Appendix C

Concept Evaluation

Concept Evaluation

Over the course of the Cornelius Pass Road Safety Alternatives Study, 27 different projects were proposed to improve safety along the roadway. The initial set of projects was evaluated to identify the proposed improvements with a high likelihood of being cost effective and feasible ways of reducing collisions on Cornelius Pass Road. The evaluation criteria and the benefit-cost methodology used to assess the projects are presented in the following sections.

Evaluation Criteria

During Design Workshop #2, the participants collaboratively agreed on the following evaluation criteria to screen the 27 proposed projects and to select 13 projects for further analyses. *The initial screening evaluation was conducted within the workshop setting using a qualitative approach.* The selected 13 projects will undergo a second round of evaluation during the next phase of the project. The list of criteria with their respective evaluation intent is provided below.

- Benefit-cost analysis
  - Assesses the overall cost effectiveness of the improvement in addressing the safety problems.
- Collision frequency and trends
  - Addresses the degree to which existing safety problems can be addressed and future safety issues minimized.
- Economic impact (e.g., temporary closure due to incident)
  - Assesses the potential economic impacts of road closures and the lack of vehicle mobility (freight and commute) along the corridor.
- Right-of-way/Environmental impacts
  - Considers the extent of potential right-of-way acquisition and environmental impacts.
- Maintenance
  - Considers potential maintenance costs (e.g., clearing sight lines).
- Future capacity
  - Indicates the quality of traffic flow experienced by future users on the corridor.
- Constructability
  - Evaluates the ability to physically and realistically construct an improvement.
- Funding sources
  - Considers the ability for a project to be funded through identified resources (e.g., Federal, State, local governments, and private resources).
- Future compatibility and consistency with the Region's vision
  - Considers the potential for an individual project to contribute to the Region's vision for the corridor.

Each project was assigned a qualitative good, fair, or poor rating relative to each of the evaluation criteria. This type of rating establishes whether the project meets the basic needs and enables a comparison of alternatives. These ratings have been defined according to the following guidelines:

- Good: Extensively addresses the criteria for the betterment of the system
- Fair: Slightly addresses the criteria with limited benefit
- Poor: No change or no benefit to the system

Evaluation Matrix of Projects

Projects / Evaluation Criteria	Benefit-Cost Analysis	Collision Frequency and Trends	Economic Impact	Right-of-Way/Environmental Impact	Maintenance	Future Capacity	Constructability	Funding Sources	Future Compatibility & Region's Vision
Project A Project 1 (Lighting: Corridor)	🟢	🟢	🟡	🟢	🔴	🟢	🟢	🟢	🟢
Project A Project 2 (Lighting: Location Specific)	🟡	🔴	🟡	🟢	🟡	🟡	🟢	🟢	🟢
Project B Project 1 (Roadside: Corridor)	🔴	🟡	🟡	🟢	🔴	🟡	🔴	🔴	🟡
Project B Project 2 (Roadside: Location Specific)	🔴	🟡	🟡	🟢	🟡	🟡	🟡	🟡	🟡
Project Area C Project 1 (Curves: Sight distance and Protection)	🟢	🟡	🟡	🟢	🟡	🟡	🟢	🟢	🟢
Project Area C Project 2 (Curves: Realign roadway)	🔴	🟢	🟢	🔴	🟢	🟢	🟡	🟡	🟡
Project Area D Project 1 (Sheltered Nook: Left-turn)	🟢	🟢	🟢	🔴	🟢	🟢	🟡	🟡	🟢
Project Area D Project 2 (Sheltered Nook: Crest curve)	🟡	🟡	🟡	🟡	🟢	🟡	🔴	🟡	🟡
Project Area E Project 1 (MP 1.4 Curve: Sight Distance)	🟡	🟡	🟡	🟡	🟡	🟡	🟢	🟢	🟢
Project Area E Project 2 (MP 1.4 Curve: Realignment)	🔴	🟢	🟢	🔴	🟢	🟢	🟡	🟡	🟡
Project Area F Project 1 (MP 1.5 Curve [8th Ave]: Sight Distance)	🟢	🟡	🟡	🟡	🟡	🟡	🟢	🟢	🟢
Project Area F Project 2 (MP 1.5 Curve [8th Ave]: Realignment)	🔴	🟢	🟢	🔴	🟢	🟢	🟡	🟡	🟡
Project Area G Project 1 (S-curves: Sight distance)	🟢	🟡	🟡	🟡	🟡	🟡	🟢	🟢	🟢
Project Area G Project 2 (S-curves: Realign roadway)	🔴	🟢	🟢	🔴	🟢	🟢	🟡	🟡	🟡
Project Area H Project 1 (15/25 mph Curves: Widen shoulders)	🟢	🟡	🔴	🟡	🟡	🟡	🟢	🟢	🟢
Project Area H Project 2 (15/25 mph Curves: Realign via viaduct)	🔴	🟢	🟢	🔴	🔴	🟢	🔴	🔴	🔴
Project Area H Project 3 (15/25 mph Curves: Realign to the west)	🟡	🟢	🟢	🔴	🟢	🟢	🟡	🟡	🟡

