Appendix D

Design Workshop #3
Material

Cornelius Pass Road Revised Project List
Design Workshop #3

Project Key

Project A – Lighting Corridor Wide

Project Area C – S-Curves, MP 0.2-0.6

- Project 1 – Construct Retaining Wall Treatments and Guardrails

Project Area D – Sheltered Nook Road Intersection, MP 1.2

- Project 1 – Construct a Northbound left turn pocket and Improve Vertical Curve

Project Area F – 8th Avenue, MP 1.5

- Project 1 – Improve Intersection and Stopping Sight Distance

Project Area G – S-Curves, MP 1.85 to 2.05

- Project 1 – Increase Stopping Sight Distance Through Curve

Project Area H – S-Curves, MP 2.8 to 3.3

- Project 1 – Widen Shoulders
- Project 2 – Realign Road to West

Project Area I – Skyline Boulevard Intersection

- Project 1 – Construct a Single Lane Roundabout
- Project 2 – Realignment and Access Management Hybrid

Project Area K – Horizontal Curve North of Kaiser Road, MP 4.5

- Project 1 – Increase Stopping Sight Distance Through Curve

Project Area L – Kaiser Road Intersection, MP 4.6

- Project 1 – Improve intersection sight distance to north and construct a Northbound right turn pocket/widen shoulder

Project M & N – Cornelius Pass Road Specific Policies & Design Guide

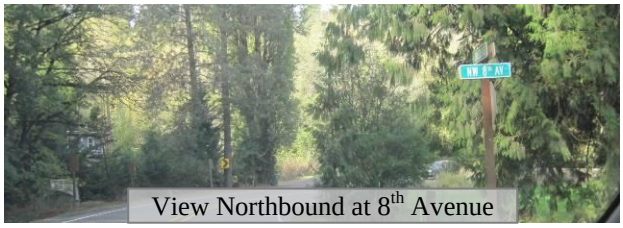
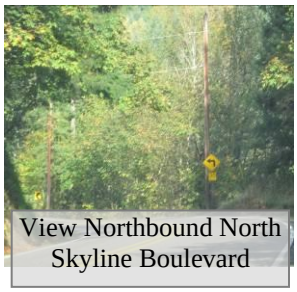
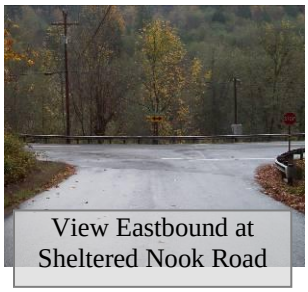
Project O – Realign Curves

- Project 1 MP 0.2-0.6
- Project 2 MP 1.4 (Sheltered Nook Road)
- Project 3 MP 1.5 (8th Avenue)
- Project 4 MP 1.85 to 2.05
- Project 5 MP 2.8 to 3.3 (Tight S-Curves, also included in Project H2)
- Project 6 MP 3.8
- Project 7 MP 4.5 (North of Kaiser Road)

Project A – Lighting Corridor Wide

Project A - Roadway Lighting

Safety Concern: Of the 171 collisions recorded on Cornelius Pass Rd in the last seven years, a fifth of them have occurred in dark, unlit sections of the road (not including the Highway 30 intersection). Most of the collisions resulted in property damage only; however one fatality, five debilitating injuries (type "A"), and seven severe injuries (type "B") were recorded. Many of these nighttime collisions occurred at locations with curves, and involved vehicles running off the road into fixed objects. The majority of Cornelius Pass Road (within the study area) does not have street lights. Select locations, such as the tight curves north of Skyline Boulevard and at the intersections of Skyline Boulevard and Highway 30 with Cornelius Pass Road do have roadway lighting.

Photos	**Proposed Improvement: Corridor Wide Lighting**
 View Northbound at 8th Avenue  View Northbound North Skyline Boulevard  View Eastbound at Sheltered Nook Road	Corridor wide optimal lighting levels could be obtained along Cornelius Pass Road (through the study area) using 200 Watt, flat lens (dark sky compliant), cobra head luminaires, mounted at a height of 35 feet and spaced at approximately 165 feet.

Preliminary Cost Estimate

The conceptual project cost estimate of $1,000,000 includes the following:

- Construction cost (incl. 40% contingency)= $740,000
- Engineering (35%) = $260,000
- Right-of-way acquisition = $0

Key assumptions are:

- This project assumes the cobra head luminaires would be mounted to new wood utility poles. Cost estimates are based on limited survey information Minimal wetland mitigation
- Minimal embankment work
- It is assumed that this project does not require additional right of way

A breakdown of the conceptual cost estimate is provided in the attachment.

Note: At some locations existing utility poles could be used to mount luminaires which would slightly reduce the project cost estimate.

How is the safety concern addressed?

The proposed improvements address several safety concerns:

- Increased sight distance throughout the corridor
- Potential to reduce nighttime collisions near intersections by approximately 10% to 60%.[1]
- Potential to reduce nighttime PDO and injury collisions by 20% to 30%.[2]
- Potential to reduce nighttime fatal collisions by approximately 70%. [3]

A preliminary benefit-cost (B/C) ratio of **2.82** was estimated based on annual benefits over 20 years and the estimated project cost of $1,000,000. A project resulting in B/C ratios greater than 1.00 indicate the project is economically valid because the estimated benefits exceed the estimated cost. A copy of ODOT's completed B/C Analysis worksheet for this project is attached.

[1] Website: http://www.cmfclearinghouse.org/study_detail.cfm?stid=163 Site funded by US Department of Federal Highway Administration and maintained by the University of North Carolina Highway Safety Research Center. Accessed on November 24, 2010.
[2] IBID.
[3] IBID.

Region Transportation Plan Scoping Tool
ODOT Region 1
Preliminary Design Unit And HHPR, Inc

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PROJECT DATA				
	Project Name	Project A - Corridor Wide Lighting	**Highway Number**	
	Highway Name	Cornelius Pass	**Posted Number**	
	County/City	Multnomah and Washington	**Maint. District**	
	Type of Project	Rural Non Freeway	**Key No**	
			Esimated By	DKS

		Unit	Quantity	Unit Cost	Cost
SQUARE FOOT' COSTS FROM STUDY PROJECTS (Costs Inflated to January 2011 Dollars)	**Roadway & Pavement**				
	New Work	sf		$ 15.00	$ -
	2" Overlay (With Mod)	sf		$ 1.00	$ -
	2" Overlay (Pres Only)	sf		$ 4.00	$ -
	Structures				
	New Bridge Spans >120'	sf		$ 180.00	$ -
	New Bridge Spans <120'	sf		$ 125.00	$ -
	New Bridge Spans under fill	sf		$ 300.00	$ -
	Bridge Widening	sf		$ 250.00	$ -
	Retaining Walls - CIP	sf		$ 125.00	$ -
	Retaining Walls - MSE	sf		$ 85.00	$ -
	Retaining Walls - Seg.	sf		$ 35.00	$ -
	Sound Walls - Precast	sf		$ 35.00	$ -
	Miscellaneous				
	Street Light Installation	Each	160	$ 2,700.00	$ 432,000.00
	CONSTRUCTION SUBTOTAL				***$ 432,000.00***

		Unit	Quantity	Unit Cost	Cost
	Miscellaneous Items - At the Estimator's Discretion				
	Mobilization	%	1	15%	$ 64,800.00
	Contractor Overhead and Profit	%	1	15%	$ 64,800.00
	CONSTRUCTION ESTIMATE TOTAL				$ 561,600.00
Other Costs	Preliminary Engineering	%	1	25%	$ 140,400.00
	Construction Engineering	%	1	10%	$ 56,160.00
	Contingencies	%	1	40%	$ 224,640.00
	Right of Way	LS	1	$ -	$ -
	TOTAL PROJECT ESTIMATE				***$ 982,800***

Assumptions:

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OREGON DEPARTMENT OF TRANSPORTATION
HIGHWAY SAFETY PROJECTS
BENEFIT/COST ANALYSIS WORKSHEET

Project Name: **Cornelius Pass Road Improvement Projects** Region: **1** Date: **12/1/10**

Project on Local Agency Facility

Route Number: Street Name: **Cornelius Pass Road** MP Range or Cross Street: **MP 0.00 to MP 5.00**

Project on State Highway

Route Number: Hwy Name: MP From: **0.00** to **5.00**

Road Character: **RURAL** Facility Type: **OTHER STATE HIGHWAY**

County: **MULTNOMAH** City: **N/A** Crash Data From: **1/1/2003** to **12/31/2009**

Project Description: **Safety Evaluation**

Prepared By: **Project Team** Title: **Project A - Corridor Lighting**

		Fatal Crash Reduction Factor	Injury Crash Reduction Factor	PDO Crash Reduction Factor
Countermeasure 1	Lighting	23%	23%	23%
Countermeasure 2		0%	0%	0%
Countermeasure 3		0%	0%	0%
Countermeasure 4		0%	0%	0%
		23% [1]	**23%** [1]	**23%** [1]

	Number of Crashes	Number of Preventable Crashes	Economic Value per Crash		Total Economic Value
Fatal Crashes	**1**	**0.2**	$1,500,000	=	**$ 345,000**
Severe (Injury A) Injury Crashes	**3**	**0.7**	$1,500,000	=	**$ 1,035,000**
Moderate (Injury B) Injury Crashes	**7**	**1.6**	$55,000	=	**$ 89,000**
Minor (Injury C) Injury Crashes	**4**	**0.9**	$55,000	=	**$ 51,000**
PDO Crashes	**17**	**3.9**	$15,000	=	**$ 59,000**

Comprehensive Economic Value per Crash		
Highway Type	Urban	Rural
PDO [3]		
All facilities	$15,000	$15,000
Moderate (Injury B) and Minor (Injury C) Injury [4]		
Interstate	$48,900	$54,800
Other State Highway	$47,900	$55,000
Fatal and Severe (Injury A) Injury [4]		
Interstate	$850,000	$1,460,000
Other State Highway	$840,000	$1,500,000

Total Crash Value for **84** Months = **$ 1,579,000**

Annual Benefits = Total Crash Value / Total Months / 12 = **$ 226,000**

Estimated Project Cost = **$ 1,000,000**

Uniform Series Present Worth Factor (5%)	
10 years	20 years
7.72	12.46

B/C Ratio = Annual Benefits X Present Worth Factor (10 or 20 years) / Estimated Project Cost

B/C Ratio = $ 226,000 x 12.46 [2] = **2.82**

$ 1,000,000

Notes

1 Composite crash reduction factor calculated if more than one countermeasure is applied

2 Select a PWF for the life of countermeasure. See instructions

3 PDO value is $7,500 per crash adjusted with an under reporting factor of 2.0. National Safety Council, 2005 estimates of value per crash.

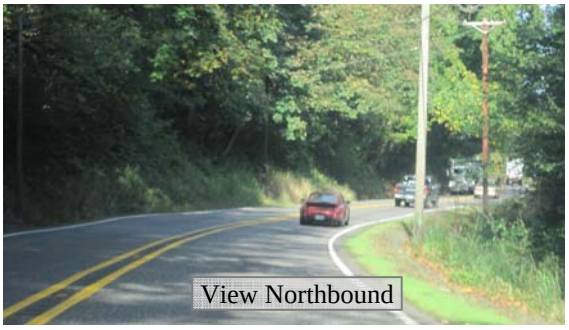
4 Economic costs per crash are calculated using 2004-2006 Oregon crash data and FHWA's Technical Advisory "Motor Vehicle Accident Costs, T 7570.2, October 31, 1994 updated to 2007 dollars with GDP implicit price deflator.

Project Area C – S-Curves, MP 0.2-0.6

- **Project 1 – Construct Retaining Wall Treatments and Guardrails**

Project Area C: Roadside Improvements along S-Curves (MP 0.15 to 0.6)

Safety Concern:
A series of five curves with varying radii (approximately 710, 380, 340, 250, and 820 feet, respectively) exist over a short segment of roadway. Over the past seven years, all of the ten reported collisions within this short segment had a collision type of "out of control" resulting in a collision with a fixed object or ditch. Six of these are injury-related; including one fatality.
There are also three existing retaining walls located very close to the edge of the southbound travel lane with little to no protection.

Photographs	**Proposed Improvement: Roadside Improvements and Sight Distance**
 View Northbound  View Southbound at Retaining Wall	The proposed improvements at the S-Curves between MP 0.15 and 0.6 entail the following: • Provide end treatments at all retaining wall ends and object delineation signs affixed to the face of retaining walls. • Provide guardrails (or roadside protection) along steep drop-offs, where warranted based on AASHTO Roadside Design Guide. • Provide stopping sight distance (SSD) along the S-curves via tree/vegetation removal. This will require some minor cut into the embankments along the west side of Cornelius Pass Road. These improvements are illustrated in the attached exhibit.

Supporting Data	
The conceptual project cost estimate of $1.376 million includes the following: • Construction cost (incl. 40% contingency) = $1.019 million • Engineering (35%) = $357,000 • Right-of-way acquisition = None	Key assumptions are: • Based on aerial photography • Incidental earthwork anticipated • No geotechnical stabilization anticipated • Gravel shoulder improvement along guardrail installation only • No environmentally sensitive areas • May require temporary construction easements A breakdown of the conceptual cost estimate is provided in the attachment.

How is the safety concern addressed?

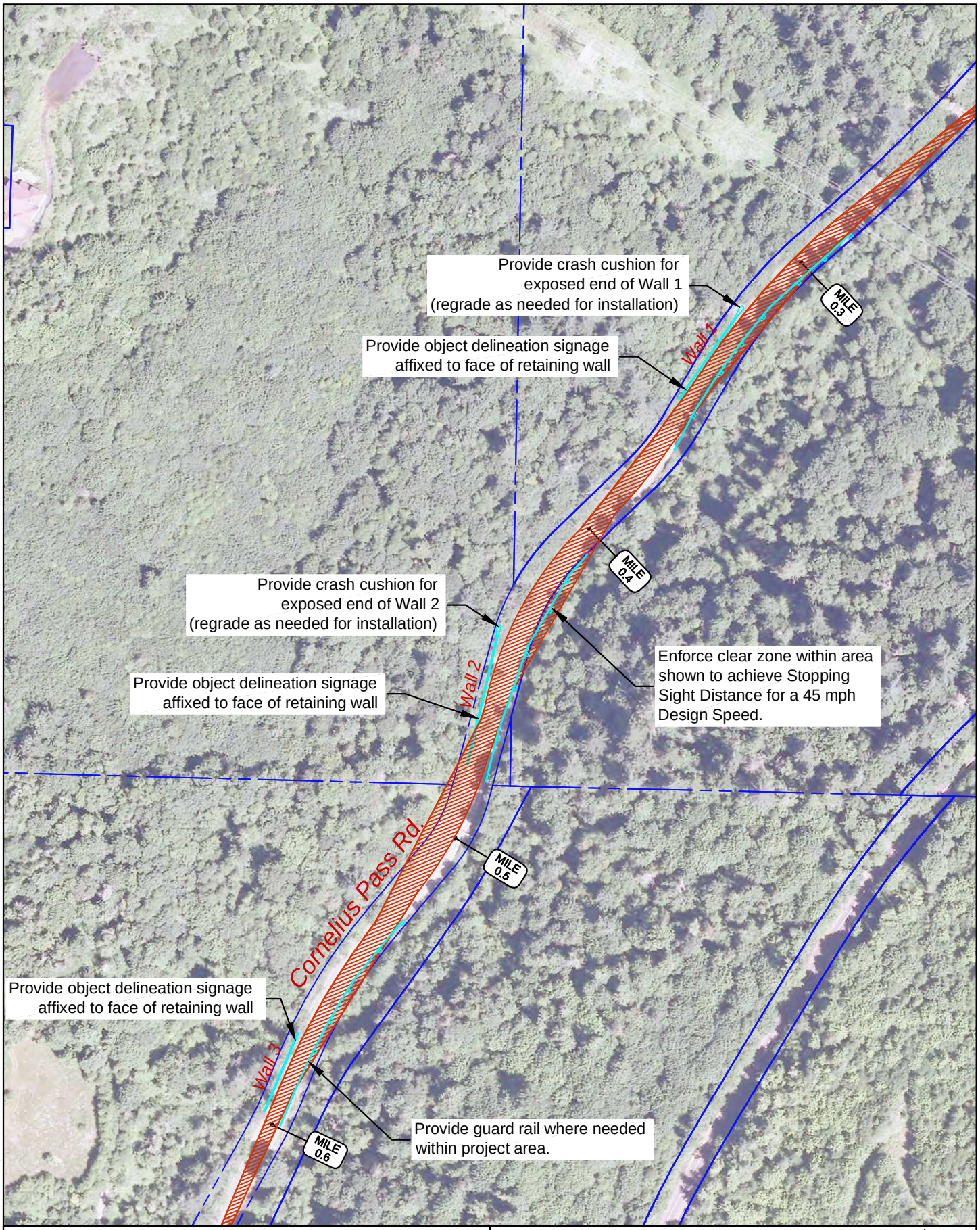
The proposed improvements address several safety concerns:

- Delineation signs provide additional visual cues about winding roadway.
- End treatments on retaining walls provide protection for motorists in case of collisions.
  - National research indicates approximately 69% of fixed object injury crashes are reduced when crash cushions are used at fixed roadside features. [1]
- Guardrails provide protection for out-of-control vehicles from leaving the roadway into the steep embankment and/or down steep fill slopes.
- Clearing along insides of curves provides appropriate stopping sight distance.
  - National research shows that the removal of roadside obstacles in the clear zone can reduce collisions by 22% to 44% depending on the increase in clear zone. [1]
  - Research summarized by ODOT also indicates widening the shoulder (which has the physical affect of increasing sight distance on curves) can decrease collisions by 5% to 12% depending on the increase in shoulder width.[2]

A preliminary benefit-cost (B/C) ratio of 0.56 was estimated based on annual benefits over 20 years and the estimated project cost of $1.376 million. A project resulting in B/C ratios less than 1.00 indicate the project is not economically valid because the estimated benefits fell short of the estimated cost. A copy of ODOT's completed B/C Analysis worksheet for this project is attached.

[1] American Association of State Highway Transportation Officials (AASHTO), *Highway Safety Manual (HSM), 1st Edition*, 2010.

[2] Oregon Department of Transportation (ODOT) Crash Reduction Factor (CRF) Website: http://its.pdx.edu/CRF/CRFweb/



Project Area C: S-Curves
MP 0.1-0.6 (Wall Signs & End Treatments)

Scale: 1 inch = 200 feet

200 100 0 100 200

PROJECT DATA				
PROJECT NAME	Cornelius Pass - Safety Study	**PROJECT AREA**	Project Area C
HIGHWAY NAME	Cornelius Pass Road	**PROJECT NUMBER**	Project 1
COUNTY/CITY	Multnomah County	**MILE POST/INTER.**	0.15 - 0.60
ESTIMATE CLASSIFICATION	CLASS IV (Per AACE)	**ESTIMATED BY**	JTE/JDH

PROJECT CONSTRUCTION COSTS		Unit	Quantity	Unit Cost	Cost
	Demolition/ Site Management				
	Clearing and Grubbing	SF	13,000	$2.50	$32,500
	Erosion Control	LS	1	$22,000	$22,000
	Traffic Control	LS	1	$73,000	$73,000
	Roadway and Pavement				
	Guardrail	LF	1,000	$25.00	$25,000
	Impact Attenuator	EA	2	$28,000.00	$56,000
	Signing/Delineation	LS	1	$7,500	$7,500
	Gravel Shoulder	LF	1,000	$12.00	$12,000
	Geotechnical Stabilization	LF	500	$1,000.00	$500,000
	Structures				
	Miscellaneous				

		Unit	Quantity	Unit Cost	Cost
	Miscellaneous Items - At the Estimator's Discretion				
	Project Subtotal				$728,000
	Project Scope Contingencies	%	$728,000	40%	$291,200
	CONSTRUCTION ESTIMATE TOTAL				$1,019,000

OTHER COSTS					
	Preliminary Engineering	LS	1	*20% of Construction	$204,000
	Construction Engineering	LS	1	*15% of Construction	$153,000

TOTAL PROJECT ESTIMATE ***$1,376,000***

** rounded value = nearest $1,000*

Key Assumptions:

- This estimate is based off of 2009 aerial photography and Multnomah County GIS resources
- Earthwork will be incidental and no geotechnical stabilization will be required
- Vegetation clearing will consist of sight obstructions only
- Gravel shoulder improvements will occur adjacent to guardrail installation only
- No environmentally sensitive areas will be disturbed beyond exemption thresholds

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OREGON DEPARTMENT OF TRANSPORTATION
HIGHWAY SAFETY PROJECTS
BENEFIT/COST ANALYSIS WORKSHEET

Project Name: **Cornelius Pass Road Improvement Projects** Region: **1** Date: **12/1/10**

Project on Local Agency Facility

Route Number: Street Name: **Cornelius Pass Road** MP Range or Cross Street: **MP 0.15 to MP 0.6**

Project on State Highway

Route Number: Hwy Name: MP From: **0.15** to **0.60**

Road Character: **RURAL** Facility Type: **OTHER STATE HIGHWAY**

County: **MULTNOMAH** City: **N/A** Crash Data From: **1/1/2003** to **12/31/2009**

Project Description: **Safety Evaluation**

Prepared By: **Project Team** Title: **Project C - Curves**

		Fatal Crash Reduction Factor	Injury Crash Reduction Factor	PDO Crash Reduction Factor
Countermeasure 1	Increase stopping sight distance (wider shoulders)	12%	12%	12%
Countermeasure 2		0%	0%	0%
Countermeasure 3		0%	0%	0%
Countermeasure 4		0%	0%	0%
		12% [1]	**12%** [1]	**12%** [1]

	Number of Crashes	Number of Preventable Crashes	Economic Value per Crash		Total Economic Value
Fatal Crashes	**0**	**0.0**	$1,500,000	=	**$ -**
Severe (Injury A) Injury Crashes	**2**	**0.2**	$1,500,000	=	**$ 360,000**
Moderate (Injury B) Injury Crashes	**6**	**0.7**	$55,000	=	**$ 40,000**
Minor (Injury C) Injury Crashes	**4**	**0.5**	$55,000	=	**$ 26,000**
PDO Crashes	**4**	**0.5**	$15,000	=	**$ 7,000**

Comprehensive Economic Value per Crash		
Highway Type	Urban	Rural
PDO [3]		
All facilities	$15,000	$15,000
Moderate (Injury B) and Minor (Injury C) Injury [4]		
Interstate	$48,900	$54,800
Other State Highway	$47,900	$55,000
Fatal and Severe (Injury A) Injury [4]		
Interstate	$850,000	$1,460,000
Other State Highway	$840,000	$1,500,000

Total Crash Value for **84** Months = **$ 433,000**

Annual Benefits = Total Crash Value / Total Months / 12 = **$ 62,000**

Estimated Project Cost = **$ 1,376,000**

Uniform Series Present Worth Factor (5%)	
10 years	20 years
7.72	12.46

B/C Ratio = Annual Benefits X Present Worth Factor (10 or 20 years) / Estimated Project Cost

B/C Ratio = $ 62,000 x 12.46 [2] = **0.56**

$ 1,376,000

Notes

1 Composite crash reduction factor calculated if more than one countermeasure is applied

2 Select a PWF for the life of countermeasure. See instructions

3 PDO value is $7,500 per crash adjusted with an under reporting factor of 2.0. National Safety Council, 2005 estimates of value per crash.

4 Economic costs per crash are calculated using 2004-2006 Oregon crash data and FHWA's Technical Advisory "Motor Vehicle Accident Costs, T 7570.2, October 31, 1994 updated to 2007 dollars with GDP implicit price deflator.

Project Area D – Sheltered Nook Road Intersection, MP 1.2

- **Project 1 – Construct a Northbound left turn pocket and Improve Vertical Curve**

Project Area D - Sheltered Nook Road Intersection

Safety Concern: Over the last seven years there have been eighteen collisions that resulted in two debilitating injuries (type "A") and six severe injuries (type "B") at the intersection of Sheltered Nook Road and Cornelius Pass Road. Approximately 40% of the collisions were rear end resulting in injury types "B" or "C". The majority of these instances occurred in the northbound lane of traffic. Additionally, nearly 20% of the collisions were the result of side-swipe and had associated injuries of "A" and "B". The majority of the collisions occurred on dry days in daylight, suggesting that driver behavior and the road geometry may have a greater impact on the collisions than other environmental conditions.

Approximate sight distance from Sheltered Nook northbound is 250 feet and southbound is 450 feet. The intersection sight distance required for left turning vehicles on a 45 mph facility is 500 feet. The left turn from Sheltered Nook to Cornelius Pass Road is 250 feet short of meeting this sight distance requirement.

Photos	**Proposed Improvement: Left Turn Lane & Vertical Curve**
 View Northbound (at Vertical Curve)  View Northbound  View Southbound	The proposed project adds a 100 foot long northbound left turn pocket 14 feet in width at Sheltered Nook Road. Following Multnomah County design standards, this improvement would require approach and departure tapers of 630 ft (assuming a design speed of 45mph). The proposed project will also flatten the existing vertical crest curve on the northern leg of the Cornelius Pass Road/Shelter Nook Road intersection. The length vertical curve affected by the proposed improvement is approximately 500 feet.

Preliminary Cost Estimate

The conceptual project cost estimate of $1,820,000 includes the following:

- Construction cost (incl. 40% contingency) = $1,335,000
- Engineering (35%) = $465,000
- Right-of-way acquisition = $20,000

Key assumptions are:

- Cost estimates are based on limited survey information Minimal wetland mitigation
- Minimal right of way impact or acquisition was included in cost estimate
- Minimal re-grading of approaches
- No roadway lighting is included in this cost

A breakdown of the conceptual cost estimate is provided in the attachment.

How is the safety concern addressed?

The proposed improvements address several safety concerns:

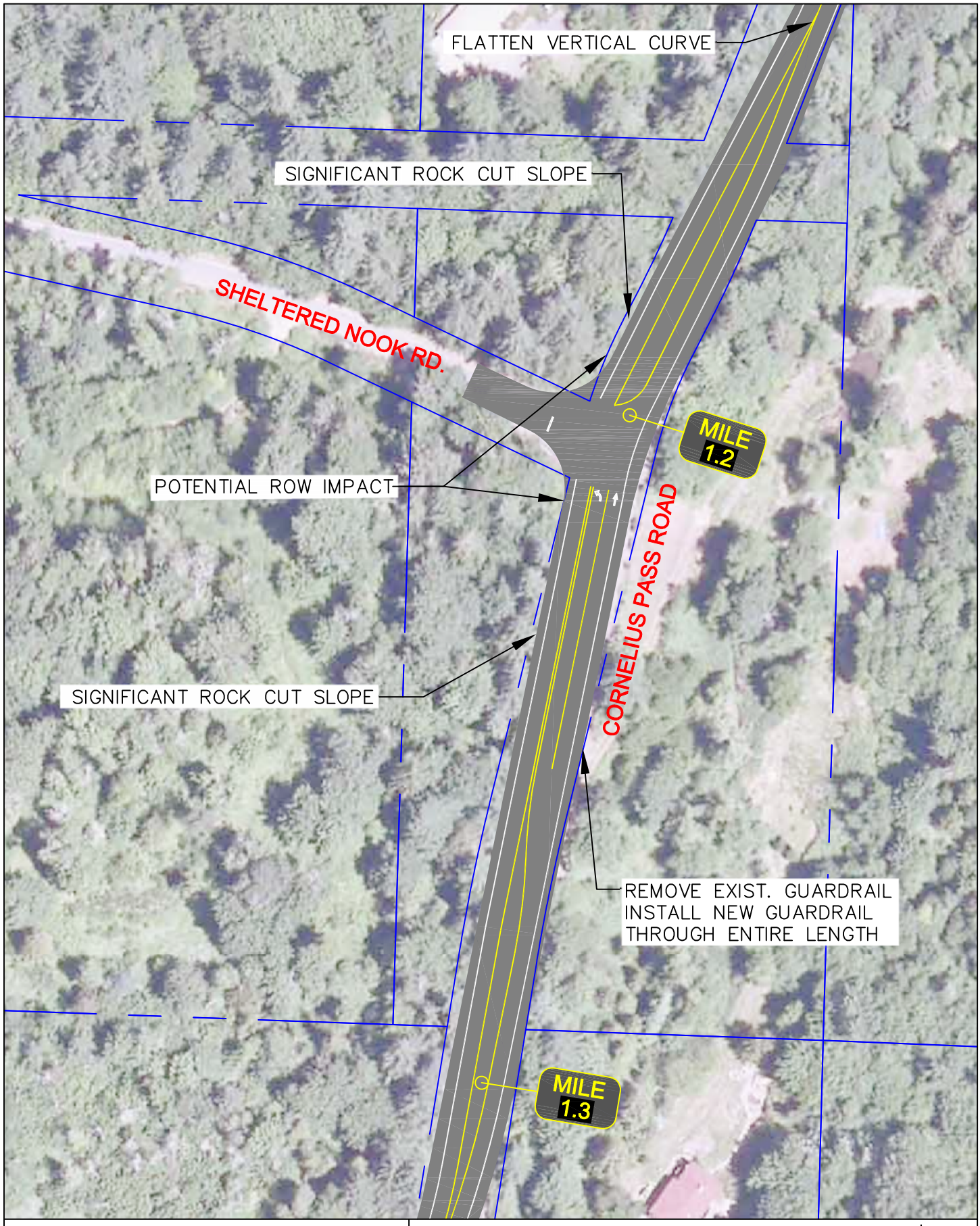
- The left turn lane reduces potential for northbound rear end collisions by creating storage space.
- The improved vertical curve increases sight distance to the north for vehicles exiting Sheltered Nook Road.
- The improved vertical curve increases sight distance to north for northbound left turning vehicles entering Sheltered Nook Road.

