	Build
Urban Multilane Highway or Freeway	2200 vphpl		
Rural/Small Urban Freeway	2000 vphpl		
2 Lane Highway	1400 vphpl		
Arterial	1600 vphpl		
HOV Lane	1500 vphpl		

Capacity without improvement 0

Capacity with improvement 0 Imp Cap = 0

1/(V/C WITH IMP)*(YEAR 20 PH VO

V/C Ratio

Year 1			Year 20		
Without Improvemen	0.00		Without Improvemen	0.00	
With Improvement	-0.05		With Improvement	-0.05	

FOR TWLT W/ IMP V/C = V/C W/O - 0.05

Travel Time (TT) Hours

The following table calculates the TT when the V/C ratio is > 1

Year 1	V/C > 1	TT	Year 20	V/C > 1	TT
Without Improvemen	NO	0.00	Without Improvemen	NO	0.00
With Improvement	NO	0.00	With Improvement	NO	0.00

((Volume - Capacity) / 2 x Distance) + (Volume x Distance / 30)

If the V/C ratio is < 1, then the following method is used to determine the Travel Time. Using the appropriate charts (Figure 16.1, 8, 13, or 14) from the Traffic Engineering Handbook (Second edition) input the Operating Speed for those scenarios alone.

Year 1		Year 20	
Operating Speed w/o imprvmnt		Operating Speed w/o imprvmnt	
Operating Speed w/ imprvmnt		Operating Speed w/ imprvmnt	

Travel Time is automatically calculated using the Operating Speed and Length of Sectior being evaluated.

Year 1		Year 20	
Travel Time w/o imprvmnt	0.00	Travel Time w/o imprvmnt	0.00
Travel Time w/ imprvmnt	0.00	Travel Time w/ imprvmnt	0.00

(Volume x Distance / Speed)

Travel Time Savings (TTS)

TT(Build)-TT(No-Build)=TTS(Year 1 or 20)

Year 1			Year 20		
Travel Time Savings	0.00	Hrs	Travel Time Savings	0.00	Hrs

Travel Time Savings Distribution

If the HOV percentage is known then the detailed traffic composition is used to calculat following TTS. (Based on the values entered in above Working Peak Hr. Volumes section

Year 1			Year 20		
TTS - SOV	0.00		TTS - SOV	0.00	
TTS - HOV	0.00		TTS - HOV	0.00	
TTS - Trucks	0.00		TTS - Trucks	0.00	

If HOV percentage is NOT known then the traffic composition is determined from the Tr and General Purpose% alone (must total 100%) and the TTS distribution is calculated as f

Year 1			Year 20		
TTS - GP	0.00		TTS - GP	0.00	
TTS - Truck	0.00		TTS - Truck	0.00	

RURAL = 1
URBAN = 2

User Benefits

Year 1	Year 20
$0	**$0**

Present Value Factor (PVF)

PVF = 0.00

Present Value of User Benefits (Peak Hour)

$0

Present Value of User Benefits (24 Hour)

x 10 = ***$0***

SR	0
MP	0 to 0
Project Title	
Analyst	0
Truck %	3.00%
Date	8/14/96
Growth Rate	2.00%

Year 1 No-Build

Total Approach Volume	1234
Number of Lanes	12
Average Delay	34
Intersection V/C	1.1

Year 1 Build

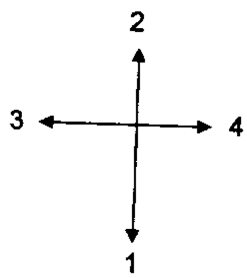
Total Approach Volume	1200
Number of Lanes	12
Average Delay	23
Intersection V/C	0.9

Build Scenario % Reduction By Approac

Approach 1	0.00%
Approach 2	0.00%
Approach 3	0.00%
Approach 4	0.00%

Cost Information

Auto Occupancy	1.1
Truck Occupancy	1.0
Cost Parameter - Auto	$10.00
Cost Parameter - Truck	$50.00



NOTE:
INPUT VOLUMES IN THE APPROPRIATE COLUMN UNDER THE DIRECTIONAL ARROWS

Existing Vol

Hour	Approach 1	Approach 2	Approach 3	Approach 4
0100	0	0	0	0
0200	0	0	0	0
0300	0	0	0	0
0400	0	0	0	0
0500	0	0	0	0
0600	0	0	0	0
0700	0	0	0	0
0800	0	0	0	0
0900	0	0	0	0
1000	0	0	0	0
1100	0	0	0	0
1200	0	0	0	0
1300	0	0	0	0

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1400	0	0	0	0
1500	0	0	0	0
1600	0	0	0	0
1700	0	0	0	0
1800	0	0	0	0
1900	0	0	0	0
2000	0	0	0	0
2100	0	0	0	0
2200	0	0	0	0
2300	0	0	0	0
2400	0	0	0	0

	User Benefits			
	Year 1	Year 20	PVF	Present Value
0100	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
0200	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
0300	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
0400	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
0500	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
0600	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
0700	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
0800	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
0900	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
1000	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
1100	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
1200	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
1300	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
1400	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
1500	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
1600	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
1700	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
1800	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
1900	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
2000	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
2100	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
2200	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
2300	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
2400	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
SUM	**#DIV/0!**	**#DIV/0!**		

Present Value of User Benefits

$0

0 Hours at capacity for year 1 no build
0 Hours at capacity for year 1 build
0 Hours at capacity for year 20 no build
0 Hours at capacity for year 20 build

HOV CAPACITY IMPROVEMENT WORKSHEET

SR	[illegible]		
Project Title	[illegible]		
Analysis Direction	[illegible]		
Begin & End MP	[illegible]	&	[illegible]
Length of Section	1.13	miles	
Evaluated by	[illegible]		

Analysis period (yrs): [illegible]

TRAFFIC COMPOSITION

	BEGIN YR 1	[illegible]	Source
3+ HOV Growth Rate [illegible]			PSRC
HOV+GP Growth Rate [illegible]			PSRC
Peak Hour Volume (GP+HOV)	[illegible]	4,540	TPE
2+ HOV Percentage	20.4%	25.7%	UW TRAC
2+ HOV Volumes	870	[illegible]	Enter capacity constrained volume from below
3+ HOV Percentage	4.6%	8.0%	UW TRAC
3+ HOV Volumes	196	[illegible]	Enter capacity constrained volume from below
Sum HOV Volumes	**870**	**1,167**	Based on capacity constraint
Assigned HOV Designation	[illegible]	[illegible]	Present min. occupancy req. increases to 3+ wh

Assumptions:

1.) HOV percentages include all eligible HOV users, including motorcycles.
2.) If HOV designation changes from 2+ to 3+, the change occurs at the end of the year that HOV volumes exceed capacity.
3.) HOV growth rate for 3+ is the same as the 2+ HOV growth rate.
4.) HOV percentages are based on the current composition of the corridor.

End of Year (Start of Study)	+ HOV Volum	*3+ HOV Volumes*	Bus avc	Persons/2+ Lane	Pool AVO constraine d-2+	Pool Volume at 3+ minimum (converted avo=3.11, projected 3+ avo=3.79)
	870	*196*	**30**	2510	2.35	
1	965	*218*	32	2812	2.35	
2	1071	*241*	33	3150	2.35	
3	1187	*268*	35	3528	2.35	
4	1317	*297*	36	3951	2.35	
5	1460	*329*	38	4425	2.35	
6	**1619**	***365***	**39**	**4955**	[illegible]	[illegible]
7	1796	*405*	41	5548	[illegible]	[illegible]
8	1992	*449*	42	6211	[illegible]	[illegible]
9	2209	*498*	44	6953	[illegible]	[illegible]
10	2449	*552*	45	7783	[illegible]	[illegible]
11	2716	*613*	47	8711	[illegible]	[illegible]
12	3013	*679*	48	9749	[illegible]	[illegible]
13	3341	*753*	50	10910	[illegible]	[illegible]
14	**3705**	***835***	**51**	**12209**	[illegible]	[illegible]
15	4109	*927*	53	13660	[illegible]	[illegible]
16	4557	*1028*	54	15283	[illegible]	[illegible]
17	5053	*1140*	56	17098	[illegible]	[illegible]
18	5604	*1264*	57	19126	[illegible]	[illegible]
19	6215	*1401*	59	21394	[illegible]	[illegible]
20	6893	*1554*	60	23928	[illegible]	[illegible]

***constrain pool AVO for User Benefit calc. in Yr.20, if 3+ volumes exceed 1500 capacity.**

TRAVEL TIME WITHOUT IMPROVEMENT (GP lanes only)

Use the following table to estimate the appropriate capacity and operating speeds for the section:

Section Type	Capacity (vphpl)	Operating Speed Curves
Urban Multilane Highway	2,200	Traffic Engr. Handbook, 2 ed., Fig 16.8, 70 mph avg. speed curve
Rural/Small Urban Freeway	2,000	Traffic Engr. Handbook, 2 ed., Fig 16.13, 60 mph avg. speed curve
Two Lane Rural Highway	1,300	Traffic Engr. Handbook, 2 ed., Fig 16.14, 60 mph avg. speed curve
Urban Multilane HOV Facility	1,500	Figure 16, "HOV Facilities" 10/90, Parsons Brinckerhoff study & WSDOT System Policy.

Capacity Without Improvement

Number of Lanes	[illegible]	
Capacity for Section	[illegible]	vphpl
Total Capacity	4,400	vph

Roadway Characteristics Without Improvement

V/C YEAR 1	0.97
[illegible]	1.03

If the above V/C ratio is under 1.0, then calculate travel time as:
Travel Time (hrs) = (Distance x Volume)/Speed

If the above V/C ratio is over 1.0, then calculate travel time in three steps.
1.) For the portion of volume where V/C = 1, Travel Time (hrs) = (Distance x Volume)/30 mph
2.) For the portion of volume over V/C = 1, Travel Time (hrs) = (Volume - Capacity)/2
3.) Add Travel Time (hrs) from steps 1 and 2.

V/C Ratio < 1

	BEGIN YR 1	END YR 6
Operating Speed		
Travel Time-No Build	129	#DIV/0!

{speeds are estimated from HCM v/c curves}

V/C Ratio > 1

	BEGIN YR 1	END YR 6
Part 1: Operating Speed		
(1)Travel Time-No Build	#DIV/0!	166
Part 2: (2)Travel Time-No Build	-67	70
Part 3: Total Travel Time-No Build	#DIV/0!	236

Final Travel Time-No Build
{enter total TT -no build}

YEAR 1		END YR 6	
128.6	**veh-hrs**	**235.9**	**veh-hrs**

TRAVEL TIME WITH IMPROVEMENT

GENERAL PURPOSE TRAVEL TIME SAVINGS:

Use the same table given in the Travel Time Without Improvement to estimate the appropriate volume and operating speeds for the section.

GP TRAFFIC ONLY

	BEGIN YR 1	END YR 6
GP Volume	3,397	3,373
V/Cgp with improvement	0.77	0.77

If the above V/C ratio is under 1.0, then calculate travel time as:
Travel Time (hrs) = (Distance x Volume)/Speed

If the above V/C ratio is over 1.0, then calculate travel time in three steps.
1.) For the portion of volume where V/C = 1, Travel Time (hrs) = (Distance x Volume)/30 mph
2.) For the portion of volume over V/C = 1, Travel Time (hrs) = (Volume - Capacity)/2
3.) Add Travel Time (hrs) from steps 1 and 2.

GP TRAFFIC V/C Ratio < 1

	BEGIN YR 1	END YR 6
Operating Speed	[illegible]	[illegible]
Travel Time GP-Build	81	80

{speeds are estimated from figure 16.8 -see above}

GP TRAFFIC V/C Ratio > 1

	BEGIN YR 1	END YR 6
Part 1:		
Operating Speed		
(1)Travel Time GP-Build	#DIV/0!	#DIV/0!
Part 2:		
(2)Travel Time GP-Build	-502	-513
Part 3: Total		
Travel Time GP-Build	#DIV/0!	#DIV/0!

GP TRAFFIC ONLY
Final Travel Time GP-Build
{enter the total TT from above}

	BEGIN YR 1		END YR 6	
	80.8	**veh-hrs**	**80.2**	**veh-hrs**

TRAVEL TIME SAVINGS

Calculate travel time savings (TTS) experienced in the general purpose lane by taking the difference between the travel time without the improvements (Travel Time-No Build) and travel time with improvements (Travel Time GP-Build).

GP TRAFFIC ONLY	**BEGIN YR 1**		**END YR 6**	
Final Travel Time-No Build	129	veh-hrs	236	veh-hrs
Final Travel Time GP-Build	81	veh-hrs	80	veh-hrs
Travel Time Savings GP	48	veh-hrs	156	veh-hrs

Finally, separate the truck and non-truck GP traffic and calculate the travel time savings for each. To obtain the travel time savings for the non-truck volumes, multiply the Travel Time Savings-GP by the % of non-trucks. Similarly, multiply the travel time savings for GP traffic by the % trucks to obtain the travel time savings for the truck volumes.

Truck Percentage [illegible]

GP TRAFFIC ONLY	**BEGIN YR 1**		**END YR 6**	
Travel Time Savings Non-trucks	**46**	**veh-hrs**	**150**	**veh-hrs**
Travel Time Savings Trucks	**2**	**veh-hrs**	**6**	**veh-hrs**

HOV TRAVEL TIME SAVINGS:

Use the same table given in the Travel Time Without Improvement to estimate the appropriate volume and operating speeds for the section.