Table continues on next page.

Projects / Evaluation Criteria	Benefit-Cost Analysis	Collision Frequency and Trends	Economic Impact	Right-of-Way/Environmental Impact	Maintenance	Future Capacity	Constructability	Funding Sources	Future Compatibility & Region's Vision
Project Area I Project 1 (Skyline: Access and sight distance)	🔴	🟡	🟡	🟡	🟡	🔴	🟡	🟡	🟡
Project Area I Project 2 (Skyline: Offset T-intersections)	🔴	🟡	🟡	🔴	🟡	🟡	🟡	🟡	🔴
Project Area I Project 3 (Skyline: Southbound passing lane)	🔴	🔴	🟡	🔴	🟡	🟡	🟡	🟡	🟡
Project Area I Project 4 (Skyline: Roundabout)	🟢	🟢	🟢	🟡	🟢	🟢	🟡	🟡	🟢
Project Area J Project 1 (MP 3.8 Curve: Sight Distance)	🟡	🟡	🟡	🟡	🟡	🟡	🟢	🟢	🟢
Project Area J Project 2 (MP 3.8 Curve: Realignment)	🔴	🟢	🟢	🔴	🟢	🟢	🟡	🟡	🟡
Project Area K Project 1 (MP 4.5 Curve: Sight Distance)	🟢	🟡	🟡	🟡	🟡	🟡	🟢	🟢	🟢
Project Area K Project 2 (MP 4.5 Curve: Realignment)	🔴	🟢	🟢	🔴	🟢	🟢	🟡	🟡	🟡
Project Area L Project 1 (Kaiser: Southbound left)	🔴	🟡	🟢	🔴	🟢	🟢	🟡	🟢	🟢
Project Area L Project 2 (Kaiser: Northbound right & sight distance)	🟡	🟢	🟡	🔴	🟡	🟢	🟢	🟢	🟢
Project M (Cornelius Pass Road Design Guide)	🟡	🟡	🟢	🟡	🟢	🟢	🟡	🟢	🟢
Project N (Cornelius Pass Road Policies)	🟡	🟡	🟢	🟡	🟢	🟢	🟡	🟢	🟢

The following modifications were identified during the workshop:

- The two projects at the Sheltered Nook Road intersection (Project Area D) were combined into one improvement project.
- Although *"Project Area I (Skyline Boulevard) Project 1 (Access and Sight Distance Improvements)"* does not appear favorable based on the evaluation criteria, the participants decided to carry forward an additional alternative to the proposed roundabout, since the implementation of roundabouts in Oregon is a relative new traffic control treatment.
- Better documentation of the cost estimates for *"Project Area H (15/25-mph Curves) Project 3 (Realign to the West)"* that improves the tight S-curves to a 45-mph facility are needed.
- The work session participants did not see a noticeable improvement for providing a southbound left-turn at the Kaiser Road intersection (Project Area L), but due to the low cost for the northbound right-turn and the existing substandard intersection sight distance to the south, this portion of the project will be forwarded for further consideration.