- National research shows the addition of a left turn lane on rural roads results in a decrease of all collision types by 44% and injury collisions by 35%.[1]
- Improved sight distance has the potential to reduce fatal and injury collisions by approximately 50% and all collision severity types by 20%.[2]

A preliminary benefit-cost (B/C) ratio of **2.14** was estimated based on annual benefits over 20 years and the estimated project cost of $1,820,000. A project resulting in B/C ratios greater than 1.00 indicate the project is economically valid because the estimated benefits exceed the estimated cost. A copy of ODOT's completed B/C Analysis worksheet for this project is attached.

[1] Website: http://www.cmfclearinghouse.org/study_detail.cfm?stid=24 Site funded by US Department of Federal Highway Administration and maintained by the University of North Carolina Highway Safety Research Center. Accessed on November 24, 2010.

[2] Website: http://www.cmfclearinghouse.org/study_detail.cfm?stid=72 Site funded by US Department of Federal Highway Administration and maintained by the University of North Carolina Highway Safety Research Center. Accessed on November 24, 2010.



Project Area D: Project 1- Sheltered Nook Rd MP 1.2 (Left Turn Pocket)

Scale: 1 inch = 100 feet

100 50 0 50 100

N

Region Transportation Plan Scoping Tool
ODOT Region 1
Preliminary Design Unit And HHPR, Inc

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PROJECT DATA				
Project Name	Project D1 - Sheltered Nook Left Turn	**Highway Number**		
Highway Name	Cornelius Pass	**Posted Number**		
County/City	Multnomah and Washington	**Maint. District**		
Type of Project	Rural Non Freeway	**Key No**		
		Esimated By	HL	

SQUARE FOOT' COSTS FROM STUDY PROJECTS (Costs Inflated to January 2011 Dollars)		Unit	Quantity	Unit Cost	Cost
	Roadway & Pavement				
	New Work	sf	36347	$ 15.00	$ 545,205.00
	2" Overlay (With Mod)	sf	48233	$ 1.00	$ 48,233.00
	2" Overlay (Pres Only)	sf		$ 4.00	$ -
	Structures				
	New Bridge Spans >120'	sf		$ 180.00	$ -
	New Bridge Spans <120'	sf		$ 125.00	$ -
	New Bridge Spans under fill	sf		$ 300.00	$ -
	Bridge Widening	sf		$ 250.00	$ -
	Retaining Walls - CIP	sf		$ 125.00	$ -
	Retaining Walls - MSE	sf		$ 85.00	$ -
	Retaining Walls - Seg.	sf		$ 35.00	$ -
	Sound Walls - Precast	sf		$ 35.00	$ -
	Miscellaneous				
	Traffic Signals	Intersection		$ 270,000.00	$ -
	Streetscape Peripherals	lf of roadway		High - $500/lf	$ -

		Unit	Quantity	Unit Cost	Cost
	Miscellaneous Items - At the Estimator's Discretion				
	Cut	CY	6728	$ 7.00	$ 47,096.00
	Rock Cut	CY	6829	$ 15.00	$ 102,435.00
	Guardrail	LF	1780	$ 25.00	$ 44,500.00
	Project Subtotal				$ 787,469.00
	Project Scope Contingencies	%	1	40%	$ 314,987.60
	CONSTRUCTION ESTIMATE TOTAL				$ 1,102,456.60
Other Costs	Preliminary Engineering	%	1	20%	$ 220,491.32
	Construction Engineering	%	1	15%	$ 165,368.49
	Environmental Studies	LS	1	$ 30,000.00	$ 30,000.00
	Right of Way	LS*	1	$ 300,000.00	$ 300,000.00
	TOTAL PROJECT ESTIMATE				***$ 1,818,316***

Assumptions:

* Assume 1 AC ROW take to allow cut slope
$300,000/AC including real estate attoney fees

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OREGON DEPARTMENT OF TRANSPORTATION
HIGHWAY SAFETY PROJECTS
BENEFIT/COST ANALYSIS WORKSHEET

Project Name: **Cornelius Pass Road Improvement Projects** Region: **1** Date: **12/1/10**

Project on Local Agency Facility

Route Number: Street Name: **Cornelius Pass Road** MP Range or Cross Street: **MP 0.00 to MP 5.00**

Project on State Highway

Route Number: Hwy Name: MP From: **0.00** to **5.00**

Road Character: **RURAL** Facility Type: **OTHER STATE HIGHWAY**

County: **MULTNOMAH** City: **N/A** Crash Data From: **1/1/2003** to **12/31/2009**

Project Description: **Safety Evaluation**

Prepared By: **Project Team** Title: **Project D Sheltered Nook Road**

		Fatal Crash Reduction Factor	Injury Crash Reduction Factor	PDO Crash Reduction Factor
Countermeasure 1	Left Turn Lane	55%	55%	44%
Countermeasure 2	Intersection Sight Distance	13%	13%	13%
Countermeasure 3		0%	0%	0%
Countermeasure 4		0%	0%	0%
		61% [1]	**61%** [1]	**51%** [1]

	Number of Crashes	Number of Preventable Crashes	Economic Value per Crash		Total Economic Value
Fatal Crashes	**0**	**0.0**	$1,500,000	=	**$ -**
Severe (Injury A) Injury Crashes	**2**	**1.2**	$1,500,000	=	**$ 1,826,000**
Moderate (Injury B) Injury Crashes	**6**	**3.7**	$55,000	=	**$ 201,000**
Minor (Injury C) Injury Crashes	**4**	**2.4**	$55,000	=	**$ 134,000**
PDO Crashes	**4**	**2.1**	$15,000	=	**$ 31,000**

Comprehensive Economic Value per Crash		
Highway Type	Urban	Rural
PDO [3]		
All facilities	$15,000	$15,000
Moderate (Injury B) and Minor (Injury C) Injury [4]		
Interstate	$48,900	$54,800
Other State Highway	$47,900	$55,000
Fatal and Severe (Injury A) Injury [4]		
Interstate	$850,000	$1,460,000
Other State Highway	$840,000	$1,500,000

Total Crash Value for **84** Months = **$ 2,192,000**

Annual Benefits = Total Crash Value / Total Months / 12 = **$ 313,000**

Estimated Project Cost = **$ 1,820,000**

Uniform Series Present Worth Factor (5%)	
10 years	20 years
7.72	12.46

B/C Ratio = Annual Benefits X Present Worth Factor (10 or 20 years) / Estimated Project Cost

B/C Ratio = $ 313,000 x 12.46 [2] = **2.14**

$ 1,820,000

Notes

1 Composite crash reduction factor calculated if more than one countermeasure is applied

2 Select a PWF for the life of countermeasure. See instructions

3 PDO value is $7,500 per crash adjusted with an under reporting factor of 2.0. National Safety Council, 2005 estimates of value per crash.

4 Economic costs per crash are calculated using 2004-2006 Oregon crash data and FHWA's Technical Advisory "Motor Vehicle Accident Costs, T 7570.2, October 31, 1994 updated to 2007 dollars with GDP implicit price deflator.

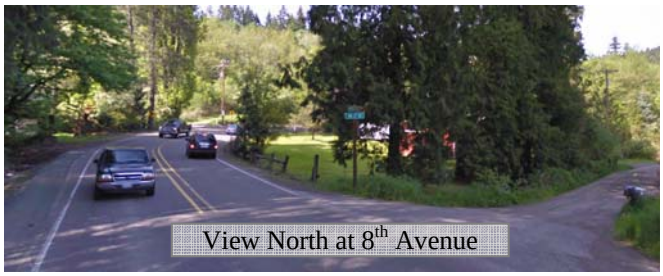
Project Area F – 8th Avenue at MP 1.5

- **Project 1 – Improve Intersection and Stopping Sight Distance**

Project Area F: Sight Distance Improvements at 8th Avenue (MP 1.5)

Safety Concern:
The combination of sharp horizontal curves, the 8th Avenue intersection, and limited sight distance at the intersection and along the curves all contribute to the safety concerns at this location. The existing curve has a radius of approximately 170 feet, resulting in a 35-mph design speed. Ten collisions were reported at this location over a seven-year period (2003 – 2009). Six of these were "out of control" (collision type) resulting in a collision with a fixed object or ditch. Four of these resulted in injuries.

Photographs


View North at 8th Avenue


View South

Proposed Improvement: Sight Distance

The proposed improvements at the 8th Avenue intersection and S-Curves at MP 1.5 entail the following:

- Provide a minimum of 360 feet of stopping sight distance (SSD) for a 45-mph design speed along the S-curves via tree and vegetation removal. Although the curve geometry will limit the speed to approximately 35 mph, the overall objective is to provide SSD consistently for 45 mph.
- Provide intersection sight distance (ISD) at the 8th Avenue intersection via tree and vegetation removal. The existing building to the north of the intersection restricts ISD to the north to approximately 33 mph. There is no intent to impact the building.
- Obtain public easements for sight distance purposes.

These improvements are illustrated in the attached exhibits.

Preliminary Cost Estimate

The conceptual project cost estimate of $191,000 includes the following:

- Construction cost (incl. 40% contingency) = $98,000
- Engineering (35%) = $34,000
- Public easement acquisition = $58,000

Key assumptions are:

- Based on aerial photography
- Incidental earthwork anticipated
- No geotechnical stabilization anticipated
- Revegetation with ground cover and low height plantings
- No allowance for upkeep and maintenance of public easement

A breakdown of the conceptual cost estimate is provided in the attachment.

How is the safety concern addressed?

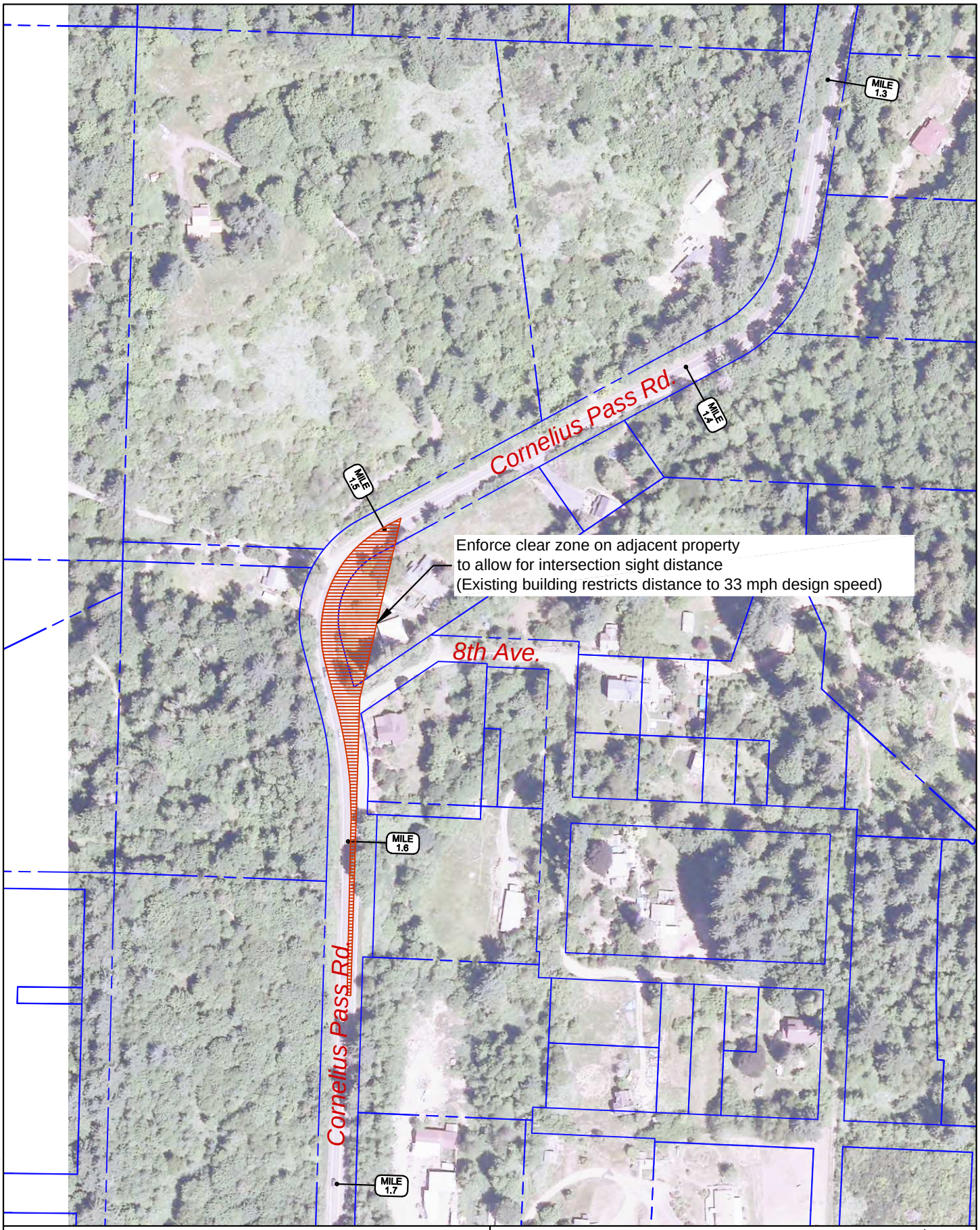
The proposed improvements address several safety concerns:

- Providing appropriate stopping sight distance (SSD) along the S-curves will improve motorists' ability to avoid obstacles in the road (i.e. stopped vehicles) and increase overall sight lines approaching the curves.
  - National research shows that the removal of roadside obstacles in the clear zone can reduce collisions by 22% to 44% depending on the increase in clear zone. [1]
  - Research summarized by ODOT also indicates widening the shoulder (which has the physical affect of increasing sight distance on curves) can decrease collisions by 5% to 12% depending on the increase in shoulder width.[2]
- Providing intersection sight distance (ISD) at the 8th Avenue intersection will enhance overall safety and operations at this intersection while addressing the intersection related collisions.
  - Research summarized by ODOT indicates improving intersection sight distance can reduce crashes by 5% to 17% depending on the intersection quadrant where sight distance is improved.[2]

A preliminary benefit-cost (B/C) ratio of 3.33 was estimated based on annual benefits over 20 years and the estimated project cost of $191,000. A project resulting in B/C ratios greater than 1.00 indicate the project is economically valid because the estimated benefits exceed the estimated cost. A copy of ODOT's completed B/C Analysis worksheet for this project is attached.

[1] American Association of State Highway Transportation Officials (AASHTO), *Highway Safety Manual (HSM), 1st Edition*, 2010.

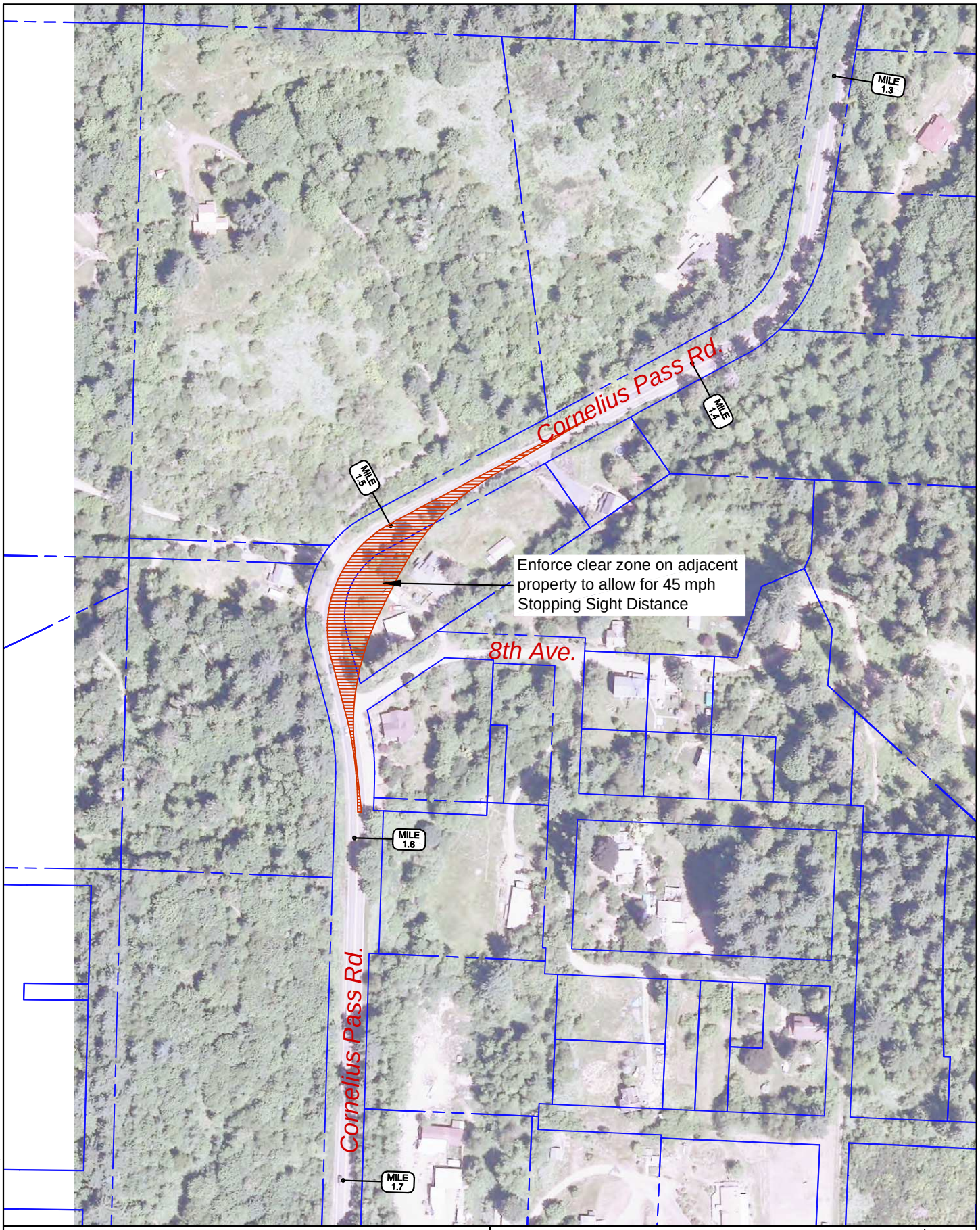
[2] Oregon Department of Transportation (ODOT) Crash Reduction Factor (CRF) Website: http://its.pdx.edu/CRF/CRFweb/



Project Area F: 8th Ave MP 1.5
(Intersection Sight Distance Clearing)

Scale: 1 inch = 200 feet

200 100 0 100 200



Project Area F: 8th Ave MP 1.5
(Stopping Sight Distance Clearing)

Scale: 1 inch = 200 feet

200 100 0 100 200

PROJECT DATA				
PROJECT NAME	Cornelius Pass - Safety Study	**PROJECT AREA**	Project Area F
HIGHWAY NAME	Cornelius Pass Road	**PROJECT NUMBER**	Project 1
COUNTY/CITY	Multnomah County	**MILE POST/INTER.**	1.5
ESTIMATE CLASSIFICATION	CLASS IV (Per AACE)	**ESTIMATED BY**	JTE/JDH

PROJECT CONSTRUCTION COSTS		Unit	Quantity	Unit Cost	Cost
	Demolition/ Site Management				
	Clearing and Grubbing	SF	14,400	$2.50	$36,000
	Erosion Control	LS	1	$2,000	$2,000
	Traffic Control	LS	1	$7,000	$7,000
	Roadway and Pavement				
	Gravel Shoulder	LF	500	$12.00	$6,000
	Landscaping	SF	12,500	$1.50	$18,750
	Structures				
	Miscellaneous				

		Unit	Quantity	Unit Cost	Cost
	Miscellaneous Items - At the Estimator's Discretion				
	Project Subtotal				$69,750
	Project Scope Contingencies	%	$69,750	40%	$27,900
	CONSTRUCTION ESTIMATE TOTAL				$98,000

OTHER COSTS					
	Preliminary Engineering	LS	1	*20% of Construction	$20,000
	Construction Engineering	LS	1	*15% of Construction	$15,000
	Easement Acquisition	SF	11,500	$5.00	$58,000

TOTAL PROJECT ESTIMATE ***$191,000***

** rounded value = nearest $1,000*

Key Assumptions:

- This estimate is based off of 2009 aerial photography and Multnomah County GIS resources
- Earthwork will be incidental and no geotechnical stabilization will be required
- Vegetation clearing will consist of sight obstructions only
- Revegetation will consist of ground cover and low height plantings
- No allowance has been made for easement upkeep and maintenance

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OREGON DEPARTMENT OF TRANSPORTATION
HIGHWAY SAFETY PROJECTS
BENEFIT/COST ANALYSIS WORKSHEET

Project Name: **Cornelius Pass Road Improvement Projects** Region: **1** Date: **12/1/10**

Project on Local Agency Facility

Route Number: Street Name: **Cornelius Pass Road** MP Range or Cross Street: **8th Avenue**

Project on State Highway

Route Number: Hwy Name: MP From: **1.50** to **1.50**

Road Character: **RURAL** Facility Type: **OTHER STATE HIGHWAY**

County: **MULTNOMAH** City: **N/A** Crash Data From: **1/1/2003** to **12/31/2009**

Project Description: **Safety Evaluation**

Prepared By: **Project Team** Title: **Project F 8th Avenue**

		Fatal Crash Reduction Factor	Injury Crash Reduction Factor	PDO Crash Reduction Factor
Countermeasure 1	Intersection Sight Distance	9%	9%	9%
Countermeasure 2	Increase stopping sight distance (wider shoulders)	12%	12%	12%
Countermeasure 3		0%	0%	0%
Countermeasure 4		0%	0%	0%
		20% [1]	**20%** [1]	**20%** [1]

	Number of Crashes	Number of Preventable Crashes	Economic Value per Crash		Total Economic Value
Fatal Crashes	**0**	**0.0**	$1,500,000	=	**$ -**
Severe (Injury A) Injury Crashes	**1**	**0.2**	$1,500,000	=	**$ 299,000**
Moderate (Injury B) Injury Crashes	**3**	**0.6**	$55,000	=	**$ 33,000**
Minor (Injury C) Injury Crashes	**1**	**0.2**	$55,000	=	**$ 11,000**
PDO Crashes	**5**	**1.0**	$15,000	=	**$ 15,000**

Comprehensive Economic Value per Crash		
Highway Type	Urban	Rural
PDO [3]		
All facilities	$15,000	$15,000
Moderate (Injury B) and Minor (Injury C) Injury [4]		
Interstate	$48,900	$54,800
Other State Highway	$47,900	$55,000
Fatal and Severe (Injury A) Injury [4]		
Interstate	$850,000	$1,460,000
Other State Highway	$840,000	$1,500,000

Total Crash Value for **84** Months = **$ 358,000**

Annual Benefits = Total Crash Value / Total Months / 12 = **$ 51,000**

Estimated Project Cost = **$ 191,000**

Uniform Series Present Worth Factor (5%)	
10 years	20 years
7.72	12.46

B/C Ratio = Annual Benefits X Present Worth Factor (10 or 20 years) / Estimated Project Cost

B/C Ratio = $ 51,000 x 12.46 [2] / $ 191,000 = **3.33**

Notes

1 Composite crash reduction factor calculated if more than one countermeasure is applied

2 Select a PWF for the life of countermeasure. See instructions

3 PDO value is $7,500 per crash adjusted with an under reporting factor of 2.0. National Safety Council, 2005 estimates of value per crash.

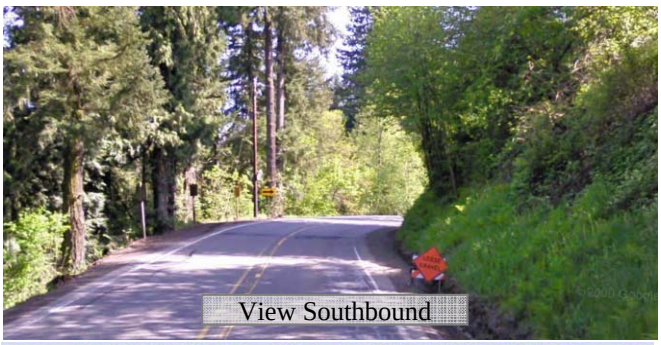
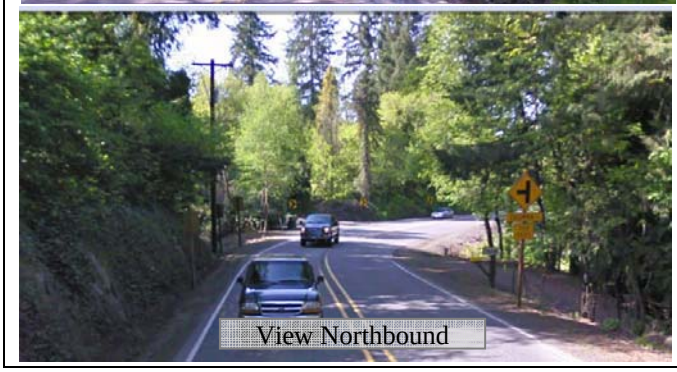
4 Economic costs per crash are calculated using 2004-2006 Oregon crash data and FHWA's Technical Advisory "Motor Vehicle Accident Costs, T 7570.2, October 31, 1994 updated to 2007 dollars with GDP implicit price deflator.

Project Area G – S-Curves, MP 1.85 to 2.05

- **Project 1 – Increase Stopping Sight Distance Through Curve**

Project Area G: Sight Distance Improvements at S-Curves (MP 1.8 to 2.1)

Safety Concern:
Thirteen collisions were reported along this 0.3 mile segment of Cornelius Pass Road over a seven-year period (2003 – 2009). Eight of the collisions occurred within the S-curves (6 were "out of control" [collision type] resulting in a collision with a fixed object) and the remaining five occurred at the Columbia Street intersection. The existing curves have radii that range from 140-160 feet with a 105-foot tangent section in between, resulting in design speeds of approximately 20 mph. Sight distance is limited along these curves and at the Columbia Street intersection due to existing trees/vegetation, as well as the existing topography, which all likely also contributes to the safety concerns at this location.