HOV TRAFFIC ONLY

	BEGIN YR 1	END YR 6
HOV Volume	870	1,167
Assigned HOV Min. Designation	2+	3+

(In a split analysis, these volumes must be Yr 1 <1500, and Yr 20 < or = 1500, -see above)

Calculate travel time as: Travel Time (hrs) = (Distance x Volume)/Speed

HOV TRAFFIC V/C Ratio < 1

	BEGIN YR 1	END YR 6
Operating Speed*	[illegible]	[illegible]
Travel Time HOV-Build	**18**	**25**

(These speeds estimated from Parsons Brinckerl "HOV Facilities", Fig.16 & WSDOT System Polic

* Operating speed based on HOV volumes ("HOV Facilities: Current Planning, Operation, & Design", Oct. 1990, Figure 16)

Calculate the travel time of the HOV volume without the HOV lane, multiply the HOV percentage by the travel time without the improvement (Travel Time-No Build).

HOV TRAFFIC ONLY	**BEGIN YR 1**		**END YR 6**	
Travel Time HOV-No Build	26	veh-hrs	61	veh-hrs
Travel Time HOV-Build	18	veh-hrs	25	veh-hrs
Travel Time Savings HOV	**8**	**veh-hrs**	**36**	**veh-hrs**

USER BENEFITS CALCULATION

Translate travel time saving estimates into user benefits using the following equation:

User Benefits =

(Travel Time Savings Non-Trucks*Cost Parameter Non-Trucks*260) +
(Travel Time Savings HOV*Cost Parameter HOV*260) +
~~(Travel Time Savings HOV*Public Transit Percentage*$50.00*260) +~~
(Travel Time Savings Trucks*Cost Parameter Trucks*260)

where

Cost Parameter Non-Trucks=	$10.00	x AVO Non-Trucks
Cost Parameter HOV=	$10.00	x AVO HOV
Cost Parameter Trucks=	$50.00	x AVO Trucks

For example, the AVO is calculated as follows (if Year 1 is 2+ and Year 20 is 3+ HOV):

Year 1 AVO (2+ HOV) = [(% 2 person x 2) + (%3 person x 3) + ((%4+ person + vanpool + other bus) x 4.1) + (public transit % x avg. bus occupancy) + (% motorcycle x 1)]/HOV %

Year 20 AVO (3+ HOV) = Adjusted per conversion constraint
{The AVO is calculated above using the persons/2+ lane based on Yr.1 vehicle type distributions.
It is assumed that the converted 2-person carpools will transfer into AVO=3.11 vehicles and the AVO for the rest of the traffic is transferred in from the second analysis period spreadsheet AVO estimates based on 3+ volumes only. }

Assumptions:

1.) Composition of the traffic stream in Year 1 is the same in Year 20. (& buses = 1 vehicle in traffic)
2.) In Year 20, the average bus occupancy is 60 people.
3.) All 2-person carpools will convert to 3+ vehicle as the minimum occupancy requirement is increased.

Average Bus Occupancy : YEAR 1= [illegible]
END YR 6 39

Assumption: 1.) Average bus occupancy linearly increases to Year 20. {see above}

Year 1 3+ HOV % = 4.6%

YEAR 1 DATA	[illegible]	HOV proportion based on 2+	based on 3+
SOV	[illegible]		
2 person	[illegible]	0.77	
3 person	[illegible]	0.13	0.5652
4+ person	[illegible]	0.06	0.26
vanpool	[illegible]	0.01	0.04
public transit	[illegible]	0.02	0.09
other bus	[illegible]	0.00	0.02
motorcycle	[illegible]	0.00	0.02

Assumption:
1.) Traffic composition remains constant through YR1 to YR 20.

	BEGIN YR	END YR 6
HOV Designation	2+	3+
HOV %	[illegible]	25.7
AVO Non-Trucks	1.30	1.30
AVO HOV	2.83	6.24
AVO Trucks	1	1

Assumptions:
1.) All eligible HOVs use the HOV lane.
2.) All trucks are SOVs.
3.) IF HOV volume > 1500 at 3+ min., the constrained Pool AVO will be transfen Yr. 20 User Benefits.

USER BENEFITS CALCULATION

	BEGIN YR 1	END YR 6
Travel Time Savings Non-trucks	46	150
Travel Time Savings HOV	8	36
Travel Time Savings Transit	~~0~~	~~1~~
Travel Time Savings Trucks	2	6
Cost Parameter Non-Trucks	$13.00	$13.00
Cost Parameter HOV	$28.26	$62.39
Cost Parameter Transit	~~$50.00~~	~~$50.00~~
Cost Parameter Trucks	$50.00	$50.00
User Benefits	**$239,815**	**$1,161,241**

PRESENT VALUE OF USER BENEFITS

[illegible]	4.84	
Annual Growth Rate, r	0.26	[illegible]
Analysis Period, n	6	
Discount Rate, i	0.04	
Present Value Function	12.60	[(exp((r-i)n)-1)/(r-i)]

To determine the present value of the user travel time savings benefits, multiply the Year 1 user benefits by the present value function.

PRESENT VALUE of USER BENEI END YR 6 $3,022,258

HOV CAPACITY IMPROVEMENT WORKSHEET

This is good evaluation iff use TRAC HOVs --see other

SR	[illegible]		
Project Title	[illegible]		
Analysis Direction	[illegible]		
Begin & End MP	[illegible]	&	[illegible]
Length of Section	1.13	miles	
Evaluated by	[illegible]		

Analysis period: [illegible]

TRAFFIC COMPOSITION

	[illegible]	END YR 20	Source
3+ HOV Growth Rate [illegible]			[illegible]
HOV+GP Growth Rate, YR 10 [illegible]			[illegible]
Peak Hour Volume (GP+HOV)	[illegible]	5,248	
2+ HOV Percentage			
2+ HOV Volumes			[illegible]
3+ HOV Percentage	25.7%	28.6%	[illegible]
3+ HOV Volumes {enter from below}	[illegible]	1,500	[illegible]
Enter Final HOV Volumes	[illegible]	**1,500**	[illegible]
Assigned HOV Designation	[illegible]	[illegible]	[illegible]

Assumptions:

1.) HOV percentages include all eligible HOV users, including motorcycles.

2.) If HOV designation changes from 2+ to 3+, the change occurs at the end of the year that HOV volumes exceed capacity.

3.) HOV growth rate for 3+ is the same as the 2+ HOV growth rate.

4.) HOV percentages are based on the current composition of the corridor.

Enter & highlight Volumes in beginning year of second analysis period (see other):

NOTE: this type of split in analysis should occur the first year that 2+ volumes exceed capacity of the lane (1500)

End of Year (Start of Study)	+ HOV Volume	*3+ HOV Volumes*	Bus avo	*Persons/3+ Lane*	*3+pool AVO*	Pool Volume at 3+ minimum
0	0	*0*	[illegible]	*0*	*#DIV/0!*	
1	0	*0*	32	*0*	*#DIV/0!*	
2	0	*0*	34	*0*	*#DIV/0!*	
3	0	*0*	35	*0*	*#DIV/0!*	
4	0	*0*	37	*0*	*#DIV/0!*	
5	0	*0*	38	*0*	*#DIV/0!*	
6	1619	*365*	40	*2468*	*#DIV/0!*	
7	1795	*405*	41	*2788*	*3.69*	[illegible]
8	1991	*449*	43	*3148*	*3.69*	[illegible]
9	2208	*498*	44	*3554*	*3.69*	[illegible]
10	2449	*552*	46	*4011*	*3.69*	[illegible]
11	2716	*612*	47	*4526*	*3.69*	[illegible]
12	3012	*679*	48	*5104*	*3.69*	[illegible]
13	3340	*753*	50	*5756*	*3.69*	[illegible]
14	3704	*835*	51	***6488***	*3.69*	[illegible]
15	4108	*926*	53	*7312*	*3.69*	[illegible]
16	4556	*1027*	54	*8239*	*3.69*	[illegible]
17	5052	*1139*	56	*9281*	*3.69*	[illegible]
18	5603	*1263*	57	*10452*	*3.69*	[illegible]
19	6214	*1401*	59	*11767*	*3.69*	[illegible]
20	6891	*1554*	60	*13246*	*3.69*	[illegible]
					[illegible]	[illegible]

**see below, GP-Build, for discussion of Pool AVO in YR

TRAVEL TIME WITHOUT IMPROVEMENT (GP lanes only)

Use the following table to estimate the appropriate capacity and operating speeds for the section:

Section Type	Capacity (vphpl)	Operating Speed Curves
Urban Multilane Highway	2,200	Traffic Engr. Handbook, 2 ed., Fig 16.8, 70 mph avg speed curve
Rural/Small Urban Freeway	2,000	Traffic Engr. Handbook, 2 ed., Fig 16.13, 60 mph avg speed curve
Two Lane Rural Highway	1,300	Traffic Engr. Handbook, 2 ed., Fig 16.14, 60 mph avg speed curve
Urban Multilane HOV Facility	1,500	Figure 16, "HOV Facilities" 10/90, Parsons Brinckerhoff study & WSDOT System Policy.

Capacity Without Improvement

Number of Lanes	[illegible]	
Capacity for Section	[illegible]	vphpl
Total Capacity	4,400	vph

Roadway Characteristics Without Improvement (V/C ratio)

BEGIN YR 7	1.03
YEAR 20	1.19

If the above V/C ratio is under 1.0, then calculate travel time as:
Travel Time (hrs) = (Distance x Volume)/Speed

If the above V/C ratio is over 1.0, then calculate travel time in three steps.
1.) For the portion of volume where V/C = 1, Travel Time (hrs) = (Distance x Volume)/30 mph
2.) For the portion of volume over V/C = 1, Travel Time (hrs) = (Volume - Capacity)/2
3.) Add Travel Time (hrs) from steps 1 and 2.

V/C Ratio < 1

	BEGIN YR 7	END YR 20
Operating Speed Travel Time-No Build	#DIV/0!	#DIV/0!

{speeds are estimated from HCM v/c curves}

V/C Ratio > 1

	BEGIN YR 7	END YR 20
Part 1: Operating Speed	[illegible]	[illegible]
(1)Travel Time-No Build	166	166
Part 2: (2)Travel Time-No Build	70	424
Part 3: Total Travel Time-No Build	236	590

{30mph is the standard v/c=1.0 speed assumption, see figure 16.8}

Final Travel Time-No Build {enter total TT -no build}	**BEGIN YR 7**		**END YR 20**	
	235.7	**veh-hrs**	**589.5**	**veh-hrs**

TRAVEL TIME WITH IMPROVEMENT

GENERAL PURPOSE TRAVEL TIME SAVINGS:

Use the same table given in the Travel Time Without Improvement to estimate the appropriate capacity and operating speeds for the section.

GP TRAFFIC ONLY

	BEGIN YR 7	END YR 20
GP Volume	3,373	3,748
V/Cgp with improvement	0.77	0.85

{HOV volume = 1500 in Year 20, -see above estimate}

{If in YR 20, 100 of eligible HOV vehicles used the GP lanes due to slight speed advantage, then the v/c would be ~ .87 and speed =45mph. The HOV speeds would remain at 45mph & 1500veh, but the AVO would ~decr (per calculation from YR1-2 wksht). Hence, these corrections were made to ensr the HOV traffic moved no slower than the GP lanes.}

If the above V/C ratio is under 1.0, then calculate travel time as:
Travel Time (hrs) = (Distance x Volume)/Speed

If the above V/C ratio is over 1.0, then calculate travel time in three steps.
1.) For the portion of volume where V/C = 1, Travel Time (hrs) = (Distance x Volume)/30 mph
2.) For the portion of volume over V/C = 1, Travel Time (hrs) = (Volume - Capacity)/2
3.) Add Travel Time (hrs) from steps 1 and 2.

GP TRAFFIC V/C Ratio < 1

	BEGIN YR 7	END YR 20
Operating Speed	[illegible]	45.0
Travel Time GP-Build	80	94

GP TRAFFIC V/C Ratio > 1

	BEGIN YR 7	END YR 20
Part 1:		
Operating Speed		
(1)Travel Time GP-Build	#DIV/0!	#DIV/0!
Part 2:		
(2)Travel Time GP-Build	-514	-326
Part 3: Total		
Travel Time GP-Build	#DIV/0!	#DIV/0!

{30mph is the standard v/c=1.0 speed assumption}

GP TRAFFIC ONLY
Final Travel Time GP-Build
{enter the total TT from above}

	BEGIN YR 7		END YR 20	
	80.2	**veh-hrs**	**94.1**	**veh-hrs**

TRAVEL TIME SAVINGS

Calculate travel time savings (TTS) experienced in the general purpose lane by taking the difference between the travel time without the improvements (Travel Time-No Build) and travel time with improvements (Travel Time GP-Build).

GP TRAFFIC ONLY	**BEGIN YR 7**		**END YR 20**	
Final Travel Time-No Build	236	veh-hrs	590	veh-hrs
Final Travel Time GP-Build	80	veh-hrs	94	veh-hrs
Travel Time Savings GP	155	veh-hrs	495	veh-hrs

Finally, separate the truck and non-truck GP traffic and calculate the travel time savings for each. To obtain the travel time savings for the non-truck volumes, multiply the Travel Time Savings-GP by the % of non-trucks. Similarly, multiply the travel time savings for GP traffic by the % trucks to obtain the travel time savings for the truck volumes.

