Appendix B

Design Workshop #2
Material

Cornelius Pass Road JTA
Design Workshop #2

Project Key

Corridor Wide Statistics

Project A – Lighting Corridor Wide

Project B – Roadside Protection Corridor Wide

Project Area C – S-Curves, MP 0.2-0.6

- Project 1 – Construct Retaining Wall Treatments and Guardrails
- Project 2 – Realign Roadway

Project Area D – Sheltered Nook Road Intersection, MP 1.2

- Project 1 – Construct a Northbound left turn pocket
- Project 2 – Improve Vertical Curve

Project Area E – Horizontal Curve South of Sheltered Nook Road Intersection, MP 1.4

- Project 1 – Increase Stopping Sight Distance Through Curve
- Project 2 – Improve Curve Radius

Project Area F – 8th Avenue, MP 1.5

- Project 1 – Improve Intersection and Stopping Sight Distance
- Project 2 – Improve Curve and Intersection

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

- Project 1 – Increase Stopping Sight Distance Through Curve
- Project 2 – Improve Curve Radius

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

- Project 1 – Widen Shoulders
- Project 2 – Construct a Bridge Structure
- Project 3 – Realign Road to West

Project Area I – Skyline Boulevard Intersection

- Project 1 – Access Management and Improve Intersection Sight Distance
- Project 2 – Realignment of Cornelius Pass Road and Plainview Road
- Project 3 – Realignment of Cornelius Pass Road and Introduce Southbound Passing Lane
- Project 4 – Construct a Single Lane Roundabout

Project Area J –Roadway Curve, MP 3.8

- Project 1 – Increase Stopping Sight Distance Through Curve
- Project 2 – Improve Curve Radius

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

- Project 1 – Increase Stopping Sight Distance Through Curve
- Project 2 – Improve Curve Radius

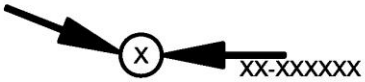
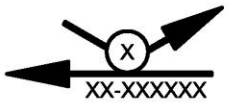
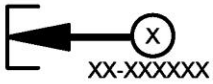
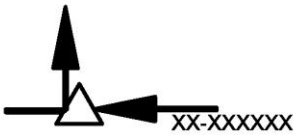
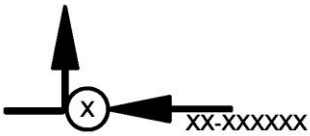
Project Area L – Kaiser Road Intersection, MP 4.6

- Project 1 – Construct a Southbound left turn pocket
- Project 2 – Construct a Northbound right turn pocket/widen shoulder

Project M – Cornelius Pass Road Specific Design Guide

Project N – Cornelius Pass Road Specific Policies

Collision Legend

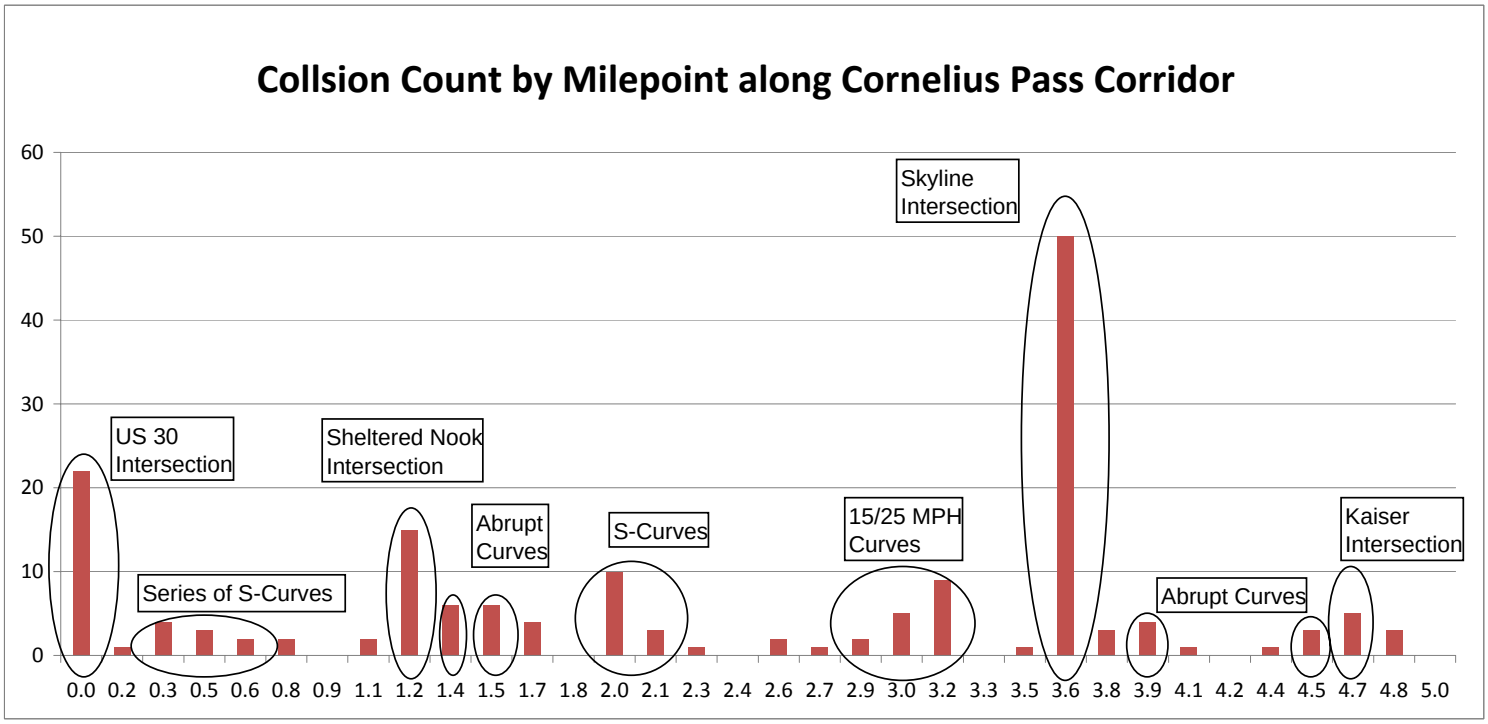
Collision Type	Colision Diagrams for "Property Damage Only" or PDO Incidents	Collision Diagrams for Incidents in which an injury has occurred.
Rear End		
Head On		
Angle		
Sideswipe - Same Direction		
Sideswipe - Opposite Direction		
Out of Control		
Collision with a Fixed Object	 	 
Turning		

(X) "X" is designated as "A", "B" or "C" depending on injury severity.
- Type "A" is the most severe & defined as an incapacitating injury.
- Type "B" is not as severe & defined as a non-incapacitating injury.
- Type "C" is the least severe & defined as a possible injury.

● Collisions in which a fatality have occurred are depicted with a solid circle.

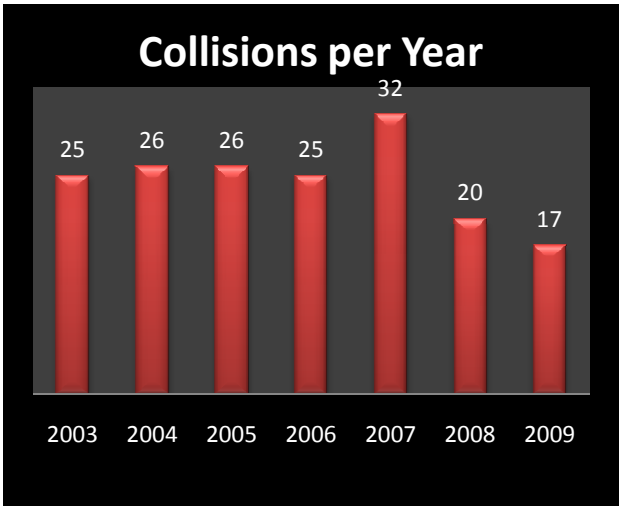
Corridor Wide Statistics

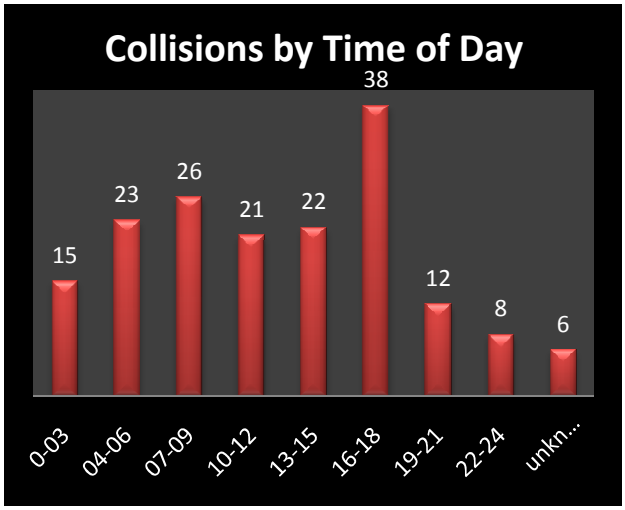
Cornelius Pass Road 2003 - 2009 Collisions
Corridor, MP 0.0 - 5.0

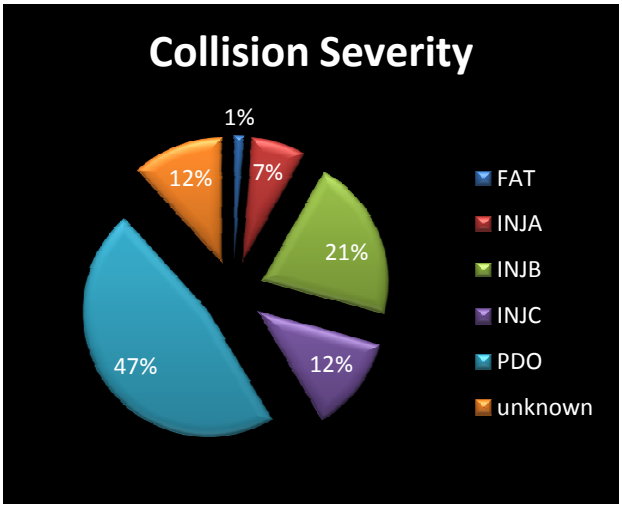


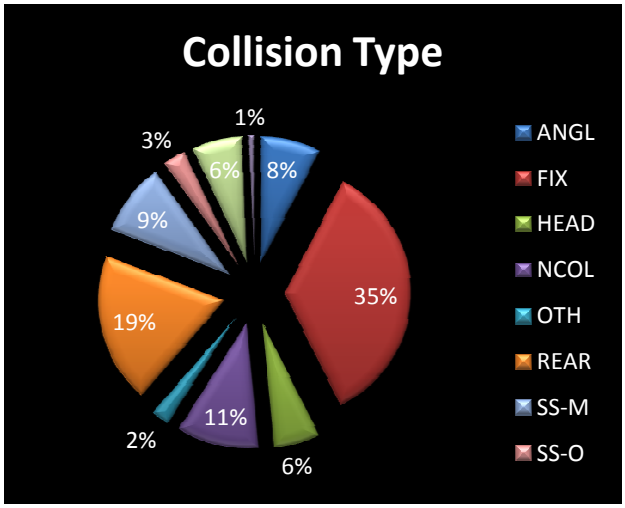
ODOT Project:	US 30 Intersection Improvement
Project Area C:	Series of S-Curves at MP 0.15 - 0.60
Project Area D:	Sheltered Nook Road Intersection
Project Area E:	Horizontal Curve south of Sheltered Nook Road Intersection
Project Area F:	S-Curves at MP 1.5 - 1.6 & 8th Avenue Intersection
Project Area G:	Roadway S-Curves at MP 1.8 - 2.1
Project Area H:	MP 2.8 - 3.3 (Tight Curves)
Project Area I:	Skyline Boulevard Intersection
Project Area J:	Roadway Curve at MP 3.8-3.9
Project Area K:	Horizontal Curve north of Kaiser Road
Project Area L:	Kaiser Road Intersection