Photographs	Proposed Improvement: Sight Distance
 View Southbound  View Northbound	The proposed improvements at the S-Curves between MP 1.8 and 2.1 entail the following: • Provide stopping sight distance (SSD) along the S-curves via tree and vegetation removal and cutback of side-slopes. • Provide intersection sight distance (ISD) at the Columbia Street intersection via tree and vegetation removal. • Require likely geotechnical stabilization for cutting into embankment at approximately MP 1.93. • Obtain public easements for sight distance purposes. These improvements are illustrated in the attached exhibits.

Preliminary Cost Estimate

The conceptual project cost estimate of $914,000 includes the following:

- Construction cost (incl. 40% contingency) = $666,000
- Engineering (35%) = $233,000
- Public easement acquisition = $15,000

Key assumptions are:

- Based on aerial photography
- Incidental earthwork anticipated
- Geotechnical stabilization for slope cutback
- Revegetation with ground cover and low height plantings

A breakdown of the conceptual cost estimate is provided in the attachment.

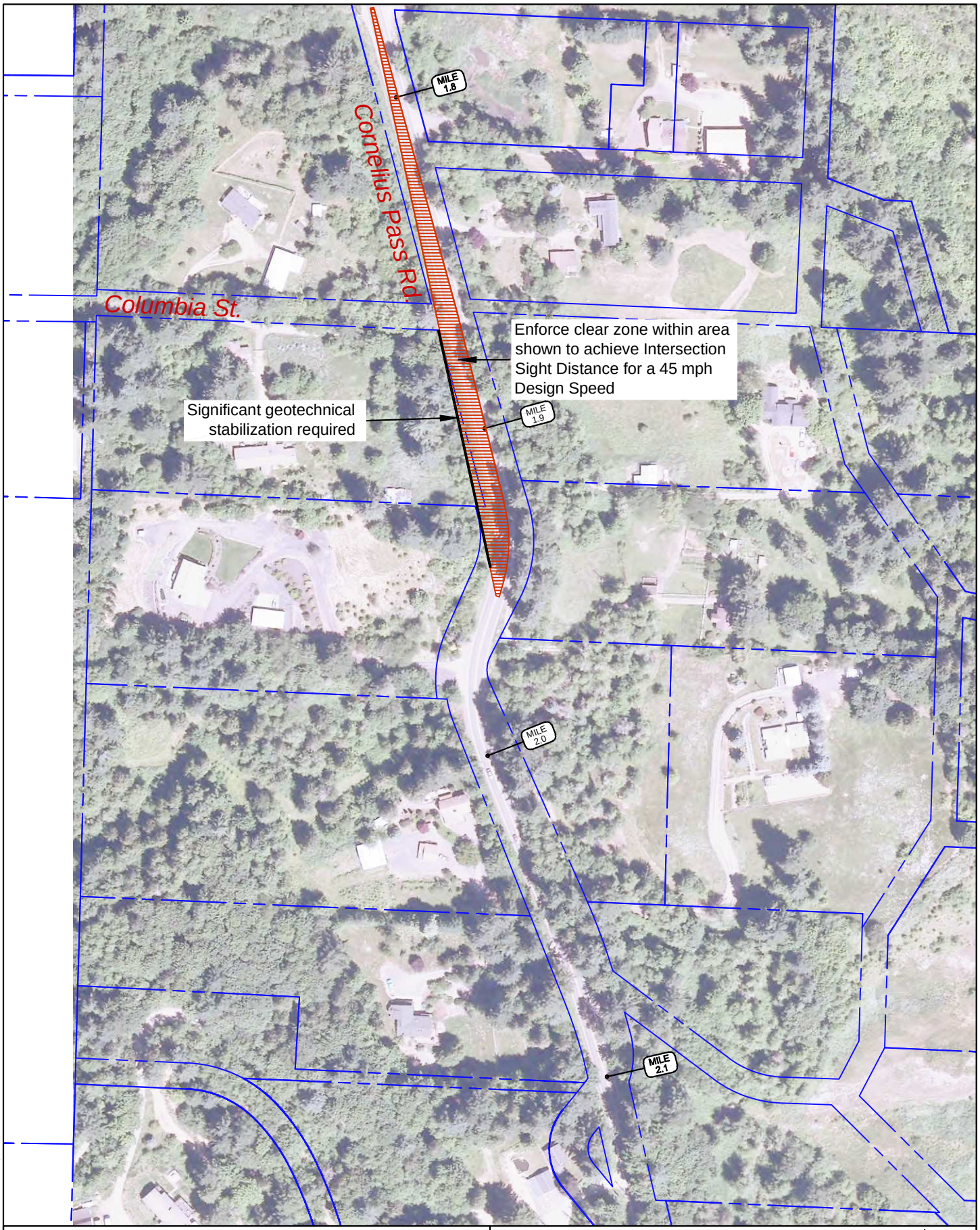
How is the safety concern addressed?

The proposed improvements address several safety concerns:

- Providing appropriate stopping sight distance (SSD) along the S-curves will improve motorists' ability to avoid obstacles in the road (i.e. stopped vehicles) and increase overall sight lines approaching the curves.
  - National research shows that the removal of roadside obstacles in the clear zone can reduce collisions by 22% to 44% depending on the increase in clear zone. [1]
  - Research summarized by ODOT also indicates widening the shoulder (which has the physical affect of increasing sight distance on curves) can decrease collisions by 5% to 12% depending on the increase in shoulder width.[2]
- Providing intersection sight distance (ISD) at the Columbia Street intersection will enhance overall safety and operations at this intersection while addressing the intersection related collisions.
  - Research summarized by ODOT indicates improving intersection sight distance can reduce crashes by 5% to 17% depending on the intersection quadrant where sight distance is improved.[2]

A preliminary benefit-cost (B/C) ratio of 0.11 was estimated based on annual benefits over 20 years and the estimated project cost of $914,000. A project resulting in B/C ratios less than 1.00 indicate the project is not economically valid because the estimated benefits fell short of the estimated cost. A copy of ODOT's completed B/C Analysis worksheet for this project is attached.

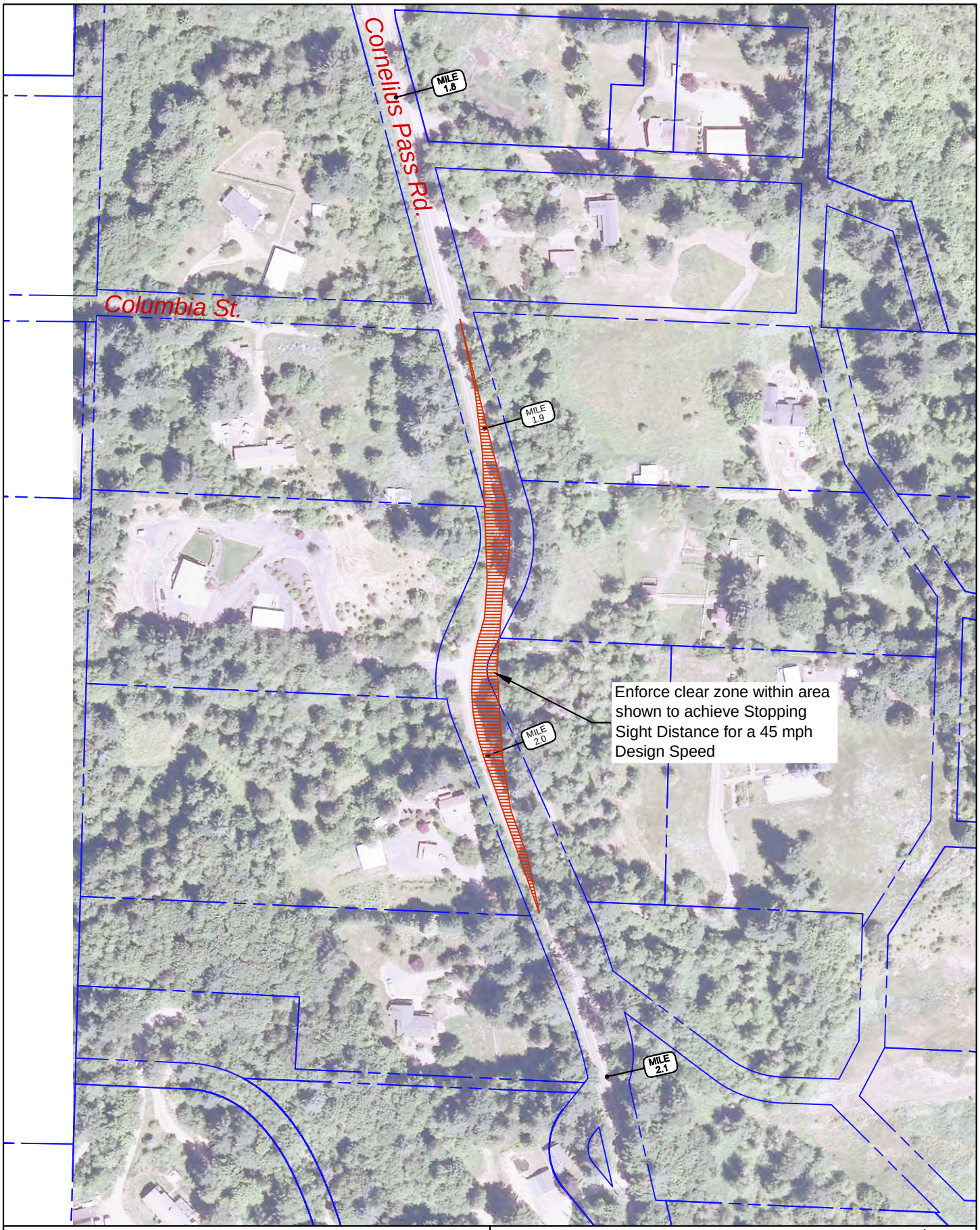
[1] American Association of State Highway Transportation Officials (AASHTO), *Highway Safety Manual (HSM), 1st Edition*, 2010.
[2] Oregon Department of Transportation (ODOT) Crash Reduction Factor (CRF) Website: http://its.pdx.edu/CRF/CRFweb/



Project Area G: MP 1.8 Curves (Intersection Sight Distance Clearing)

Scale: 1 inch = 200 feet

200 100 0 100 200



Project Area G: MP 1.8 Curves
(Stopping Sight Distance Clearing)

Scale: 1 inch = 200 feet

200 100 0 100 200

PROJECT DATA				
PROJECT NAME	Cornelius Pass - Safety Study	**PROJECT AREA**	Project Area G
HIGHWAY NAME	Cornelius Pass Road	**PROJECT NUMBER**	Project 1
COUNTY/CITY	Multnomah County	**MILE POST/INTER.**	1.8
ESTIMATE CLASSIFICATION	CLASS IV (Per AACE)	**ESTIMATED BY**	JTE/JDH

		Unit	Quantity	Unit Cost	Cost
PROJECT CONSTRUCTION COSTS	**Demolition/ Site Management**				
	Clearing and Grubbing	SF	14,500	$2.50	$36,250
	Erosion Control	LS	1	$14,500	$14,500
	Traffic Control	LS	1	$47,500	$47,500
	Roadway and Pavement				
	Gravel Shoulder	LF	950	$12.00	$11,400
	Landscaping	SF	10,500	$1.50	$15,750
	Geotechnical Stabilization	LF	350	$1,000.00	$350,000
	Structures				
	Miscellaneous				

		Unit	Quantity	Unit Cost	Cost
	Miscellaneous Items - At the Estimator's Discretion				
	Project Subtotal				$475,400
	Project Scope Contingencies	%	$475,400	40%	$190,160
	CONSTRUCTION ESTIMATE TOTAL				$666,000
OTHER COSTS	Preliminary Engineering	LS	1	*20% of Construction	$133,000
	Construction Engineering	LS	1	*15% of Construction	$100,000
	Easement Acquisition	SF	3,000	$5.00	$15,000

TOTAL PROJECT ESTIMATE ***$914,000***

** rounded value = nearest $1,000*

Key Assumptions:

- This estimate is based off of 2009 aerial photography and Multnomah County GIS resources
- Vegetation clearing will consist of sight obstructions only
- Revegetation will consist of ground cover and low height plantings
- No environmentally sensitive areas will be disturbed beyond exemption thresholds

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OREGON DEPARTMENT OF TRANSPORTATION
HIGHWAY SAFETY PROJECTS
BENEFIT/COST ANALYSIS WORKSHEET

Project Name: **Cornelius Pass Road Improvement Projects** Region: **1** Date: **12/1/10**

Project on Local Agency Facility

Route Number: Street Name: **Cornelius Pass Road** MP Range or Cross Street: **MP 1.85 to 2.05**

Project on State Highway

Route Number: Hwy Name: MP From: **1.85** to **2.05**

Road Character: **RURAL** Facility Type: **OTHER STATE HIGHWAY**

County: **MULTNOMAH** City: **N/A** Crash Data From: **1/1/2003** to **12/31/2009**

Project Description: **Safety Evaluation**

Prepared By: **Project Team** Title: **Project G Curves**

		Fatal Crash Reduction Factor	Injury Crash Reduction Factor	PDO Crash Reduction Factor
Countermeasure 1	Increase stopping sight distance (wider shoulders)	12%	12%	12%
Countermeasure 2	Intersection Sight Distance	9%	9%	9%
Countermeasure 3		0%	0%	0%
Countermeasure 4		0%	0%	0%
		20% [1]	**20%** [1]	**20%** [1]

	Number of Crashes	Number of Preventable Crashes	Economic Value per Crash		Total Economic Value
Fatal Crashes	**0**	**0.0**	$1,500,000	=	**$ -**
Severe (Injury A) Injury Crashes	**0**	**0.0**	$1,500,000	=	**$ -**
Moderate (Injury B) Injury Crashes	**2**	**0.4**	$55,000	=	**$ 22,000**
Minor (Injury C) Injury Crashes	**0**	**0.0**	$55,000	=	**$ -**
PDO Crashes	**11**	**2.2**	$15,000	=	**$ 33,000**

Comprehensive Economic Value per Crash		
Highway Type	Urban	Rural
PDO [3]		
All facilities	$15,000	$15,000
Moderate (Injury B) and Minor (Injury C) Injury [4]		
Interstate	$48,900	$54,800
Other State Highway	$47,900	$55,000
Fatal and Severe (Injury A) Injury [4]		
Interstate	$850,000	$1,460,000
Other State Highway	$840,000	$1,500,000

Total Crash Value for **84** Months = **$ 55,000**

Annual Benefits = Total Crash Value / Total Months / 12 = **$ 8,000**

Estimated Project Cost = **$ 914,000**

Uniform Series Present Worth Factor (5%)	
10 years	20 years
7.72	12.46

B/C Ratio = Annual Benefits X Present Worth Factor (10 or 20 years) / Estimated Project Cost

B/C Ratio = $ 8,000 x 12.46 [2] / $ 914,000 = **0.11**

Notes

1 Composite crash reduction factor calculated if more than one countermeasure is applied

2 Select a PWF for the life of countermeasure. See instructions

3 PDO value is $7,500 per crash adjusted with an under reporting factor of 2.0. National Safety Council, 2005 estimates of value per crash.

4 Economic costs per crash are calculated using 2004-2006 Oregon crash data and FHWA's Technical Advisory "Motor Vehicle Accident Costs, T 7570.2, October 31, 1994 updated to 2007 dollars with GDP implicit price deflator.

Project Area H – S-Curves, MP 2.8 to 3.3

- **Project 1 – Widen Shoulders**
- **Project 2 – Realign Road to West**

Project Area H - MP 2.8-3.3 (Tight Curves)

Safety Concern: The sharp curves north of Skyline Boulevard (between mile-points 2.8-3.3) are a recognized hazard for drivers and there are advisory speed limits of 25 mph and 15 mph posted. However, there have been fifteen collisions in the past seven years including ten instances of vehicles overturning or running off the road. Two of the collisions resulted in severe (type "B") injuries and the remaining 13 collisions were less severe with ten of them being property damage only collisions. These sharp curves continue to present a risk for drivers.

Approximate sight distance from the middle of the 25mph curve is 175 ft in each direction. This meets the required stopping sight distances (227 ft westbound and 179 ft southbound, assuming a design speed of 30 mph and grade of 9%). Curve warning signs,, and street lighting are already present along these curves, and concrete guardrails are present along an exposed section of the 25 mph curve..

Photos	Proposed Improvement: Shoulders & Realign Road
 View Southbound  View Northbound  View Northbound	**Project 1: Widen Shoulders** This project would widen the shoulders for both directions of traffic through the area of the 25 mph and 15 mph curves. This widening would require relocation of existing barrier and utility poles to provide additional recovery area for vehicles. **Project 2: Realign Road to West** This project would replace the 25mph and 15 mph curves with a new alignment to the west. The new alignment would cut into the existing embankment to create gentler horizontal curves through this area.

Preliminary Cost Estimate

Project 1: Widen Shoulders

The conceptual project cost estimate of $260,000 includes the following:

- Construction cost (incl. 40% contingency) = $193,000
- Engineering (35%) = $67,000
- Right-of-way acquisition = $0

Key assumptions are:

- Cost estimates are based on limited survey information Relocation of utility poles will be necessary d
- No Roadway lighting is included in this cost
- It is assumed that this project does not require additional right of way

A breakdown of the conceptual cost estimate is provided in the attachment.

Project 2: Realign Road to West

The conceptual project cost estimate of $13,500,000 includes the following:

- Construction cost (incl. 40% contingency) = $8,150,000
- Engineering (35%) = $2,850,000
- Right-of-way acquisition = $2,500,000

Key assumptions are:

- Cost estimates are based on limited survey information
- Significant earthwork and stabilization required
- Vegetation clearing required
- No Roadway lighting is included in this cost

A breakdown of the conceptual cost estimate is provided in the attachment.

How is the safety concern addressed?

The proposed improvements address several safety concerns:

Project 1: Widen Shoulders

- Will provide drivers with the space to regain control of their vehicles
- Reduce the likelihood that vehicles will run off the road and overturn or hit fixed objects
- Potential to reduce all collision types by approximately 5% to 20% when a shoulder is widened beyond six feet.[1]

Project 2: Realign Road to West

- Reduce the risk of drivers leaving the road or overturning by providing a gentler curve
- National research shows that increasing horizontal curvature by one degree increases run off the road collisions by approximately 5%, from this information, it can be inferred that by decreasing horizontal curvature, run off the road collisions also decrease by a factor of the change in curvature.[2]

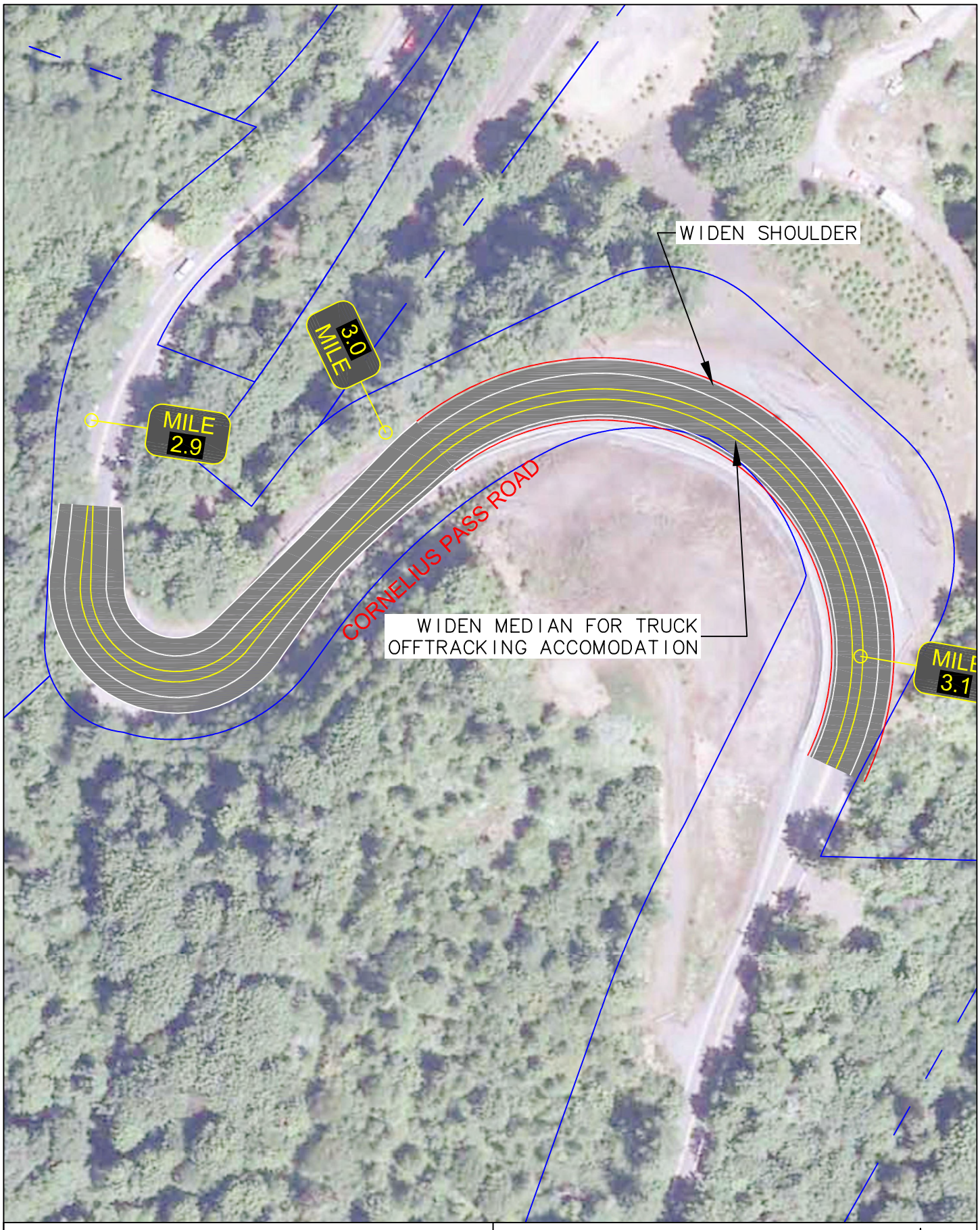
For Project 1, the shoulder widening, a preliminary benefit-cost (B/C) ratio of **0.29** was estimated based on annual benefits over 20 years and the estimated project cost of $260,000.

For Project 2, the realigning of the road to the West, a preliminary benefit-cost (B/C) ratio of **0.05** was estimated based on annual benefits over 20 years and the estimated project cost of $13,500,000.

Both projects result in a B/C ratio less than 1.00 indicating that both projects are not economically feasible because the estimated benefits fell short of the estimated cost. A copy of ODOT's completed B/C Analysis worksheet for this project is attached.

[1] Website: http://www.cmfclearinghouse.org/study_detail.cfm?stid=69. Site funded by US Department of Federal Highway Administration and maintained by the University of North Carolina Highway Safety Research Center. Accessed on November 24, 2010.

[2] Website: http://www.its.pdx.edu/CRF/CRFweb/output.php?id=150. Site funded by ODOT Research Unit and maintained by Portland State University. Accessed on December 23, 2010.

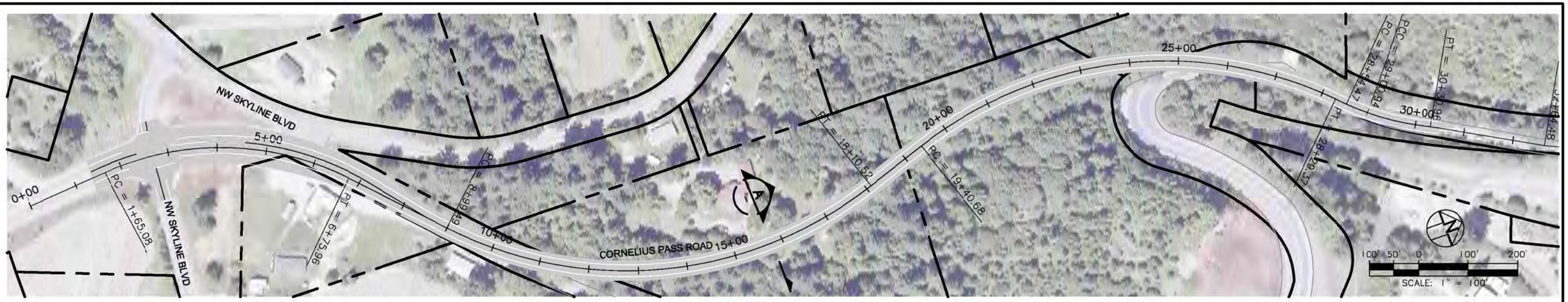


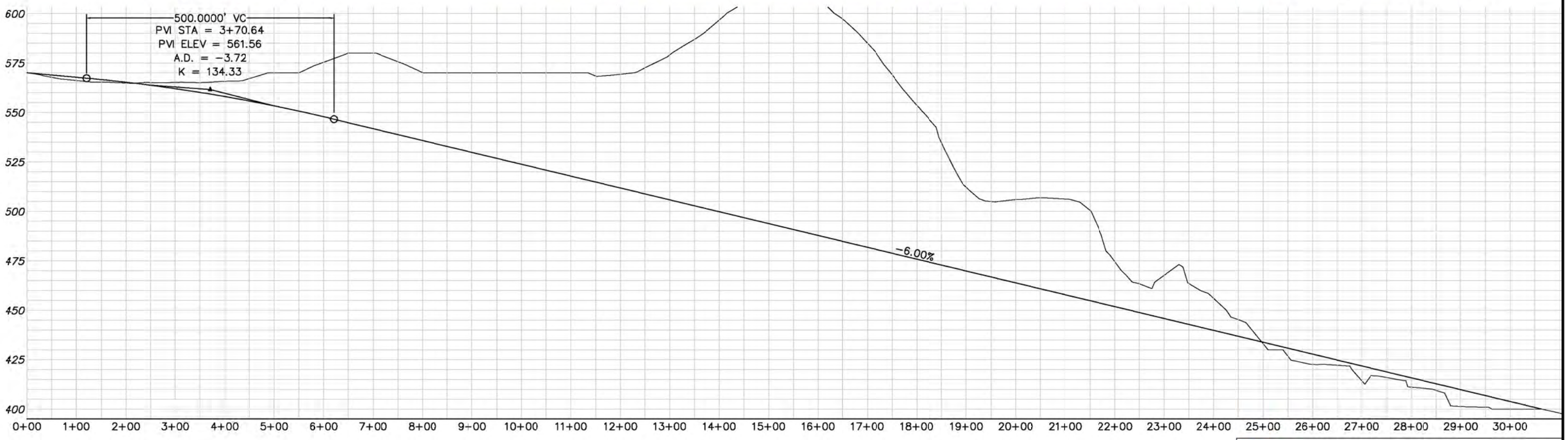
Project Area H: S Curves MP 2.8-3.3
Project 1 - Widen Shoulders

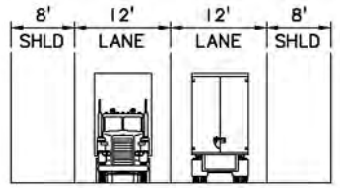
Scale: 1 inch = 100 feet

100 50 0 50 100

N







SECTION A–A

OREGON DEPARTMENT OF TRANSPORTATION

CONVERGENT PACIFIC

PROJECT AREA H: PROJECT 2 – REALIGN ROAD TO WEST
CORNELIUS PASS RAOD
WASHINGTON & MULTNOMAH COUNTIES

Reviewed By – H. LI
Designed By – M. RANDALL
Drafted By – CP CAD

PLAN AND PROFILE

SHEET NO.