Truck Percentage [illegible]

GP TRAFFIC ONLY	**BEGIN YR 7**		**END YR 20**	
Travel Time Savings Non-trucks	**150**	veh-hrs	**477**	veh-hrs
Travel Time Savings Trucks	**6**	veh-hrs	**18**	veh-hrs

HOV TRAVEL TIME SAVINGS:

Use the same table given in the Travel Time Without Improvement to estimate the appropriate volume and operating speeds for the section.

HOV TRAFFIC ONLY

	BEGIN YR 7	END YR 20
HOV Volume	1,167	1,500
Assigned HOV Min. Designation	3+	3+

{HOV lane is at capacity in Yr 20 -see above estimate}

Calculate travel time as: Travel Time (hrs) = (Distance x Volume)/Speed

HOV TRAFFIC V/C Ratio < 1

	BEGIN YR 7	END YR 20
Operating Speed*	[illegible]	45
Travel Time HOV-Build	**25**	**38**

* Operating speed based on HOV volumes & WSDOT System Policy min.=45n {see above for discussion of YR 20 HOV estimate.}
("HOV Facilities: Current Planning, Operation, & Design", Oct. 1990, Figure 16)

Calculate the travel time of the HOV volume without the HOV lane, multiply the HOV percentage by the travel time without the improvement (Travel Time-No Build).

HOV TRAFFIC ONLY	**BEGIN YR 7**		**END YR 20**	
Travel Time HOV-No Build	61	veh-hrs	169	veh-hrs
Travel Time HOV-Build	25	veh-hrs	38	veh-hrs
Travel Time Savings HOV	**36**	**veh-hrs**	**131**	**veh-hrs**

USER BENEFITS CALCULATION

Translate travel time saving estimates into user benefits using the following equation:

User Benefits =

(Travel Time Savings Non-Trucks*Cost Parameter Non-Trucks*260) +
(Travel Time Savings HOV*Cost Parameter HOV*260) +
~~(Travel Time Savings HOV*Public Transit Percentage*$50.00*260) +~~
(Travel Time Savings Trucks*Cost Parameter Trucks*260)

where

Cost Parameter Non-Trucks=	$10.00	x AVO Non-Trucks
Cost Parameter HOV=	$10.00	x AVO HOV
Cost Parameter Trucks=	$50.00	x AVO Trucks

For example, the AVO is calculated as follows (if Year 1 is 2+ and Year 20 is 3+ HOV):

Year 1 AVO (2+ HOV) = [(% 2 person x 2) + (%3 person x 3) + (%4+ person x 4.1) + ((vanpool + other bus) x 8.0) + (public transit % x avg bus occupancy) + (% motorcycle x 1)] / HOV Volume

Year 20 AVO (3+ HOV) = Adjusted per conversion constraint
{see volume projection calculations on the first (Yr.1) analysis period spreadsheet}

Assumptions:

1.) Composition of the traffic stream in Year 1 is the same in Year 20. (& buses = 1 vehicle in traffic)
2.) In Year 20, the average bus occupancy is 60 people.
3.) All 2-person carpools will convert to 3+ vehicle as the minimum occupancy requirement is increased.

Average Bus Occupancy: BEGIN YR 7 [illegible]
END YR 20 [illegible]

Assumption: 1.) Average bus occupancy linearly increases to Year 20.

Year 1 3+ HOV % = 4.6%

YEAR 1 DATA	[illegible]	HOV proportion -based on 2+-	based on 3+
SOV	[illegible]		
2 person	[illegible]	0.77	
3 person	[illegible]	0.13	0.5652
4+ person	[illegible]	0.06	0.26
vanpool	[illegible]	0.01	0.04
public transit	[illegible]	0.02	0.09
other bus	[illegible]	0.00	0.02
motorcycle	[illegible]	0.00	0.02

Assumption:
1.) Traffic composition remains constant through YR1 to YR 20.

	BEGIN YR 7	END YR 20
HOV Designation	3+	3+
HOV %	25.7	28.6
AVO Non-Trucks	1.30	1.30
AVO HOV	[illegible]	[illegible]
AVO Trucks	1	1

Assumptions:
1.) All eligible HOVs use the HOV lane.
2.) All trucks are SOVs.
3.) IF HOV volume > 1500 at 3+ min., the constrained Pool AVO will be transfer
Yr. 20 User Benefits.

USER BENEFITS CALCULATION

	BEGIN YR 7	END YR 20
Travel Time Savings Non-trucks	150	477
Travel Time Savings HOV	36	131
~~Travel Time Savings Transit~~	~~1~~	~~3~~
Travel Time Savings Trucks	6	18
Cost Parameter Non-Trucks	$13.00	$13.00
Cost Parameter HOV	$62.40	$156.41
~~Cost Parameter Transit~~	~~$50.00~~	~~$50.00~~
Cost Parameter Trucks	$50.00	$50.00
User Benefits	**$1,160,324**	**$7,172,070**

{these totals do not assess transit operating costs beyond the portion already included in the WSDOT truck percentage reports}

PRESENT VALUE OF USER BENEFITS

	6.18	
Annual Growth Rate, r	0.13	
Analysis Period, n	14	
Discount Rate, i	0.04	
Present Value Function	28.09	[(exp((r-i)n)-1)/(r-i)]

To determine the present value of the user travel time savings benefits, multiply the Year 1 user benefits by the present value function.

PRESENT VALUE of USER BENEFITS

BEGIN YR 7 END YR 20 $32,588,299

To determine the present value of user benefits for the entire 20 years, add the two time periods together.

PRESENT VALUE of USER BENEFITS

YEAR 1

BEGIN YR 7 END YR 20 $32,588,299

PRESENT VALUE OF USER BENEFITS YR 1 - YR 20 $35,610,557

CLIMBING LANE DAILY BENEFIT WORKSHEET

Capacity Improvement (Added Climbing Lane)

			No - Build	Build	
SR:	2	Posted Speed:	60	60	
Project Title:	SR 2 E. of Tye River EB Truck Climbing Lane				
Subject Section:	MP	52.6	to MP	53.7	
Length of Subject Section:		1.1	Miles		
Number of Lanes:	No - Build	2	Build	4	
Direction of Facility:	NB/WB		SB/EB	X	

Traffic Data

	Year 1	Year 20	Year 20
ADT	4600		8464
Peak Hour Volume			
K factor			
Truck %	14%		14%
Grade	0		
Length of grade	1.1		
Growth Rate	4.20%		

Traffic Volume Distribution Curve

Curve Number	0
Peak Period AVO	1.1

Capacity

Roadway Type	Base		Section Type No Build	Section Type Build
Urban Multilane Highway or Freeway	2200	vphpl		
Rural/Small Urban Freeway	2000	vphpl		
2 Lane Highway	1300	vphpl		
Arterial	1600	vphpl		

Capacity without improvement	***0***
Capacity with improvement	***0***

CLIMBING LANE DAILY BENEFIT WORKSHEET

Capacity Improvement (Added Climbing Lane)

			No - Build	Build	
SR:	2	**Posted Speed:**	60	60	
Project Title:	SR 2 E. of Tye River EB Truck Climbing Lane				
Subject Section:	**MP**	52.6	**to MP**	53.7	

User Benefits

Hour	North or West	South or East	Total
1	$0	#VALUE!	#VALUE!
2	$0	#VALUE!	#VALUE!
3	$0	#VALUE!	#VALUE!
4	$0	#VALUE!	#VALUE!
5	$0	#VALUE!	#VALUE!
6	$0	#VALUE!	#VALUE!
7	$0	#VALUE!	#VALUE!
8	$0	#VALUE!	#VALUE!
9	$0	#VALUE!	#VALUE!
10	$0	#VALUE!	#VALUE!
11	$0	#VALUE!	#VALUE!
12	$0	#VALUE!	#VALUE!
13	$0	#VALUE!	#VALUE!
14	$0	#VALUE!	#VALUE!
15	$0	#VALUE!	#VALUE!
16	$0	#VALUE!	#VALUE!
17	$0	#VALUE!	#VALUE!
18	$0	#VALUE!	#VALUE!
19	$0	#VALUE!	#VALUE!
20	$0	#VALUE!	#VALUE!
21	$0	#VALUE!	#VALUE!
22	$0	#VALUE!	#VALUE!
23	$0	#VALUE!	#VALUE!
24	$0	#VALUE!	#VALUE!

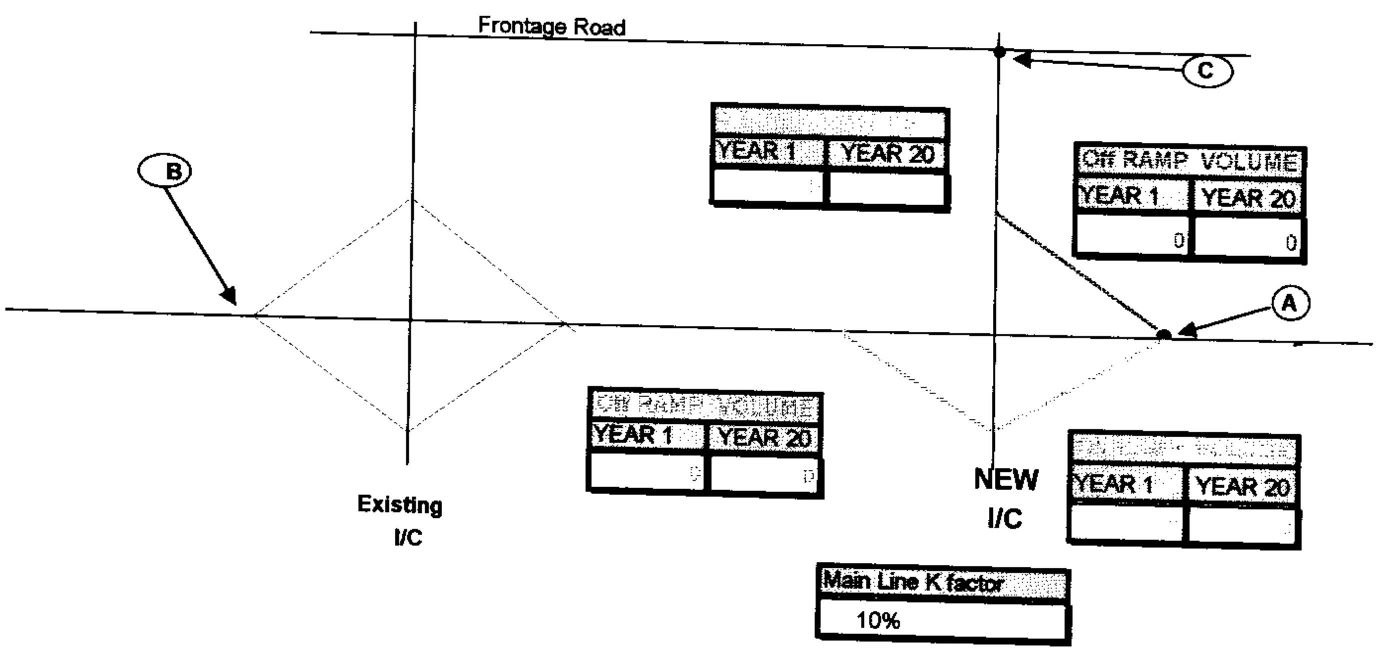
Total Present Value of User Benefits

#VALUE!

USER BENEFIT WORKSHEET for a
New Interchange at a NEW Access Point

SR: 0
Project Title:
Evaluated by: 0
Average Vehicle Occupancy : 1.35
% Trucks: 0
Posted Speed:

Input (ADT*K) or (DHV*peak adjust %) for the Working Peak Hour Volumes below.