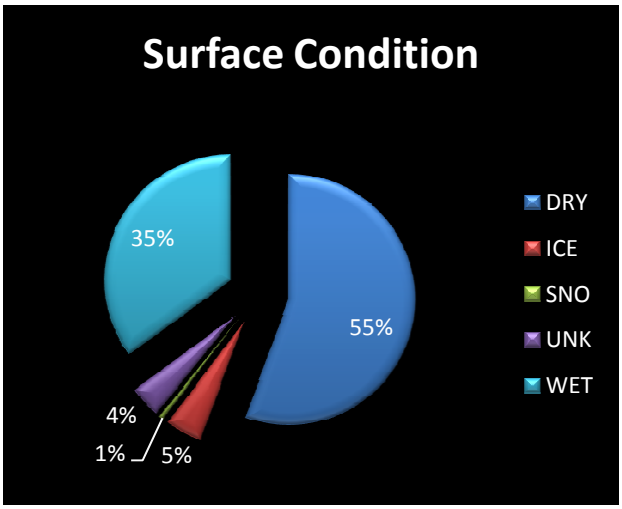
Cornelius Pass Road 2003 - 2009 Collisions
Entire Corridor

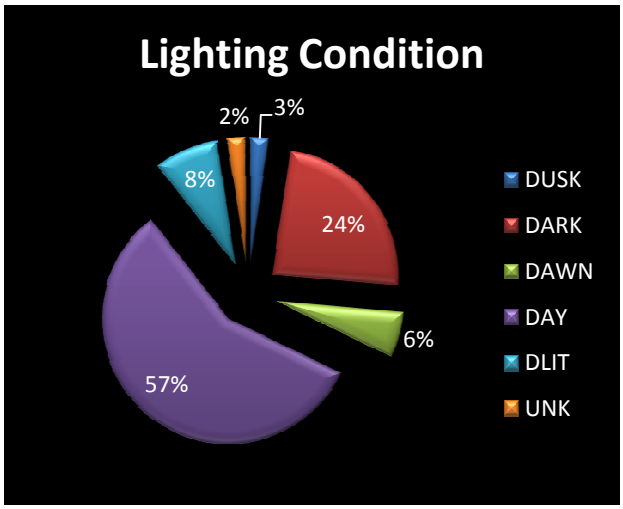




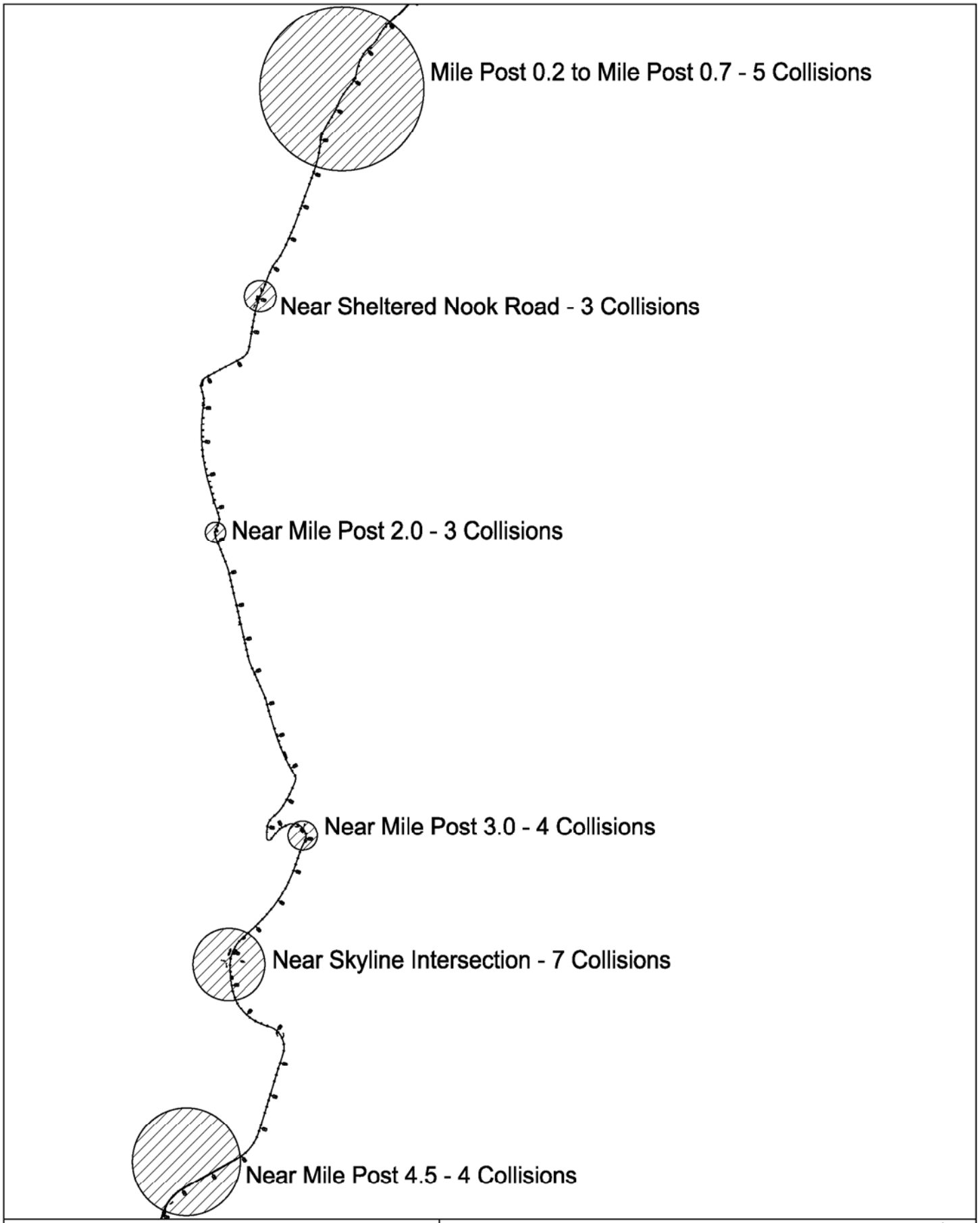








Project A – Lighting Corridor Wide



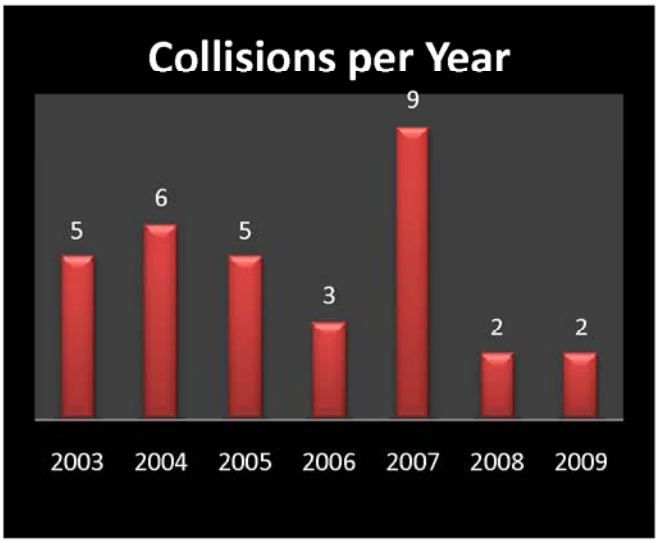
Collision Diagram
Project Area A (Lighting)

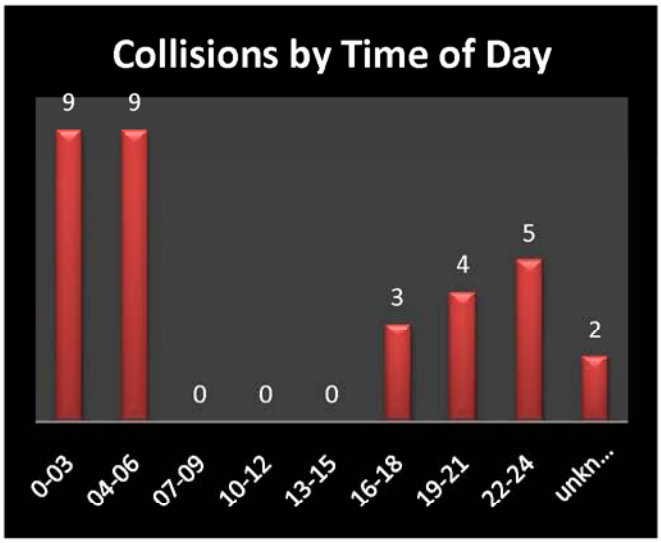
Scale: 1 inch = 2000 feet

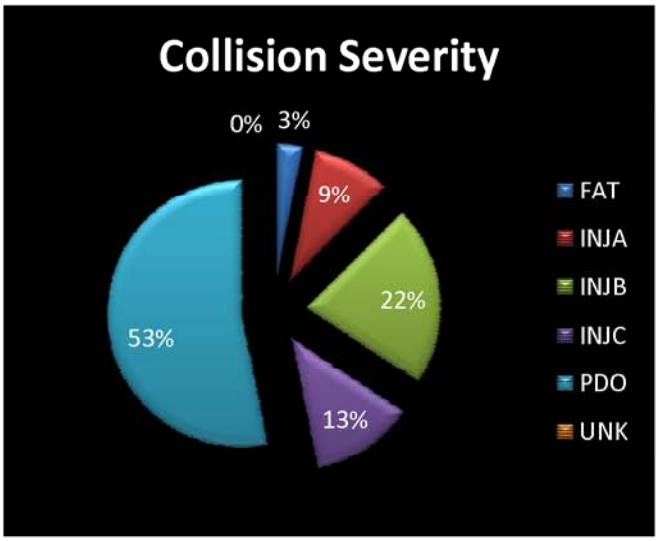
2000 1000 0 1000 2000

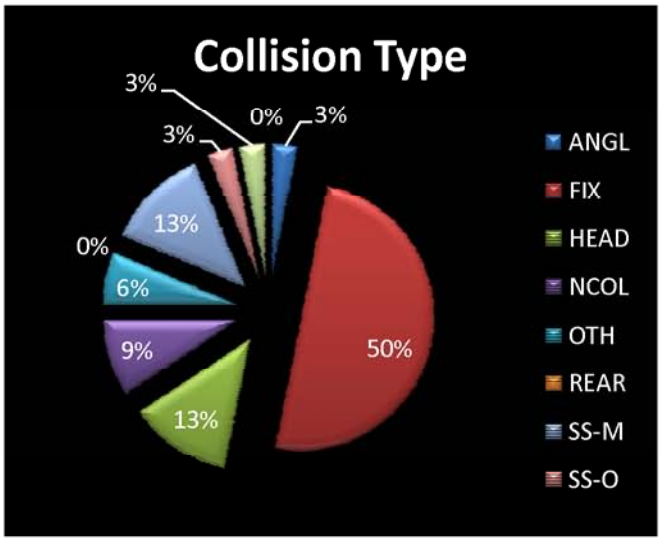
N

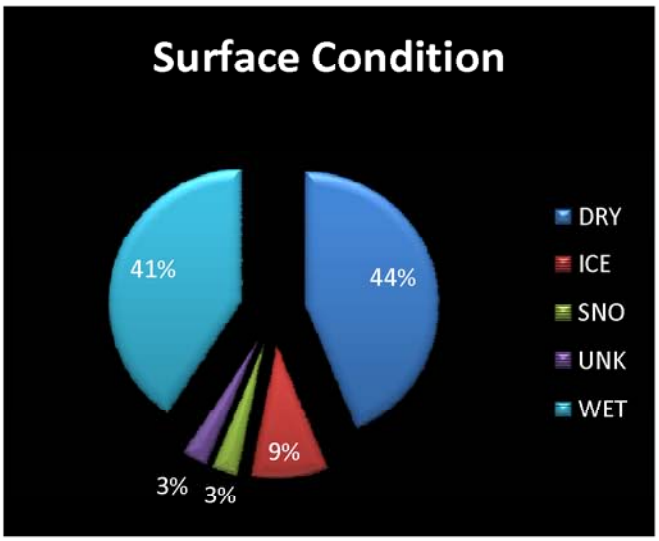
Cornelius Pass Road 2003 - 2009 Collisions
Project A: Entire Corridor MP 0.0 - 5.0, Dark Conditions