- Based on the evaluation, an additional project (Project O) was identified to improve the overall alignment of Cornelius Pass Road to establish a consistent 45-mph facility along the entire length. *Project O (Providing a 45-mph Facility)* combines the following projects:
    - Project Area C Project 2 (Curves [MP 0.15-0.60]: Realign roadway)
    - Project Area E Project 2 (MP 1.4 Curve: Realignment)
    - Project Area F Project 2 (MP 1.5 Curve [8th Ave]: Realignment and Intersection Improvement)
    - Project Area G Project 2 (S-curves: Realign roadway)
    - Project Area H Project 3 (15/25 mph Curves: Realign to the west)
    - Project Area J Project 2 (MP 3.8 Curve: Realignment)
    - Project Area K Project 2 (MP 4.5 Curve: Realignment)
    - It is assumed that when these curves are improved that the intersection improvements at Sheltered Nook Road, Skyline Boulevard, and Kaiser Road would occur prior and/or at the same time.

The 13 projects highlighted in dark blue (assuming the combination of Project Area D: Sheltered Nook Road intersection projects) in the evaluation matrix plus the new larger project (Project O) was selected to be evaluated in more detail during the next phase of the project.

Benefit-Cost Analysis Methodology

A benefit-cost (B/C) analysis was conducted for each of the 13 projects identified for further analysis (see the dark blue highlighted projects in the table above). The B/C analysis was conducted using Oregon Department of Transportation (ODOT) B/C analysis worksheets, which serve as a calculator to compute the B/C ratio for a project based on inputs such as the cost of the project, anticipated safety benefits (i.e., estimated reduction in crashes), and service life of the project. Projects resulting in B/C ratios greater than 1.00 indicate the project is economically valid because the estimated benefits exceed the estimated cost.

The subsequent sections outline the analysis assumptions and methodology used for estimating project benefits and costs.

Benefit Estimates

Safety benefits were estimated for the proposed projects using empirically-based crash modification factors (CMFs) and crash reduction factors (CRFs). These factors provide an estimate of the potential reduction in crashes (i.e., percent decrease in crashes) due to changes in physical characteristics of a roadway segment or intersection. The potential percent reduction in crashes was then applied to the historical crash data on Cornelius Pass Road to determine the potential number of crashes reduced due to a given project. The economic value of a crash, based on severity (i.e., property damage only, injury or fatal), is multiplied by the number of crashes estimated to be reduced to obtain a monetary estimate of the benefit associated with the project.

The potential crash reduction for each project was estimated using CMFs and/or CRFs from the publications below in the order listed.

1. CRFs published on ODOT's CRF Website at http://its.pdx.edu/CRF/CRFweb/
2. CMFs published in the *AASHTO Highway Safety Manual (HSM), 1st Edition*
3. FHWA's Crash Modification Clearinghouse at http://www.cmfclearinghouse.org

The majority of projects included improvements for which CMFs and/or CRFs were available in one of the three resources, making it possible to estimate the potential monetary crash reduction benefits from the project. The table below summarizes the CRF values used to estimate the safety benefits of the key features included in the proposed projects.

Countermeasure	Estimated CRF	Applicable Crash Type/Severity	Source of the CMF or CRF
Lighting	23%	All Crash Types/All Severities	ODOT CRF Website
Left Turn Lane at Unsignalized Intersection	55%	Fatal/Injury Crashes	ODOT CRF Website
Left Turn Lane at Unsignalized Intersection	44%	PDO Crashes	ODOT CRF Website
Right Turn Lane at Unsignalized Intersection	23%	Fatal/Injury Crashes	ODOT CRF Website
Right Turn Lane at Unsignalized Intersection	14%	PDO Crashes	ODOT CRF Website
Intersection Sight Distance for Quadrant #3	13%	All Crash Types/All Severities	ODOT CRF Website
Intersection Sight Distance for Quadrant #2	9%	All Crash Types/All Severities	ODOT CRF Website
Increase Paved Shoulder Width from 2 to 8 feet	12%	All Crash Types/All Severities	ODOT CRF Website
Increase Paved Shoulder Width from 4 to 8 feet	9%	All Crash Types/All Severities	ODOT CRF Website
Improve Horizontal Curvature[1]	$\frac{\left(.55 \times L_C\right) + \left(\frac{80.2}{R}\right) - \left(.012 \times S\right)}{\left(.55 \times L_C\right)}$	All Crash Types/All Severities	HSM CMF (Equation 13-5)
Roundabout[2]	87%	Fatal/Injury Crashes	HSM CMF (Table 14-4)
Roundabout[2]	71%	PDO Crashes	HSM CMF (Table 14-4)

Notes:

[1] The equation shown is used to calculate the CMF for a given horizontal curve. The corresponding CRF is: CRF = 1- CMF. The CMF for a horizontal curve varies based on curve length (L_C), radius (R), and presence of a spiral curve (S).