USER BENEFIT WORKSHEET for a
New Interchange at a NEW Access Point

SR: 0

Project Title:

Evaluated by: 0

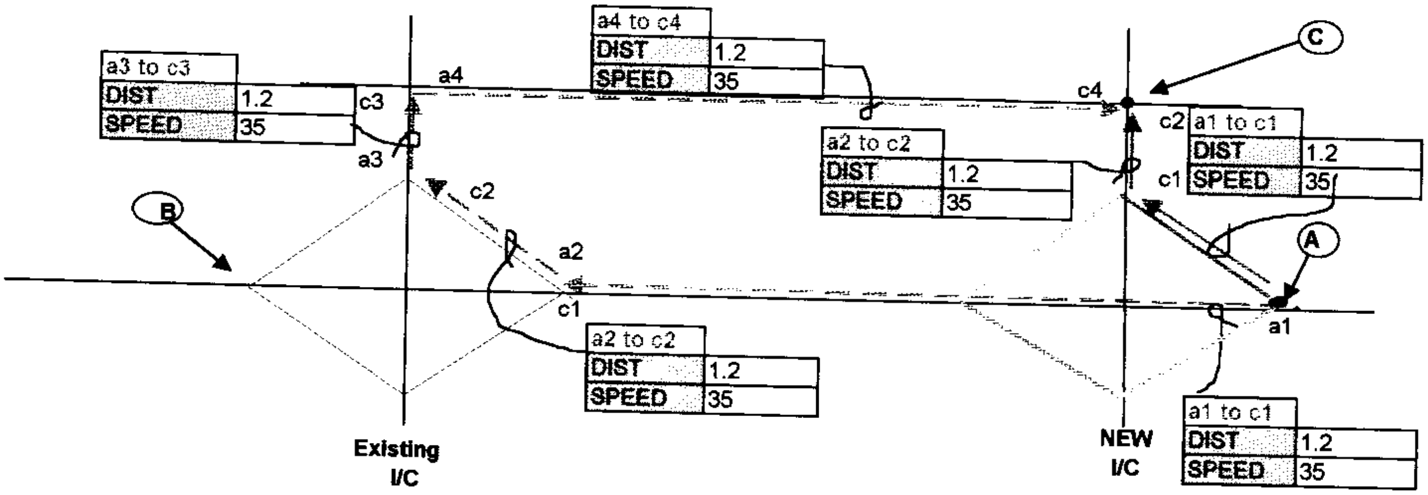
Average Vehicle Occupancy : 1.35

% Trucks: 0

Posted Speed:

ORIGIN A to DESTINATION C

Volume		K
YEAR 1	YEAR 20	FACTOR
0	0	10%



Travel Path	No Build Segment → Speed mph	Length mi.	Calc. Trav. Time(Hrs)	Model Travel Time(min)	Build Segment ← Speed mph	Length mi.	Calc. Trav. Time(Hrs)	Model Travel Time(min)
a1 to c1	35	1.2	0.034	3.82	35	1.2	0.034	1.1
a2 to c2	35	1.2	0.034		35	1.2	0.034	
a3 to c3	35	1.2	0.034				0.000	
a4 to c4	35	1.2	0.034				0.000	
a5 to c5			0.000				0.000	
a6 to c6			0.000				0.000	
a7 to c7			0.000				0.000	
a8 to c8			0.000				0.000	
a9 to c9			0.000				0.000	
a10 to c10			0.000				0.000	

USER BENEFIT WORKSHEET for a
New Interchange at a NEW Access Point

SR: 0

Project Title:

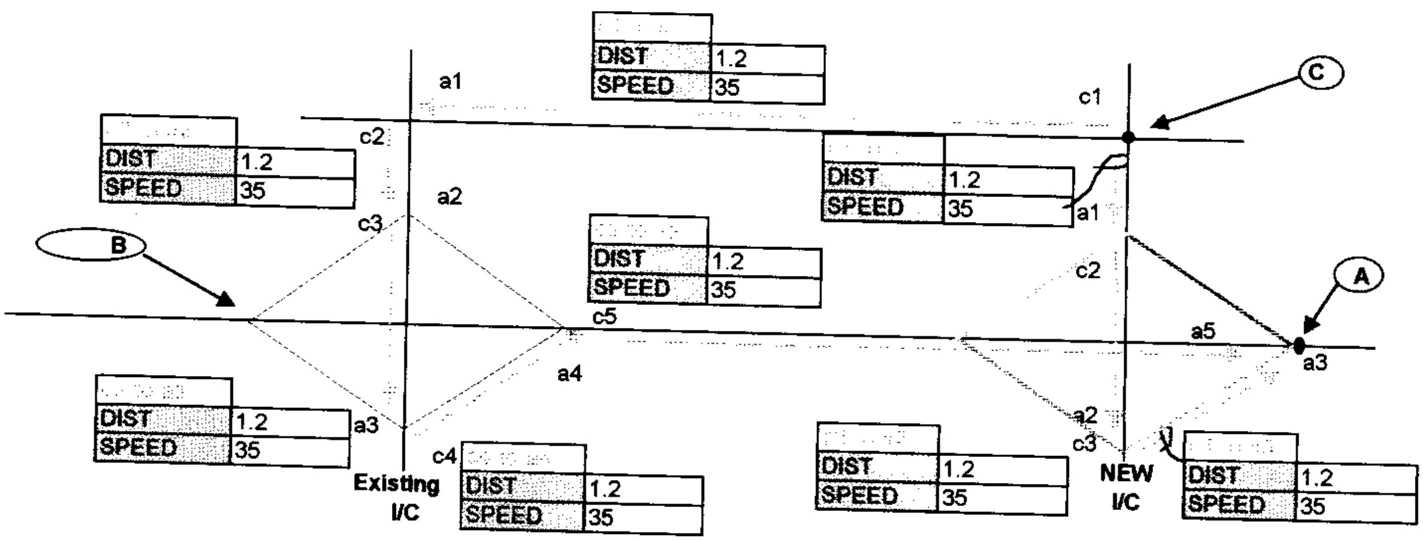
Posted Speed:

Evaluated by: 0

Average Vehicle Occupancy : 1.35

% Trucks: 0

Volume		K
YEAR 1	YEAR 20	FACTOR
		10%



Travel Path	No Build Segment				Build Segment			
	Speed mph	Length mi.	Calc.Trav. Time(Hrs)	Model Travel Time(min)	Speed mph	Length mi.	Calc.Trav. Time(Hrs)	Model Travel Time(min)
[illegible]	35	1.2	0.034	3.94	35	1.2	0.034	1.13
[illegible]	35	1.2	0.034		35	1.2	0.034	
[illegible]	35	1.2	0.034		35	1.2	0.034	
[illegible]	35	1.2	0.034				0.000	
[illegible]	35	1.2	0.034				0.000	
[illegible]			0.000				0.000	
[illegible]			0.000				0.000	
[illegible]			0.000				0.000	
[illegible]			0.000				0.000	
[illegible]			0.000				0.000	
							0.000	

USER BENEFIT WORKSHEET for a
New Interchange at a NEW Access Point

SR: 0

Project Title:

Evaluated by: 0

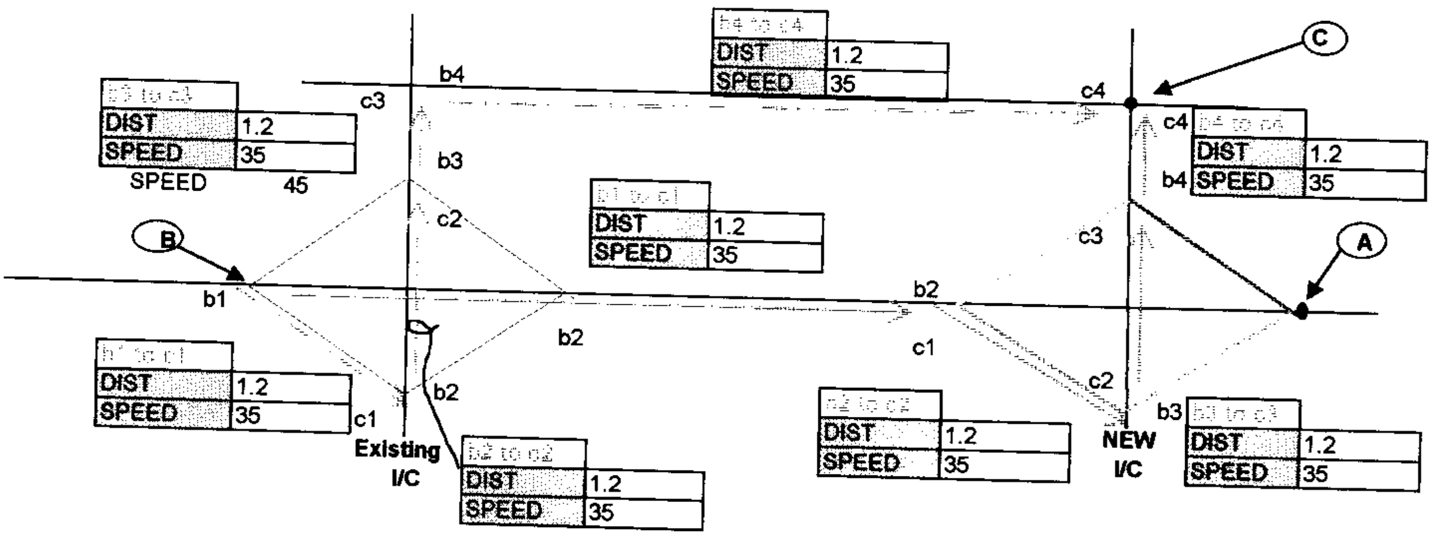
Average Vehicle Occupancy : 1.35

% Trucks: 0

Posted Speed:

ORIGIN B to DESTINATION C

Volume		K
YEAR 1	YEAR 20	FACTOR
0	0	10%



Travel Path	No Build Segment Speed mph	Length mi.	Calc.Trav. Time(Hrs)	Model Travel Time(min)	Build Segment Speed mph	Length mi.	Calc.Trav. Time(Hrs)	Model Travel Time(min)
b1 to c1	35	1.2	0.034	2.89	35	1.2	0.034	1.28
b2 to c2	35	1.2	0.034		35	1.2	0.034	
b3 to c3	35	1.2	0.034		35	1.2	0.034	
b4 to c4	35	1.2	0.034		35	1.2	0.034	
b5 to c5	35	1.2	0.034				0.000	
b6 to c6			0.000				0.000	
b7 to c7			0.000				0.000	
b8 to c8			0.000				0.000	
b9 to c9			0.000				0.000	
b10 to c10			0.000				0.000	

appendix forms.xls

USER BENEFIT WORKSHEET for a
New Interchange at a NEW Access Point

SR: 0

Project Title:

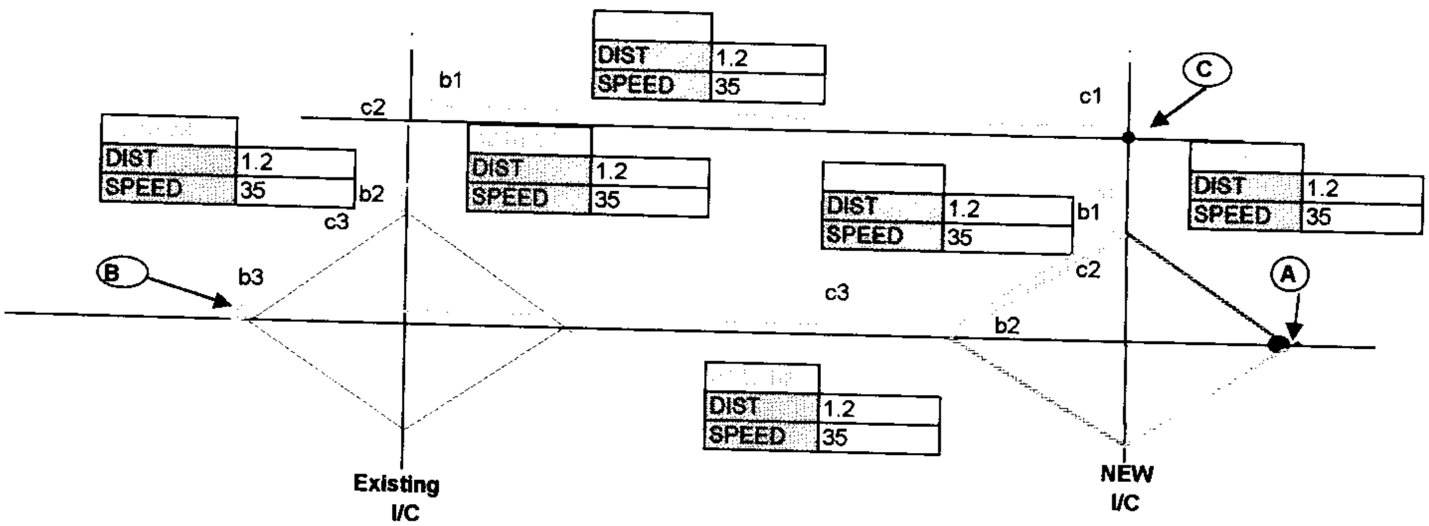
Evaluated by: 0

Average Vehicle Occupancy : 1.35

% Trucks: 0

Posted Speed:

Volume		K
YEAR 1	YEAR 20	FACTOR
		10%



Travel Path	No Build Segment				Build Segment			
	Speed mph	Length mi.	Calc.Trav. Time(Hrs)	Model Travel Time(min)	Speed mph	Length mi.	Calc.Trav. Time(Hrs)	Model Travel Time(min)
	35	1.2	0.034	2.57	35	1.2	0.034	1.03
	35	1.2	0.034		45	0.3	0.007	
	35	1.2	0.034		35	1.2	0.034	
			0.000				0.000	
			0.000				0.000	
			0.000				0.000	
			0.000				0.000	
			0.000				0.000	
			0.000				0.000	
			0.000				0.000	
							0.000	

PARK AND RIDE LOT WORKSHEET

SR
Project Title
Number of Stalls
Begin & End MP &
MP of nearest SR5 on-ramp to Seattle CBD

Evaluated by

Assumptions:

1.) 35% of Park & Ride users are newly formed carpoolers.
2.) All newly formed HOVs go to downtown Seattle.
3.) A continuous HOV lane exists from the Park & Ride's nearest SR5 on-ran
4.) All HOVs use the HOV lane.
5.) The average destination is the Columbia-James St. off-ramp (MP 165.86).
6.) The freeway operates at capacity.
(52 mph in the HOV lane, 30 mph in the GP lane)

TRAVEL TIME BEFORE THE SOVs FORMED CARPOOLS:
Travel Time = (Distance from lot to CBD)*(# of newly formed carpoolers)/(Operating speed)

Distance to Seattle CBD	27.80	miles
New carpoolers =	105	people
GP Operating Speed	30	mph

TTsov (veh-hrs) = 97.3

TRAVEL TIME AFTER THE SOVs FORMED CARPOOLS:
Travel Time = (Distance from lot to CBD)*(# of newly formed carpoolers)/(Operating speed)

Distance to Seattle CBD	27.80	miles
New carpoolers =	105	people
HOV Operating Speed	52	mph

TThov (veh-hrs) = 56.1

TRAVEL TIME SAVINGS:
TTS = TTsov - TThov

TTS (veh-hrs) = 41.2 one-way

TTS (veh-hrs) = 82.3 24 hour

USER BENEFITS CALCULATION

User Benefits YR 1 = (Travel Time Savings*Cost Parameter*260) + (Annual Parking
User Benefits YR 20 = User Benefits YR 1

where Cost Parameter = $10.00 per new carpooler

Annual Parking Cost
Source: Parking Inventory for Seattle and Bellevue, Oct. 1992, PSOG.