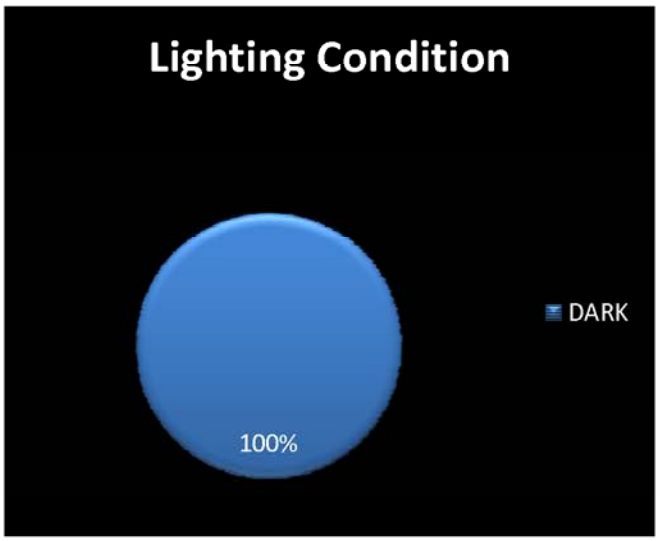






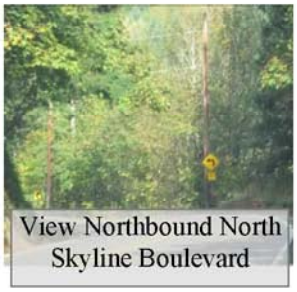
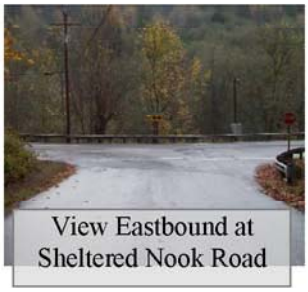






Project A - Roadway Lighting

Problem Statement: Of the 171 collisions recorded on Cornelius Pass Rd in the last eight 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; however one fatality and five debilitating injuries 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 street lights.

Photos	Proposed Project
 View Northbound at 8th Avenue  View Northbound North Skyline Boulevard  View Eastbound at Sheltered Nook Road	**Project 1:** Corridor wide optimal lighting levels could be obtained using 200 Watt, flat lens (dark sky compliant), cobra head luminaires, mounted at a height of 35 feet and spaced at approximately 165 feet. This project assumes the cobra head luminaires could be mounted to new wood utility poles. **Project 2:** A short term project could include lighting select locations along Cornelius Pass Road where nighttime collision frequency is greatest, instead of lighting the entire corridor. The top six locations for nighttime collisions are: near Skyline intersection (7 collisions), mile post 0.2 to 0.7 (5 collisions), mile post 3.0 (4 collisions – some street lighting already installed), mile post 4.5 (4 collisions), near Sheltered Nook Road (3 collisions), and mile post 2.0 (3 collisions).

Supporting Data

Total Collisions 2003-2007 that occurred in dark conditions along the 5 mile segment of Cornelius Pass Road = 32 (19%)

By type:

- 50% fixed object, 16% other/overturn, 28% head-on or sideswipe, 6% turning/angled

By severity:

- 3% Fatal, 9% Injury A, 22% Injury B, 12% Injury C, 53% PDO

Roadway Characteristic

- 69% on a curve or grade, 22% on a straight section, 3% at an intersection, 6% unknown

By location:

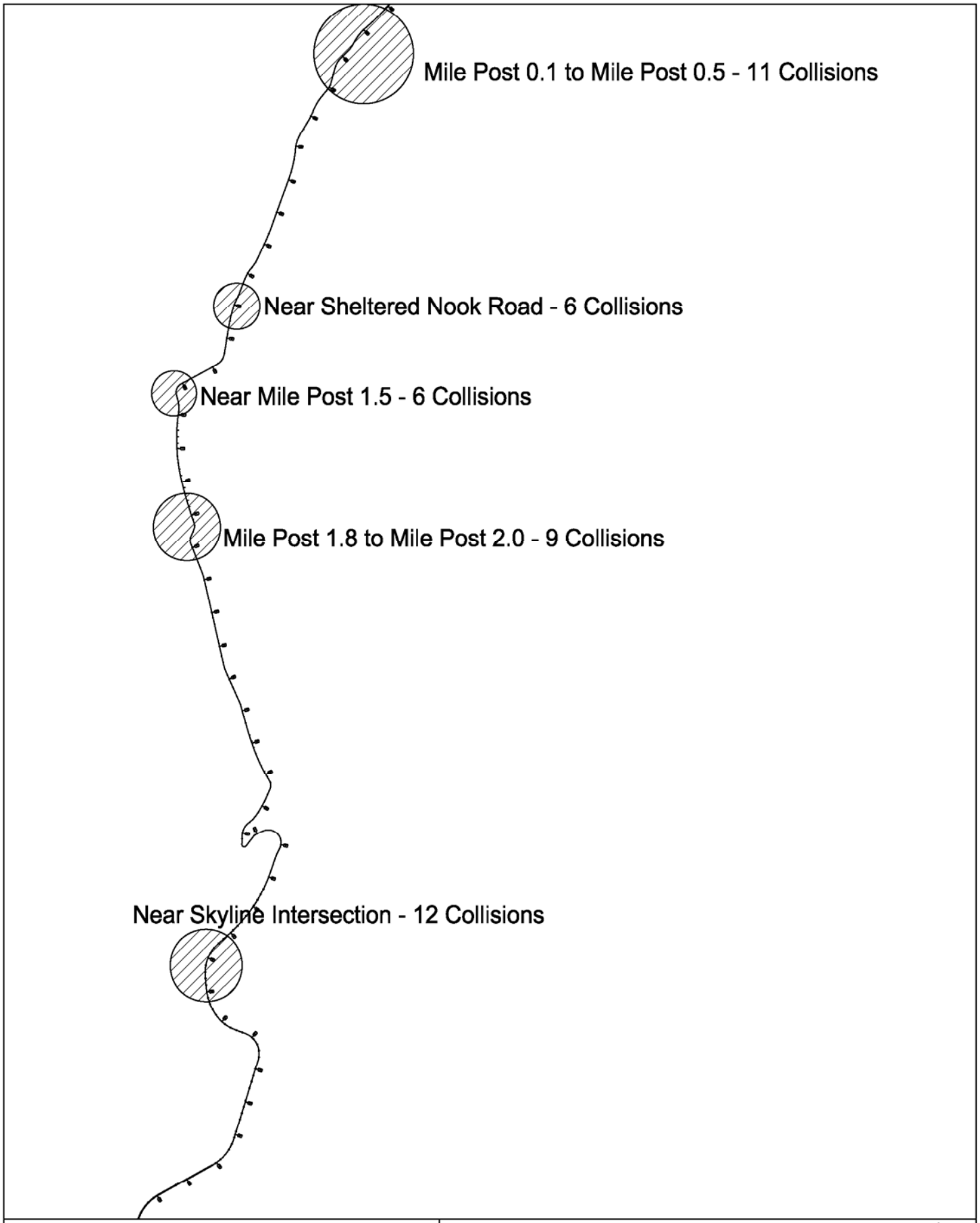
- Within 0.2 miles of an intersection = 47% *(28% Skyline, 9% Kaiser, 9% Sheltered Nook)*
- 53% not near an intersection

Improvement Options	Benefits	Costs
Project 1: Install roadway lighting along the entire corridor	• Potential to reduce nighttime fatal collisions by approximately 70%.[1] • Potential to reduce nighttime PDO and injury collisions by 20% to 30%.[1]	$500,000 to $700,000
Project 2: Install roadway lighting at select nighttime high collision locations	• Potential to reduce nighttime collisions near intersections by approximately 10%[2] to 60%[1] • Potential to reduce nighttime PDO and injury collisions by 20% to 30%.[1] • Potential to reduce nighttime fatal collisions by approximately 70%.[1]	$25,000 to $35,000 per intersection or per 1,200 feet of lit roadway
Other Considerations		
• In some cases existing utility poles may be used, which could decrease the project cost. • Around tight curves and through dense tree canopies, the lights may need to be spaced closer than 165 ft, or lower than 35 feet. • Wetland mitigates may be required at some pole locations.		

[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.

[2] 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.