Region Transportation Plan Scoping Tool
ODOT Region 1
Preliminary Design Unit And HHPR, Inc

Updated May 2007 - AJI

PROJECT DATA				
Project Name	Project H1 - Widening Shoulder	**Highway Number**		
Highway Name	Cornelius Pass	**Posted Number**		
County/City	Multnomah and Washington	**Maint. District**		
Type of Project	Rural Non Freeway	**Key No**		
		Esimated By	HL	

		Unit	Quantity	Unit Cost	Cost
SQUARE FOOT' COSTS FROM STUDY PROJECTS (Costs Inflated to January 2011 Dollars)	**Roadway & Pavement**				
	New Work	sf	7200	$ 15.00	$ 108,000.00
	2" Overlay (With Mod)	sf	7200	$ 1.00	$ 7,200.00
	2" Overlay (Pres Only)	sf		$ 4.00	$ -
	Structures				
	New Bridge Spans >120'	sf		$ 180.00	$ -
	New Bridge Spans <120'	sf		$ 125.00	$ -
	New Bridge Spans under fill	sf		$ 300.00	$ -
	Bridge Widening	sf		$ 250.00	$ -
	Retaining Walls - CIP	sf		$ 125.00	$ -
	Retaining Walls - MSE	sf		$ 85.00	$ -
	Retaining Walls - Seg.	sf		$ 35.00	$ -
	Sound Walls - Precast	sf		$ 35.00	$ -
	Miscellaneous				
	Traffic Signals	Intersection		$ 270,000.00	$ -
	Streetscape Peripherals	lf of roadway		High - $500/lf	$ -

		Unit	Quantity	Unit Cost	Cost
	Miscellaneous Items - At the Estimator's Discretion				
	Striping	LF	575	$ 2.00	$ 1,150.00
	Guardrail Removal	LF	400	$ 5.00	$ 2,000.00
	New Guardrail	LF	900	$ 20.00	$ 18,000.00
	Project Subtotal				$ 136,350.00
	Project Scope Contingencies	%	1	40%	$ 54,540.00
	CONSTRUCTION ESTIMATE TOTAL				$ 190,890.00
Other Costs	Preliminary Engineering	%	1	20%	$ 38,178.00
	Construction Engineering	%	1	15%	$ 28,633.50
	Environmental Studies	LS	1		$ -
	Right of Way	LS	1		$ -
	TOTAL PROJECT ESTIMATE				***$ 257,702***

Assumptions:

Region Transportation Plan Scoping Tool
ODOT Region 1
Preliminary Design Unit And HHPR, Inc

Updated May 2007 - AJI

PROJECT DATA				
Project Name	Project H2 - S Curve Realign-West	**Highway Number**		
Highway Name	Cornelius Pass	**Posted Number**		
County/City	Multnomah and Washington	**Maint. District**		
Type of Project	Rural Non Freeway	**Key No**		
		Esimated By	HL	

SQUARE FOOT' COSTS FROM STUDY PROJECTS (Costs Inflated to January 2011 Dollars)		Unit	Quantity	Unit Cost	Cost
	Roadway & Pavement				
	New Work	sf	120638	$ 15.00	$ 1,809,570.00
	2" Overlay (With Mod)	sf	16200	$ 1.00	$ 16,200.00
	2" Overlay (Pres Only)	sf		$ 4.00	$ -
	Structures				
	New Bridge Spans >120'	sf		$ 180.00	$ -
	New Bridge Spans <120'	sf		$ 125.00	$ -
	New Bridge Spans under fill	sf		$ 300.00	$ -
	Bridge Widening	sf		$ 250.00	$ -
	Retaining Walls - CIP	sf		$ 125.00	$ -
	Retaining Walls - MSE	sf	4500	$ 85.00	$ 382,500.00
	Retaining Walls - Seg.	sf		$ 35.00	$ -
	Sound Walls - Precast	sf		$ 35.00	$ -
	Miscellaneous				
	Traffic Signals	Intersection		$ 270,000.00	$ -
	Streetscape Peripherals	lf of roadway		High - $500/lf	$ -

		Unit	Quantity	Unit Cost	Cost
	Miscellaneous Items - At the Estimator's Discretion				
	Rock Cut	CY	118669	$ 15.00	$ 1,780,027.50
	Cut	CY	356006	$ 7.00	$ 2,492,038.50
	Embankment	CY	7639	$ 16.00	$ 122,222.22
	Project Subtotal				$ 6,602,558.22
	Project Scope Contingencies	%	1	40%	$ 2,641,023.29
	CONSTRUCTION ESTIMATE TOTAL				$ 9,243,581.51
Other Costs	Preliminary Engineering	%	1	20%	$ 1,848,716.30
	Construction Engineering	%	1	15%	$ 1,386,537.23
	Environmental Studies	LS	1	$ 100,000.00	$ 100,000.00
	Right of Way	LS*	1	$ 895,316.80	$ 895,316.80
	TOTAL PROJECT ESTIMATE				***$ 13,474,152***

Assumptions:

* Assume 200' wide ROW to allow 2:1 cut/embankment slope.
$150,000/AC including real estate attoney fees

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File Code: PRO 08 -_____-_____-_

OREGON DEPARTMENT OF TRANSPORTATION
HIGHWAY SAFETY PROJECTS
BENEFIT/COST ANALYSIS WORKSHEET

Project Name: **Cornelius Pass Road Improvement Projects** Region: **1** Date: **12/1/10**

Project on Local Agency Facility

Route Number: Street Name: **Cornelius Pass Road** MP Range or Cross Street: **MP 2.8 to 3.3**

Project on State Highway

Route Number: Hwy Name: MP From: **2.80** to **3.30**

Road Character: **RURAL** Facility Type: **OTHER STATE HIGHWAY**

County: **MULTNOMAH** City: **N/A** Crash Data From: **1/1/2003** to **12/31/2009**

Project Description: **Safety Evaluation**

Prepared By: **Project Team** Title: **Project H S-Curves**

		Fatal Crash Reduction Factor	Injury Crash Reduction Factor	PDO Crash Reduction Factor
Countermeasure 1	Widen Shoulders	9%	9%	9%
Countermeasure 2		0%	0%	0%
Countermeasure 3		0%	0%	0%
Countermeasure 4		0%	0%	0%
		9% [1]	**9%** [1]	**9%** [1]

	Number of Crashes	Number of Preventable Crashes	Economic Value per Crash		Total Economic Value
Fatal Crashes	**0**	**0.0**	$1,500,000	=	**$ -**
Severe (Injury A) Injury Crashes	**0**	**0.0**	$1,500,000	=	**$ -**
Moderate (Injury B) Injury Crashes	**2**	**0.2**	$55,000	=	**$ 10,000**
Minor (Injury C) Injury Crashes	**3**	**0.3**	$55,000	=	**$ 15,000**
PDO Crashes	**10**	**0.9**	$15,000	=	**$ 14,000**

Total Crash Value for **84** Months = **$ 39,000**

Annual Benefits = Total Crash Value / Total Months / 12 = **$ 6,000**

Estimated Project Cost = **$ 260,000**

Comprehensive Economic Value per Crash		
Highway Type	Urban	Rural
PDO [3]		
All facilities	$15,000	$15,000
Moderate (Injury B) and Minor (Injury C) Injury [4]		
Interstate	$48,900	$54,800
Other State Highway	$47,900	$55,000
Fatal and Severe (Injury A) Injury [4]		
Interstate	$850,000	$1,460,000
Other State Highway	$840,000	$1,500,000

Uniform Series Present Worth Factor (5%)	
10 years	20 years
7.72	12.46

B/C Ratio = Annual Benefits X Present Worth Factor (10 or 20 years) / Estimated Project Cost

B/C Ratio = $ 6,000 x 12.46 [2] = **0.29**

$ 260,000

Notes

1 Composite crash reduction factor calculated if more than one countermeasure is applied

2 Select a PWF for the life of countermeasure. See instructions

3 PDO value is $7,500 per crash adjusted with an under reporting factor of 2.0. National Safety Council, 2005 estimates of value per crash.

4 Economic costs per crash are calculated using 2004-2006 Oregon crash data and FHWA's Technical Advisory "Motor Vehicle Accident Costs, T 7570.2, October 31, 1994 updated to 2007 dollars with GDP implicit price deflator.

OREGON DEPARTMENT OF TRANSPORTATION
HIGHWAY SAFETY PROJECTS
BENEFIT/COST ANALYSIS WORKSHEET

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File Code: PRO 08 -_____-_____

Project Name: **Cornelius Pass Road Improvement Projects** Region: **1** Date: **12/1/10**

Project on Local Agency Facility

Route Number: Street Name: **Cornelius Pass Road** MP Range or Cross Street: **MP 2.8 to 3.3**

Project on State Highway

Route Number: Hwy Name: MP From: **2.80** to **3.30**

Road Character: **RURAL** Facility Type: **OTHER STATE HIGHWAY**

County: **MULTNOMAH** City: **N/A** Crash Data From: **1/1/2003** to **12/31/2009**

Project Description: **Safety Evaluation**

Prepared By: **Project Team** Title: **Project H S-Curves (Realignment)**

		Fatal Crash Reduction Factor	Injury Crash Reduction Factor	PDO Crash Reduction Factor
Countermeasure 1	Improve Horizontal Curve (25mph)	53%	53%	53%
Countermeasure 2	Improve Horizontal Curve (15mph)	71%	71%	71%
Countermeasure 3		0%	0%	0%
Countermeasure 4		0%	0%	0%
		86% [1]	**86%** [1]	**86%** [1]

	Number of Crashes	Number of Preventable Crashes	Economic Value per Crash		Total Economic Value
Fatal Crashes	**0**	**0.0**	$1,500,000	=	**$ -**
Severe (Injury A) Injury Crashes	**0**	**0.0**	$1,500,000	=	**$ -**
Moderate (Injury B) Injury Crashes	**2**	**1.7**	$55,000	=	**$ 95,000**
Minor (Injury C) Injury Crashes	**3**	**2.6**	$55,000	=	**$ 143,000**
PDO Crashes	**10**	**8.6**	$15,000	=	**$ 130,000**

Total Crash Value for **84** Months = **$ 368,000**

Annual Benefits = Total Crash Value / Total Months / 12 = **$ 53,000**

Estimated Project Cost = **$ 13,500,000**

Comprehensive Economic Value per Crash		
Highway Type	Urban	Rural
PDO [3]		
All facilities	$15,000	$15,000
Moderate (Injury B) and Minor (Injury C) Injury [4]		
Interstate	$48,900	$54,800
Other State Highway	$47,900	$55,000
Fatal and Severe (Injury A) Injury [4]		
Interstate	$850,000	$1,460,000
Other State Highway	$840,000	$1,500,000

Uniform Series Present Worth Factor (5%)	
10 years	20 years
7.72	12.46

B/C Ratio = Annual Benefits X Present Worth Factor (10 or 20 years) / Estimated Project Cost

B/C Ratio = $ 53,000 x 12.46 [2] = **0.05**

$ 13,500,000

Notes

1 Composite crash reduction factor calculated if more than one countermeasure is applied

2 Select a PWF for the life of countermeasure. See instructions

3 PDO value is $7,500 per crash adjusted with an under reporting factor of 2.0. National Safety Council, 2005 estimates of value per crash.

4 Economic costs per crash are calculated using 2004-2006 Oregon crash data and FHWA's Technical Advisory "Motor Vehicle Accident Costs, T 7570.2, October 31, 1994 updated to 2007 dollars with GDP implicit price deflator.

Project Area I – Skyline Boulevard Intersection

- **Project 1 – Construct a Single Lane Roundabout**
- **Project 2 – Realignment and Access Management Hybrid**

Project Area I: Roundabout at Skyline Boulevard Intersection

Safety Concern:

At the Skyline Boulevard intersection there is a high occurrence (54) of collisions over a seven-year period (2003 – 2009), which represents approximately 32% for the crashes along the 5-mile corridor. Approximately 21% of these collisions are either injury "A" or "B". Roughly 41% of all reported collisions are either angle, turning, or read-end crashes (all crash types typical at an unsignalized intersection). Sixty eight percent of the collisions occur during morning and evening commute periods.

The intersection is located along an alignment with a short undesirable tangent between two curves in the same direction (broken-back arrangement of curves with radii of approximately 565 and 655 feet, respectively). The grocery store located in the northeast corner of the intersection currently has two fairly wide driveways (north and south of building) with no defined access points along Cornelius Pass Road, which likely also contributes to the safety concerns at this location.

Photographs

View Southbound

View Northbound

Proposed Improvement: Roundabout

The proposed improvements at the Skyline Boulevard intersection entail the following:

- Construct a single-lane roundabout with an inscribed diameter of approximately 160 feet as an alternative intersection control.
- Provide landscape screening between Cornelius Pass Road and Old Cornelius Pass Road.
- Provide a northbound left-turn at the Plainview Road intersection.
- Consolidate the grocery store's driveways into one well defined access point immediately south of the existing building with a southbound left off Cornelius pass Road.
- Realign the west leg of the intersection to be continuous with Old Cornelius Pass Road to the south.
- Relocate existing utilities as needed.
- Provide intersection roadway lighting.
- Negotiate with the property owner in the northeast corner of the intersection regarding property impact (i.e., acquisition, access, and on-site circulation.)
- Obtain temporary construction easements as needed for proposed improvements.

These improvements are illustrated in the attached exhibit.

Preliminary Cost Estimate

The conceptual project cost estimate of $3.746 million includes the following:

- Construction cost (incl. 40% contingency) = $2.716 million
- Engineering (35%) = $950,000
- Right-of-way acquisition = $80,000

Key assumptions are:

- Based on aerial photography
- Incidental earthwork anticipated
- No geotechnical stabilization anticipated
- Landscaping consistent with minimum guidelines
- No environmentally sensitive areas
- Roadway lighting

A breakdown of the conceptual cost estimate is provided in the attachment.

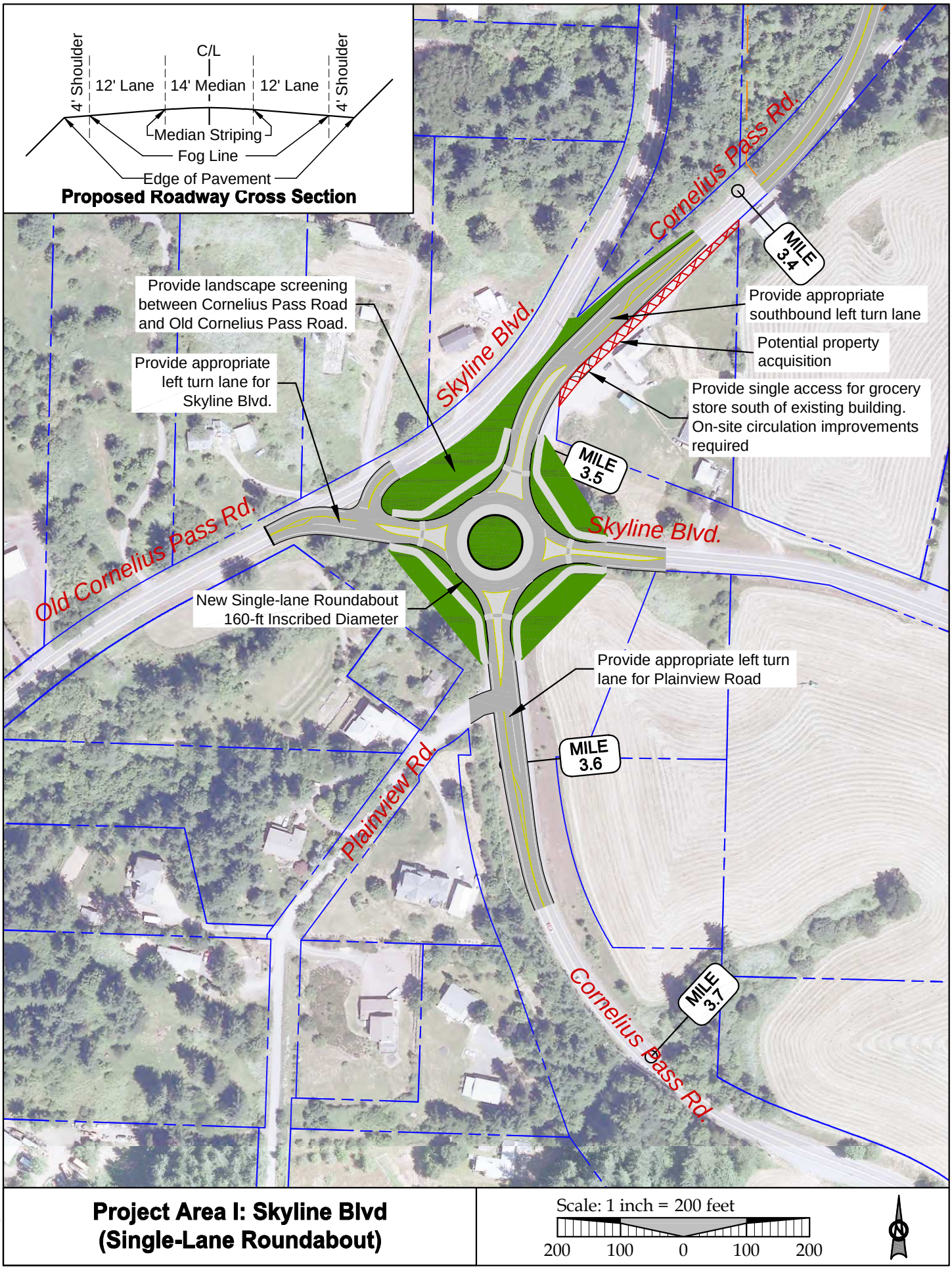
How is the safety concern addressed?

The proposed improvements address several safety concerns:

- The proposed ***single-lane roundabout*** alternative can improve safety and operations at this intersection by reducing the number of conflict points while providing additional capacity.
  - National research shows that the conversion of two-way stop controlled intersections to roundabouts can result in a decrease in total crashes of approximately 71% and a reduction in injury/fatal crashes by approximately 87%. [1]
- Consolidating the grocery store driveways into a well-defined unsignalized driveway will reduce the number of conflict points along Cornelius Pass Road.
- The introduction of appropriate left-turn lanes at the grocery store driveway and the Plainview Road intersection would move the decelerating turning movements from the through lane and would reduce the rear-end collisions.
  - National research indicates installing a left turn lane on a single major approach (on rural roads) results in a potential decrease of all crash types by 44%, and injury crashes by 55%.[2]
- Motorists approaching the roundabout will be slowed down by introducing cross sectional changes such as curbing and raised medians (i.e., splitter islands).
  - National research shows a positive effect by the introduction of a roundabout, approaching curvature, and splitter islands. [3] In addition, the entries of the roundabout will be design to slow traffic to 20-25 mph. Therefore, there is no need to realign the approaching to eliminate the existing broken-back arrangement of curves.
- The roadway lighting would emphasize the existence of the Plainview Road intersection and grocery store driveway, as well as lit the entries and exits at the roundabout.
  - Research summarized by ODOT indicates the potential to reduce nighttime crashes near intersections by approximately 23%.[2]

A preliminary benefit-cost (B/C) ratio of 2.61 was estimated based on annual benefits over 20 years and the estimated project cost of $3.746 million. A project resulting in B/C ratios greater than 1.00 indicate the project is economically valid because the estimated benefits exceed the estimated cost. A copy of ODOT's completed B/C Analysis worksheet for this project is attached.

[1] American Association of State Highway Transportation Officials (AASHTO), *Highway Safety Manual (HSM), 1st Edition*, 2010.
[2] Oregon Department of Transportation (ODOT) Crash Reduction Factor (CRF) Website: http://its.pdx.edu/CRF/CRFweb/.



Project Area I: Skyline Blvd (Single-Lane Roundabout)

Scale: 1 inch = 200 feet

200 100 0 100 200

PROJECT DATA				
PROJECT NAME	Cornelius Pass - Safety Study	**PROJECT AREA**	Project Area I
HIGHWAY NAME	Cornelius Pass Road	**PROJECT NUMBER**	Roundabout
COUNTY/CITY	Multnomah County	**MILE POST/INTER.**	Skyline Blvd
ESTIMATE CLASSIFICATION	CLASS IV (Per AACE)	**ESTIMATED BY**	JTE/JDH

PROJECT CONSTRUCTION COSTS		Unit	Quantity	Unit Cost	Cost
	Demolition/ Site Management				
	Clearing and Grubbing	SF	86,250	$2.50	$215,625
	Erosion Control	LS	1	$58,000	$58,000
	Traffic Control	LS	1	$194,000	$194,000
	Roadway and Pavement				
	New Road - Low Earthwork	SF	86,250	$15.00	$1,293,750
	Driveways	EA	1	$2,500.00	$2,500
	Signing/Delineation	LS	1	$19,500.00	$19,500
	Street Lighting	LS	1	$87,500.00	$87,500
	Landscaping	SF	46,000	$1.50	$69,000
	Structures				
	Miscellaneous				

		Unit	Quantity	Unit Cost	Cost
	Miscellaneous Items - At the Estimator's Discretion				
	Project Subtotal				$1,939,875
	Project Scope Contingencies	%	$1,939,875	40%	$775,950
	CONSTRUCTION ESTIMATE TOTAL				$2,716,000

OTHER COSTS					
	Preliminary Engineering	LS	1	*20% of Construction	$543,000
	Construction Engineering	LS	1	*15% of Construction	$407,000
	Right-of-Way Acquisition	SF	8,000	$10.00	$80,000

TOTAL PROJECT ESTIMATE ***$3,746,000***

** rounded value = nearest $1,000*

Key Assumptions:

- This estimate is based off of 2009 aerial photography and Multnomah County GIS resources
- Earthwork will be incidental and no geotechnical stabilization will be required
- An assumed allowance for utility construction is included in new roadway pricing
- New landscaping will consist of minimum standard
- No environmentally sensitive areas will be disturbed beyond exemption thresholds

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OREGON DEPARTMENT OF TRANSPORTATION
HIGHWAY SAFETY PROJECTS
BENEFIT/COST ANALYSIS WORKSHEET

Project Name: **Cornelius Pass Road Improvement Projects** Region: **1** Date: **12/1/10**

Project on Local Agency Facility

Route Number: Street Name: **Cornelius Pass Road** MP Range or Cross Street: **Skyline**

Project on State Highway

Route Number: Hwy Name: MP From: **3.45** to **3.65**

Road Character: **RURAL** Facility Type: **OTHER STATE HIGHWAY**

County: **MULTNOMAH** City: **N/A** Crash Data From: **1/1/2003** to **12/31/2009**

Project Description: **Safety Evaluation**

Prepared By: **Project Team** Title: **Project I Skyline Boulevard**

		Fatal Crash Reduction Factor	Injury Crash Reduction Factor	PDO Crash Reduction Factor
Countermeasure 1	Roundabout	87%	87%	71%
Countermeasure 2	Left-turns at Plainview and Grocery Store	55%	55%	44%
Countermeasure 3		0%	0%	0%
Countermeasure 4		0%	0%	0%
		94% [1]	**94%** [1]	**84%** [1]

	Number of Crashes	Number of Preventable Crashes	Economic Value per Crash		Total Economic Value
Fatal Crashes	**0**	**0.0**	$1,500,000	=	$ -
Severe (Injury A) Injury Crashes	**3**	**2.8**	$1,500,000	=	$ 4,237,000
Moderate (Injury B) Injury Crashes	**8**	**7.5**	$55,000	=	$ 414,000
Minor (Injury C) Injury Crashes	**8**	**7.5**	$55,000	=	$ 414,000
PDO Crashes	**35**	**29.3**	$15,000	=	$ 440,000

Comprehensive Economic Value per Crash		
Highway Type	Urban	Rural
PDO [3]		
All facilities	$15,000	$15,000
Moderate (Injury B) and Minor (Injury C) Injury [4]		
Interstate	$48,900	$54,800
Other State Highway	$47,900	$55,000
Fatal and Severe (Injury A) Injury [4]		
Interstate	$850,000	$1,460,000
Other State Highway	$840,000	$1,500,000

Total Crash Value for **84** Months = **$ 5,505,000**

Annual Benefits = Total Crash Value / Total Months / 12 = **$ 786,000**

Estimated Project Cost = **$ 3,746,000**

Uniform Series Present Worth Factor (5%)	
10 years	20 years
7.72	12.46

B/C Ratio = Annual Benefits X Present Worth Factor (10 or 20 years) / Estimated Project Cost

B/C Ratio = $ 786,000 x 12.46 [2] = **2.61**

$ 3,746,000

Notes

1 Composite crash reduction factor calculated if more than one countermeasure is applied

2 Select a PWF for the life of countermeasure. See instructions

3 PDO value is $7,500 per crash adjusted with an under reporting factor of 2.0. National Safety Council, 2005 estimates of value per crash.

4 Economic costs per crash are calculated using 2004-2006 Oregon crash data and FHWA's Technical Advisory "Motor Vehicle Accident Costs, T 7570.2, October 31, 1994 updated to 2007 dollars with GDP implicit price deflator.

Project Area I: Skyline Blvd Intersection – Realignment & Access Management

Safety Concern:
At the Skyline Boulevard intersection there is a high occurrence (54) of collisions over a seven-year period (2003 – 2009), which represents approximately 32% for the crashes along the 5-mile corridor. Approximately 21% of these collisions are either injury "A" or "B". Roughly 41% of all reported collisions are either angle, turning, or read-end crashes (all crash types typical at an unsignalized intersection). Sixty eight percent of the collisions occur during morning and evening commute periods.

The intersection is located along an alignment with a short undesirable tangent between two curves in the same direction (broken-back arrangement of curves with radii of approximately 565 and 655 feet, respectively). The grocery store located in the northeast corner of the intersection currently has two fairly wide driveways (north and south of building) with no defined access points along Cornelius Pass Road, which likely also contributes to the safety concerns at this location.

Photographs


View Southbound


View Northbound


View Southbound

Proposed Improvement: Realignment & Access Management

The proposed improvements at the Skyline Boulevard intersection entail the following:

- Provide an approximately 850-foot circular curve on Cornelius Pass Road to eliminate the broken-back arrangement of curves.
- Improve existing left-turn lanes at the Skyline Boulevard intersection
- Improve intersection sight distance by cutting into the embankment in the southeast intersection corner.
- Provide landscape screening between Cornelius Pass Road and Old Cornelius Pass Road.
- Provide a northbound left-turn at the Plainview Road intersection.
- Negotiate with the property owner in the northeast intersection corner (i.e., building impact). Provide one consolidated access to property in northeast intersection corner.
- Provide appropriate stopping sight distance along Cornelius Pass Road by cutting into the embankment along the inside of the curve.
- Relocate existing utilities as needed.
- Provide intersection roadway lighting.
- Obtain temporary construction easements as needed for proposed improvements.

These improvements are illustrated in the attached exhibit.

Preliminary Cost Estimate

The conceptual project cost estimate of $5.304 million includes the following:

- Construction cost (incl. 40% contingency) = $3.367 million
- Engineering (35%) = $1.178 million
- Right-of-way acquisition = $759,000

Key assumptions are:

- Based on aerial photography
- Incidental earthwork anticipated
- No geotechnical stabilization anticipated
- Landscaping consistent with minimum guidelines
- No environmentally sensitive areas
- Roadway lighting

A breakdown of the conceptual cost estimate is provided in the attachment.