[2] CRF information is for a roundabout replacing an intersection with stop-control on the minor street.

Several projects include improving the stopping sight distance along horizontal curves; however, CMFs and CRFs are not available to quantify this type of improvement. In these instances, widening the existing shoulder (from 2 feet to 8 feet) was used as a surrogate for increasing the stopping sight distance because one of the physical affects in the field that occurs when a shoulder is widened on a curved segment is increased stopping sight distance for motorists.

Some projects include replacing shorter, smaller radii horizontal curves with longer larger radii horizontal curves, which research shows tends to help reduce collisions. In these instances, the CRF was calculated by using equation 13-5 in the HSM to calculate a CMF for the existing condition and the proposed condition. These CMF values were divided (proposed condition divided by the existing

condition) to arrive at the CMF due to the change in the geometry; one minus this value provided the CRF value used in the B/C analysis. In instances where a single longer, larger radii curve is proposed to replace multiple shorter, smaller radii curves, equation 13-5 in the HSM was used to calculate the average CMF for the existing curves and the CMF for the proposed curve. These values were divided to determine the CMF due to the change in the horizontal geometry; one minus this value provided the CRF value used in the B/C analysis.

Cost Estimates

The conceptual project costs were estimated to provide a general idea of the magnitude of costs anticipated with the proposed improvements. The conceptual cost estimates are subdivided into general items using planning-level unit prices. The cost estimates include an itemized breakdown of major earthwork, structures (including retaining walls), pavement structure, and other identifiable major components, (e.g., street lighting). Groups of items (such as traffic control) are lumped together and the estimates provided are based on similar work for other projects. These cost estimates do not include an escalation factor; therefore, if portions of the proposed improvements are postponed into the future, the costs will need to be adjusted accordingly.

The individual project packets contain the preliminary cost estimating worksheets for each project.

Benefit/Cost Ratio Matrix

The table below summarizes the results of the B/C analysis for the 13 projects over a service life of 20 years.

Projects	Benefit Estimate	Cost Estimate	B/C Ratio
Series of S-Curves at MP 0.15-0.60	$773,000	$1.38 Million	0.56
Sheltered Nook Road Intersection	$3.89 Million	$1.82 Million	2.14
S-Curves and 8th Avenue Intersection at MP 1.5	$636,000	$191,000	3.33
S-Curves and Columbia Street Intersection at MP 1.8-2.1	$100,000	$914,000	0.11
Tight 15/25-mph Curves at MP 2.8-3.3 (Minor Widening)	$75,000	$260,000	0.29
Tight 15/25-mph Curves at MP 2.8-3.3 (Realignment to the West)	$675,000	$13.50 Million	0.05
Skyline Boulevard Intersection (Roundabout)	$9.79 Million	$3.75 Million	2.61
Skyline Boulevard Intersection (Realignment and Access Management)	$6.58 Million	$5.30 Million	1.24
Curve at MP 4.5	$1.70 Million	$1.3 Million	1.31
Kaiser Road Intersection	$960,000	$200,000	4.80
Corridor Roadway Lighting	$2.82 Million	$1.00 Million	2.82
Improve Cornelius Pass Road Corridor to 45-mph Facility	$29.1 Million	$26.8 Million	1.08
Corridor Design Guide and Policies	-	-	-

The Cornelius Pass Road Design Guide and Polices do not have collision benefit estimates or a B/C ratio because it is not feasible to reasonably estimate the potential monetary safety benefit of these projects. To arrive at a monetary safety benefit, it would be necessary to estimate the potential reduction in crashes due to the project and unfortunately, resources do not currently exist to estimate the potential crash reductions from implementing a road design guide and policies.

The individual project packets contain the B/C analysis worksheets for each project.