Project B – Roadside Protection Corridor Wide



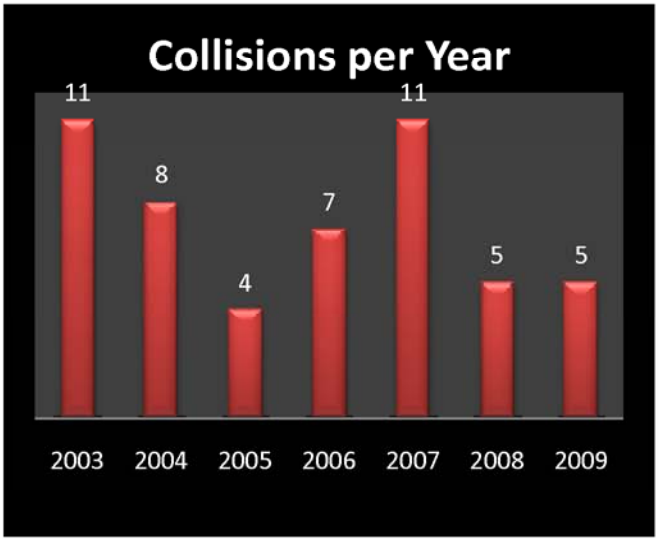
Collision Diagram
Project Area B (Roadside Protection)

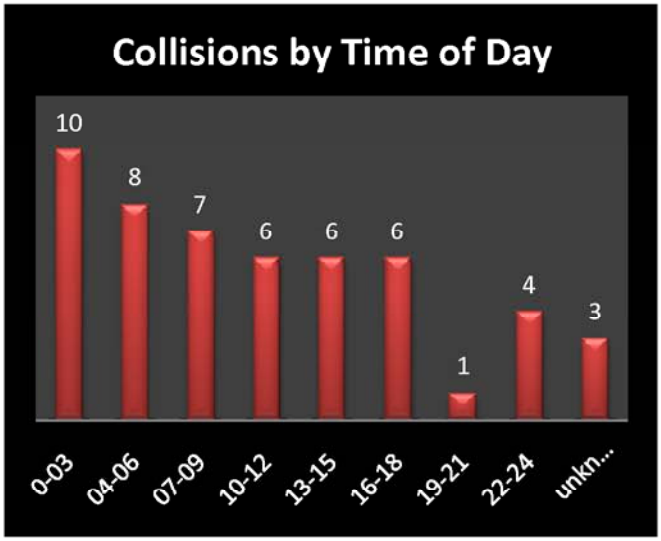
Scale: 1 inch = 2000 feet

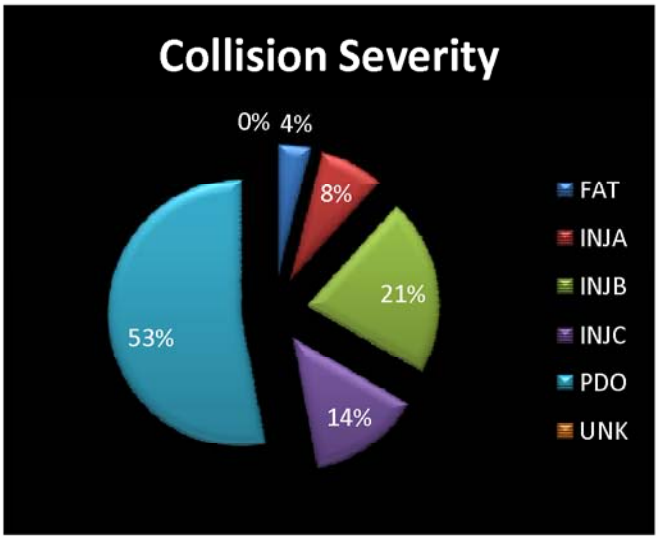
2000 1000 0 1000 2000

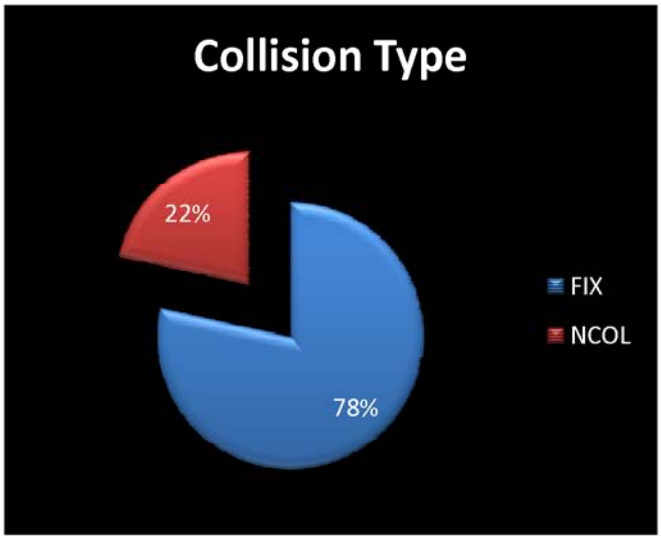
Cornelius Pass Road 2003 - 2009 Collisions

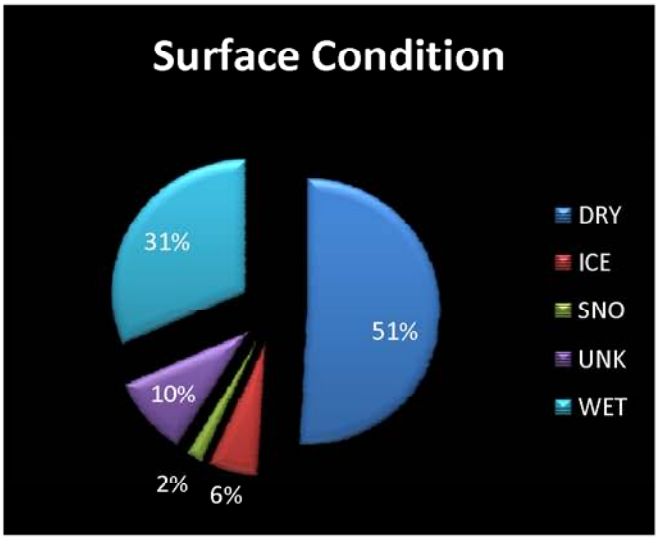
Project B: Entire Corridor MP 0.0 - 5.0, Off Roadway

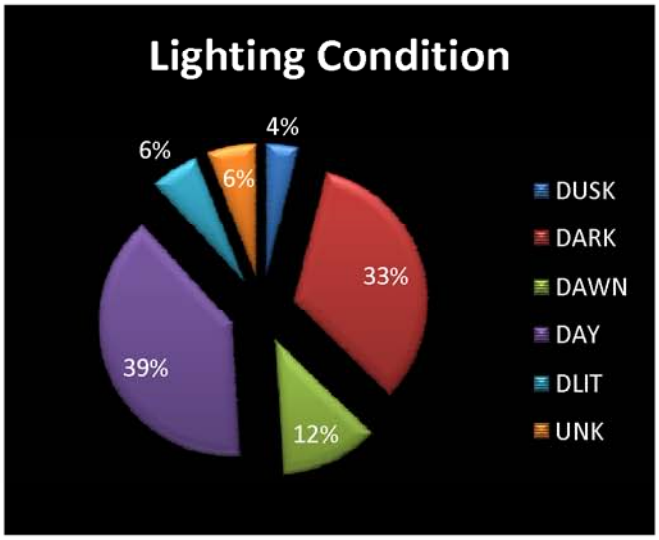












Project B – Roadside Protection

Problem Statement: Of the 171 collisions recorded on Cornelius Pass Road in the last eight years, almost a third of them have involved individual vehicles running off the road into fixed objects or overturning (not including collisions at Highway 30). Most of these collisions have fortunately only resulted in property damage, but there were two fatalities and six debilitating injuries. The severity of these single vehicle run-off-the-road type collisions may have been reduced if guard rail had been installed. There are many stretches of Cornelius Pass Road with unshielded roadside hazards in the clear zone, including narrow shoulders, steep embankments or slopes, trees, utility poles and other obstacles.

Photos	Proposed Project
 View Northbound North of Sheltered Nook Road  View Northbound South of Sheltered Nook Road	**Project 1:** Roadside protection should be installed along the road in areas there is a high risk of vehicles running off the road into fixed objects or down a steep embankment. **Project 2:** Alternatively, instead of installing roadside protection along all the potentially high-risk areas along the corridor, roadside protection could be installed along the road in specific areas where there have been high occurrences of collisions involving vehicles running off the road.

Supporting Data

Total Collisions 2003-2007 that involved vehicles running off the road along the 5 mile segment of Cornelius Pass Road = 51 (30%)

By type:

- 78% fixed object, 22% overturn

By severity:

- 4% Fatal, 8% Injury A, 22% Injury B, 14% Injury C, 53% PDO

Other Collision Factors:

- Road surface: 51% dry, 31% wet, 8% snow/ice
- Light conditions: 39%, 33% dark unlit

By location:

- In clusters of 4 or more within approximately 250 ft of a milepost = 70% (*8% mp 0.45;12% mp 1.2; 12% mp 1.55;16% mp 1.95; 24% mp 3.5)*

Improvement Options	Benefits
Project 1: Install roadside protection along all areas of the road with potential hazards	National research has shown that the installation of roadside protection along an embankment can reduce injuries and fatalities from run off the road type collisions by 47% and 44%, respectively.[2]
Project 2: Install roadside protection along high-collision areas on the corridor	National research has shown that the installation of roadside protection along an embankment can reduce injuries and fatalities from run off the road type collisions by 47% and 44%, respectively.[3]

Other Considerations

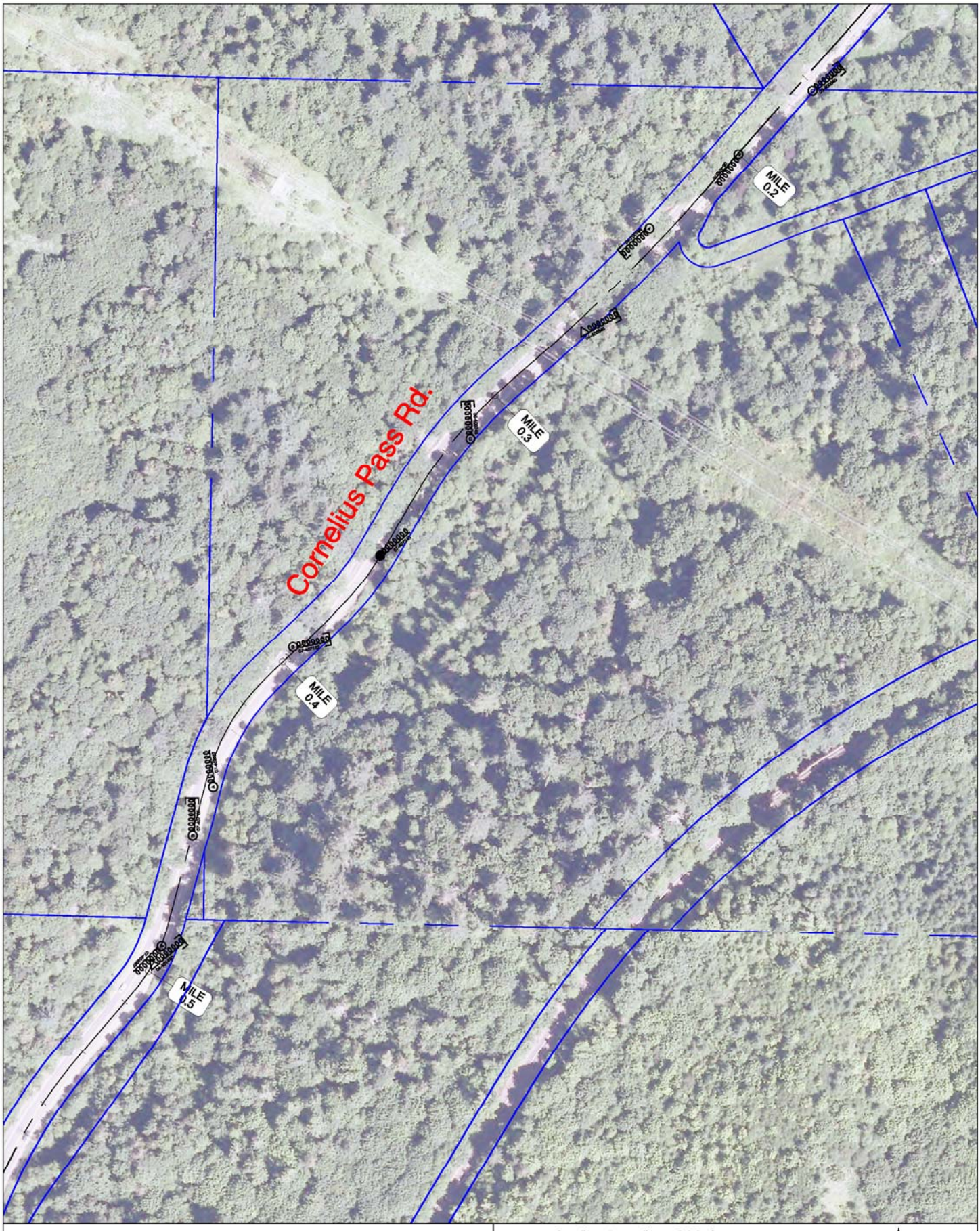
- There are narrow shoulders and little to no recovery areas at many places along Cornelius Pass Road.
- There are frequent hazards along the road, including trees, utility poles and ditches or steep drop-offs.