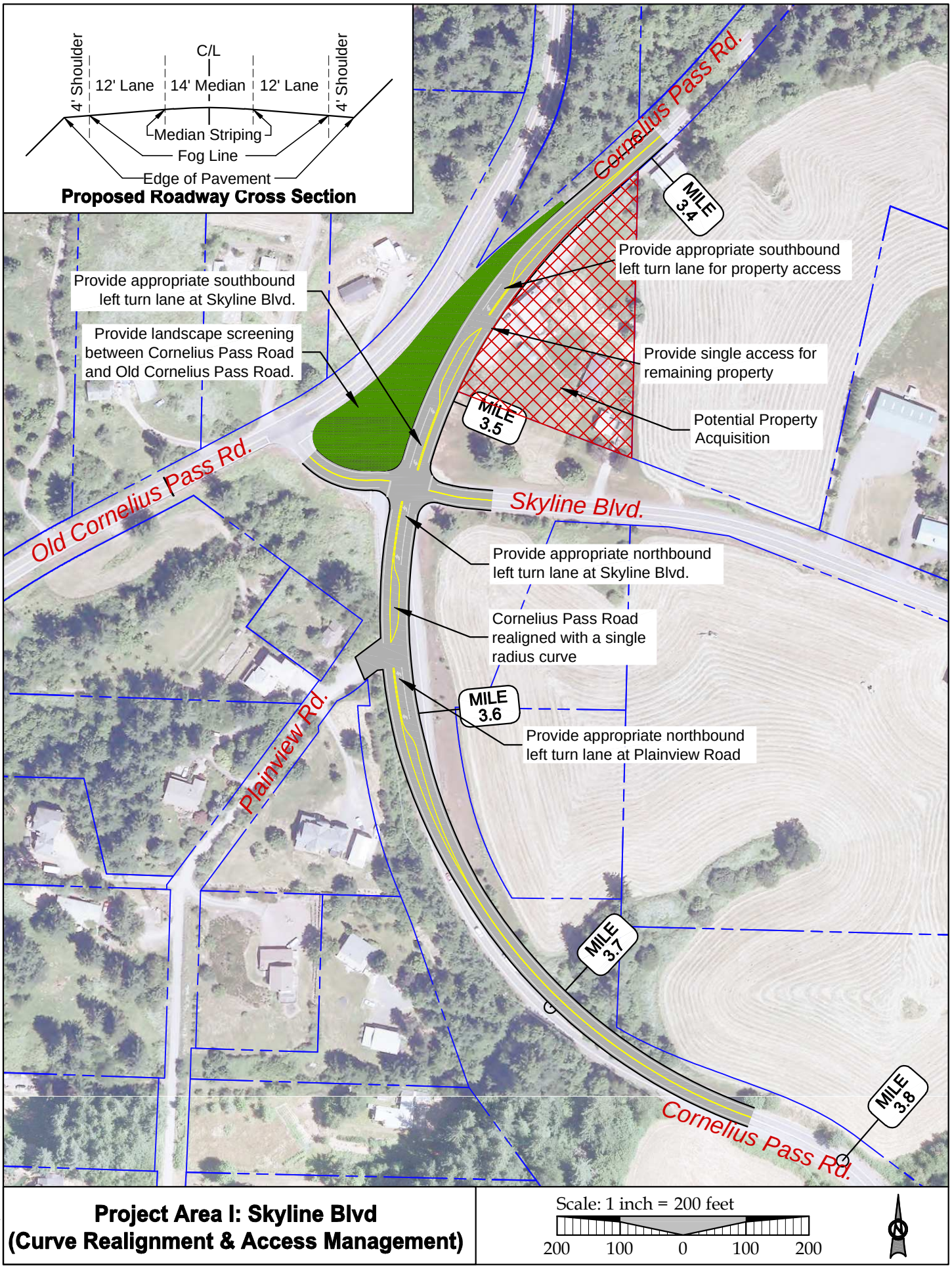
How is the safety concern addressed?

The proposed improvements address several safety concerns:

- Eliminating the broken-back arrangement of curves with the introduction of an approximately 850-foot circular curve would meet driver expectancy, especially for the through traffic along Cornelius Pass Road, which represents approximately 85-90% of the traffic at this intersection.
    - National research shows that increasing horizontal curvature by one degree increases run off the road collisions by approximately 5%, from this information, it can be inferred that by decreasing horizontal curvature, run off the road collisions also decrease by a factor of the change in curvature. [1]
    - AASHTO's *Highway Safety Manual, 1st Edition* contains an equation to calculate the potential reduction in crashes for a given horizontal curve based on curve length, radius, and the presence of spiral transition. This information was used to estimate the specific potential crash reductions for the proposed horizontal curvature within this project.[2]
- Providing one consolidated driveways into the property in the northeast corner of the intersection will reduce the number of conflict points along the highway.
- The introduction of appropriate left-turn lanes at the Skyline Boulevard intersection, the consolidated driveway for the property in the northeast corner, and the Plainview Road intersection would move the decelerating turning movements from the through lane and likely reduce the rear-end collisions.
    - Research summarized by ODOT indicates installing a left turn lane on a single major approach (on rural roads) can potentially decrease all crash types by 44%, and fatal/injury crashes by 55%.[3]
- The roadway lighting would emphasize the existence of the intersections along this segment of Cornelius Pass Road.
    - Research summarized by ODOT indicates the potential to reduce nighttime crashes near intersections by approximately 23%.[3]
- Clearing along insides of curves provides appropriate stopping sight distance.
    - National research shows that the removal of roadside obstacles in the clear zone can reduce collisions by 22% to 44% depending on the increase in clear zone. [2]
    - Research summarized by ODOT also indicates widening the shoulder (which has the physical affect of increasing sight distance on curves) can decrease collisions by 5% to 12% depending on the increase in shoulder width.[3]

A preliminary benefit-cost (B/C) ratio of 1.24 was estimated based on annual benefits over 20 years and the estimated project cost of $5.304 million. A project resulting in B/C ratios greater than 1.00 indicate the project is economically valid because the estimated benefits exceed the estimated cost. A copy of ODOT's completed B/C Analysis worksheet for this project is attached.

[1] Website: http://www.cmfclearinghouse.org/study_detail.cfm?stid=30 Site funded by US Department of Federal Highway Administration and maintained by the University of North Carolina Highway Safety Research Center. Accessed on November 24, 2010.
[2] American Association of State Highway Transportation Officials (AASHTO), *Highway Safety Manual (HSM), 1st Edition*, 2010.
[3] Oregon Department of Transportation (ODOT) Crash Reduction Factor (CRF) Website: http://its.pdx.edu/CRF/CRFweb/.



Project Area I: Skyline Blvd
(Curve Realignment & Access Management)

Scale: 1 inch = 200 feet

200 100 0 100 200

PROJECT DATA				
PROJECT NAME	Cornelius Pass - Safety Study	**PROJECT AREA**	Project Area I
HIGHWAY NAME	Cornelius Pass Road	**PROJECT NUMBER**	Curve Alignment
COUNTY/CITY	Multnomah County	**MILE POST/INTER.**	Skyline Blvd
ESTIMATE CLASSIFICATION	CLASS IV (Per AACE)	**ESTIMATED BY**	JTE/JDH

PROJECT CONSTRUCTION COSTS		Unit	Quantity	Unit Cost	Cost
	Demolition/ Site Management				
	Clearing and Grubbing	SF	87,400	$2.50	$218,500
	Erosion Control	LS	1	$72,000	$72,000
	Traffic Control	LS	1	$240,500	$240,500
	Roadway and Pavement				
	New Road - Low Earthwork	SF	30,000	$15.00	$450,000
	New Road - High Earthwork	SF	57,500	$21.00	$1,207,500
	Signing/Delineation	LS	1	$24,000.00	$24,000
	Landscaping	SF	56,500	$1.50	$84,750
	Street Lighting	LS	1	$108,000.00	$108,000
	Structures				
	Miscellaneous				

		Unit	Quantity	Unit Cost	Cost
	Miscellaneous Items - At the Estimator's Discretion				
	Project Subtotal				$2,405,250
	Project Scope Contingencies	%	$2,405,250	40%	$962,100
	CONSTRUCTION ESTIMATE TOTAL				$3,367,000

OTHER COSTS					
	Preliminary Engineering	LS	1	*20% of Construction	$673,000
	Construction Engineering	LS	1	*15% of Construction	$505,000
	Right-of-Way Acquisition	SF	75,900	$10.00	$759,000

TOTAL PROJECT ESTIMATE ***$5,304,000***

** rounded value = nearest $1,000*

Key Assumptions:

- This estimate is based off of 2009 aerial photography and Multnomah County GIS resources
- An assumed allowance for utility construction is included in new roadway pricing
- New landscaping will consist of minimum standard
- No environmentally sensitive areas will be disturbed beyond exemption thresholds

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OREGON DEPARTMENT OF TRANSPORTATION
HIGHWAY SAFETY PROJECTS
BENEFIT/COST ANALYSIS WORKSHEET

Project Name: **Cornelius Pass Road Improvement Projects** Region: **1** Date: **12/1/10**

Project on Local Agency Facility

Route Number: Street Name: **Cornelius Pass Road** MP Range or Cross Street: **Skyline**

Project on State Highway

Route Number: Hwy Name: MP From: **3.45** to **3.65**

Road Character: **RURAL** Facility Type: **OTHER STATE HIGHWAY**

County: **MULTNOMAH** City: **N/A** Crash Data From: **1/1/2003** to **12/31/2009**

Project Description: **Safety Evaluation**

Prepared By: **Project Team** Title: **Project I (Hybrid) Skyline Boulevard**

		Fatal Crash Reduction Factor	Injury Crash Reduction Factor	PDO Crash Reduction Factor
Countermeasure 1	Intersection Sight Distance	13%	13%	13%
Countermeasure 2	Horizontal Curve	57%	57%	57%
Countermeasure 3		0%	0%	0%
Countermeasure 4		0%	0%	0%
		63% [1]	**63%** [1]	**63%** [1]

	Number of Crashes	Number of Preventable Crashes	Economic Value per Crash		Total Economic Value
Fatal Crashes	**0**	**0.0**	$1,500,000	=	**$ -**
Severe (Injury A) Injury Crashes	**3**	**1.9**	$1,500,000	=	**$ 2,817,000**
Moderate (Injury B) Injury Crashes	**8**	**5.0**	$55,000	=	**$ 275,000**
Minor (Injury C) Injury Crashes	**8**	**5.0**	$55,000	=	**$ 275,000**
PDO Crashes	**35**	**21.9**	$15,000	=	**$ 329,000**

Comprehensive Economic Value per Crash		
Highway Type	Urban	Rural
PDO [3]		
All facilities	$15,000	$15,000
Moderate (Injury B) and Minor (Injury C) Injury [4]		
Interstate	$48,900	$54,800
Other State Highway	$47,900	$55,000
Fatal and Severe (Injury A) Injury [4]		
Interstate	$850,000	$1,460,000
Other State Highway	$840,000	$1,500,000

Total Crash Value for **84** Months = **$ 3,696,000**

Annual Benefits = Total Crash Value / Total Months / 12 = **$ 528,000**

Estimated Project Cost = **$ 5,304,000**

Uniform Series Present Worth Factor (5%)	
10 years	20 years
7.72	12.46

B/C Ratio = Annual Benefits X Present Worth Factor (10 or 20 years) / Estimated Project Cost

B/C Ratio = $ 528,000 x 12.46 [2] / $ 5,304,000 = **1.24**

Notes

1 Composite crash reduction factor calculated if more than one countermeasure is applied

2 Select a PWF for the life of countermeasure. See instructions

3 PDO value is $7,500 per crash adjusted with an under reporting factor of 2.0. National Safety Council, 2005 estimates of value per crash.

4 Economic costs per crash are calculated using 2004-2006 Oregon crash data and FHWA's Technical Advisory "Motor Vehicle Accident Costs, T 7570.2, October 31, 1994 updated to 2007 dollars with GDP implicit price deflator.

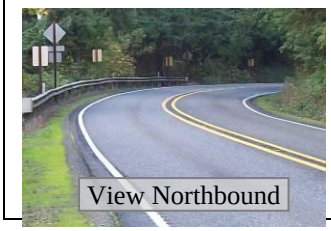
Project Area K – Horizontal Curve North of Kaiser Road, MP 4.5

- **Project 1 – Increase Stopping Sight Distance Through Curve**

Project Area K: Horizontal Curve North of Kaiser Road

Safety Concern: On the horizontal curve approximately 500 feet north of the Kaiser Road intersection, there have been four collisions that resulted in a fatality, a debilitating injury (type "A"), and a severe injury (type "B), over the last seven years. Approximately 50% of the collisions were overturning with one of these resulting in a fatality. The remaining two collisions included a rear-end collision and a head-on collision that resulted in injury types "A" or "B'. The embankment and vegetation on the curve north of Kaiser Road limits stopping sight distances through the curve, creating a potential hazard for drivers. Note that curve warning signs and guardrail are currently present.

Sight distance from the middle of the curve northbound is approximately 260 feet, and southbound is approximately 275 feet. The required stopping sight distance for this curve is 350 feet in the northbound direction and 380 feet in the southbound direction, so the current stopping sight distances are 100 feet shy of the required distance.

Photos	**Proposed Improvement: Increase Stopping Distance**
 View Southbound  View Northbound  View Southbound	The proposed project improves stopping sight distance around the curve by creating a clear zone of vegetation and hillside. The clear zone would be created on the east side of the roadway, and could be up to 45 feet horizontally from the fog line of the roadway. The extents of this project would be approximately 900 feet in length, around the horizontal curve. Assuming a design speed of 45 mph the required stopping sight distance is 380 feet in the southbound direction and 350 feet in the northbound direction. These stopping sight distances assume a 3% grade (with no grade the stopping sight distance would be 360 feet).

Preliminary Cost Estimate

The conceptual project cost estimate of $1,300,000 includes the following:

- Construction cost (incl. 40% contingency)= $965,000
- Engineering (35%) = $335,000
- Right-of-way acquisition = $0

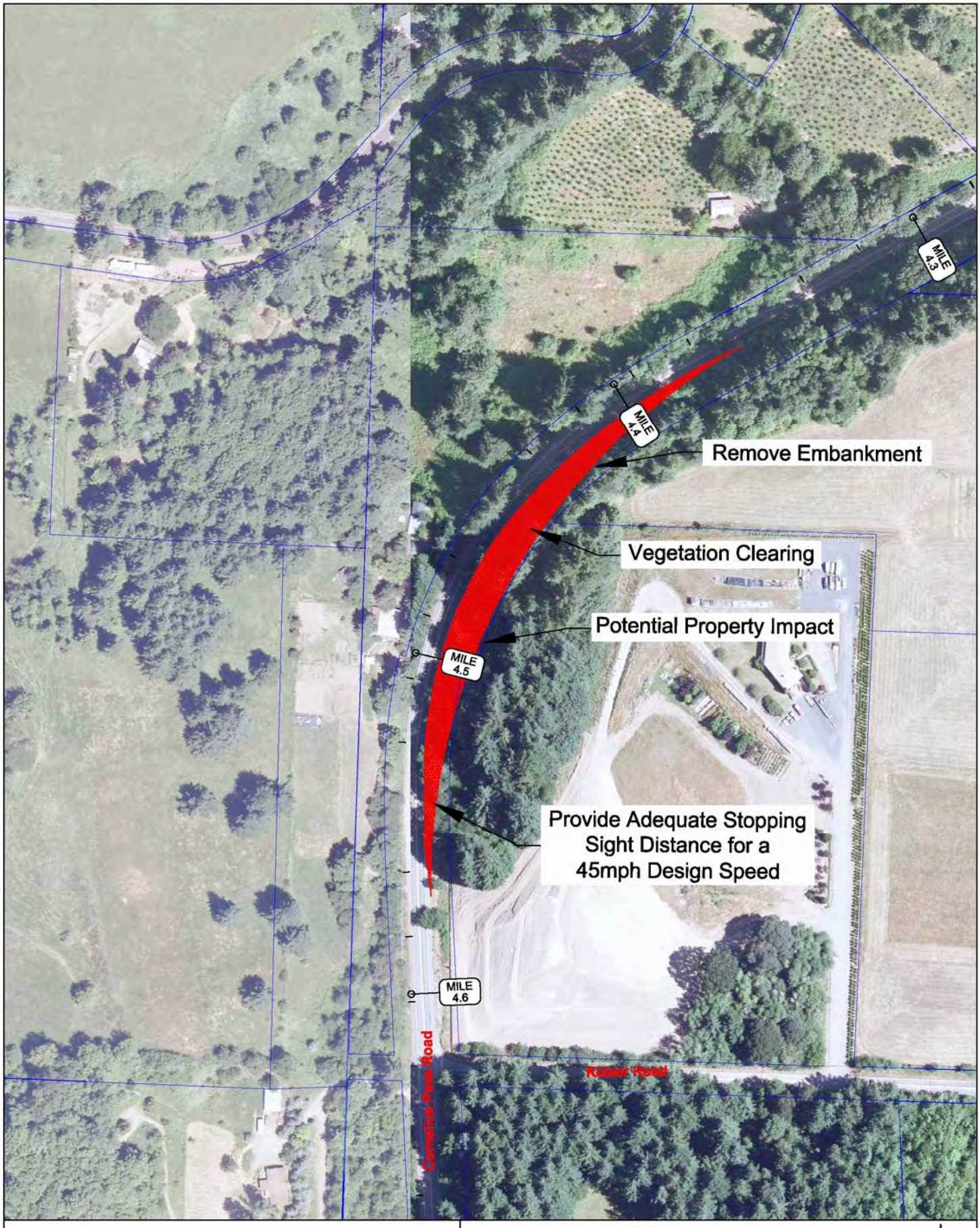
Key assumptions are:

- Cost estimates are based on limited survey information
- It is assumed that this project does not require additional right of way
- Minimal embankment stabilization
- No roadway lighting is included in this cost

A breakdown of the conceptual cost estimate is provided in the attachment.

How is the safety concern addressed?
The proposed improvement addresses many safety concerns: • The removal of material at this location will allow for a recoverable clear zone. • The clear zone will meet the requirements for stopping sight distance along the curve. • National research shows that the removal of roadside obstacles in the clear zone can reduce collisions by 22% to 44% depending on the increase in clear zone. [1] • The clearing activities will allow for a widened shoulder which provides additional recovery room. A preliminary benefit-cost (B/C) ratio of **1.31** was estimated based on annual benefits over 20 years and the estimated project cost of $1,300,000. A copy of ODOT's completed B/C Analysis worksheet is attached.

[1] Website: http://www.cmfclearinghouse.org/study_detail.cfm?stid=14 Site funded by US Department of Federal Highway Administration and maintained by the University of North Carolina Highway Safety Research Center. Accessed on November 24, 2010.



Project Area K: Project 1- Curve MP 4.5 (Sight Distance Improvements)

Scale: 1 inch = 200 feet

200 100 0 100 200

Region Transportation Plan Scoping Tool
ODOT Region 1
Preliminary Design Unit And HHPR, Inc

Updated May 2007 - AJI

PROJECT DATA				
Project Name	Project K1 - Kaiser Curve	**Highway Number**		
Highway Name	Cornelius Pass	**Posted Number**		
County/City	Multnomah and Washington	**Maint. District**		
Type of Project	Rural Non Freeway	**Key No**		
		Esimated By	HL	

SQUARE FOOT' COSTS FROM STUDY PROJECTS (Costs Inflated to January 2011 Dollars)		Unit	Quantity	Unit Cost	Cost
	Roadway & Pavement				
	New Work	sf	34000	$ 15.00	$ 510,000.00
	2" Overlay (With Mod)	sf	8000	$ 1.00	$ 8,000.00
	2" Overlay (Pres Only)	sf		$ 4.00	$ -
	Structures				
	New Bridge Spans >120'	sf		$ 180.00	$ -
	New Bridge Spans <120'	sf		$ 125.00	$ -
	New Bridge Spans under fill	sf		$ 300.00	$ -
	Bridge Widening	sf		$ 250.00	$ -
	Retaining Walls - CIP	sf		$ 125.00	$ -
	Retaining Walls - MSE	sf		$ 85.00	$ -
	Retaining Walls - Seg.	sf		$ 35.00	$ -
	Sound Walls - Precast	sf		$ 35.00	$ -
	Miscellaneous				
	Traffic Signals	Intersection		$ 270,000.00	$ -
	Streetscape Peripherals	lf of roadway		High - $500/lf	$ -

		Unit	Quantity	Unit Cost	Cost
	Miscellaneous Items - At the Estimator's Discretion				
	Rock Cut	CY	500	$ 15.00	$ 7,500.00
	Cut	CY	10667	$ 7.00	$ 74,666.67
	Vegetation Clearing	LS	1	$ 10,000.00	$ 10,000.00
	Project Subtotal				$ 610,166.67
	Project Scope Contingencies	%	1	40%	$ 244,066.67
	CONSTRUCTION ESTIMATE TOTAL				$ 854,233.33
Other Costs	Preliminary Engineering	%	1	20%	$ 170,846.67
	Construction Engineering	%	1	15%	$ 128,135.00
	Environmental Studies	LS	1	$ 10,000.00	$ 10,000.00
	Right of Way	LS	1	$ 100,000.00	$ 100,000.00
	TOTAL PROJECT ESTIMATE				***$ 1,263,215***

Assumptions:

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OREGON DEPARTMENT OF TRANSPORTATION
HIGHWAY SAFETY PROJECTS
BENEFIT/COST ANALYSIS WORKSHEET

Project Name: **Cornelius Pass Road Improvement Projects** Region: **1** Date: **12/1/10**

Project on Local Agency Facility

Route Number: Street Name: **Cornelius Pass Road** MP Range or Cross Street: **Kaiser Road**

Project on State Highway

Route Number: Hwy Name: MP From: **4.40** to **4.50**

Road Character: **RURAL** Facility Type: **OTHER STATE HIGHWAY**

County: **MULTNOMAH** City: **N/A** Crash Data From: **1/1/2003** to **12/31/2009**

Project Description: **Safety Evaluation**

Prepared By: **Project Team** Title: **Project K Curve North of Kaiser Road**

		Fatal Crash Reduction Factor	Injury Crash Reduction Factor	PDO Crash Reduction Factor
Countermeasure 1	Increase Shoulder Width	12%	12%	12%
Countermeasure 2	Increase Distance to Roadside Obstacle	22%	22%	22%
Countermeasure 3		0%	0%	0%
Countermeasure 4		0%	0%	0%
		31% [1]	**31%** [1]	**31%** [1]

	Number of Crashes	Number of Preventable Crashes	Economic Value per Crash		Total Economic Value
Fatal Crashes	**1**	**0.3**	$1,500,000	=	**$ 470,000**
Severe (Injury A) Injury Crashes	**1**	**0.3**	$1,500,000	=	**$ 470,000**
Moderate (Injury B) Injury Crashes	**1**	**0.3**	$55,000	=	**$ 17,000**
Minor (Injury C) Injury Crashes	**0**	**0.0**	$55,000	=	**$ -**
PDO Crashes	**1**	**0.3**	$15,000	=	**$ 5,000**

Comprehensive Economic Value per Crash		
Highway Type	Urban	Rural
PDO [3]		
All facilities	$15,000	$15,000
Moderate (Injury B) and Minor (Injury C) Injury [4]		
Interstate	$48,900	$54,800
Other State Highway	$47,900	$55,000
Fatal and Severe (Injury A) Injury [4]		
Interstate	$850,000	$1,460,000
Other State Highway	$840,000	$1,500,000

Total Crash Value for **84** Months = **$ 962,000**

Annual Benefits = Total Crash Value / Total Months / 12 = **$ 137,000**

Estimated Project Cost = **$ 1,300,000**

Uniform Series Present Worth Factor (5%)	
10 years	20 years
7.72	12.46

B/C Ratio = Annual Benefits X Present Worth Factor (10 or 20 years) / Estimated Project Cost

B/C Ratio = $ 137,000 x 12.46 [2] = **1.31**

$ 1,300,000

Notes

1 Composite crash reduction factor calculated if more than one countermeasure is applied

2 Select a PWF for the life of countermeasure. See instructions

3 PDO value is $7,500 per crash adjusted with an under reporting factor of 2.0. National Safety Council, 2005 estimates of value per crash.

4 Economic costs per crash are calculated using 2004-2006 Oregon crash data and FHWA's Technical Advisory "Motor Vehicle Accident Costs, T 7570.2, October 31, 1994 updated to 2007 dollars with GDP implicit price deflator.

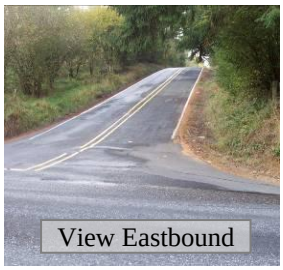
Project Area L – Kaiser Road Intersection, MP 4.6

- **Project 1 – Improve intersection sight distance to the north and construct a Northbound right turn pocket/widen shoulder**

Project Area L: Kaiser Road Intersection

Safety Concern: There have been five collisions, two of which resulted in a debilitating injury (type "A") and a severe injury (type "B") at the Kaiser Road intersection with Cornelius Pass Road over the last seven years. Approximately 40% of the collisions were rear end, and resulted in injury types "A" or B." Many of these collisions involved northbound vehicles on Cornelius Pass Road. The majority of these collisions occurred during dry conditions in the daylight, suggesting that driver behavior and the road geometry may have a greater impact on the collisions than other environmental conditions.

Approximate sight distance from Kaiser Road northbound is approximately 450 ft and southbound is approximately 1,000 ft. The intersection sight distance required for minor street left turning vehicles on a 45 mph facility is 500 feet. The left turn from Kaiser Road to Cornelius Pass Road is approximately 50 feet short of meeting this distance.

Photos	Proposed Improvement: Right Turn Lane & Sight Distance
 View Southbound  View Northbound  View Eastbound	**Project 1: Right Turn Lane** In the northbound direction the roadway could be widened to create a 50 foot long northbound paved right turn pocket (12 feet in width). This would require a 130 foot taper beginning 265 feet south of the intersection. A second alternative would be to provide a wider gravel shoulder (approximately 14 feet wide) for a distance of 50 feet prior to the intersection for northbound vehicles. The second option would not require a taper. Widening the northbound approach with either a turn pocket or just the shoulder would improve sight distance in the southeast quadrant of the intersection. **Project 2: Intersection Sight Distance** Improve intersection sight distance to the north through vegetation removal at the horizontal curve north of the intersection. (Note: this project is also encompassed in Project K)

Preliminary Cost Estimate

The conceptual project cost estimate of $200,000 includes the following:

- Construction cost (incl. 40% contingency)= $165,000
- Engineering (35%) = $55,000
- Right-of-way acquisition = $0

Key assumptions are:

- Cost estimates are based on limited survey information It is assumed that this project does not require additional right of way
- Minimal re-grading of approaches
- Minimal embankment work needed
- Project 2 costs are covered under Project Area L
- No Roadway lighting is included in this cost

A breakdown of the conceptual cost estimate is provided in the attachment.

How is the safety concern addressed?

The proposed improvements address several safety concerns:

- The northbound right turn lane removes slower moving vehicles from the traffic stream, reducing the likelihood of a northbound rear end collision.
- National research shows that the construction of a right turn lane on a single major approach has the potential to reduce all collision types by 14% and injury or fatal collisions by 23%. [1]
- The construction of the northbound right turn lane would also have the added benefit of increased sight distance to the south for vehicles turning onto Cornelius Pass Road from Kaiser Road.
- Vegetation removal from the horizontal curve north of Kaiser Road would improve intersection sight distance to the north at this location.

A preliminary benefit-cost (B/C) ratio of **4.80** was estimated based on annual benefits over 20 years and the estimated project cost of $200,000. A project resulting in B/C ratios greater than 1.00 indicate the project is economically valid because the estimated benefits exceed the estimated cost. A copy of ODOT's completed B/C Analysis worksheet for this project is attached.

[1] Website: http://www.cmfclearinghouse.org/study_detail.cfm?stid=24 Site funded by US Department of Federal Highway Administration and maintained by the University of North Carolina Highway Safety Research Center. Accessed on November 24, 2010.