	Avg Parking Cost Seattle CBD ($)	Annual Cost Per Sov ($)
(Monthly Rate)	110.00	1320.00

Assumption:
1.) On average, the newly formed carpoolers have 3 people to a car in Year 1 and Year 20.

Annual Parking Savings
Annual Parking Savings = [(Annual Cost Per Sov) - (Annual Cost Per Person in Carpool)] x Number of Ne

	Annual Parking Cost Savings New Carpoolers (35% of lot)
(Monthly Rate)	$92,400

User Benefits

	New Carpoolers (35% of lot)
Travel Time Savings	82.3
Cost Parameter ($)	10.00
Annual Parking Cost Savings:	
Monthly Rate	$92,400
User Benefits (Monthly Rate)	**$306,460**

PRESENT VALUE OF USER BENEFITS

Year 20/Year 1 User Benefits	1.00	
Annual Growth Rate, r	0.00	[ln(Year 20/Year 1 Us
Analysis Period, n	20	
Discount Rate, i	0.04	
Present Value Function	13.77	[(exp((r-i)n)-1)/(r-i)]

To determine the present value of the park & ride user benefits, multiply the Year 1 user benefits by the present value function.

PRESENT VALUE OF USER BENEFITS

	New Carpoolers (35% of lot)
Present Value (Monthly Rate)	**$4,218,966**

USER BENEFIT WORKSHEET for a
New Interchange at a NEW Access Point

SR: 0
Project Title:
Evaluated by: 0
Average Vehicle Occupancy : 1.35
% Trucks: 0

Posted Speed:

From / To	Year 1 without improvement: Volumes	Travel Time	Hours		Year 1 with improvement: Volumes	Travel Time	Hours
A to C	0	0.064	0.00	A to C	0	0.018	0.00
[illegible]	0	0.066	0.00	[illegible]	0	0.019	0.00
B to C	0	0.048	0.00	B to C	0	0.021	0.00
	0	0.043	0.00		0	0.017	0.00
Total Hours			0.00				0.00

From / To	Year 20 without improvement: Volumes	Travel Time	Hours		Year 20 with improvement: Volumes	Travel Time	Hours
A to C	0	0.064	0.00	A to C	0	0.018	0.00
[illegible]	0	0.066	0.00	[illegible]	0	0.019	0.00
B to C	0	0.048	0.00	B to C	0	0.021	0.00
	0	0.043	0.00		0	0.017	0.00
Total Hours			0.00				0.00

Travel Time

Year 1		Year 20	
Travel Time w/o imprvmnt	0.00	Travel Time w/o imprvmnt	0.00
Travel Time w/ imprvmnt	0.00	Travel Time w/ imprvmnt	0.00

Travel Time Savings (TTS)

TT(Build)-TT(No-Build)=TTS(Year 1 or 20)

Year 1		Year 20	
Travel Time Savings	0.00 Hrs	Travel Time Savings	0.00 Hrs

Travel Time Savings Distribution

Year 1		Year 20	
TTS - GP	0.00	TTS - GP	0.00
TTS - Truck	0.00	TTS - Truck	0.00

User Benefits

Year 1	Year 20
$0	**$0**

Present Value Factor (PVF)

PVF = 0.00

Present Value of User Benefits

$0

appendix forms.xls

BENEFIT/COST WORKSHEET
Grade Intersection Removals

Project/Improvement Description: Snow Shed Benefit Cost Hig Lowest Cost

1. **Initial Project Cost, I** $0

2. **Annual Op. Costs, K** $0 (if there are annual operational benefits, enter as a negative value)

3. Annual Safety Benefits by Costs of Crashes:

Crash Type	Cost	x	No. (Crashes Removed	=	
a) Fatal & Disabling Injury	$700,000	x	0	=	$0
c) Evident Injury	$57,000	x	16.59	=	$945,630
d) Possible Injury	$30,000	x	0	=	$0
e) Property Damage Only	$5,300	x	0	=	$0
			f) Total, B		$945,630

4. Service Life, n	40
5a. Interest Rate, i	0.04
5b. ADT Growth, g	0.03

6. Salvage Value, T

Feature	Cost (from est.)	x	Factor	=	
a)Right of Way	$0	x	0.45	=	$0
b)Grading & Drainage	$0	x	0.40	=	$0
c)Structures	$0	x	0.43	=	$0
			Total, T	=	$0

9. Present Worth of Costs, PWOC:

a) Present Worth Factor, PWni	0.21
b) Present Worth, uniform series, SPWin	28.39
c) PWOC= I + K(SPWin) - T	$0

10. Present Worth of Benefits, PWOB=B(SPWin) $26,845,190

11. **Benefit Cost Ratio, B/C=PWOB/PWOC** #DIV/0!

12. **Net Benefit=PWOB-PWOC** $26,845,190

SAFETY BENEFITS WORKSHEET

ACCIDENT SAVINGS-SAFETY PROJECTS

System Plan List. #________ Section: #________ Improvement Identifier:# ________

Safety Impvmt. Loc.: SR ___0___ MP ___0___ to MP ___0___

Safety Improvement Descrip.: ____________________

Evaluator: ___________0___________ Date: ___1/0/00___

1 Initial Project Cost: (I) = $0

2 Net Annual Operations & Maintenance costs: (K) = $0

3 Annual safety Benefits in Number of Collisions:

Collision Type	(factor)	Total Acc.	Three (3) Year Study Period Ann. Acc.	Ann. Benefit
a) Fatality (2)	0.3	0	0	0
b) Disabling injury (5)	0.3	0	0	0
c) Evident Injury (6)	0.3	0	0	0
d) Possible Injury (7)	0.3	0	0	0
e) PDO (1)	0.4	0	0	0

4 Costs Per Collision(FHWA-RD-91-005)

Collision Type	Costs
a) Fatality	$700,000
b) Disabling injury	$700,000
c) Evident Injury	$57,000
d) Possible Injury	$30,000
e) PDO	$5,300

5 Annual Safety Benefits by Costs of Collisions

a) (3a)(4a) =	$0
b) (3b)(4b) =	$0
c) (3c)(4c) =	$0
d) (3d)(4d) =	$0
e) (3e)(4c) =	$0
f) Total, (B) =	$0

6 Service Life,(n) = 20

7 Salvage Value, (T) = 0

8 Interest Rate, (i) = 0.04

9 Present Worth of Cost, PWOC:

a) Present Worth Factor, PWni 0.46

b) Present Worth Factor, of a Uniform Service, SPWin 13.59

c) PWOC = I + K (SWPin) - T (PWni) $0

10 Present Worth of Benefits, PWOB = B (SPWin) $0

11 Benefit Cost Ratio, B/C = PWOB /PWOC #DIV/0!

12 Net Benefit = PWOB - PWOC $0

appendix forms.xls

Appendix B

Memos and Additional Documentation

Included in this Appendix is:

- Memo from WashDOT economist Eric Meade re: PV Analysis and Discount Rates
- Peak Hour Reduction Factors Memo
- Residual Value Memo
- Interchange Projects Memo

Washington State
Department of Transportation

Memorandum

Date: December 2, 1993

From: Eric R. Meale
Phone: 705-7942

Subject: Present Value Analysis
Discount Rates

To: Tracy Reed

A primary element in the Mobility Prioritization formula is the calculation of the net present value of project costs and benefits as outlined in the "Cost Efficiency Worksheet." The calculation of present values, in turn, requires the use of an appropriate discount rate. The discount rate for performing present value calculations on public projects should represent the opportunity cost of capital to the taxpayer. The rate at which money could be alternatively invested is generally termed the opportunity cost of capital; i.e. the estimated average market rate of interest.

The accepted practice of estimating future benefits and costs in constant dollars, however, means that using the market rate of interest to present value the future benefits and costs is inappropriate because the market rate of interest includes an allowance for expected inflation as well as a return that represents the real opportunity cost of capital. Constant dollars express costs and benefits in terms of price levels prevailing at a particular (constant) date in time, usually what the costs and benefits would be at the time the study is conducted, such as 1993. Current dollars, on the other hand, express costs and benefits in terms of price levels prevailing at the time the costs or benefits are incurred, such as in the year 2000. Valuing costs and benefits in current dollars requires the use of an average rate of inflation to account for price changes and there are good reasons to expect highly significant differences in the rate of price changes for some costs or benefits of a proposed project. The constant dollar approach to estimating future benefits and costs is preferable, in most cases, to using current dollars for economic analysis, since it avoids the need for speculation about future inflation in arriving at the projected benefits and costs of the proposed project. Since constant dollars do not include inflationary effects and the market rate of interest does include an allowance for inflation, if future benefits and costs are computed in constant dollars, they will be understated in terms of their present value if a market rate of interest is used. Therefore, when future benefits and costs are calculated in constant dollars, only the real cost of capital should be used as the discount rate. As shown in the attached table, the real cost of capital has been estimated at about 4 percent in recent years.

To summarize, if benefits and costs are expressed in constant dollars, a constant dollar discount rate should be used. The constant dollar discount rate is about 4 percent. If a current dollar discount rate is used, such as 8 or 9 percent (which includes the anticipated inflation rate), the benefits and costs of the proposed project must be inflated to current dollars also. The constant dollar approach is preferable with the use of a 4 percent discount rate to compute the present value of proposed project costs or benefits.

ERM:em
Attachment

Year	Prime Interest Rate	Inflation Rate	Estimated Real Cost of Capital
1970	7.9%	4.6%	3.1%
1971	5.7%	4.8%	0.9%
1972	5.2%	3.9%	1.3%
1973	8.0%	5.7%	2.2%
1974	10.8%	10.1%	0.7%
1975	7.9%	8.2%	-0.3%
1976	6.8%	5.9%	0.9%
1977	6.8%	7.0%	-0.2%
1978	9.1%	7.3%	1.7%
1979	12.7%	8.9%	3.5%
1980	15.3%	10.4%	4.4%
1981	18.9%	8.9%	9.2%
1982	14.9%	5.7%	8.7%
1983	10.8%	4.8%	5.7%
1984	12.0%	4.0%	7.7%
1985	9.9%	3.9%	5.8%
1986	8.3%	3.1%	5.0%
1987	8.2%	4.2%	3.9%
1988	9.3%	4.2%	4.9%
1989	10.9%	4.8%	5.7%
1990	10.0%	5.2%	4.6%
1991	8.5%	4.3%	4.0%
1992	6.3%	3.3%	2.8%
AVERAGE	9.7%	5.8%	3.7%

Source:
DRI/McGraw-Hill, Lexington, MA.

Note:
1/ The rate of inflation is based upon the implicit price deflator for consumer spending.

PEAK HOUR REDUCTION FACTORS

The following factors are useable to lower the design hour volume taken from design reports. K 30 (DHV) to average weekday peak hour percent of ADT (working peak hour volume) which is to be used for the mobility project calculations.

	K 30 REDUCTION FACTOR	AVERAGE WEEKDAY PEAK HOUR PERCENT OF ADT
LARGE URBAN AREAS	0.90	8.34
OTHER URBAN COMMUTER	0.88	9.89
COMBINATION - COMMUTER & SOCIAL-RECREATIONAL	0.83	9.12
RURAL	0.75	8.98
SOCIAL-RECREATIONAL	0.60	9.04
MOUNTAIN PASSES	0.45	9.35

NOTE: The design hour volumes for high use social-recreational routes are typically the 100th highest hour of the year instead of the 30th hour. Therefore a working peak hour volume of not less than 9 percent of the ADT should be used for social-recreational routes.

NOTE-2: Specific Projects may be in close proximity to permanent traffic recorders maintained by the Transportation Data Office. These locations may have specific factors that can be provided on request.

Date: August 31, 1994

From: Randy Hain/Pat Morin

To: Hank Peters, John Baker, Paula Hammond, Doug Ficco, Bob MacNeil, Don Walther

Subject : Final Mobility Calculations for **** 95-97 Prioritization****

Residual Value

All of the benefit/cost ratios will be adjusted to account for the effect of a project's residual value at the end of the twenty year analysis period. This adjustment will take into account the value of the improvement remaining after 20 years.

The methodology for adjusting the benefit/cost ratio to account for an improvement's residual value is based on work done for AASHTO by the Texas Transportation Institute. Cambridge Systematics has reviewed this methodology and agrees with the concept and approach. The methodology adjusts a project's benefit/cost ratio by modifying the project estimate to approximate the residual value. This is done by applying the following factors to the project estimate.