[2] 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.

[3] IBID

Project Area C – S-Curves, MP 0.2-0.6

- **Project 1 – Construct Retaining Wall Treatments and Guardrails**
- **Project 2 – Realign Roadway**



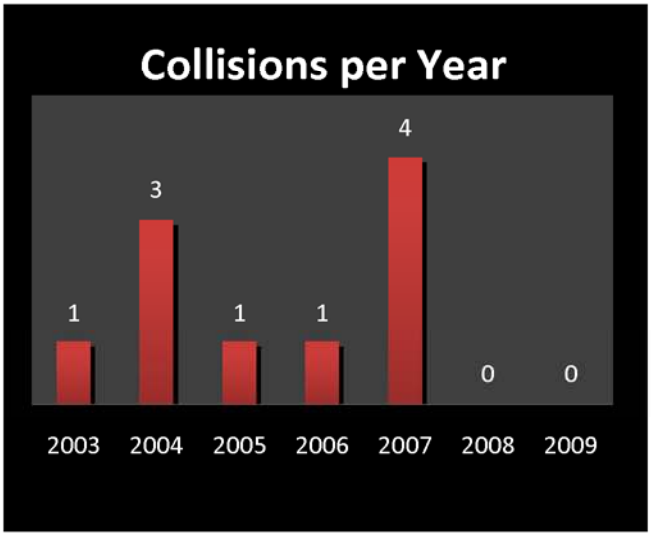
Collision Diagram
Project Area C (S-Curves at MP 0.15 - 0.60)

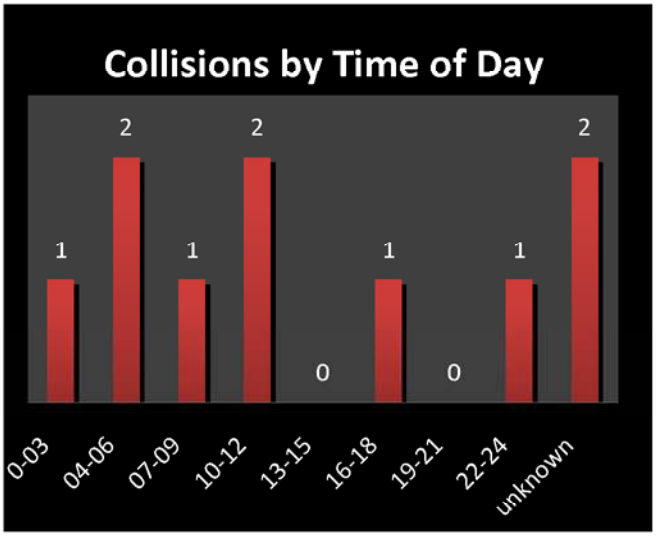
Scale: 1 inch = 200 feet

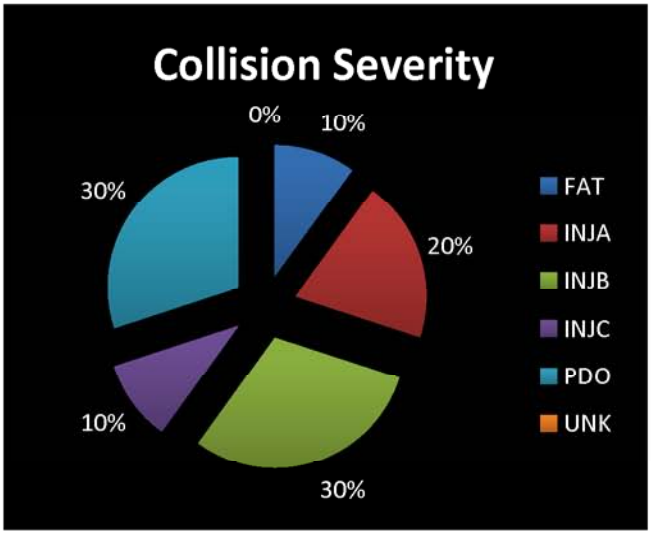
200 100 0 100 200

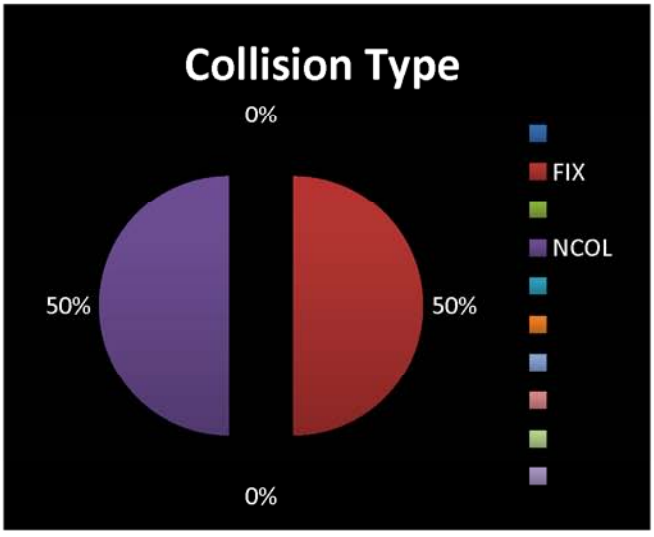
N

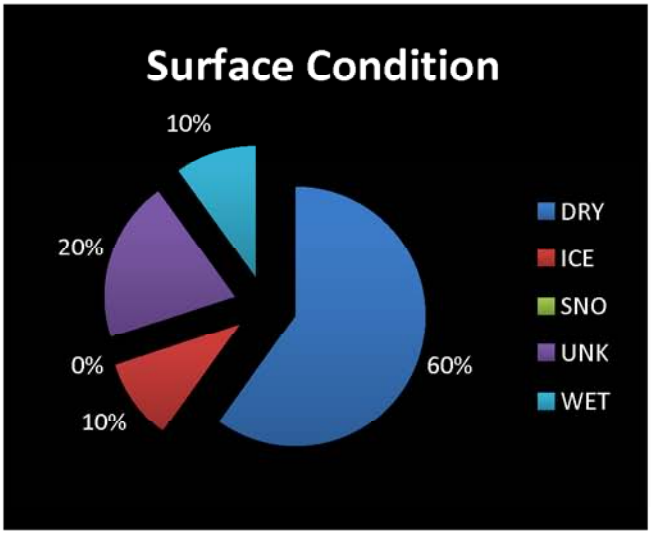
Cornelius Pass Road 2003 - 2009 Collisions
Project Area C: MP 0.15 - 0.60

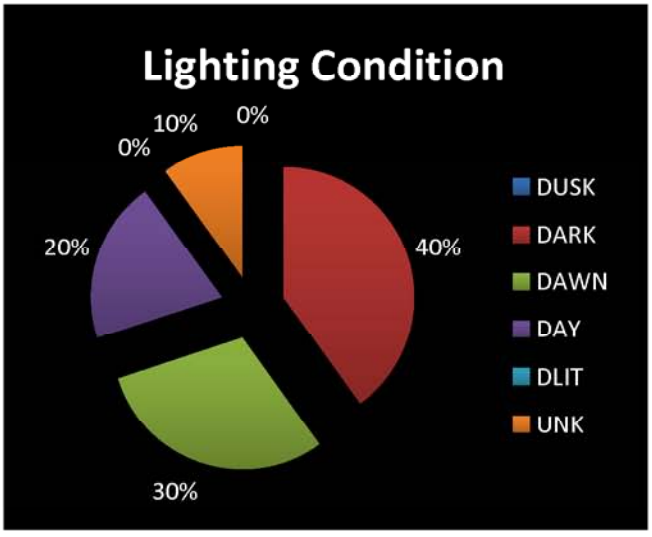






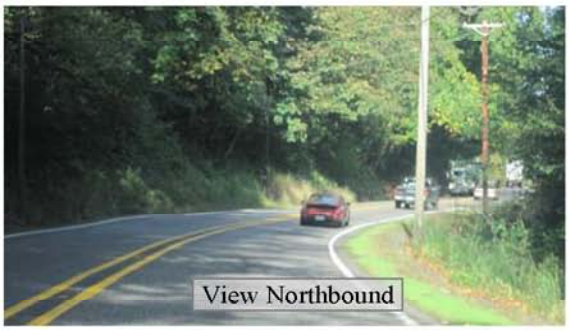






Project Area C: Series of S-Curves at MP 0.15 to 0.6

Problem Statement: 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. 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
 View Northbound  View Southbound at Retaining Wall	**Project 1:** Provide end treatments at all retaining wall ends and object delineation signs affixed to the face of retaining walls. Provide guardrails at all curves and provide appropriate stopping sight distance. **Project 2:** Eliminate the series of S-curves by reconstructing the roadway with a single curve (approximately 3,500 feet) and tying back into the tangent sections.