Project Area L: Project 1
Kaiser Road - MP 4.6 (Add Turn Lane)

Scale: 1 inch = 100 feet

100 50 0 50 100

Region Transportation Plan Scoping Tool
ODOT Region 1
Preliminary Design Unit And HHPR, Inc

Updated May 2007 - AJI

PROJECT DATA				
Project Name	Project L1 - Kaiser Turning Lane	**Highway Number**		
Highway Name	Cornelius Pass	**Posted Number**		
County/City	Multnomah and Washington	**Maint. District**		
Type of Project	Rural Non Freeway	**Key No**		
		Esimated By	HL	

		Unit	Quantity	Unit Cost	Cost
SQUARE FOOT' COSTS FROM STUDY PROJECTS (Costs Inflated to January 2011 Dollars)	**Roadway & Pavement**				
	New Work	sf	3000	$ 15.00	$ 45,000.00
	2" Overlay (With Mod)	sf	10800	$ 1.00	$ 10,800.00
	2" Overlay (Pres Only)	sf		$ 4.00	$ -
	Structures				
	New Bridge Spans >120'	sf		$ 180.00	$ -
	New Bridge Spans <120'	sf		$ 125.00	$ -
	New Bridge Spans under fill	sf		$ 300.00	$ -
	Bridge Widening	sf		$ 250.00	$ -
	Retaining Walls - CIP	sf		$ 125.00	$ -
	Retaining Walls - MSE	sf		$ 85.00	$ -
	Retaining Walls - Seg.	sf		$ 35.00	$ -
	Sound Walls - Precast	sf		$ 35.00	$ -
	Miscellaneous				
	Traffic Signals	Intersection		$ 270,000.00	$ -
	Streetscape Peripherals	lf of roadway		High - $500/lf	$ -

		Unit	Quantity	Unit Cost	Cost
	Miscellaneous Items - At the Estimator's Discretion				
	Rock Cut	CY	333	$ 15.00	$ 5,000.00
	Cut	CY	533	$ 7.00	$ 3,733.33
					$ -
	Project Subtotal				$ 64,533.33
	Project Scope Contingencies	%	1	40%	$ 25,813.33
	CONSTRUCTION ESTIMATE TOTAL				$ 90,346.67
Other Costs	Preliminary Engineering	%	1	20%	$ 18,069.33
	Construction Engineering	%	1	15%	$ 13,552.00
	Environmental Studies	LS	1	$ 5,000.00	$ 5,000.00
					$ -
	TOTAL PROJECT ESTIMATE				***$ 126,968***

Assumptions:

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OREGON DEPARTMENT OF TRANSPORTATION
HIGHWAY SAFETY PROJECTS
BENEFIT/COST ANALYSIS WORKSHEET

Project Name: **Cornelius Pass Road Improvement Projects** Region: **1** Date: **12/1/10**

Project on Local Agency Facility

Route Number: Street Name: **Cornelius Pass Road** MP Range or Cross Street: **Kaiser Road**

Project on State Highway

Route Number: Hwy Name: MP From: **4.60** to **4.65**

Road Character: **RURAL** Facility Type: **OTHER STATE HIGHWAY**

County: **MULTNOMAH** City: **N/A** Crash Data From: **1/1/2003** to **12/31/2009**

Project Description: **Safety Evaluation**

Prepared By: **Project Team** Title: **Project L Kaiser Road**

		Fatal Crash Reduction Factor	Injury Crash Reduction Factor	PDO Crash Reduction Factor
Countermeasure 1	Right Turn Lane	23%	23%	14%
Countermeasure 2	Intersection Sight Distnace	13%	13%	13%
Countermeasure 3		0%	0%	0%
Countermeasure 4		0%	0%	0%
		33% [1]	**33%** [1]	**25%** [1]

	Number of Crashes	Number of Preventable Crashes	Economic Value per Crash		Total Economic Value
Fatal Crashes	**0**	**0.0**	$1,500,000	=	**$ -**
Severe (Injury A) Injury Crashes	**1**	**0.3**	$1,500,000	=	**$ 495,000**
Moderate (Injury B) Injury Crashes	**1**	**0.3**	$55,000	=	**$ 18,000**
Minor (Injury C) Injury Crashes	**1**	**0.3**	$55,000	=	**$ 18,000**
PDO Crashes	**2**	**0.5**	$15,000	=	**$ 8,000**

Comprehensive Economic Value per Crash

Highway Type	Urban	Rural
PDO [3]		
All facilities	$15,000	$15,000
Moderate (Injury B) and Minor (Injury C) Injury [4]		
Interstate	$48,900	$54,800
Other State Highway	$47,900	$55,000
Fatal and Severe (Injury A) Injury [4]		
Interstate	$850,000	$1,460,000
Other State Highway	$840,000	$1,500,000

Total Crash Value for **84** Months = **$ 539,000**

Annual Benefits = Total Crash Value / Total Months / 12 = **$ 77,000**

Estimated Project Cost = **$ 200,000**

Uniform Series Present Worth Factor (5%)	
10 years	20 years
7.72	12.46

B/C Ratio = Annual Benefits X Present Worth Factor (10 or 20 years) / Estimated Project Cost

B/C Ratio = $ 77,000 x 12.46 [2] = **4.80**

$ 200,000

Notes

1 Composite crash reduction factor calculated if more than one countermeasure is applied

2 Select a PWF for the life of countermeasure. See instructions

3 PDO value is $7,500 per crash adjusted with an under reporting factor of 2.0. National Safety Council, 2005 estimates of value per crash.

4 Economic costs per crash are calculated using 2004-2006 Oregon crash data and FHWA's Technical Advisory "Motor Vehicle Accident Costs, T 7570.2, October 31, 1994 updated to 2007 dollars with GDP implicit price deflator.

Projects M and N – Cornelius Pass Road Specific Policies and Design Guide

Projects M and N– Corridor Design Guide and Policies

Safety Concern: The Multnomah County portion of Cornelius Pass Road has a history of collisions related to non - standard roadway design such as the narrow roadway width, limited shoulders, restricted sight distances, and significant horizontal and vertical curves. Due to environmental and topographical limitations, it is not feasible to build the entire roadway to county roadway standards; context sensitive design must be implemented along the facility. However, if driver expectations can be improved by implementing consistent design guides and policies along the roadway (within context sensitive design), safety along the corridor could be improved.

Cornelius Pass Road connects the transportation hubs between Washington County (including Tualatin Valley Highway and Sunset Highway), and communities adjacent to the Columbia River and Highway 30. Corridor users consist of commuters, rural land users, and commercial vehicle drivers, so design guides and policies must address all users. While site specific improvements are useful for high collision locations, design guides and policy level improvements are useful to address the needs and demands placed on the road by different user groups. These design and policy recommendations are needed to address safety improvements along the entire corridor.

DESIGN GUIDE

The following design guidelines could be implemented to improve driver expectancy and corridor safety.

Photographs	Proposed Improvement
 S-Curves  Trucks  Sign Spacing  Driveway	Develop a design guide that provides consistency for the following design elements and characteristics: • Cross section • Horizontal curves • Profiles • Signage • Pavement markings • Intersections and driveways • Roadside features (special delineation) • Roadside design • Illumination

Supporting Data	

• Average daily traffic (ADT) ranges between 20,000 vehicles near US 26 to as few as 8,600 vehicles near Germantown Road
• Percent of trucks is moderate ranging between 11 and 15 percent
• Hazardous materials movement is prohibited on US 26 westbound through the Vista Ridge Tunnels is redirected off of US 26 eastbound at OR 217
• See collisions graphs for more details.
	• Collision Summary
	  ○ Total of 171 collisions (2003 – 2009)
	  ○ 30% Injury-related collisions including two fatalities
	  ○ 37% during morning and evening peak periods
	  ○ 47% at curves
	  ○ Half of the collisions are out-of-control related
	  ○ 45% at intersections/driveways (numerous are located along and/or at curves)
	  ○ 35% fixed object type collisions
	  ○ 40% during wet, snow or ice conditions
	  ○ 58% during day light conditions
	  ○ Collisions are equally split between northbound and southbound traffic

Improvement Options	Benefits
Cross Section	It is preferred to provide/maintain a consistent cross section along the entire corridor. For example, having a consistent shoulder width will avoid surprises from a driver expectancy point of view, especially if a shoulder narrows from 8 feet to 1 foot. In addition, there may be a need to provide left-turn lanes at key intersections and/or driveways. • The topography does not provide latitude to consider wider shoulders along the entire corridor. Future improvement projects should maintain a cross section along the corridor that is consistent with the environment. • Providing additional width (left-turn lane) at key intersections would address rear-end collisions.
Horizontal Curves	Numerous horizontal curves have insufficient stopping sight distance. • At a minimum, providing stopping sight distance (SSD) consistent with the posted speed would address the run-off the road collisions.
Profiles	There are abrupt crest curves that may not comply with an appropriate stopping sight distance (SSD) based on the posted speed. • At this stage, it appears that these crest curves do not contribute to specific collisions, but if there are opportunities to provide SSD with a nearby project, then consideration should be given to address abrupt crest curves.
Signage	Due to the number of S-curves including tight abrupt consecutive curves, it is infeasible to provide warning signs based on the MUTCD guidance. In addition, there is "man-made" delineation (reflectors) for private properties, because it is challenging for visitors to find places, which typically result in unexpected stops and/or undesirable turnarounds. • Provide a uniform spacing policy that would communicate information in a consistent way along the entire corridor that would coincide with driver expectancy. • Develop a policy for property owners to provide consistent delineation/signage for private driveways. In the near-term, changes can be incorporated as part of improvement projects.
Pavement Markings	The current no passing double yellow centerline striping with the fog lines one foot off the edge of pavement appear to be appropriate and should be maintained. The existing rumble strips along the edge lines as well as the centerline appear to be appropriate and should be maintained. • The addition of recessed raised pavement markers should be considered for additional delineation.
Intersections and Driveways	Almost half of the collisions occur at intersections and/or driveways. The following should be considered at private driveways: • Provide appropriate intersection sight distance (ISD) and stopping sight distance (SSD). • Improve driveways by considering asphalt/concrete for first 20 feet approximately of driveway. • Current topography limits improving driveway angles and/or approach grades, but if there are projects in the area, then consideration should be given to improve the intersection angle.

	• Review mailbox placements and consider clustering several mailboxes with appropriate turnout areas. • Project Areas D, I, and L address improvements at the Sheltered Nook Road, Skyline Boulevard, and Kaiser Road intersections, respectively.
Road Delineation	Due to the winding nature of the road, delineation of the facility plays a key role in navigating traffic along the corridor. It is likely infeasible to provide guardrail along the entire corridor, but the provision of delineators can be considered as follows: • Provide white delineators (e.g., ODOT standard drawings TM570) at 200-foot spacing along tangent sections, 50-100 foot spacing along curves, and 20-50 foot spacing at intersection. • Provide colored (e.g., blue) delineators to indicate driveways.
Roadside Design	See Project B for guardrail consideration
Illumination	See Project A for details

POLICY RECOMMENDATIONS

The following policy recommendations could be implemented to improve corridor safety:

Photo	**Proposed Policy: Implementation of Variable Speed Limits**
 ***Source: DKS Associates***	Provide variable speed limit (VSL) zones for inclement weather conditions to reduce driver speeds to levels that are appropriate and safe for the conditions. • There is a concern that the posted speeds could provide a false sense of security. • Oregon law currently does not provide for enforceable speeds based on weather data. • What process should be followed to change current legislation and laws? Should the variable speeds be advisory rather than regulatory? • May consider other factors and driving conditions other than weather (e.g. time of day, lighting, traffic volumes, etc).

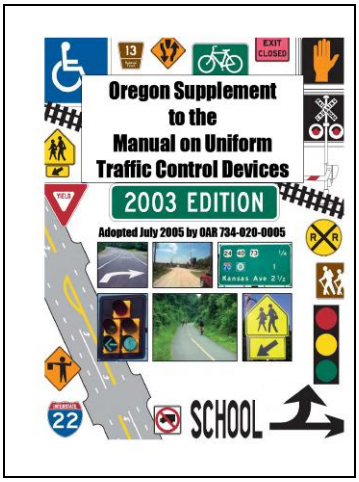
Photo	Proposed Policy: Appropriate Sign Guidelines
 ***Source: 2003 Oregon Supplement to MUTCD***	Implementing appropriate sign guidelines would provide a consistency throughout the corridor to reduce driver confusion. • Complete an inventory and plan that identifies existing signs that may be removed or consolidated to reduce the information that drivers must process. • Providing a uniform spacing policy would communicate information in a consistent way along the entire corridor. • Sign size and reflectivity should be considered to enhance visibility to drivers.

Photo	Proposed Policy: Way-finding for Private Driveways
 ***Source: Multnomah County Rural Fire District 14***	Improved way-finding for private driveways would reduce the likelihood that a vehicle is stopped or making abrupt maneuvers while trying to locate a private residence. • Develop appropriate and consistent signage to clearly communicate addresses. • Coordinate with Tualatin Valley Fire and Rescue (TVFR) to ensure that address markings meet the needs of emergency response. • Review mailbox placements and consider clustering several mailboxes with appropriate turnout areas.

Photo	Proposed Policy: Communicate Services with VMS


Source: DKS Associates
	Communicate specific services to road users along the corridor with potential variable message signs (VMS). The VMS signs would warn road users of slow or stopped vehicles (such as school buses, garbage trucks, and postal delivery vehicles).
	• Key locations for sign installation would be:
	  ○ North of Skyline Boulevard for northbound traffic, and
	  ○ South of Highway 30 for southbound traffic.
	• Provide pull-off areas for service vehicles which currently stop in the road (i.e. postal, garbage, police, and other frequent service providers)
	• Coordinate with agencies/providers to determine schedules and flexibility. Having several service providers operating in the area simultaneously would reduce the total time in which this sign would be needed.
	• The signs could be used to communicate other variable data when it is not being used to warn of slow or stopped vehicles in the road.

Photo	Proposed Policy: Private Driveway Strategies
 ***Source: DKS Associates***	Managing private driveways along the corridor is needed to reduce potential vehicle conflicts, improve sight distance and reduce the amount of information that a driver must process. • Consolidation of driveways as part of potential future development. • Identify existing driveways that could provide a safety benefit with relocation and/or consolidation. • Identify driveways that could provide a safety improvement with turn restrictions. • Coordinate with property owners to improve intersection sight distance (i.e. removing vegetation, embankments, and improving driveway geometrics).

Project O – Improve Cornelius Pass Road to 45-mph Facility

- **Project O1 – S-Curves at MP 0.2-0.6**
- **Project O2 – Sheltered Nook Road Intersection**
- **Project O3 – S-Curves at MP 1.3-1.6 (New 8th Avenue Alignment)**
- **Project O4 – S-Curves at MP 1.8-2.1**
- **Project O5 – Skyline Boulevard Intersection (Roundabout)**
- **Project O6 – Curve at MP 3.8**
- **Project O7 – Curve at MP 4.5**
- **Project O8 –Kaiser Road Intersection**
- **Corridor Roadway Lighting**

Project O: Improve Cornelius Pass Road to 45-mph Facility

Safety Concern:
Cornelius Pass Road connects the important transportation corridors of Tualatin Valley Highway (OR 8), Sunset Highway (US 26), and Lower Columbia River Highway (US 30). Cornelius Pass Road has two-lanes, substandard shoulder widths and no turn lanes (with the exception of the Skyline Boulevard intersection). The topography along this corridor defines a horizontal alignment with the majority of the curves having radii not meeting the 45-mph posted speed.

The 5-mile segment between the Multnomah County line to the south and US 30 to the north had 171 collisions over a seven-year period (2003 – 2009), of which approximately 47% for the collisions occur at curves and roughly 45% at intersections and driveways (some located in curves). Approximately 30% of all the collisions are either injury "A" or "B", including two fatalities.

Photographs	**Proposed Improvement: Provide 45-mph Facility**
 Roughly MP 1.0  Roughly MP 1.3  Roughly MP 1.5  Roughly MP 3.1  Roughly MP 3.6  Roughly MP 3.8	The specific 45-mph curve radii depend on the super-elevation for the respective curves. For example: • 8% super-elevation results in a 587-foot curve • 4% super-elevation results in a 711-foot curve • Normal crown results in a 1,039-foot curve The proposed curve improvements for 45-mph design speed along the corridor entail of the following: • Eliminate the series of S-curves at MP 0.15 to 0.6 by reconstructing the roadway with a single curve and tying back into the tangent sections. • Eliminate the tight S-curves at MP 1.5 and provide a more consistent travel path along a single curve. • Provide flatter S-curves at MP 1.8-2.1 for driver expectance approaching along tangents. • Improve the substandard curves at MP 1.35, MP 3.8, and MP 4.5 to comply with 45-mph curves. • No improvements at the 15/25-mph curves. • Investigate remaining "substandard" curves along the corridor that did not have collisions, because these may become areas of concerns when all the other curves have been improved. • Relocate existing utilities as needed. • Negotiate with the property owners regarding property impact along inside of curves (i.e., acquisition). • Obtain temporary construction easements as needed for proposed improvements. Refer to Projects D, I and L for intersection related improvements. These improvements at the curves and intersections are illustrated in the attached exhibits. This corridor project also includes roadway lighting along the 5-mile section.

Conceptual Cost Estimate

The conceptual project cost estimate of approximately $32.3 million includes the following:

- Curves:
  - MP 0.2-0.6 = $7.5 million
  - MP 1.35 = $1.5 million
  - MP 1.5 = $3.5 million
  - MP 1.8-2.1 = $2.5 million
  - MP 3.8 = $2.5 million
  - MP 4.5 = $2.5 million
  - Exclude improvements at 15/25 mph tight curves
- Intersection related projects are excluded:
  - Sheltered Nook = $1.82 million (Project Area D)
  - Skyline Roundabout = $3.78 million (Project Area I)
  - Kaiser = $0.20 million (Project Area L)
- Roadway Lighting for 5-mile corridor = $1.0 million

Key assumptions are:

- Based on aerial photography
- Significant earthwork anticipated
- There will likely be the need for geotechnical stabilization
- There will likely be environmentally sensitive areas
- Limited information regarding property acquisition

How is the safety concern addressed?

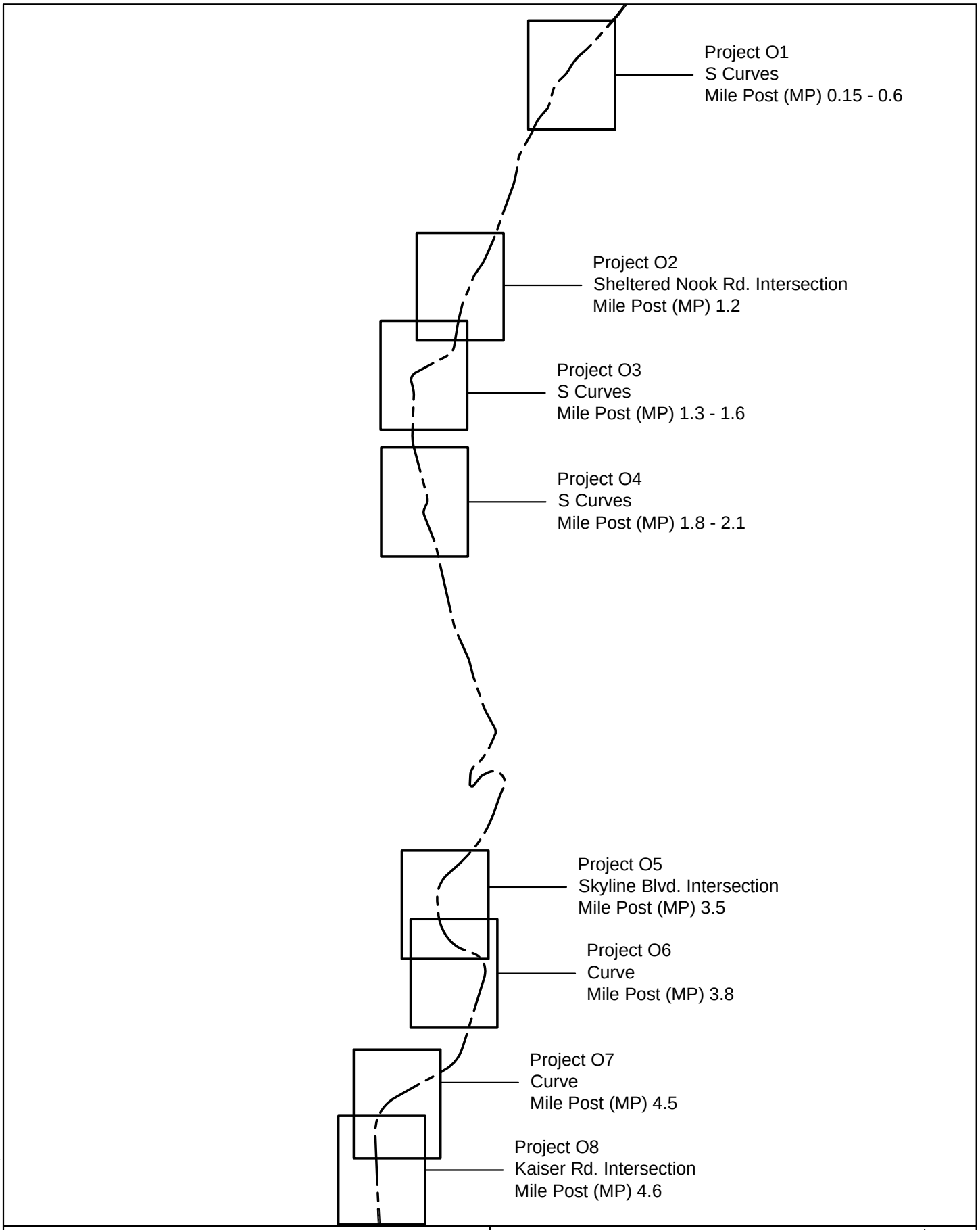
The proposed improvements for horizontal curves address several safety concerns:

- Reducing the number of curves by replacing them with single curves and improving curve radii to comply with a consistent design speed of 45 mph would meet driver expectancy along the entire corridor.
  - National research shows that increasing horizontal curvature by one degree increases run off the road collisions by approximately 5%, from this information, it can be inferred that by decreasing horizontal curvature, run off the road collisions also decrease by a factor of the change in curvature. [1]
  - AASHTO's *Highway Safety Manual, 1st Edition* contains an equation to calculate the potential reduction in crashes for a given horizontal curve based on curve length, radius, and the presence of spiral transition. This information was used to estimate the specific potential crash reductions for the proposed horizontal curvature within this project.[2]
- Clearing along insides of curves provides appropriate stopping sight distance.
  - National research shows that the removal of roadside obstacles in the clear zone can reduce collisions by 22% to 44% depending on the increase in clear zone. [2]
  - Research summarized by ODOT also indicates widening the shoulder (which has the physical affect of increasing sight distance on curves) can decrease collisions by 5% to 12% depending on the increase in shoulder width.[3]

Refer to Project Packages D, I, and L for improvements at the Sheltered Nook Road, Skyline Boulevard, and Kaiser Road intersections, respectively. Project Package A contains all information related to the corridor roadway lighting.

For improving the horizontal alignment including the intersection improvements and roadway lighting, a preliminary benefit-cost (B/C) ratio of 1.08 was estimated based on annual benefits over 20 years and the estimated project cost of $26.77 million. A project resulting in B/C ratios greater than 1.00 indicate the project is economically valid because the estimated benefits exceed the estimated cost. A copy of ODOT's completed B/C Analysis worksheets for the subprojects and a summary for Project O are attached.

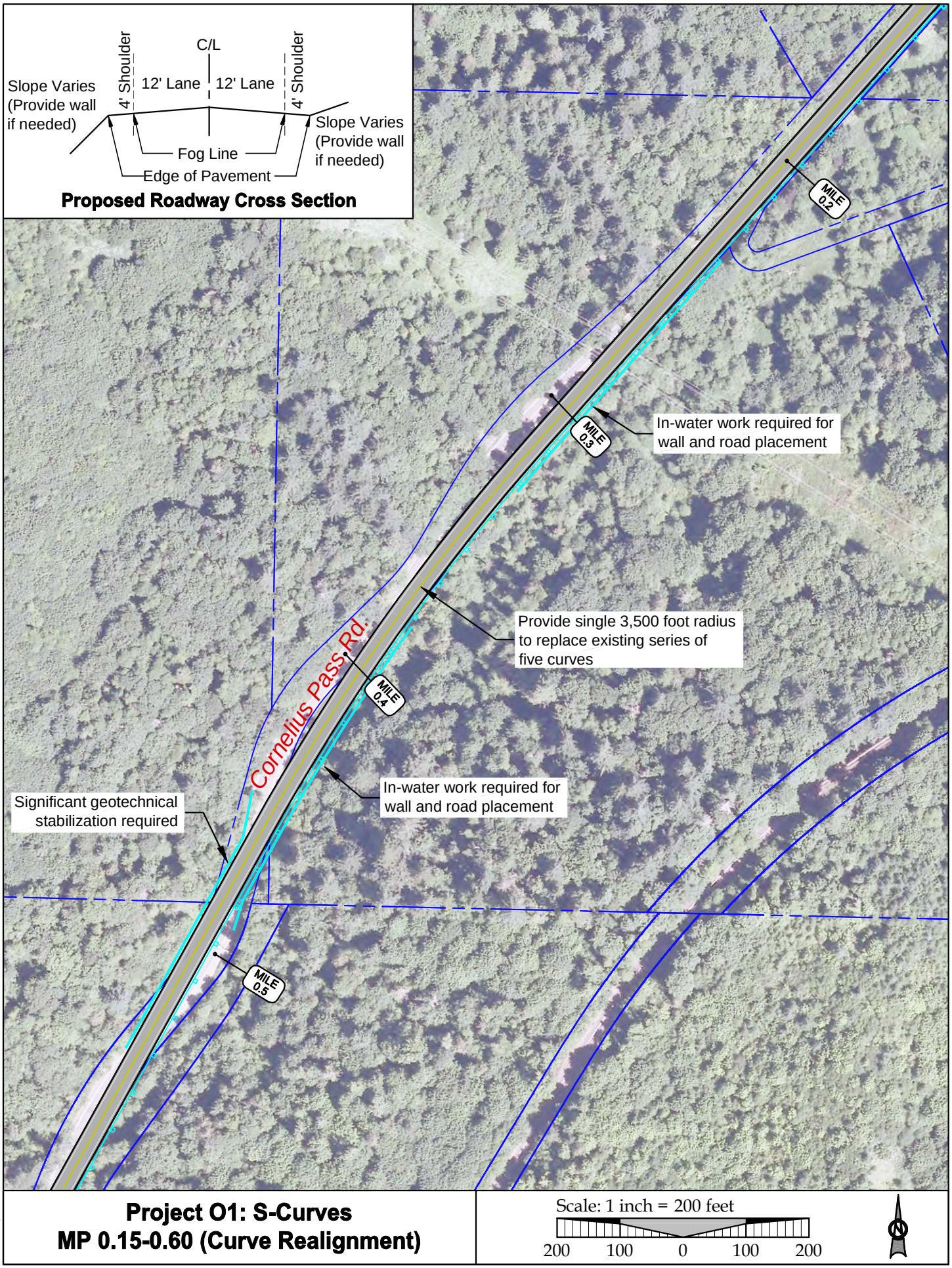
[1] Website: http://www.cmfclearinghouse.org/study_detail.cfm?stid=30 Site funded by US Department of Federal Highway Administration and maintained by the University of North Carolina Highway Safety Research Center. Accessed on November 24, 2010.
[2] American Association of State Highway Transportation Officials (AASHTO), *Highway Safety Manual (HSM), 1st Edition*, 2010.
[3] Oregon Department of Transportation (ODOT) Crash Reduction Factor (CRF) Website: http://its.pdx.edu/CRF/CRFweb/