1.	Right of way	0.55
2.	Grading and Drainage	0.60
3.	Structures	0.57
4.	All other costs (including PE)	1.00

In those cases where a region does not have the estimate broken out by the four groupings, they may approximate how much of the project cost is in right of way, grading, drainage and structures and use a factor of 0.59. All other costs will use a factor of 1.00.

Issued: 1/10/94

INTERCHANGE PROJECTS

When analyzing interchange proposals there are several different base scenarios - they may be independent or in combination, and may primarily improve traffic flow outside of the project limits in some cases. Therefore, there is not ONE standard method that can be used in every case. Many will require professional judgement on a case-by-case basis.
The basic principle to keep in mind is that we need to analyze who is stopping and where (i.e. which movements), and then to estimate the delay (sec/veh or total hours) before and after the proposed improvement. Focus on the improvements to the mainline traffic, and turning movements ONLY, unless the scenario/improvement is supported by a modeling effort.

The Traffic Data Office -Special Studies team recommend the following guidelines based on varying Current conditions (ie, BEFORE improvement):

1) Existing at grade intersection:
- calculate the intersection delay in the same manner as outlined in the User Benefit worksheet for appropriate type of intersection.
- calculate the mainline flow rate with the interchange using the HCM mainline freeway capacity calculation.
  [**assume 0.05 reduction in V/C ratio if the calculations do not reflect any improvements]

2) Existing at grade intersection with restrictions
(i.e. blocked movements -generally median barrier, etc.)[1]

- calculate distance saved for blocked movements routing (check v/c on mainline, an interchange may increase the capacity of the remaining movements).[2]
- calculate the intersection delay.

---

[1] on capacity of movements– There are blockages and delays of some movements caused by the configuration of local connections at at-grade intersections. The interchange will remove the blockage but it may not show up on a delay calculation because it is configuration delay rather than intersection delay. ie. people cannot turn left across the median if there are cars in median waiting to make the reverse movement and blocking the median space. Obvious types are median barricades that cause rerouting to make the left on.

[2] The theoretical capacity is calculated in some cases as a signalized or unsignalized intersection. Some of the barricaded movements are more reality based since the actual left turn delay due to time, space, gapping is many times more than the calculation would show. Engineering judgement must be relied upon.

Issued: 1/10/94

INTERCHANGE PROJECTS

When analyzing interchange proposals there are several different base scenarios - they may be independent or in combination, and may primarily improve traffic flow outside of the project limits in some cases. Therefore, there is not ONE standard method that can be used in <u>every</u> case. Many will require professional judgement on a case-by-case basis.
The basic principle to keep in mind is that we need to analyze who is stopping and where (i.e. which movements), and then to estimate the delay (sec/veh or total hours) before and after the proposed improvement. Focus on the improvements to the mainline traffic, and turning movements ONLY, unless the scenario/improvement is supported by a modeling effort.

The Traffic Data Office -Special Studies team recommend the following guidelines based on varying Current conditions (ie, BEFORE improvement):

1) <u>Existing at grade intersection:</u>

- calculate the intersection delay in the same manner as outlined in the User Benefit worksheet for appropriate type of intersection.

- calculate the mainline flow rate with the interchange using the HCM mainline freeway capacity calculation.
[**assume 0.05 reduction in V/C ratio if the calculations do not reflect any improvements]

2) <u>Existing at grade intersection with restrictions</u>
(i.e. blocked movements -generally median barrier, etc.)[1]

- calculate distance saved for blocked movements routing (check v/c on mainline, an interchange may increase the capacity of the remaining movements).[2]

- calculate the intersection delay.

---

[1] on capacity of movements— There are blockages and delays of some movements caused by the configuration of local connections at at-grade intersections. The interchange will remove the blockage but it may not show up on a delay calculation because it is configuration delay rather than intersection delay. ie. people cannot turn left across the median if there are cars in median waiting to make the reverse movement and blocking the median space. Obvious types are median barricades that cause rerouting to make the left on.

[2] The theoretical capacity is calculated in some cases as a signalized or unsignalized intersection. Some of the barricaded movements are more reality based since the actual left turn delay due to time, space, gapping is many times more than the calculation would show. Engineering judgement must be relied upon.

- calculate the mainline flow rate with the interchange using the HCM mainline freeway capacity calculation. [**assume 0.05 reduction in V/C ratio if the calculations do not reflect any improvements]

3) New interchange - no previous connection[3]

- Because most known projects are also related to new developments, this type of project generally requires some type of backup data for analysis. It is necessary to document any rerouting calculations and to identify any new development traffic, therefore it may be necessary to evaluate some projects using a model of the development scenario with and without a particular capital improvement.

- Some projects may be intended to reduce congestion at nearby interchanges by providing a connection that did not previously exist. In this case, a modeling effort will be required to estimate delay reduction at the affected locations.

- Trip lengths may be reduced in some cases, and b/c there are models to support those effects, there may be a need to analyze VMT data to accurately estimate delay.[4]

GENERAL COMMENTS:

- We need to keep the generated traffic data particularly well noted for these projects. Please submit detailed discussion of the source of said data for all Interchange projects.

---

3 Most of the significant new interchanges have studies that have been done over the last several years, by us or by developers. Most are model based data. This is an area where a trained analyst is needed.

4 Reduced VMT is something we have dealt with before, but --we are only using the Travel Time Savings in this years work. In the past, these are the projects that have had distance savings calculated. However, we can approximate the VMT savings by recalculating any VMT reduction as a reduction in travel time (which it basically is).

Appendix C

Non-Monetary Mobility Prioritization Worksheets

Included in this appendix:

- Community Support Worksheet
- Wetland Worksheet
- Water Quality and Permitting Worksheet
- Noise Worksheet
- Modal Integration Worksheet
- Land Use Worksheet
- Land Use Checklist

SUMMARY OF SCORES FOR NON-MONETARY CRITERIA

Project Description:

Region #: ________

SR #: ________

Project Description: ________________________________

Milepost #'s: ________

Enter a one line identification for this project: [ ]

This i.d. will appear on all of the separate worksheets.

Summary of Non-Monetary Scores:

Community Support	Wetlands Assessment	Water Quality	Noise Assessment	Modal Integration	Land Use
0	0	0	0	0	0

* These values are automatically taken from each of the completed criteria worksheets.

** They can be copied and pasted directly into the TOPSIS input worksheet.

(paste "Values" under the "Paste Special" command)

Throughout this workbook, cells requiring user input are highlighted in yellow

All calculations are performed automatically, and all cells that aren't yellow are 'write-protected'

COMMUNITY SUPPORT WORKSHEET

The purpose of this worksheet is to assess the community support and potential impact from the proposed
project. For each question, check the appropriate answer and log the score in the blank to the right.

Question		Score
1. Is local, regional or TIB financial participation anticipated?	No = 3	
If yes, identify and indicate the scale by percentage of total project costs:	If Yes, < 10% = 2 10-25% = 1 > 25% = 0	
2 a. Have any local governments endorsed this project? **Identify:**	Yes = 0 No = 3	
b. Have any local organizations endorsed this project? **Identify:**	Yes = 0 No = 1	
3 a. Have any local governments indicated opposition? **Indicate scale:**	No = 0 If Yes, minimal = 1 moderate = 2 significant = 3	
b. Have any private groups or individuals indicated opposition? **Indicate scale:**	No = 0 If Yes, minimal = 1 moderate = 2 significant = 3	

4. Will the project divide identifiable neighborhoods, schools, or business areas?	Yes = 1 No = 0	
5. Will this project displace homes, cultivated farmlands, or businesses? If yes, indicate scale of displacement:	No = 0 If Yes, < 6 acres = 1 6 - 10 acres = 2 > 20 = 3	
Has an evaluation of the potential opposition of the displacement been conducted? (check one)	Yes [ ] No [ ]	

TOTAL SCORE: 0

WETLAND WORKSHEET

The purpose of this worksheet is to assess the potential wetlands impact from the proposed project.
For each question check the appropriate answer or enter the appropriate acreage in the blank to the right.

Question | **Score**

1. Are there any wetlands within 300 feet of the edge of the present roadway?

Yes [ ]
No [ ]

If yes, identify the Class and required buffer for each wetland. No = 0
Enter the total acreage that may be affected as a result of the proposed project below:

Category 1	No. of acres:	(x 6)	0
Category 2 or Category 3			
Forested	No. of acres:	(x 3)	0
Scrub - Shrub	No. of acres:	(x 2)	0
Emergent	No. of acres:	(x 1.5)	0
Category 4	No. of acres:	(x 1.25)	0
All Buffers	No. of acres:	(x 1)	0

TOTAL SCORE: 0

WATER QUALITY AND PERMITTING WORKSHEET

The purpose of this worksheet is to assess the potential watershed impact and permitting requirements associated with the proposed project. For each question, enter the appropriate score in the blank to the right.

If a required permits have already been obtained for the expected duration of need, enter 0 points.

Question			Score
1. Will the project be located within 2000 feet of any body of water? If yes, then address the following:	No = 0		
What will the total impervious surface area be upon completion of the proposed project (within 2000 feet of any water body)?	If yes, < 6 acres = 1 6 - 20 acres =2 > 20 acres =3		
Will the project require hydraulic permits (HPAs)?	Yes = 4	No = 0	
Is there a known fish passage problem?	Yes = 1	No = 0	
Will the project require COE Section 10, 404 or Coast Guard Section 9 Permit?	Yes = 5	No = 0	
Will the project require Shoreline Development Permits?	Yes = 4	No = 0	
Is the project located within a Shoreline of Statewide Significance?	Yes = 1	No = 0	
Will any water quality permits be required (i.e. NPEDS, Short-Term Modification of Water Quality Standards)?	Yes = 4	No = 0	

Is the project a new roadway?	Yes = 1	No = 0	
2. Have any adjacent areas been identified as sensitive / critical by one or more governing jurisdictions: Identify:	Yes = 5	No = 0	
3. Is the project located within a regulatory floodway?	Yes = 4	No = 0	
4. Will the project increase impervious surface area within an EPA designate sole surface aquifer area? Identify:	Yes = 2	No = 0	
5. Will this project require the purchase of additional right-of-way? If yes, is the project located within:			
-- Forest Lands, as defined by the Dept. of Natural Resources?	Yes = 4	No = 0	
-- U.S. Forest Service 'National Forest' jurisdiction?	Yes = 1	No = 0	
-- Other jurisdiction / resource lands of regional significance? Identify:	Yes = 2	No = 0	
SUBTOTAL:			0
If permitting agencies have been contacted, are there any foreseeable conflicts or disagreements?	Yes = 1	No = 2 (subtotal divided by this number)	1
TOTAL SCORE:			0

NOISE WORKSHEET

The purpose of this worksheet is to assess the potential noise impact and associated costs due to
the proposed project. For each question, check the appropriate answer or enter the appropriate number of
residences, and the correct score will be
calculated.

Question	Score

1. Have existing noise impacts been identified
   along the proposed project? Yes [ ] No [ ]

   If yes, include the cost of feasible and reasonable mitigation measures in the project cost estimate, or cite determination otherwise

2. Is this project a new or existing alignment? New [ ] Existing [ ]

   If new, evaluate the number of receptors within **400 feet** of the edge of the proposed roadway. Go to question #4a.

   If existing, go to question #3.

3. Does the proposed project include widening of an
   existing roadway? Yes [ ] No [ ]

   If yes, evaluate the number of receptors within **200 feet** of the edge of the proposed roadway. Go to question #4b.

   If no, enter scores of 0 in question #4.

4a. **Noise assessment for a new alignment:**

SUBTOTAL = (No. lanes/2) x (No. receptors) x (Risk factor)

Enter the total number of lanes added / constructed:

Enter the total number of receptor within each category		Risk Factor	SUBTOTAL
< 100 feet		4	0
101 - 200 feet		2	0
200 - 400 feet		1	0

4b. **Noise assessment for widening of an existing alignment:**

SUBTOTAL = (No. lanes/2) x (No. receptors) x (Risk factor)

Enter the total number of lanes added / constructed:

Enter the total number of receptor within each category		Risk Factor	SUBTOTAL
< 100 feet		2	0
101 - 200 feet		1	0

TOTAL SCORE: 0

MODE INTEGRATION WORKSHEET

The purpose of this worksheet is to assess the level of modal integration supported by the proposed
project. For each question, enter the appropriate score in the blank to the right.

Question		Score
1. Does the proposed project increase mobility using existing capacity? (i.e. access control, TDM/TSM, GP to HOV conversion, frontage road improvement)	Yes = 0 No = 1	
2. Does the project improve or facilitate linkage for movement of goods through port or terminal facilities? (i.e. multimodal land-based, rail/trucking, waterborne, airborne)	Yes = 0 No = 1	
3. Is the project, or does the project include, a designated HOV transfer area? (i.e. park & ride lots, sheltered turnouts, flyer stop)	Yes = 0 No = 1	
4. Does the proposed project improve integration between existing HOV facilities and connecting arterials? (i.e. improved on or off ramp transitions, improvements to HOV termini)	Yes = 0 No = 2	
5. Does the proposed project link or extend existing	Yes = 0	

HOV lanes?

No = 2

6. Is the project, or does it include, facilities designed to encourage bicycle use, or use of bicycles with other modes?

Yes = 0

No = 1

(i.e. bicycle carriers on buses, loop detectors or lane designations at intersections, storage facilities at park & rides)

7. Does the project link or extend existing or planned bikeways?

Yes = 0

No = 1

8. Does the proposed project link or extend existing or planned pedestrian facilities, and/or include additional pedestrian amenities?