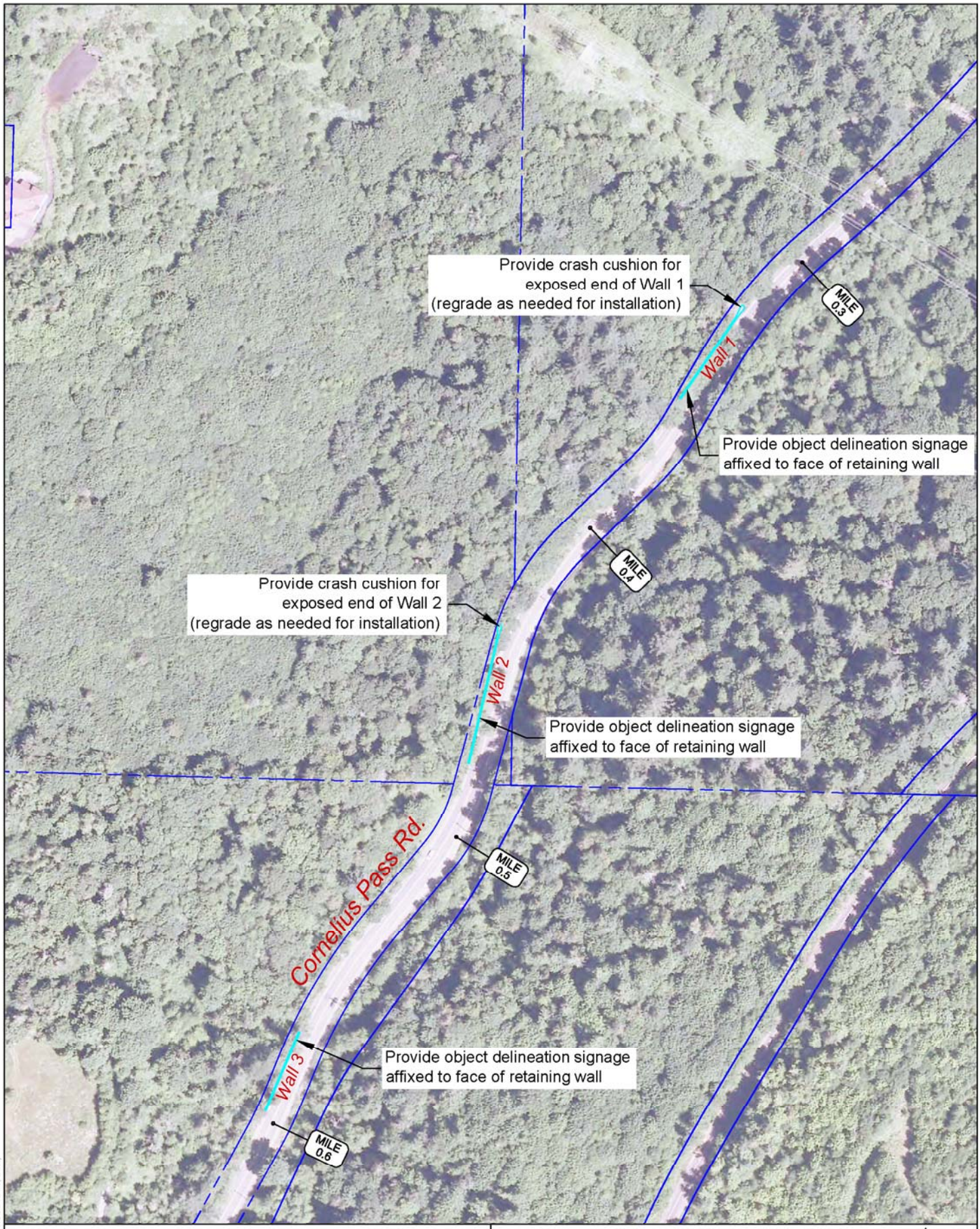
Supporting Data

- Total Collisions 2003- 2009 = 10
  - 100% "out of control" (collision type) resulting in a collision with a fixed object or ditch
  - 60% are injury-related including one fatality
  - 60% occur during wet conditions
  - 70% occur during dark and dawn conditions
- See collision diagram and graphs for more details.

Improvement Options	Benefits	Costs
Project 1: Retaining wall treatments and guardrails	• Delineation signs provide additional visual cues for winding roadway. • End treatments provide protection for motorists in cases of collisions. • 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]	$1,500,000 to $2,500,000
Project 2: Realign roadway to eliminate S-curves	• Provides a more consistent travel path for motorists and eliminate switch back along existing winding alignment. • Provides appropriate guardrail protection next to high fill sections and retaining wall treatments for traveling public protection. • 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]	$5,000,000 to $7,500,000
Other Considerations		
• Project 2 will require the relocation of utility poles. • Project 2 will require substantial earthworks; balancing cut and fill and minimizing environmental impact would be a critical component during the design phase. • Both projects may require public easements and/or right-of-way acquisition.		

[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.

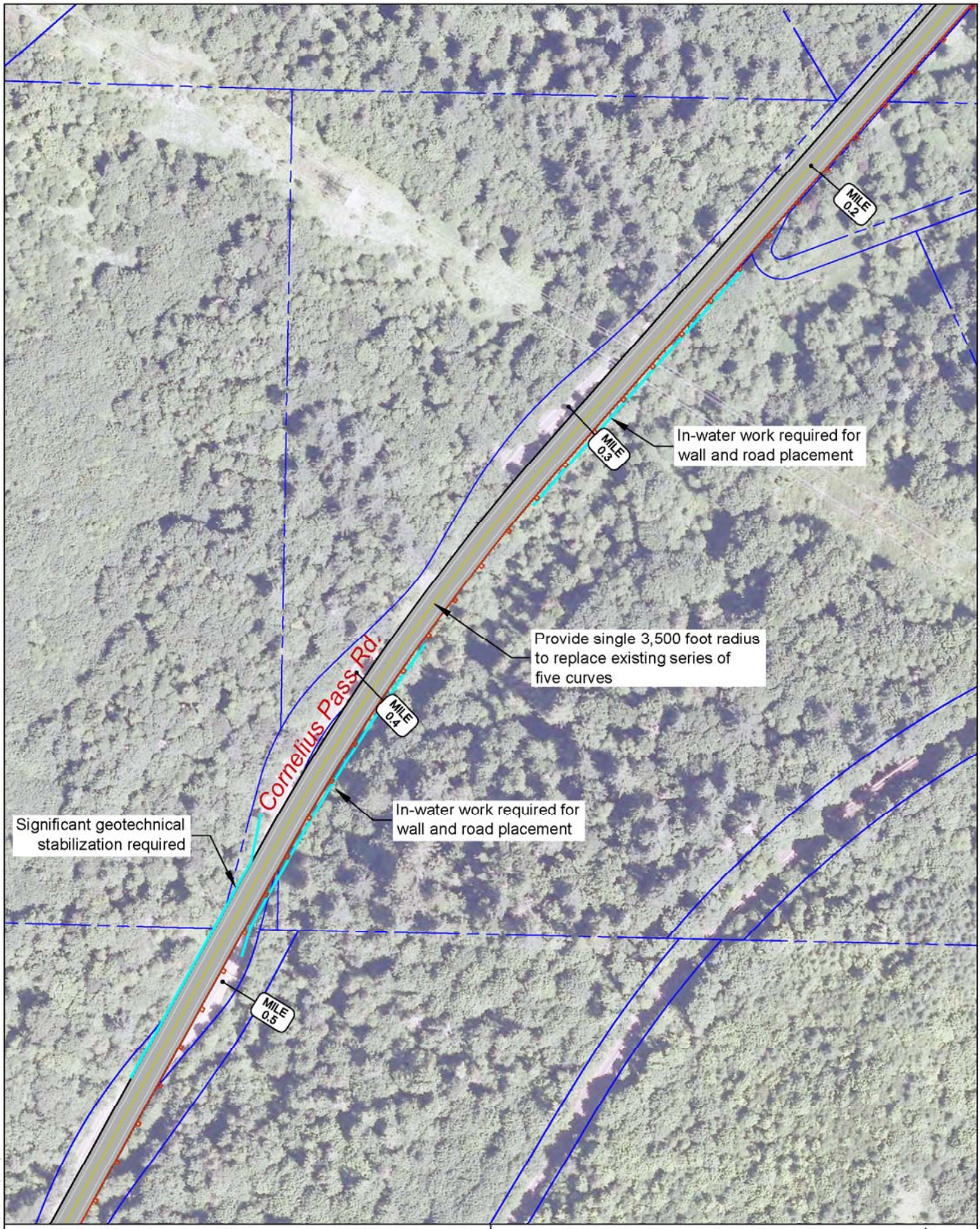
[2] Website: http://www.cmfclearinghouse.org/study_detail.cfm?stid=30 Site funded by US Department of Federal Highway Administration and maintained by the University of North Carolina Highway Safety Research Center. Accessed on November 24, 2010.



Project Area C: Project 1 - S-Curves
MP 0.1-0.6 (Wall Signs & End Treatments)

Scale: 1 inch = 200 feet

200 100 0 100 200



Project Area C: Project 1 - S-Curves
MP 0.15-0.60 (Curve Realignment)

Scale: 1 inch = 200 feet

200 100 0 100 200

Project Area D – Sheltered Nook Road Intersection, MP 1.2

- **Project 1 – Construct a Northbound left turn pocket**
- **Project 2 – Improve Vertical Curve**

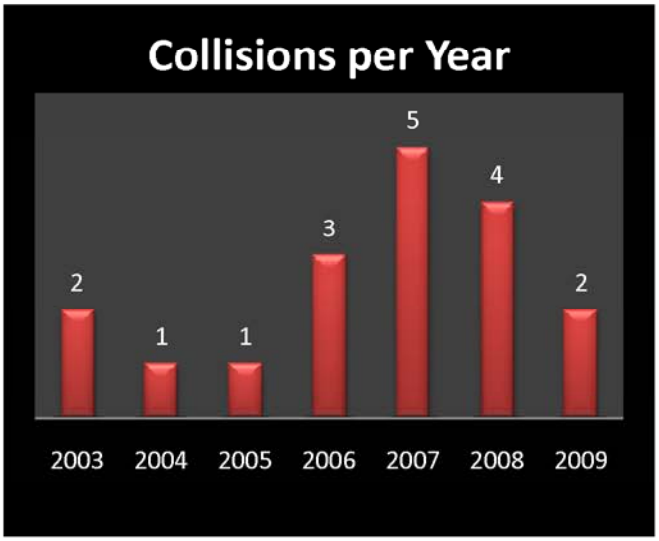
Collision Diagram
Project Area D (Sheltered Nook Road MP 1.2)

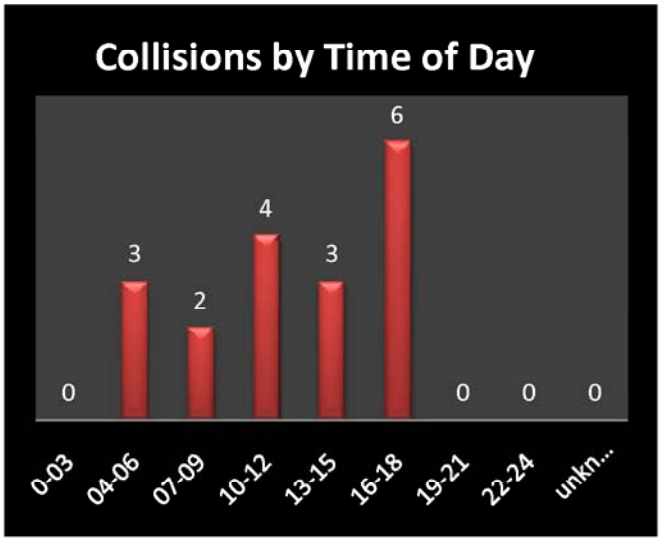
Scale: 1 inch = 100 feet

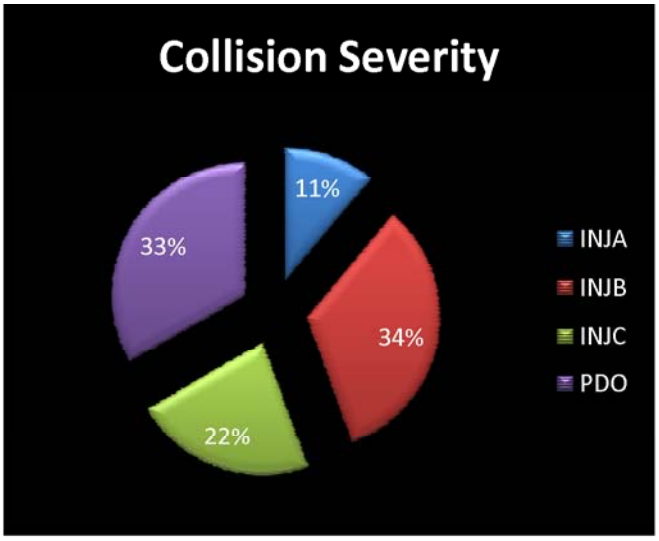
100 50 **0** 50 100

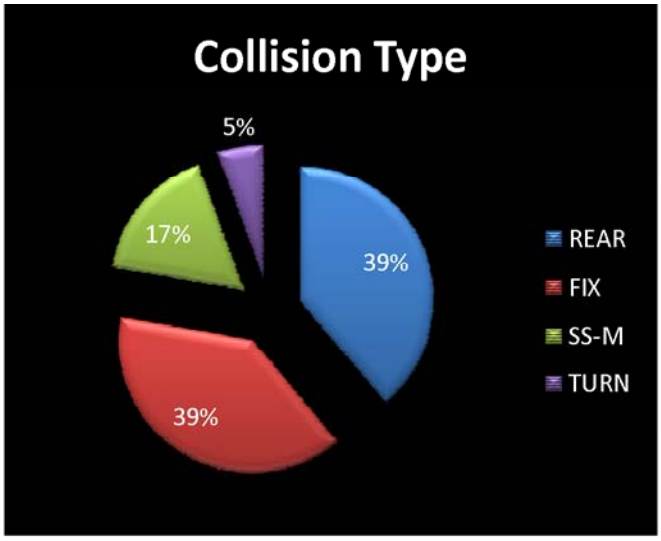
Cornelius Pass Road 2003 - 2009 Collisions