Project O
Cornelius Pass Corridor Improvements

Scale: 1 inch = 2000 feet

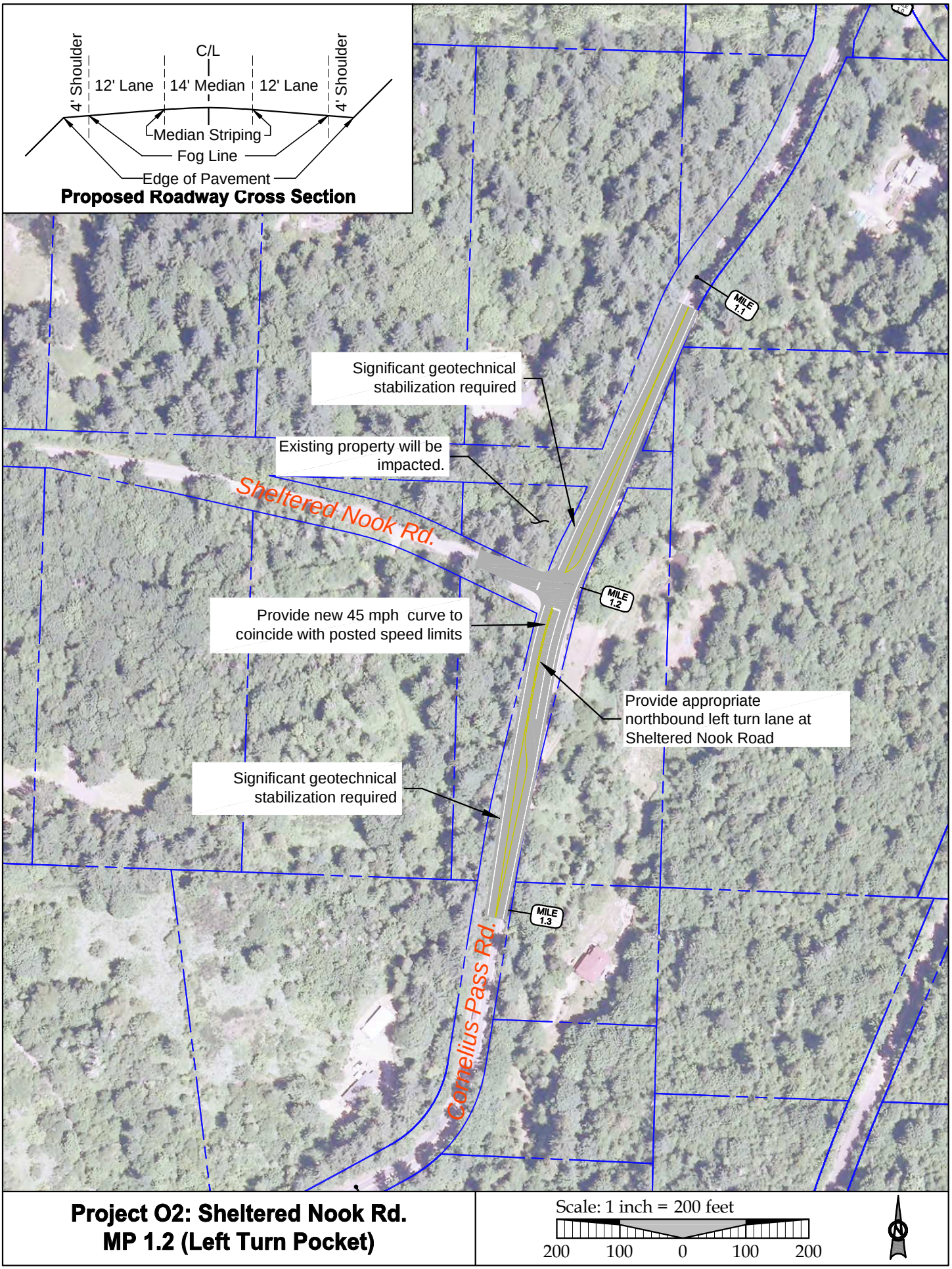
2000 1000 0 1000 2000



Project O1: S-Curves
MP 0.15-0.60 (Curve Realignment)

Scale: 1 inch = 200 feet

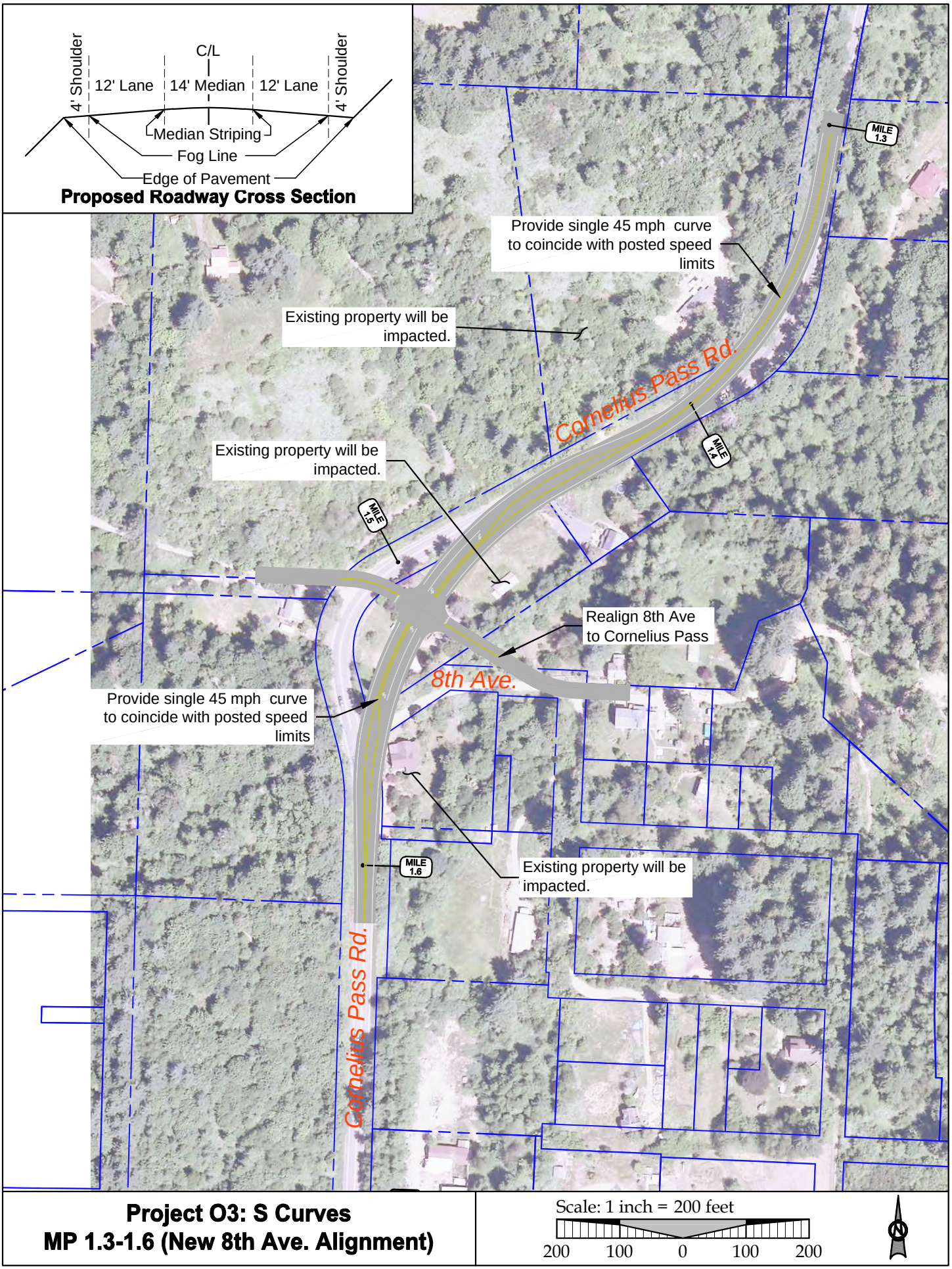
200 100 0 100 200



Project O2: Sheltered Nook Rd.
MP 1.2 (Left Turn Pocket)

Scale: 1 inch = 200 feet

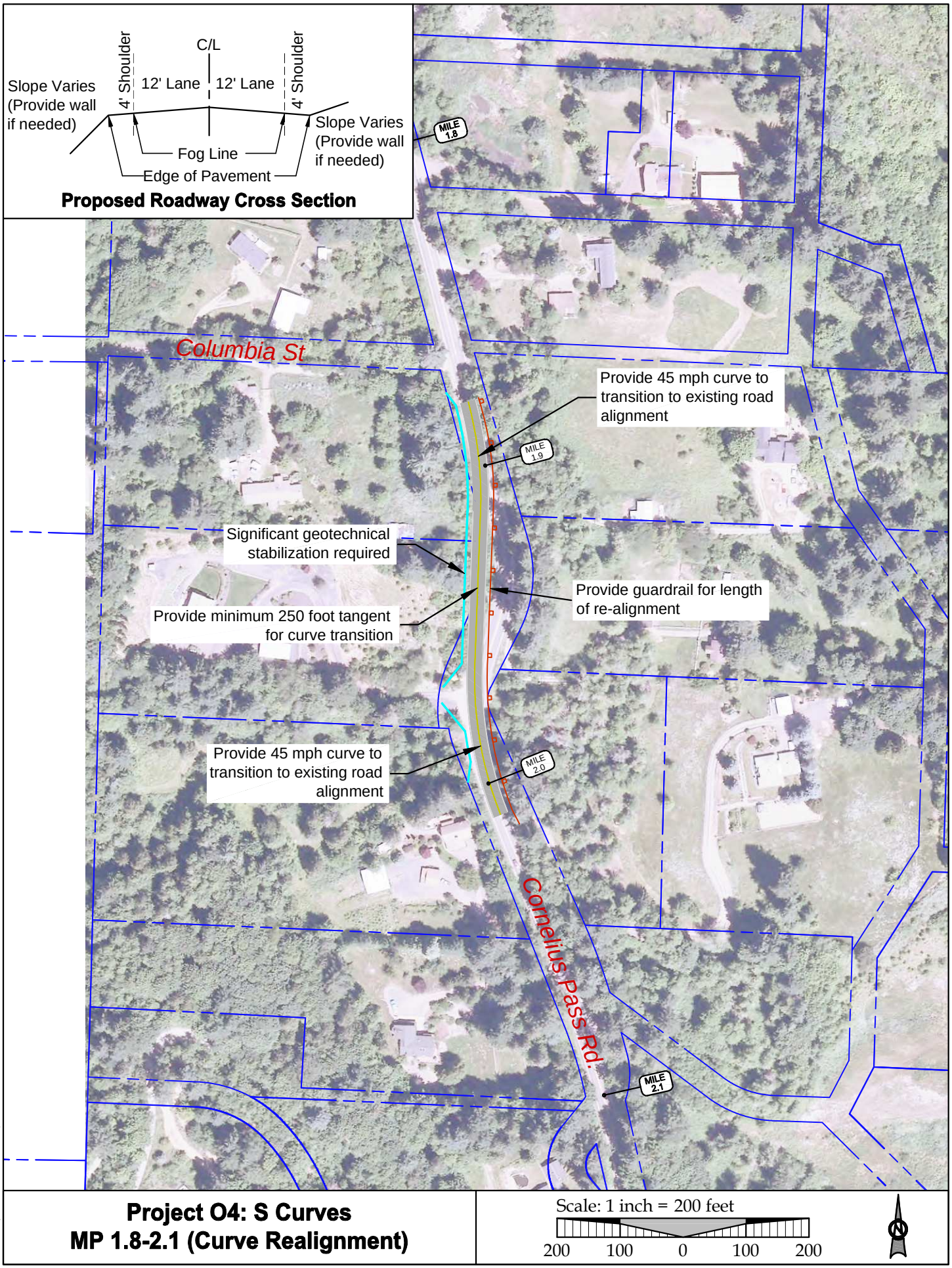
200 100 0 100 200

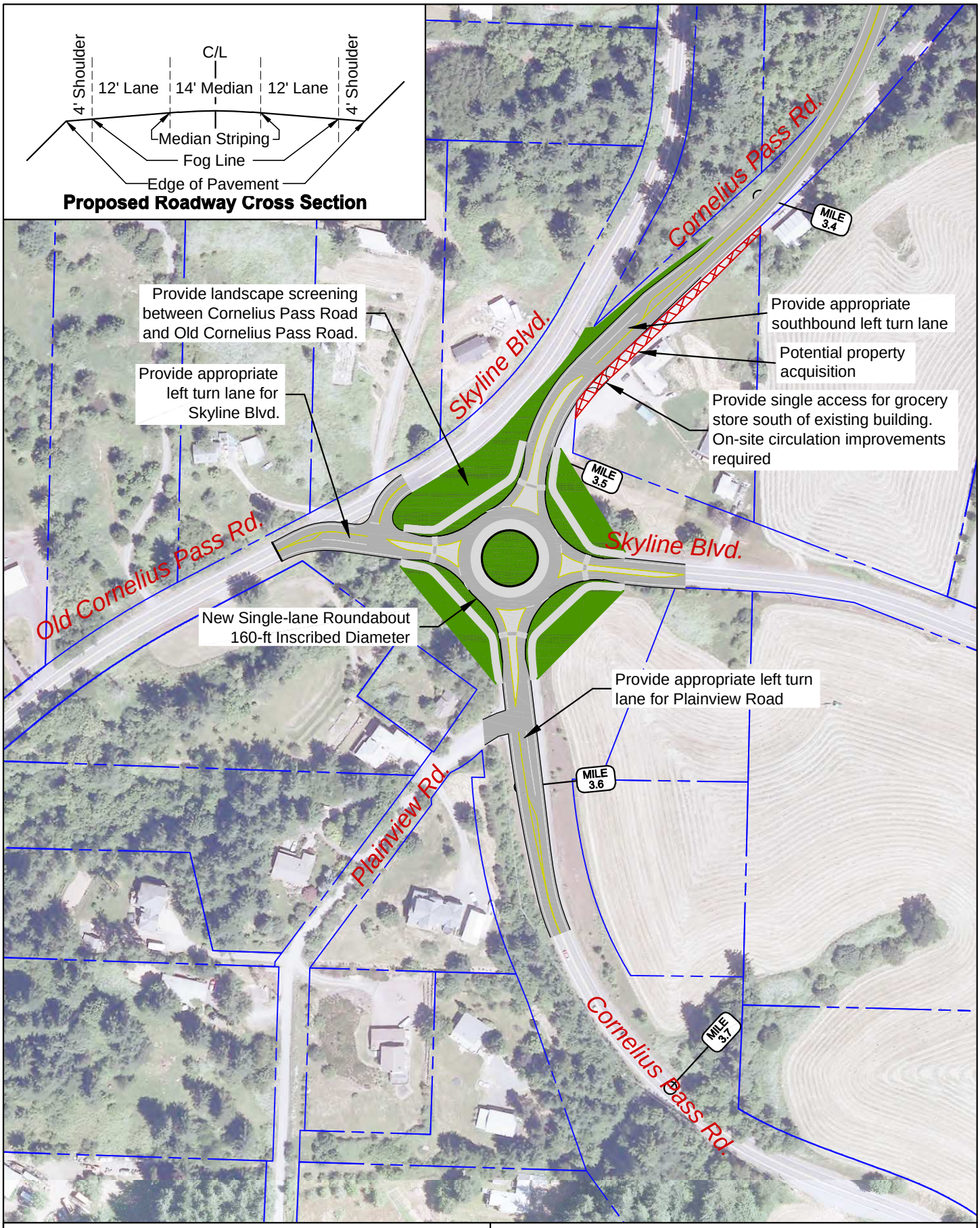


Project O3: S Curves
MP 1.3-1.6 (New 8th Ave. Alignment)

Scale: 1 inch = 200 feet

200 100 0 100 200

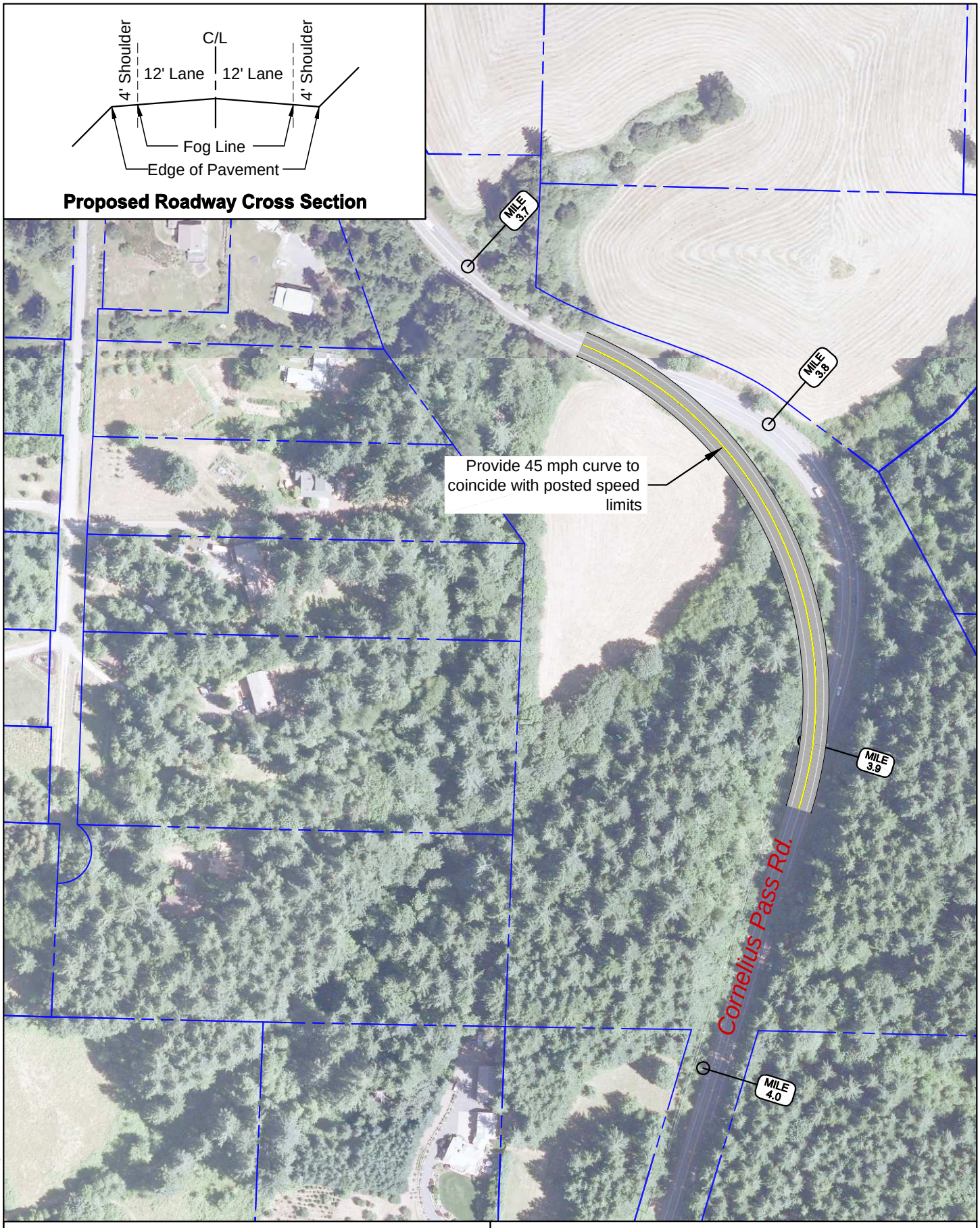




Project O5: Skyline Intersection
MP 3.5 (Single-Lane Roundabout)

Scale: 1 inch = 200 feet

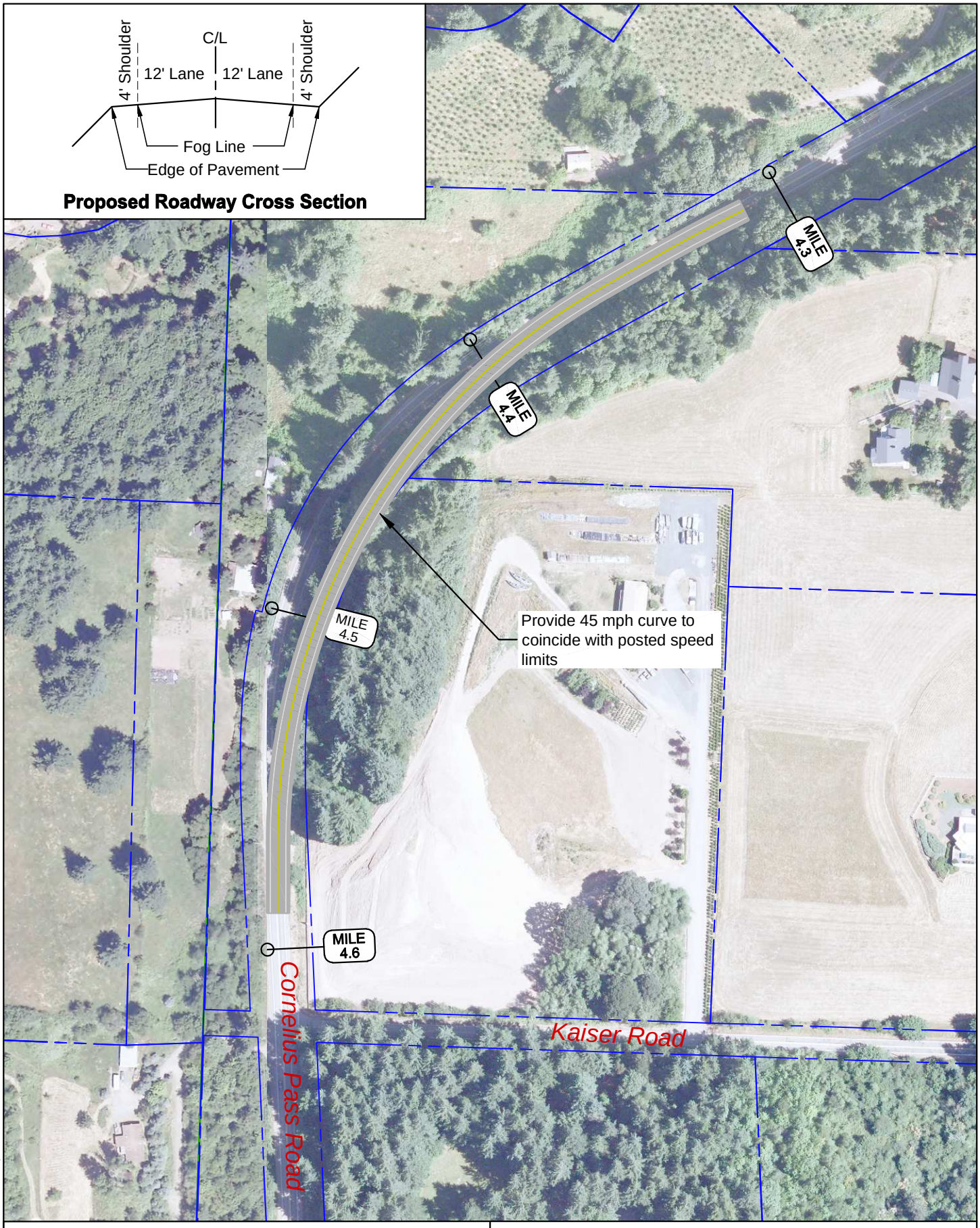
200 100 0 100 200



Project O6: Curve
MP 3.8 (New Curve Alignment)

Scale: 1 inch = 200 feet

200 100 0 100 200



Project O7: Curve
MP 4.5 (New Curve Alignment)

Scale: 1 inch = 200 feet

200 100 0 100 200

Project O8: Kaiser Road Intersection
MP 4.6 (Add Turn Lane)

Scale: 1 inch = 100 feet

100 50 0 50 100

Project O - Improve Cornelius Pass Road to 45-mph Facility

Project Description	Benefit	Cost Estimate	B/C Ratio
Project A - Lighting of entire corridor	$ 2,815,960.00	$ 1,000,000.00	2.82
Project C - S-Curves MP 0.2 - 0.6	$ 3,974,740.00	$ 7,500,000.00	0.53
Project D - Sheltered Nook Intersection	$ 3,899,980.00	$ 1,820,000.00	2.14
Project E - Curve at MP 1.35	$ 174,440.00	$ 1,500,000.00	0.12
Project F - S-Curve & 8th Avenue	$ 2,716,280.00	$ 3,500,000.00	0.78
Project G - S-Curves at MP 1.8 - 2.1	$ 336,420.00	$ 2,500,000.00	0.13
Project H - 15/25-mph Tight Curves			
Project I - Skyline Intersection	$ 9,793,560.00	$ 3,750,000.00	2.61
Project J - Curve at MP 3.8	$ 3,040,240.00	$ 2,500,000.00	1.22
Project K - Curve at MP 4.5	$ 1,333,220.00	$ 2,500,000.00	0.53
Project L - Kaiser Intersection	$ 959,420.00	$ 200,000.00	4.80
Project O (All above projects)	**$ 29,044,260.00**	**$ 26,770,000.00**	**1.08**

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OREGON DEPARTMENT OF TRANSPORTATION
HIGHWAY SAFETY PROJECTS
BENEFIT/COST ANALYSIS WORKSHEET

Project Name: **Cornelius Pass Road Improvement Projects** Region: **1** Date: **12/1/10**

Project on Local Agency Facility

Route Number: Street Name: **Cornelius Pass Road** MP Range or Cross Street: **MP 0.00 to MP 5.00**

Project on State Highway

Route Number: Hwy Name: MP From: **0.00** to **5.00**

Road Character: **RURAL** Facility Type: **OTHER STATE HIGHWAY**

County: **MULTNOMAH** City: **N/A** Crash Data From: **1/1/2003** to **12/31/2009**

Project Description: **Safety Evaluation**

Prepared By: **Project Team** Title: **Project A - Corridor Lighting (Part of Project O)**

		Fatal Crash Reduction Factor	Injury Crash Reduction Factor	PDO Crash Reduction Factor
Countermeasure 1	Lighting	23%	23%	23%
Countermeasure 2		0%	0%	0%
Countermeasure 3		0%	0%	0%
Countermeasure 4		0%	0%	0%
		23% [1]	**23%** [1]	**23%** [1]

	Number of Crashes	Number of Preventable Crashes	Economic Value per Crash		Total Economic Value
Fatal Crashes	**1**	**0.2**	$1,500,000	=	**$ 345,000**
Severe (Injury A) Injury Crashes	**3**	**0.7**	$1,500,000	=	**$ 1,035,000**
Moderate (Injury B) Injury Crashes	**7**	**1.6**	$55,000	=	**$ 89,000**
Minor (Injury C) Injury Crashes	**4**	**0.9**	$55,000	=	**$ 51,000**
PDO Crashes	**17**	**3.9**	$15,000	=	**$ 59,000**

Comprehensive Economic Value per Crash		
Highway Type	Urban	Rural
PDO [3]		
All facilities	$15,000	$15,000
Moderate (Injury B) and Minor (Injury C) Injury [4]		
Interstate	$48,900	$54,800
Other State Highway	$47,900	$55,000
Fatal and Severe (Injury A) Injury [4]		
Interstate	$850,000	$1,460,000
Other State Highway	$840,000	$1,500,000

Total Crash Value for **84** Months = **$ 1,579,000**

Annual Benefits = Total Crash Value / Total Months / 12 = **$ 226,000**

Estimated Project Cost = **$ 1,000,000**

Uniform Series Present Worth Factor (5%)	
10 years	20 years
7.72	12.46

B/C Ratio = Annual Benefits X Present Worth Factor (10 or 20 years) / Estimated Project Cost

B/C Ratio = $ 226,000 x 12.46 [2] = **2.82**

$ 1,000,000

Notes

1 Composite crash reduction factor calculated if more than one countermeasure is applied

2 Select a PWF for the life of countermeasure. See instructions

3 PDO value is $7,500 per crash adjusted with an under reporting factor of 2.0. National Safety Council, 2005 estimates of value per crash.

4 Economic costs per crash are calculated using 2004-2006 Oregon crash data and FHWA's Technical Advisory "Motor Vehicle Accident Costs, T 7570.2, October 31, 1994 updated to 2007 dollars with GDP implicit price deflator.