Yes = 0

No = 1

TOTAL SCORE: 0

LAND USE WORKSHEET

The purpose of this worksheet is to assess the current land use and local planning / transportation
policies, plans, and implementation measures of the governing jurisdictions concerned with the proposed
project area. For each question, enter the appropriate responses and enter the scores in the blank to the right.

Question		**Score**
1. Is the project included in the Comprehensive and / or Transportation Plan of any of the following? (if so, identify by name)		
Regional transportation planning organization: ______		
Other regional planning agency: ______		
County and / or City government: ______		
Other local interests / agencies: ______		
2. Do all the local governments having an interest in the project include it in their plans, as identified above?	Yes = 5 No = 0	☐
If **no,** has any action been taken by each of the appropriate planning agencies to approve the project?	Yes = 5 No = 0	☐
Indicate the action by what agency(cies):		
3. Has the *"Land Use Policy and Implementation"* file for local governments been updated in each jurisdiction that this project	Yes = 5 No = 0	☐

passes through?

4. Is the project on a roadway that directly links two or more designated growth centers?	Yes = 3 No = 0	
5. Is the project on an established or planned transit line / route?	Yes = 1 No = 0	
TOTAL SCORE:		0

LAND USE CHECKLIST

Indicate the specific zoning code/ordinances, comprehensive plan, transportation plan, road/design standards, or other adopted policy documents that implement each policy described below:

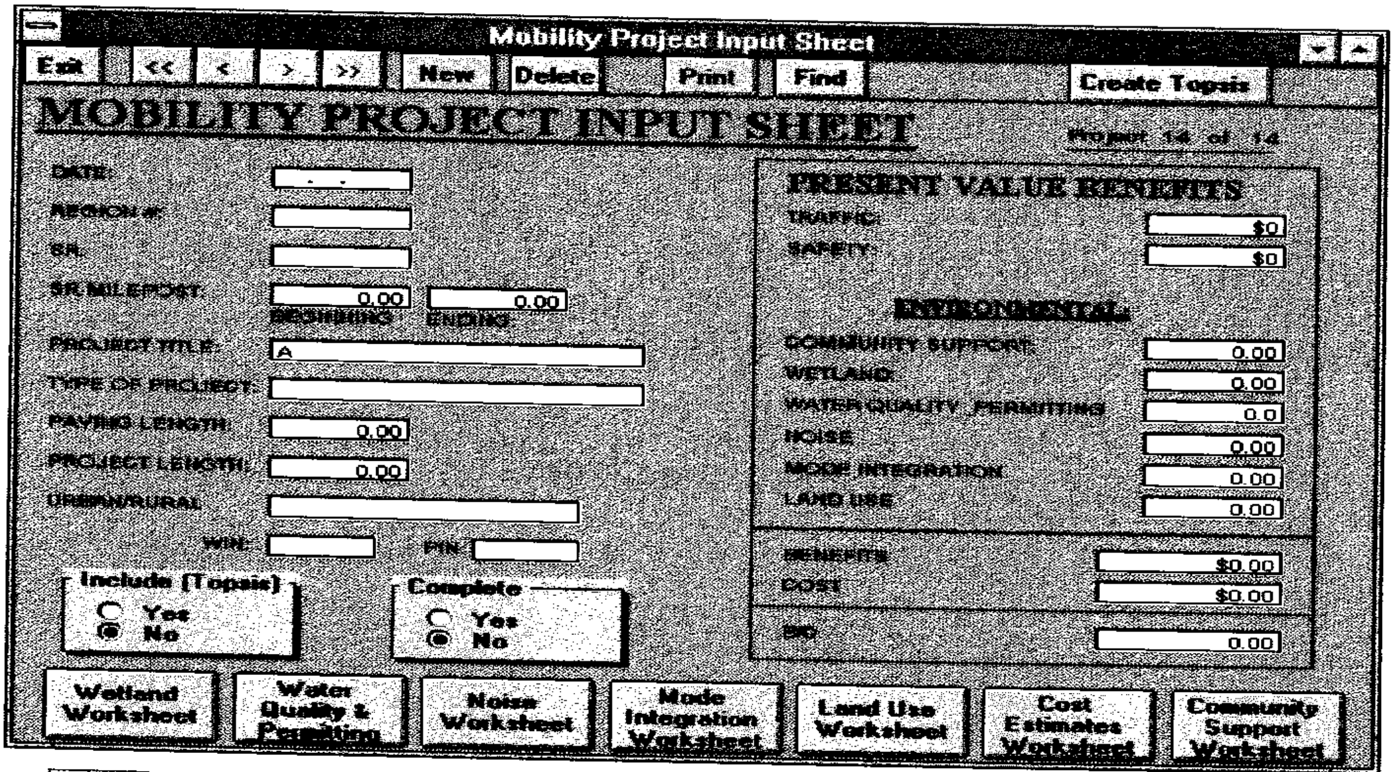
Policy	Citations:
a. Requires sidewalks as part of site planning.	
b. Requires/Encourages integrated bikeways or bicycle systems/facilities.	
c. Requires transit coordination for major residential, commercial, or retail development projects. (e.g., Bus turnouts, Sheltered passenger waiting facilities, etc.).	
d. Allows trade-offs between parking requirements and TDM measures.	
e. Requires/Encourages Clustering of major buildings	
f. Requires/Encourages physical orientation of major buildings to facilitate transit use.	
g. Requires Large-scale developments to integrate preferential lane treatment in their site design.	
h. Promotes measures to minimize impacts from development of adjacent land on roadway capacity (e.g., requiring combined driveways where possible, rear access, one-way drives, etc.).	

i. Other exceptional policies as appropriate:

Appendix D

Contained in this Appendix:

- Mobility Project Input Program



Exit Exits program. (All inputs are automatically saved in database.)

<< Returns to 1st Project. **<** Backs up to preceding project.

> Advances to next project. **>>** Advances to last project.

New To add a new project. A project title is required and must be unique.

Delete To remove a project from the database.

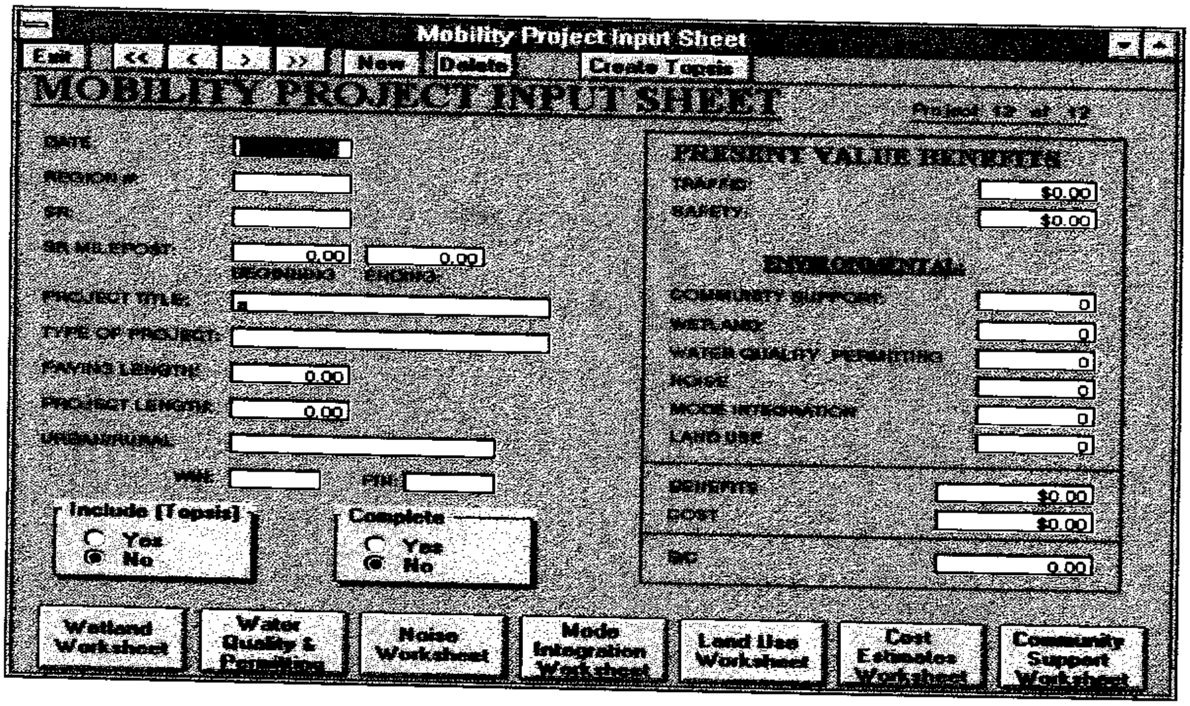
Create Topsis Automatically creates a Topsis Input sheet in Excel.

Include (Topsis)
Yes
No
For projects to be included in the Topsis Input sheet select Yes.
If you do not want a project to be included in the Topsis input sheet select No.

Complete
Yes
No
To indicate all forms and inputs are complete.
To indicate more information to be input.

The following Buttons Bring up the appropriate worksheets.

Wetland Worksheet | Water Community Quality & Permitting | Noise Worksheet | Integration Worksheet | Mode Worksheet | Land Estimates Worksheet | Use Support Worksheet | Cost



MANUAL INPUTS

1. DATE:
2. REGION #:
3. SR:
4. SR MILEPOST: BEGINNING ENDING
5. TYPE OF PROJECT:
6. PAVING LENGTH:
7. PROJECT LENGTH:
8. URBAN/RURAL

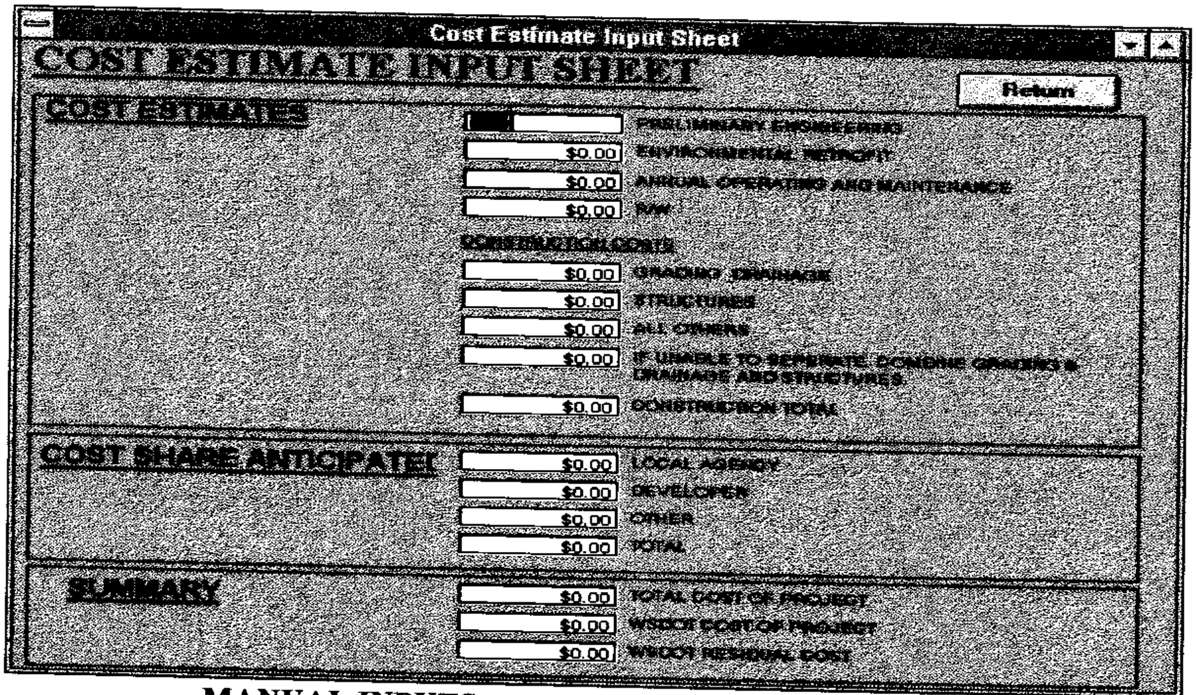
9. PRESENT VALUE BENEFITS
   - TRAFFIC
   - SAFETY
10. WORKSHEETS
    - COST ESTIMATE WORKSHEET
    - COMMUNITY SUPPORT WORKSHEET
    - WETLAND WORKSHEET
    - WATER QUALITY & PERMITTING
    - NOISE WORKSHEET
    - MODE INTEGRATION WORKSHEET
    - LAND USE WORKSHEET

AUTOMATIC INPUTS These values will fill in when worksheets are completed.

1. ENVIRONMENTAL
   - COMMUNITY SUPPORT
   - WETLAND
   - WATER QUALITY & PERMITTING
   - NOISE
   - MODE INTEGRATION
   - LAND USE
2. BENEFITS (Present Value Benefits)
3. COST (Present Value Cost)
4. B/C

NOTE: When inputting data use the TAB key for easier operation.

The automatic inputs require the worksheets be completed.