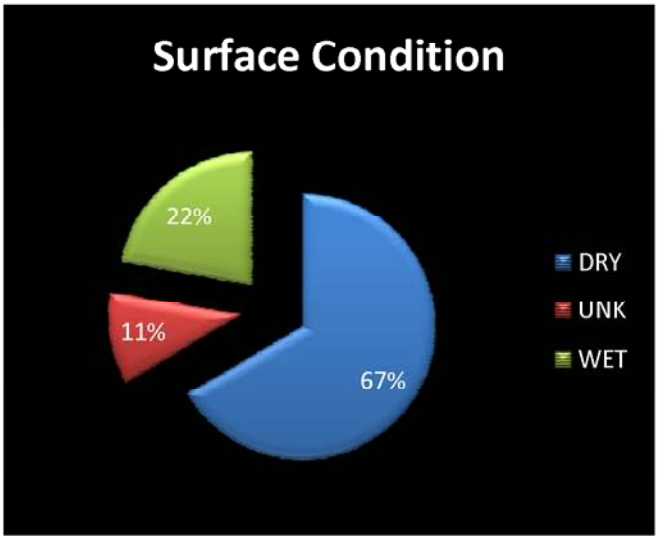
Project Area D: Sheltered Nook Road, MP 1.1 - 1.3

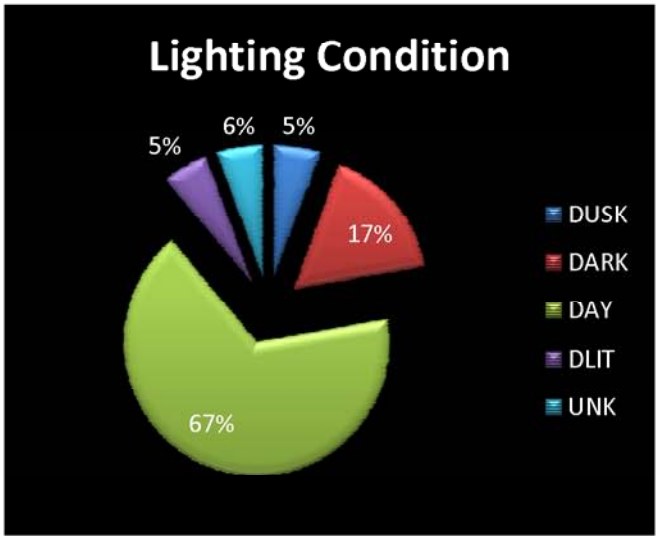












Project Area D - Sheltered Nook Road Intersection

Problem Statement: Over the last seven years there have been eighteen collisions that resulted in six severe and two debilitating injuries at the intersection of Sheltered Nook Road and Cornelius Pass Road. The majority of these collisions occurred on dry days in daylight, suggesting that driver behavior and the roadside environment may have a greater impact on the collisions than other environmental conditions.

Photos


View Northbound (at Vertical Curve)


View Northbound


View Southbound

Proposed Projects

Project 1:
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).

Project 2:
The proposed project will flatten the existing crest vertical 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.

Supporting Data

Speed, 85% = 50mph
Total Collisions 2003-2009 = 18
ADT = 10,875
Collision Rate = 0.65 (per MEV at Sheltered Nook Road)
By type:

- 39% rear end, 17% sideswipe, 5% turning, 39% fixed object

By injury:

- A 11%, B 33%, C 22%, PDO 33%
- Other collision factors:
  - 72% on dry surface
  - 72% in daylight conditions
- Approximate intersection sight distance from Sheltered Nook Road, northbound = 250 ft, southbound = 450 ft.

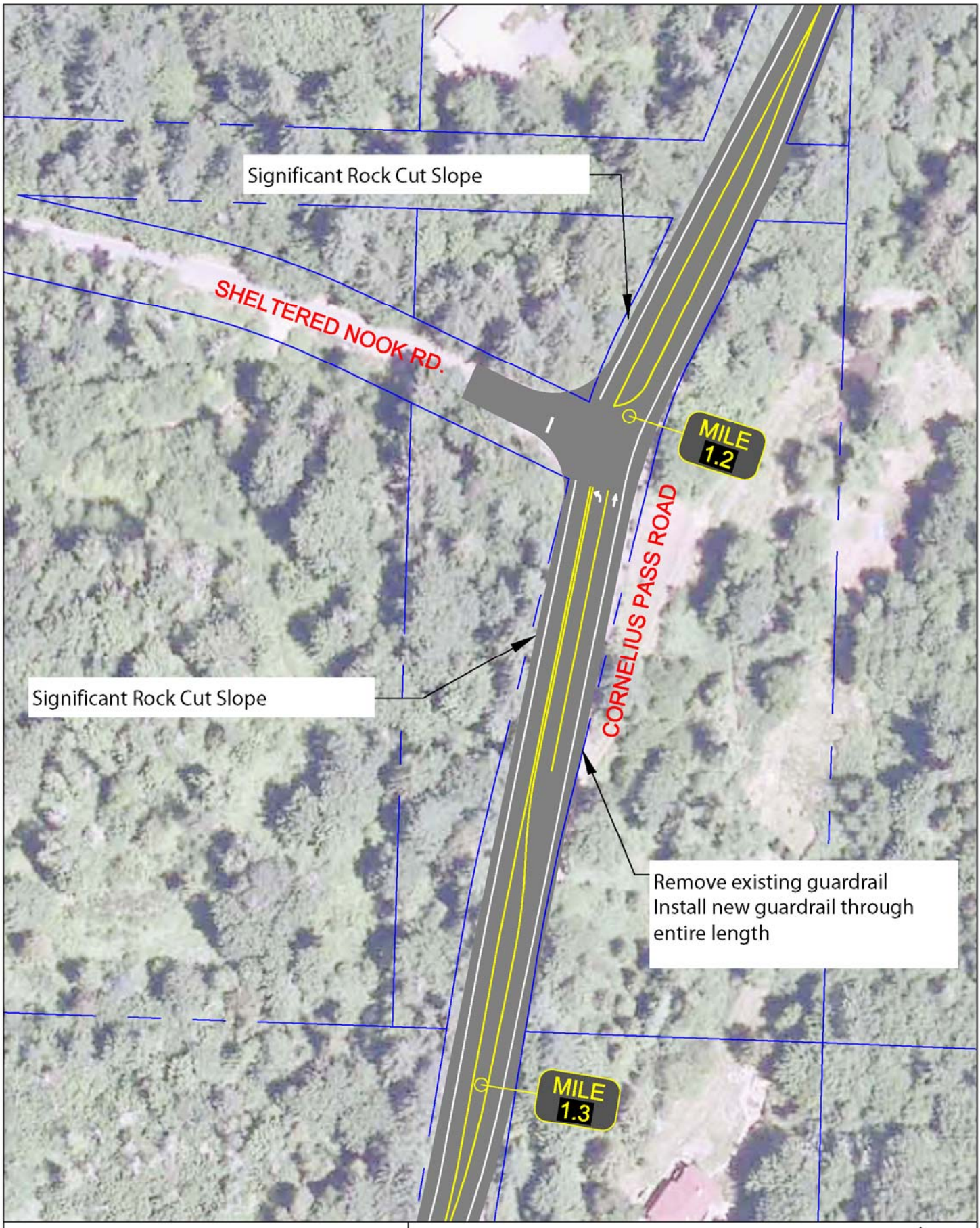
Improvement Options	Benefits	Costs
Project 1: Install a northbound left turn pocket	• Reduces potential for northbound rear end collisions by creating storage space. • National research shows this treatment on rural roads results in a decrease of all collision types by 44%, and injury collisions by 35%.[1]	$1,000,000
Project 2: Improve the vertical curve north of the intersection	• Improves sight distance to north for vehicles exiting Sheltered Nook Road. • Improves sight distance to north for northbound left turning vehicles entering Sheltered Nook Road. • Potential to reduce fatal and injury collisions by approximately 50% and all collision severity types by 20%.[2]	$600,000

Other Considerations

- Cornelius Pass Road is approximately 24 feet wide with one to three foot wide shoulders near Sheltered Nook Road.
- There is a steep slope to the east and a steep embankment to the west of Cornelius Pass Road at this location
- Widening the road to the west would require the removal of approximately 20 feet of embankment to the west of the road for the length of the taper and turn lane (800 feet) to the north and south of the intersection.
- Widening the road may infringe on wetland habitat and require additional mitigation measures.
- There are utility poles on the east side of the road, as well as a guardrail opposite from Sheltered Nook Road that may be impacted.

[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

Project Area D: Project 2- Sheltered Nook Rd MP 1.1 (Flatten Vert. Curve)