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OREGON DEPARTMENT OF TRANSPORTATION
HIGHWAY SAFETY PROJECTS
BENEFIT/COST ANALYSIS WORKSHEET

Project Name: **Cornelius Pass Road Improvement Projects** Region: **1** Date: **12/1/10**

Project on Local Agency Facility

Route Number: Street Name: **Cornelius Pass Road** MP Range or Cross Street: **MP 0.15 to MP 0.6**

Project on State Highway

Route Number: Hwy Name: MP From: **0.15** to **0.60**

Road Character: **RURAL** Facility Type: **OTHER STATE HIGHWAY**

County: **MULTNOMAH** City: **N/A** Crash Data From: **1/1/2003** to **12/31/2009**

Project Description: **Safety Evaluation**

Prepared By: **Project Team** Title: **Project C - Realign with Signular Curve (Part of Project O)**

		Fatal Crash Reduction Factor	Injury Crash Reduction Factor	PDO Crash Reduction Factor
Countermeasure 1	Improve horizontal alignment	51%	51%	51%
Countermeasure 2	Increase distance to roadside obstacle	22%	22%	22%
Countermeasure 3		0%	0%	0%
Countermeasure 4		0%	0%	0%
		62% [1]	**62%** [1]	**62%** [1]

	Number of Crashes	Number of Preventable Crashes	Economic Value per Crash		Total Economic Value
Fatal Crashes	**0**	**0.0**	$1,500,000	=	**$ -**
Severe (Injury A) Injury Crashes	**2**	**1.2**	$1,500,000	=	**$ 1,853,000**
Moderate (Injury B) Injury Crashes	**6**	**3.7**	$55,000	=	**$ 204,000**
Minor (Injury C) Injury Crashes	**4**	**2.5**	$55,000	=	**$ 136,000**
PDO Crashes	**4**	**2.5**	$15,000	=	**$ 37,000**

Comprehensive Economic Value per Crash		
Highway Type	Urban	Rural
PDO [3]		
All facilities	$15,000	$15,000
Moderate (Injury B) and Minor (Injury C) Injury [4]		
Interstate	$48,900	$54,800
Other State Highway	$47,900	$55,000
Fatal and Severe (Injury A) Injury [4]		
Interstate	$850,000	$1,460,000
Other State Highway	$840,000	$1,500,000

Total Crash Value for **84** Months = **$ 2,230,000**

Annual Benefits = Total Crash Value / Total Months / 12 = **$ 319,000**

Estimated Project Cost = **$ 7,500,000**

Uniform Series Present Worth Factor (5%)	
10 years	20 years
7.72	12.46

B/C Ratio = Annual Benefits X Present Worth Factor (10 or 20 years) / Estimated Project Cost

B/C Ratio = $ 319,000 x 12.46 [2] / $ 7,500,000 = **0.53**

Notes

1 Composite crash reduction factor calculated if more than one countermeasure is applied

2 Select a PWF for the life of countermeasure. See instructions

3 PDO value is $7,500 per crash adjusted with an under reporting factor of 2.0. National Safety Council, 2005 estimates of value per crash.

4 Economic costs per crash are calculated using 2004-2006 Oregon crash data and FHWA's Technical Advisory "Motor Vehicle Accident Costs, T 7570.2, October 31, 1994 updated to 2007 dollars with GDP implicit price deflator.

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OREGON DEPARTMENT OF TRANSPORTATION
HIGHWAY SAFETY PROJECTS
BENEFIT/COST ANALYSIS WORKSHEET

Project Name: **Cornelius Pass Road Improvement Projects** Region: **1** Date: **12/1/10**

Project on Local Agency Facility

Route Number: Street Name: **Cornelius Pass Road** MP Range or Cross Street: **MP 0.00 to MP 5.00**

Project on State Highway

Route Number: Hwy Name: MP From: **0.00** to **5.00**

Road Character: **RURAL** Facility Type: **OTHER STATE HIGHWAY**

County: **MULTNOMAH** City: **N/A** Crash Data From: **1/1/2003** to **12/31/2009**

Project Description: **Safety Evaluation**

Prepared By: **Project Team** Title: **Project D Sheltered Nook Road (Part of Project O)**

		Fatal Crash Reduction Factor	Injury Crash Reduction Factor	PDO Crash Reduction Factor
Countermeasure 1	Left Turn Lane	55%	55%	44%
Countermeasure 2	Intersection Sight Distance	13%	13%	13%
Countermeasure 3		0%	0%	0%
Countermeasure 4		0%	0%	0%
		61% [1]	**61%** [1]	**51%** [1]

	Number of Crashes	Number of Preventable Crashes	Economic Value per Crash		Total Economic Value
Fatal Crashes	**0**	**0.0**	$1,500,000	=	**$ -**
Severe (Injury A) Injury Crashes	**2**	**1.2**	$1,500,000	=	**$ 1,826,000**
Moderate (Injury B) Injury Crashes	**6**	**3.7**	$55,000	=	**$ 201,000**
Minor (Injury C) Injury Crashes	**4**	**2.4**	$55,000	=	**$ 134,000**
PDO Crashes	**4**	**2.1**	$15,000	=	**$ 31,000**

Comprehensive Economic Value per Crash		
Highway Type	Urban	Rural
PDO [3]		
All facilities	$15,000	$15,000
Moderate (Injury B) and Minor (Injury C) Injury [4]		
Interstate	$48,900	$54,800
Other State Highway	$47,900	$55,000
Fatal and Severe (Injury A) Injury [4]		
Interstate	$850,000	$1,460,000
Other State Highway	$840,000	$1,500,000

Total Crash Value for **84** Months = **$ 2,192,000**

Annual Benefits = Total Crash Value / Total Months / 12 = **$ 313,000**

Estimated Project Cost = **$ 1,820,000**

Uniform Series Present Worth Factor (5%)	
10 years	20 years
7.72	12.46

B/C Ratio = Annual Benefits X Present Worth Factor (10 or 20 years) / Estimated Project Cost

B/C Ratio = $ 313,000 x 12.46 [2] / $ 1,820,000 = **2.14**

Notes

1 Composite crash reduction factor calculated if more than one countermeasure is applied

2 Select a PWF for the life of countermeasure. See instructions

3 PDO value is $7,500 per crash adjusted with an under reporting factor of 2.0. National Safety Council, 2005 estimates of value per crash.

4 Economic costs per crash are calculated using 2004-2006 Oregon crash data and FHWA's Technical Advisory "Motor Vehicle Accident Costs, T 7570.2, October 31, 1994 updated to 2007 dollars with GDP implicit price deflator.

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OREGON DEPARTMENT OF TRANSPORTATION
HIGHWAY SAFETY PROJECTS
BENEFIT/COST ANALYSIS WORKSHEET

Project Name: **Cornelius Pass Road Improvement Projects** Region: **1** Date: **12/1/10**

Project on Local Agency Facility

Route Number: Street Name: **Cornelius Pass Road** MP Range or Cross Street:

Project on State Highway

Route Number: Hwy Name: MP From: **1.35** to **1.35**

Road Character: **RURAL** Facility Type: **OTHER STATE HIGHWAY**

County: **MULTNOMAH** City: **N/A** Crash Data From: **1/1/2003** to **12/31/2009**

Project Description: **Safety Evaluation**

Prepared By: **Project Team** Title: **Project E Curve (Part of Project O)**

		Fatal Crash Reduction Factor	Injury Crash Reduction Factor	PDO Crash Reduction Factor
Countermeasure 1	Horizontal alignment improvement	46%	46%	46%
Countermeasure 2	Increase distance to roadside obstacle	22%	22%	22%
Countermeasure 3		0%	0%	0%
Countermeasure 4		0%	0%	0%
		58% [1]	**58%** [1]	**58%** [1]

	Number of Crashes	Number of Preventable Crashes	Economic Value per Crash		Total Economic Value
Fatal Crashes	**0**	**0.0**	$1,500,000	=	**$ -**
Severe (Injury A) Injury Crashes	**0**	**0.0**	$1,500,000	=	**$ -**
Moderate (Injury B) Injury Crashes	**3**	**1.7**	$55,000	=	**$ 96,000**
Minor (Injury C) Injury Crashes	**0**	**0.0**	$55,000	=	**$ -**
PDO Crashes	**0**	**0.0**	$15,000	=	**$ -**

Comprehensive Economic Value per Crash		
Highway Type	Urban	Rural
PDO [3]		
All facilities	$15,000	$15,000
Moderate (Injury B) and Minor (Injury C) Injury [4]		
Interstate	$48,900	$54,800
Other State Highway	$47,900	$55,000
Fatal and Severe (Injury A) Injury [4]		
Interstate	$850,000	$1,460,000
Other State Highway	$840,000	$1,500,000

Total Crash Value for **84** Months = **$ 96,000**

Annual Benefits = Total Crash Value / Total Months / 12 = **$ 14,000**

Estimated Project Cost = **$ 1,500,000**

Uniform Series Present Worth Factor (5%)	
10 years	20 years
7.72	12.46

B/C Ratio = Annual Benefits X Present Worth Factor (10 or 20 years) / Estimated Project Cost

B/C Ratio = $ 14,000 x 12.46 [2] = **0.12**

$ 1,500,000

Notes

1 Composite crash reduction factor calculated if more than one countermeasure is applied

2 Select a PWF for the life of countermeasure. See instructions

3 PDO value is $7,500 per crash adjusted with an under reporting factor of 2.0. National Safety Council, 2005 estimates of value per crash.

4 Economic costs per crash are calculated using 2004-2006 Oregon crash data and FHWA's Technical Advisory "Motor Vehicle Accident Costs, T 7570.2, October 31, 1994 updated to 2007 dollars with GDP implicit price deflator.

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OREGON DEPARTMENT OF TRANSPORTATION
HIGHWAY SAFETY PROJECTS
BENEFIT/COST ANALYSIS WORKSHEET

Project Name: **Cornelius Pass Road Improvement Projects** Region: **1** Date: **12/1/10**

Project on Local Agency Facility

Route Number: Street Name: **Cornelius Pass Road** MP Range or Cross Street: **8th Avenue**

Project on State Highway

Route Number: Hwy Name: MP From: **1.50** to **1.50**

Road Character: **RURAL** Facility Type: **OTHER STATE HIGHWAY**

County: **MULTNOMAH** City: **N/A** Crash Data From: **1/1/2003** to **12/31/2009**

Project Description: **Safety Evaluation**

Prepared By: **Project Team** Title: **Project F Curves and 8th Avenue Improvement (Part of Project O)**

		Fatal Crash Reduction Factor	Injury Crash Reduction Factor	PDO Crash Reduction Factor
Countermeasure 1	Left Turn Lane	55%	55%	44%
Countermeasure 2	Horizontal alignment	51%	51%	51%
Countermeasure 3	Intersection Sight Distance	13%	13%	13%
Countermeasure 4	Increase distance to roadside obstacle	22%	22%	22%
		85% [1]	**85%** [1]	**81%** [1]

	Number of Crashes	Number of Preventable Crashes	Economic Value per Crash		Total Economic Value
Fatal Crashes	**0**	**0.0**	$1,500,000	=	**$ -**
Severe (Injury A) Injury Crashes	**1**	**0.9**	$1,500,000	=	**$ 1,276,000**
Moderate (Injury B) Injury Crashes	**3**	**2.6**	$55,000	=	**$ 140,000**
Minor (Injury C) Injury Crashes	**1**	**0.9**	$55,000	=	**$ 47,000**
PDO Crashes	**5**	**4.1**	$15,000	=	**$ 61,000**

Comprehensive Economic Value per Crash		
Highway Type	Urban	Rural
PDO [3]		
All facilities	$15,000	$15,000
Moderate (Injury B) and Minor (Injury C) Injury [4]		
Interstate	$48,900	$54,800
Other State Highway	$47,900	$55,000
Fatal and Severe (Injury A) Injury [4]		
Interstate	$850,000	$1,460,000
Other State Highway	$840,000	$1,500,000

Total Crash Value for **84** Months = **$ 1,524,000**

Annual Benefits = Total Crash Value / Total Months / 12 = **$ 218,000**

Estimated Project Cost = **$ 3,500,000**

Uniform Series Present Worth Factor (5%)	
10 years	20 years
7.72	12.46

B/C Ratio = Annual Benefits X Present Worth Factor (10 or 20 years) / Estimated Project Cost

B/C Ratio = $ 218,000 x 12.46 [2] = **0.78**

$ 3,500,000

Notes

1 Composite crash reduction factor calculated if more than one countermeasure is applied

2 Select a PWF for the life of countermeasure. See instructions

3 PDO value is $7,500 per crash adjusted with an under reporting factor of 2.0. National Safety Council, 2005 estimates of value per crash.

4 Economic costs per crash are calculated using 2004-2006 Oregon crash data and FHWA's Technical Advisory "Motor Vehicle Accident Costs, T 7570.2, October 31, 1994 updated to 2007 dollars with GDP implicit price deflator.

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OREGON DEPARTMENT OF TRANSPORTATION
HIGHWAY SAFETY PROJECTS
BENEFIT/COST ANALYSIS WORKSHEET

Project Name: **Cornelius Pass Road Improvement Projects** Region: **1** Date: **12/1/10**

Project on Local Agency Facility

Route Number: Street Name: **Cornelius Pass Road** MP Range or Cross Street: **MP 1.85 to 2.05**

Project on State Highway

Route Number: Hwy Name: MP From: **1.85** to **2.05**

Road Character: **RURAL** Facility Type: **OTHER STATE HIGHWAY**

County: **MULTNOMAH** City: **N/A** Crash Data From: **1/1/2003** to **12/31/2009**

Project Description: **Safety Evaluation**

Prepared By: **Project Team** Title: **Project G Curves (Part of Project O)**

		Fatal Crash Reduction Factor	Injury Crash Reduction Factor	PDO Crash Reduction Factor
Countermeasure 1	Horizontal alignment	56%	56%	56%
Countermeasure 2	Intersection Sight Distance	9%	9%	9%
Countermeasure 3	Increase distance to roadside obstacle	22%	22%	22%
Countermeasure 4		0%	0%	0%
		69% [1]	**69%** [1]	**69%** [1]

	Number of Crashes	Number of Preventable Crashes	Economic Value per Crash		Total Economic Value
Fatal Crashes	**0**	**0.0**	$1,500,000	=	**$ -**
Severe (Injury A) Injury Crashes	**0**	**0.0**	$1,500,000	=	**$ -**
Moderate (Injury B) Injury Crashes	**2**	**1.4**	$55,000	=	**$ 76,000**
Minor (Injury C) Injury Crashes	**0**	**0.0**	$55,000	=	**$ -**
PDO Crashes	**11**	**7.6**	$15,000	=	**$ 113,000**

Comprehensive Economic Value per Crash		
Highway Type	Urban	Rural
PDO [3]		
All facilities	$15,000	$15,000
Moderate (Injury B) and Minor (Injury C) Injury [4]		
Interstate	$48,900	$54,800
Other State Highway	$47,900	$55,000
Fatal and Severe (Injury A) Injury [4]		
Interstate	$850,000	$1,460,000
Other State Highway	$840,000	$1,500,000

Total Crash Value for **84** Months = **$ 189,000**

Annual Benefits = Total Crash Value / Total Months / 12 = **$ 27,000**

Estimated Project Cost = **$ 2,500,000**

Uniform Series Present Worth Factor (5%)	
10 years	20 years
7.72	12.46

B/C Ratio = Annual Benefits X Present Worth Factor (10 or 20 years) / Estimated Project Cost

B/C Ratio = $ 27,000 x 12.46 [2] = **0.13**

$ 2,500,000

Notes

1 Composite crash reduction factor calculated if more than one countermeasure is applied

2 Select a PWF for the life of countermeasure. See instructions

3 PDO value is $7,500 per crash adjusted with an under reporting factor of 2.0. National Safety Council, 2005 estimates of value per crash.

4 Economic costs per crash are calculated using 2004-2006 Oregon crash data and FHWA's Technical Advisory "Motor Vehicle Accident Costs, T 7570.2, October 31, 1994 updated to 2007 dollars with GDP implicit price deflator.

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OREGON DEPARTMENT OF TRANSPORTATION
HIGHWAY SAFETY PROJECTS
BENEFIT/COST ANALYSIS WORKSHEET

Project Name: **Cornelius Pass Road Improvement Projects** Region: **1** Date: **12/1/10**

Project on Local Agency Facility

Route Number: Street Name: **Cornelius Pass Road** MP Range or Cross Street: **Skyline**

Project on State Highway

Route Number: Hwy Name: MP From: **3.45** to **3.65**

Road Character: **RURAL** Facility Type: **OTHER STATE HIGHWAY**

County: **MULTNOMAH** City: **N/A** Crash Data From: **1/1/2003** to **12/31/2009**

Project Description: **Safety Evaluation**

Prepared By: **Project Team** Title: **Project I Skyline Boulevard (part of Project O)**

		Fatal Crash Reduction Factor	Injury Crash Reduction Factor	PDO Crash Reduction Factor
Countermeasure 1	Roundabout	87%	87%	71%
Countermeasure 2	Left-turns at Plainview and Grocery Store	55%	55%	44%
Countermeasure 3		0%	0%	0%
Countermeasure 4		0%	0%	0%
		94% [1]	**94%** [1]	**84%** [1]

	Number of Crashes	Number of Preventable Crashes	Economic Value per Crash		Total Economic Value
Fatal Crashes	**0**	**0.0**	$1,500,000	=	$ -
Severe (Injury A) Injury Crashes	**3**	**2.8**	$1,500,000	=	$ 4,237,000
Moderate (Injury B) Injury Crashes	**8**	**7.5**	$55,000	=	$ 414,000
Minor (Injury C) Injury Crashes	**8**	**7.5**	$55,000	=	$ 414,000
PDO Crashes	**35**	**29.3**	$15,000	=	$ 440,000

Comprehensive Economic Value per Crash		
Highway Type	Urban	Rural
PDO [3]		
All facilities	$15,000	$15,000
Moderate (Injury B) and Minor (Injury C) Injury [4]		
Interstate	$48,900	$54,800
Other State Highway	$47,900	$55,000
Fatal and Severe (Injury A) Injury [4]		
Interstate	$850,000	$1,460,000
Other State Highway	$840,000	$1,500,000

Total Crash Value for **84** Months = **$ 5,505,000**

Annual Benefits = Total Crash Value / Total Months / 12 = **$ 786,000**

Estimated Project Cost = **$ 3,746,000**

Uniform Series Present Worth Factor (5%)	
10 years	20 years
7.72	12.46

B/C Ratio = Annual Benefits X Present Worth Factor (10 or 20 years) / Estimated Project Cost

B/C Ratio = $ 786,000 x 12.46 [2] / $ 3,746,000 = **2.61**

Notes

1 Composite crash reduction factor calculated if more than one countermeasure is applied

2 Select a PWF for the life of countermeasure. See instructions

3 PDO value is $7,500 per crash adjusted with an under reporting factor of 2.0. National Safety Council, 2005 estimates of value per crash.

4 Economic costs per crash are calculated using 2004-2006 Oregon crash data and FHWA's Technical Advisory "Motor Vehicle Accident Costs, T 7570.2, October 31, 1994 updated to 2007 dollars with GDP implicit price deflator.

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OREGON DEPARTMENT OF TRANSPORTATION
HIGHWAY SAFETY PROJECTS
BENEFIT/COST ANALYSIS WORKSHEET

Project Name: **Cornelius Pass Road Improvement Projects** Region: **1** Date: **12/1/10**

Project on Local Agency Facility

Route Number: Street Name: **Cornelius Pass Road** MP Range or Cross Street:

Project on State Highway

Route Number: Hwy Name: MP From: **3.80** to **3.80**

Road Character: **RURAL** Facility Type: **OTHER STATE HIGHWAY**

County: **MULTNOMAH** City: **N/A** Crash Data From: **1/1/2003** to **12/31/2009**

Project Description: **Safety Evaluation**

Prepared By: **Project Team** Title: **Project J Curve (part of Project O)**

		Fatal Crash Reduction Factor	Injury Crash Reduction Factor	PDO Crash Reduction Factor
Countermeasure 1	Horizontal alignment improvement	41%	41%	41%
Countermeasure 2	Increase distance to roadside obstacle	22%	22%	22%
Countermeasure 3		0%	0%	0%
Countermeasure 4		0%	0%	0%
		54% [1]	**54%** [1]	**54%** [1]

	Number of Crashes	Number of Preventable Crashes	Economic Value per Crash		Total Economic Value
Fatal Crashes	**0**	**0.0**	$1,500,000	=	**$ -**
Severe (Injury A) Injury Crashes	**2**	**1.1**	$1,500,000	=	**$ 1,619,000**
Moderate (Injury B) Injury Crashes	**1**	**0.5**	$55,000	=	**$ 30,000**
Minor (Injury C) Injury Crashes	**2**	**1.1**	$55,000	=	**$ 59,000**
PDO Crashes	**0**	**0.0**	$15,000	=	**$ -**

Comprehensive Economic Value per Crash		
Highway Type	Urban	Rural
PDO [3]		
All facilities	$15,000	$15,000
Moderate (Injury B) and Minor (Injury C) Injury [4]		
Interstate	$48,900	$54,800
Other State Highway	$47,900	$55,000
Fatal and Severe (Injury A) Injury [4]		
Interstate	$850,000	$1,460,000
Other State Highway	$840,000	$1,500,000

Total Crash Value for **84** Months = **$ 1,708,000**

Annual Benefits = Total Crash Value / Total Months / 12 = **$ 244,000**

Estimated Project Cost = **$ 2,500,000**

Uniform Series Present Worth Factor (5%)	
10 years	20 years
7.72	12.46

B/C Ratio = Annual Benefits X Present Worth Factor (10 or 20 years) / Estimated Project Cost

B/C Ratio = $ 244,000 x 12.46 [2] / $ 2,500,000 = **1.22**

Notes

1 Composite crash reduction factor calculated if more than one countermeasure is applied

2 Select a PWF for the life of countermeasure. See instructions

3 PDO value is $7,500 per crash adjusted with an under reporting factor of 2.0. National Safety Council, 2005 estimates of value per crash.

4 Economic costs per crash are calculated using 2004-2006 Oregon crash data and FHWA's Technical Advisory "Motor Vehicle Accident Costs, T 7570.2, October 31, 1994 updated to 2007 dollars with GDP implicit price deflator.

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OREGON DEPARTMENT OF TRANSPORTATION
HIGHWAY SAFETY PROJECTS
BENEFIT/COST ANALYSIS WORKSHEET

Project Name: **Cornelius Pass Road Improvement Projects** Region: **1** Date: **12/1/10**

Project on Local Agency Facility

Route Number: Street Name: **Cornelius Pass Road** MP Range or Cross Street: **Kaiser Road**

Project on State Highway

Route Number: Hwy Name: MP From: **4.40** to **4.50**

Road Character: **RURAL** Facility Type: **OTHER STATE HIGHWAY**

County: **MULTNOMAH** City: **N/A** Crash Data From: **1/1/2003** to **12/31/2009**

Project Description: **Safety Evaluation**

Prepared By: **Project Team** Title: **Project K Curve North of Kaiser Road (part of Project O)**

		Fatal Crash Reduction Factor	Injury Crash Reduction Factor	PDO Crash Reduction Factor
Countermeasure 1	Horizontal alignment	3%	3%	3%
Countermeasure 2	Increase distance to roadside obstacle	22%	22%	22%
Countermeasure 3		0%	0%	0%
Countermeasure 4		0%	0%	0%
		24% [1]	**24%** [1]	**24%** [1]

	Number of Crashes	Number of Preventable Crashes	Economic Value per Crash		Total Economic Value
Fatal Crashes	**1**	**0.2**	$1,500,000	=	**$ 365,000**
Severe (Injury A) Injury Crashes	**1**	**0.2**	$1,500,000	=	**$ 365,000**
Moderate (Injury B) Injury Crashes	**1**	**0.2**	$55,000	=	**$ 13,000**
Minor (Injury C) Injury Crashes	**0**	**0.0**	$55,000	=	**$ -**
PDO Crashes	**1**	**0.2**	$15,000	=	**$ 4,000**

Comprehensive Economic Value per Crash		
Highway Type	Urban	Rural
PDO [3]		
All facilities	$15,000	$15,000
Moderate (Injury B) and Minor (Injury C) Injury [4]		
Interstate	$48,900	$54,800
Other State Highway	$47,900	$55,000
Fatal and Severe (Injury A) Injury [4]		
Interstate	$850,000	$1,460,000
Other State Highway	$840,000	$1,500,000

Total Crash Value for **84** Months = **$ 747,000**

Annual Benefits = Total Crash Value / Total Months / 12 = **$ 107,000**

Estimated Project Cost = **$ 2,500,000**

Uniform Series Present Worth Factor (5%)	
10 years	20 years
7.72	12.46

B/C Ratio = Annual Benefits X Present Worth Factor (10 or 20 years) / Estimated Project Cost

B/C Ratio = $ 107,000 x 12.46 [2] = **0.53**

$ 2,500,000

Notes

1 Composite crash reduction factor calculated if more than one countermeasure is applied

2 Select a PWF for the life of countermeasure. See instructions

3 PDO value is $7,500 per crash adjusted with an under reporting factor of 2.0. National Safety Council, 2005 estimates of value per crash.

4 Economic costs per crash are calculated using 2004-2006 Oregon crash data and FHWA's Technical Advisory "Motor Vehicle Accident Costs, T 7570.2, October 31, 1994 updated to 2007 dollars with GDP implicit price deflator.

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OREGON DEPARTMENT OF TRANSPORTATION
HIGHWAY SAFETY PROJECTS
BENEFIT/COST ANALYSIS WORKSHEET

Project Name: **Cornelius Pass Road Improvement Projects** Region: **1** Date: **12/1/10**

Project on Local Agency Facility

Route Number: Street Name: **Cornelius Pass Road** MP Range or Cross Street: **Kaiser Road**

Project on State Highway

Route Number: Hwy Name: MP From: **4.60** to **4.65**

Road Character: **RURAL** Facility Type: **OTHER STATE HIGHWAY**

County: **MULTNOMAH** City: **N/A** Crash Data From: **1/1/2003** to **12/31/2009**

Project Description: **Safety Evaluation**

Prepared By: **Project Team** Title: **Project L Kaiser Road (part of Project O)**

		Fatal Crash Reduction Factor	Injury Crash Reduction Factor	PDO Crash Reduction Factor
Countermeasure 1	Right Turn Lane	23%	23%	14%
Countermeasure 2	Intersection Sight Distnace	13%	13%	13%
Countermeasure 3		0%	0%	0%
Countermeasure 4		0%	0%	0%
		33% [1]	**33%** [1]	**25%** [1]

	Number of Crashes	Number of Preventable Crashes	Economic Value per Crash		Total Economic Value
Fatal Crashes	**0**	**0.0**	$1,500,000	=	**$ -**
Severe (Injury A) Injury Crashes	**1**	**0.3**	$1,500,000	=	**$ 495,000**
Moderate (Injury B) Injury Crashes	**1**	**0.3**	$55,000	=	**$ 18,000**
Minor (Injury C) Injury Crashes	**1**	**0.3**	$55,000	=	**$ 18,000**
PDO Crashes	**2**	**0.5**	$15,000	=	**$ 8,000**

Comprehensive Economic Value per Crash		
Highway Type	Urban	Rural
PDO [3]		
All facilities	$15,000	$15,000
Moderate (Injury B) and Minor (Injury C) Injury [4]		
Interstate	$48,900	$54,800
Other State Highway	$47,900	$55,000
Fatal and Severe (Injury A) Injury [4]		
Interstate	$850,000	$1,460,000
Other State Highway	$840,000	$1,500,000

Total Crash Value for **84** Months = **$ 539,000**

Annual Benefits = Total Crash Value / Total Months / 12 = **$ 77,000**

Estimated Project Cost = **$ 200,000**

Uniform Series Present Worth Factor (5%)	
10 years	20 years
7.72	12.46

B/C Ratio = Annual Benefits X Present Worth Factor (10 or 20 years) / Estimated Project Cost

B/C Ratio = $ 77,000 x 12.46 [2] = **4.80**

$ 200,000

Notes

1 Composite crash reduction factor calculated if more than one countermeasure is applied

2 Select a PWF for the life of countermeasure. See instructions

3 PDO value is $7,500 per crash adjusted with an under reporting factor of 2.0. National Safety Council, 2005 estimates of value per crash.

4 Economic costs per crash are calculated using 2004-2006 Oregon crash data and FHWA's Technical Advisory "Motor Vehicle Accident Costs, T 7570.2, October 31, 1994 updated to 2007 dollars with GDP implicit price deflator.