MANUAL INPUTS

COST ESTIMATES

1. PRELIMINARY ENGINEERING
2. ENVIRONMENTAL RETROFIT
3. ANNUAL OPERATING AND MAINTENANCE
4. R/W

CONSTRUCTION COSTS

5. GRADING AND DRAINAGE
6. STRUCTURES
7. ALL OTHERS
8. IF UNABLE TO SEPARATE. COMBINE GRADING AND DRAINAGE AND STRUCTURES

COST SHARE ANTICIPATED

9. LOCAL AGENCY
10. DEVELOPER
11. OTHER

AUTOMATIC INPUTS

These will be computed automatically.

CONSTRUCTION TOTAL
COST SHARE ANTICIPATED TOTAL
TOTAL COST OF PROJECT
WSDOT COST OF PROJECT
WSDOT RESIDUAL COST

+ Preliminary Engineering
+ Environmental Retrofit
+ R/W
+ Construction Total

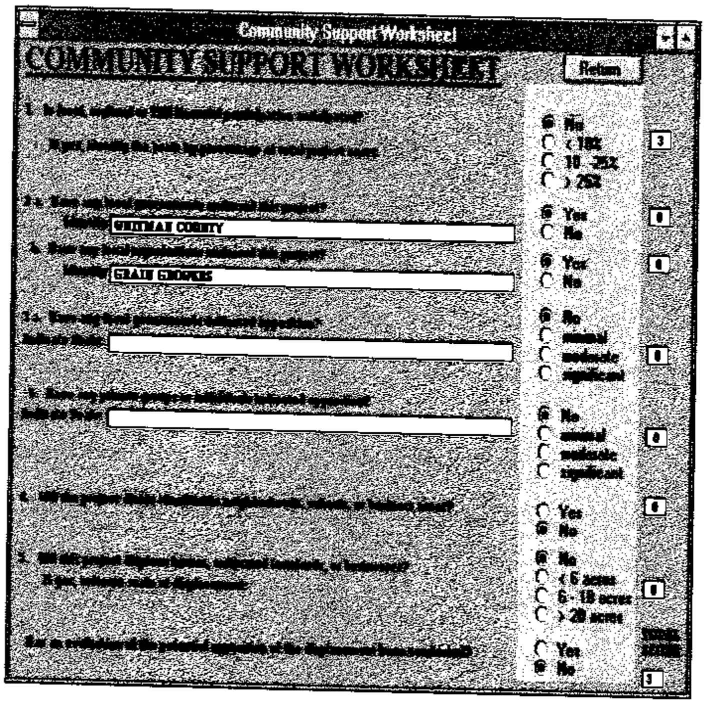
TOTAL COST OF PROJECT

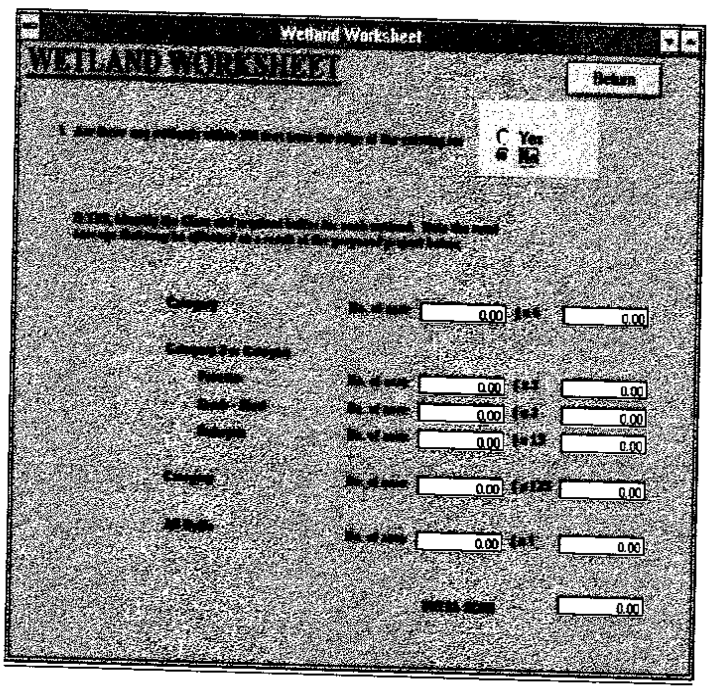
+ Total Cost of Project
- Cost Share Anticipated Total

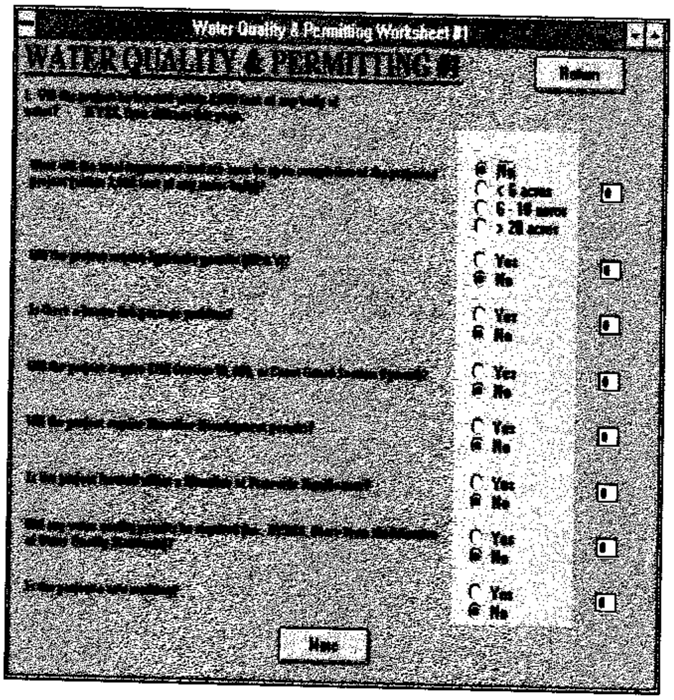
WSDOT COST OF PROJECT

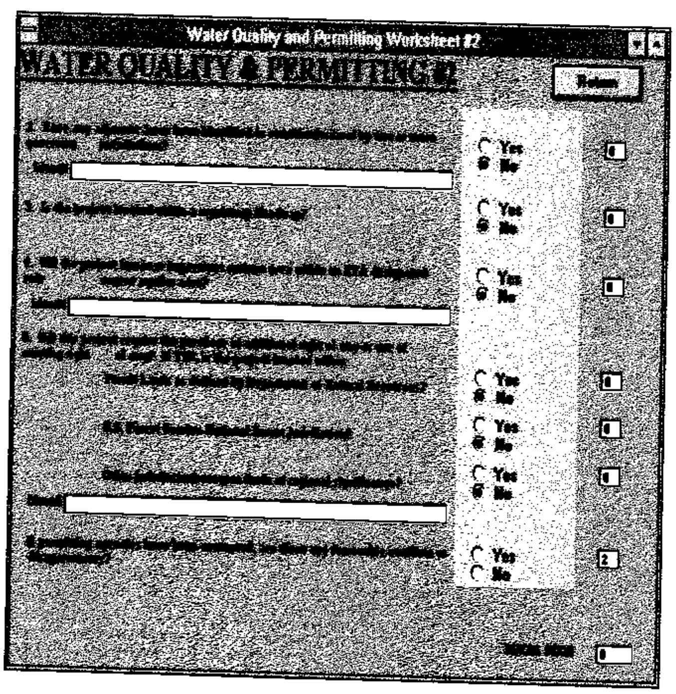
+ Preliminary Engineering
+ Environmental Retrofit
+ R/W(0.55)
+ Structures(0.57)
+ Grading & Drainage(0.60)
+ All Others
+ If unable to separate. Combine Grading & Drainage and Structures(0.59)
- Cost Share Anticipated Total

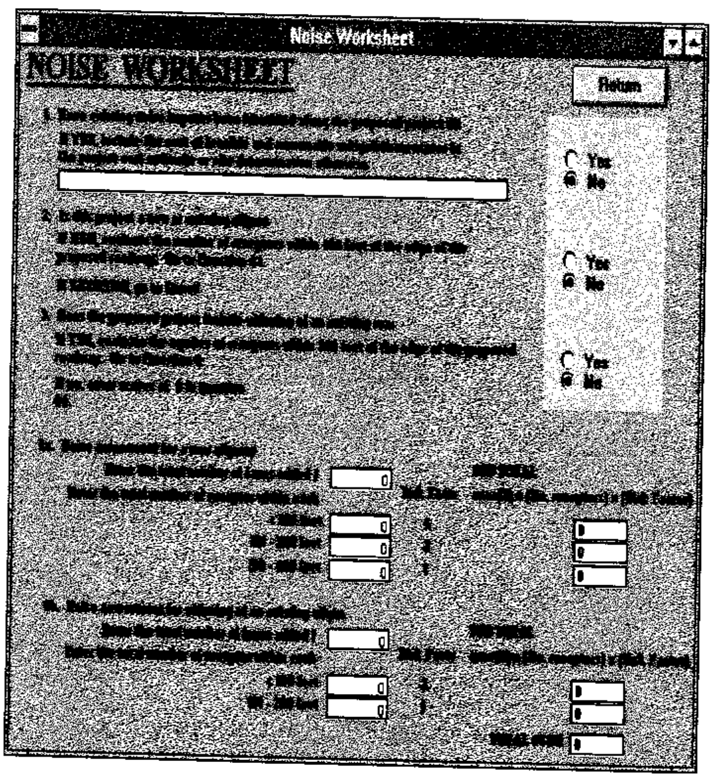
WSDOT RESIDUAL COST

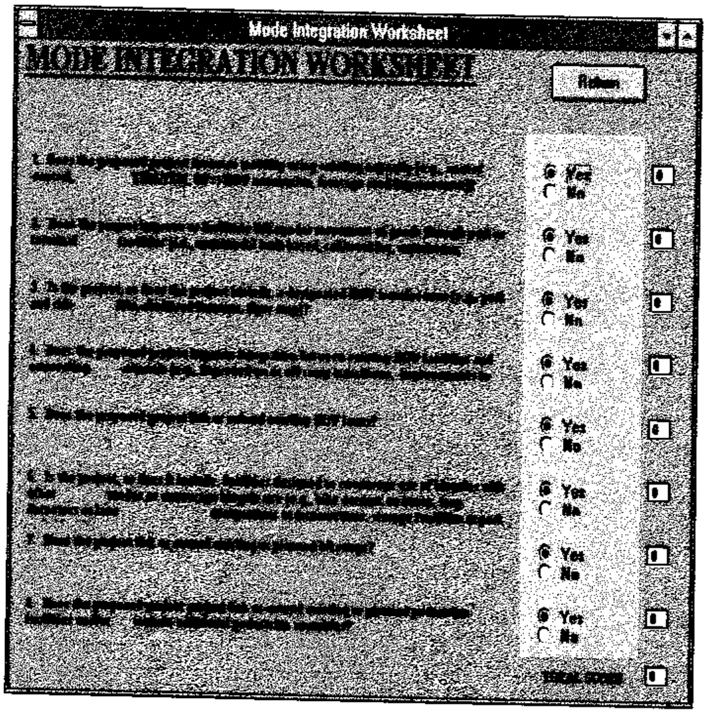

Community Support Worksheet
COMMUNITY SUPPORT WORKSHEET
Return
WHITMAN COUNTY
GRAIN GROWERS


Wetland Worksheet
WETLAND WORKSHEET
Return
Yes
No

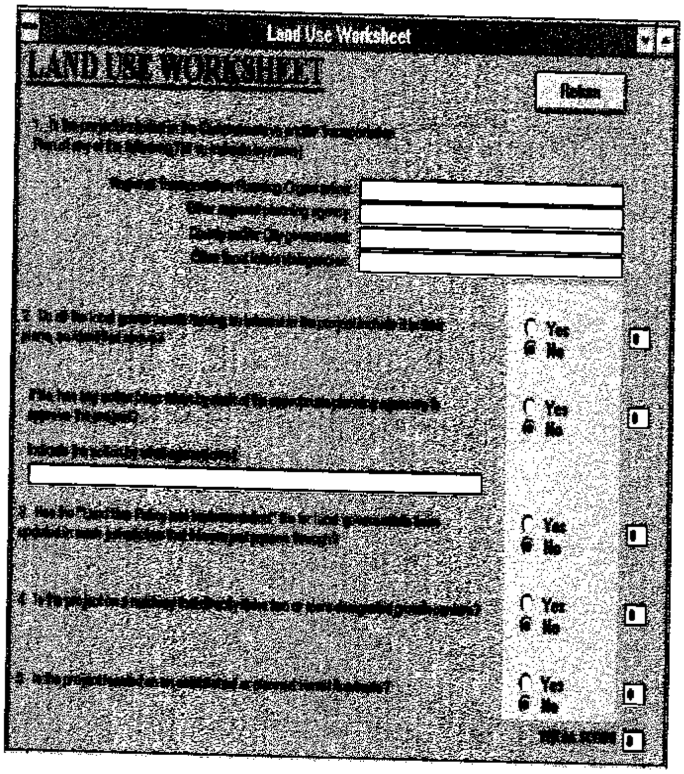

Water Quality & Permitting Worksheet #1
WATER QUALITY & PERMITTING #1
Yes
No


Water Quality and Permitting Worksheet #2
WATER QUALITY & PERMITTING #2
Yes
No


Noise Worksheet
NOISE WORKSHEET
Return
Yes
No
Yes
No
Yes
No



Note: Noise Worksheet - Question 4a & 4b should read. Enter total Number of lanes added / 2.


Land Use Worksheet
LAND USE WORKSHEET
Return
Yes
No
Yes
No
Yes
No
Yes
No
Yes
No