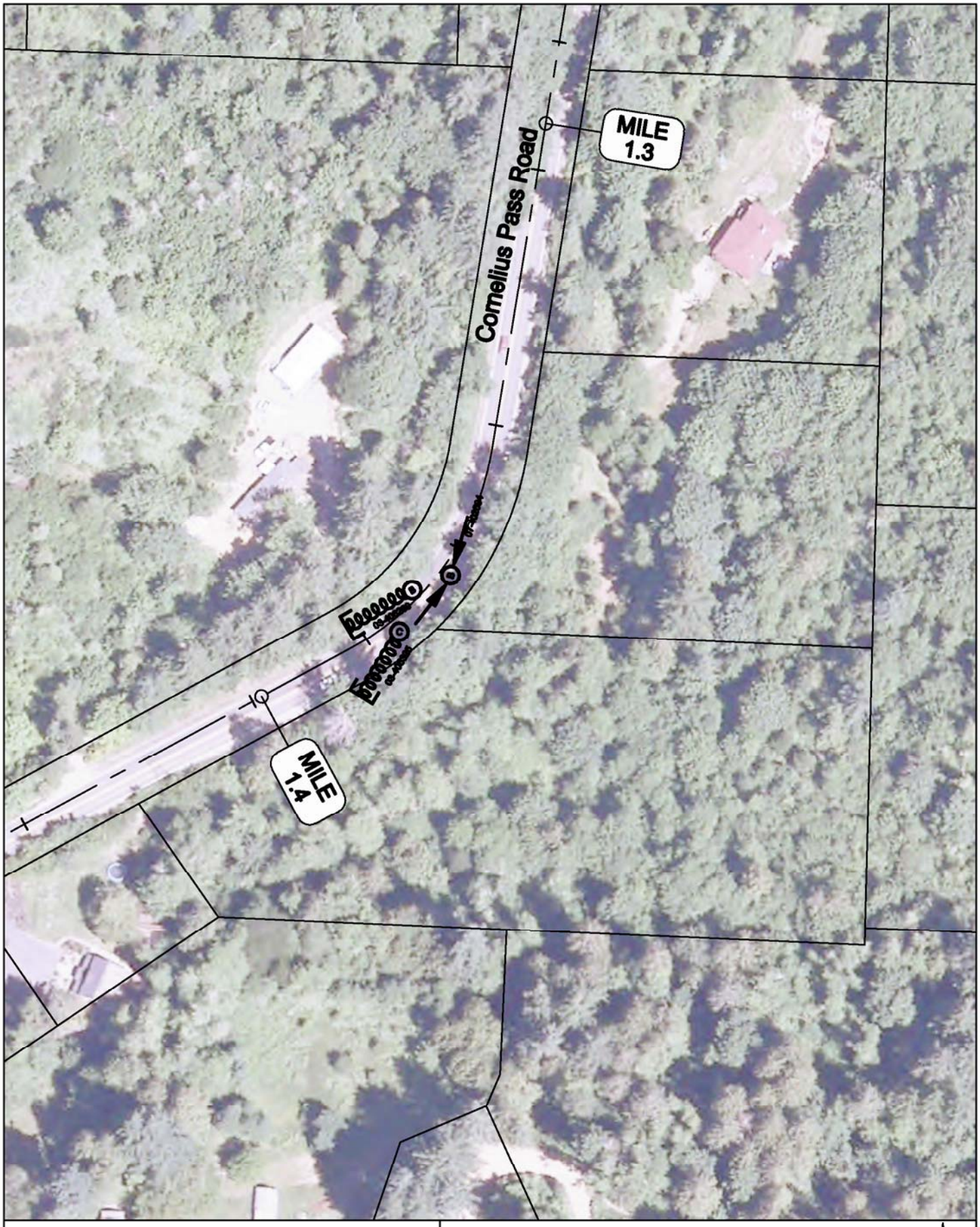
Scale: 1 inch = 100 feet

100 50 0 50 100

N

Project Area E – Horizontal Curve South of Sheltered Nook Road Intersection, MP 1.4

- **Project 1 – Increase Stopping Sight Distance Through Curve**
- **Project 2 – Improve Curve Radius**



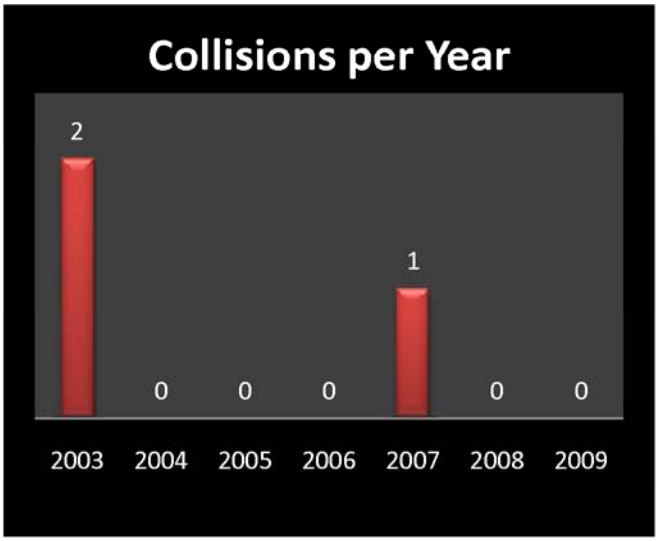
Collision Diagram
Project Area E (Curve at MP 1.4)

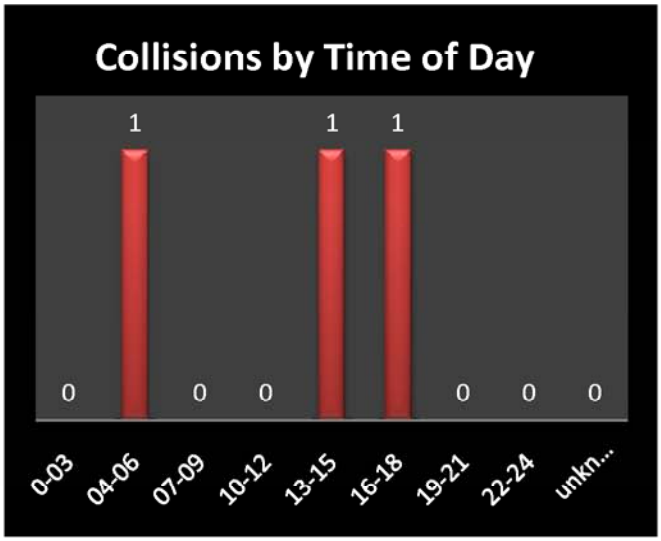
Scale: 1 inch = 100 feet

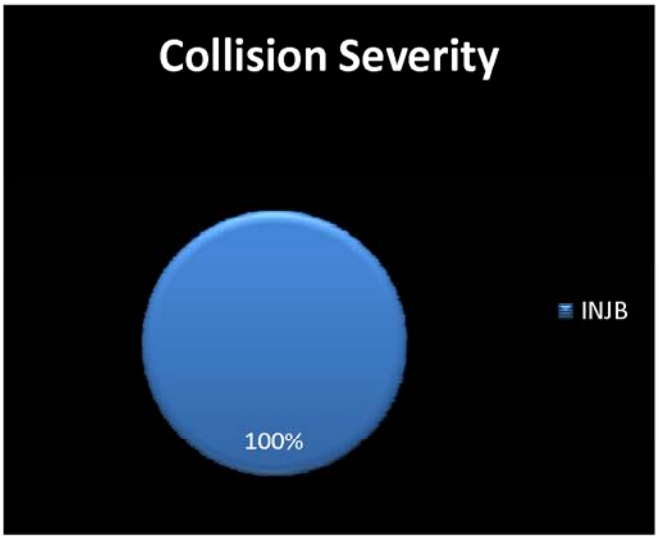
100 50 **0** 50 100

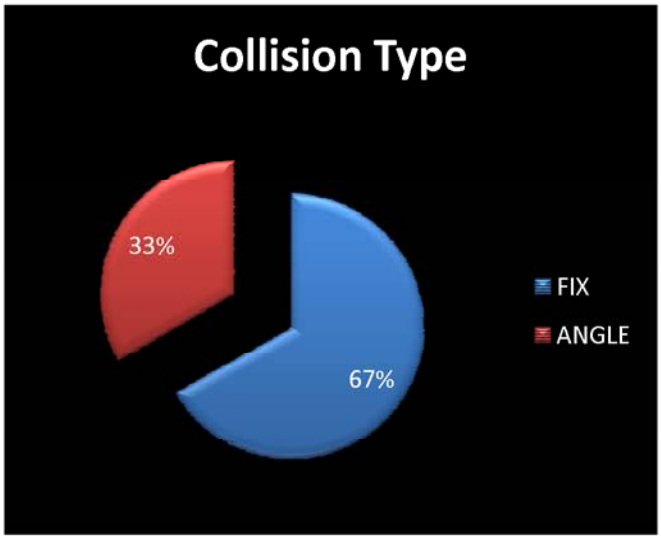
Cornelius Pass Road 2003 - 2009 Collisions

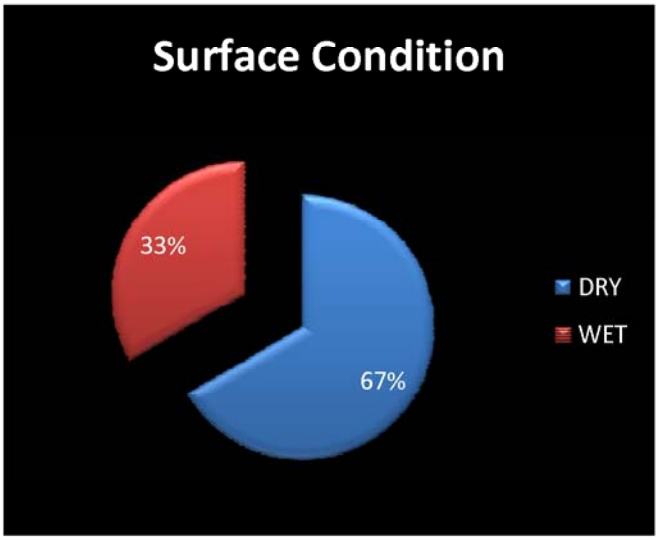
Project Area E: MP 1.3 - 1.4

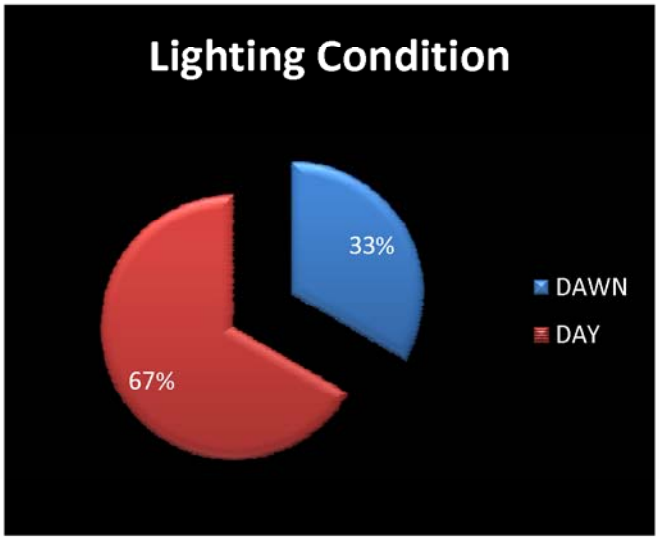






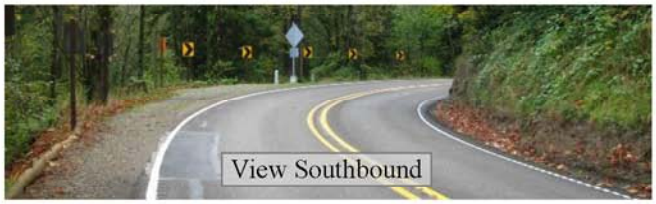






Project Area E – Horizontal Curve south of Sheltered Nook Road

Problem Statement: At the horizontal curve just south of the Sheltered Nook Road intersection there have been three severe injury collisions in the past seven years. The embankment on the curve south of Sheltered Nook Road limits stopping sight distances through the curve, creating a potential hazard for drivers.

Photos	Proposed Project
 View Southbound  View Northbound	The proposed project improves stopping sight distance by increasing the radius of the horizontal curve south of the Cornelius Pass Road/Sheltered Nook Road intersection. This improvement would be accomplished by removing a section of the embankment (between 0 and 20 feet wide) for approximately 400 feet along the length of the curve. Based on a design speed of 45 mph, the required stopping sight distance is 360 feet (assuming a grade of less than three percent).

Supporting Data

Total Collisions 2003-2009 = 3
ADT = 10,875
Collision Rate = 1.08 per million VMT
By type:
- 67% fixed object, 33% angle

By severity:
- B 100%

Other collision factors:
- 67% on dry surface
- 67% during daylight conditions

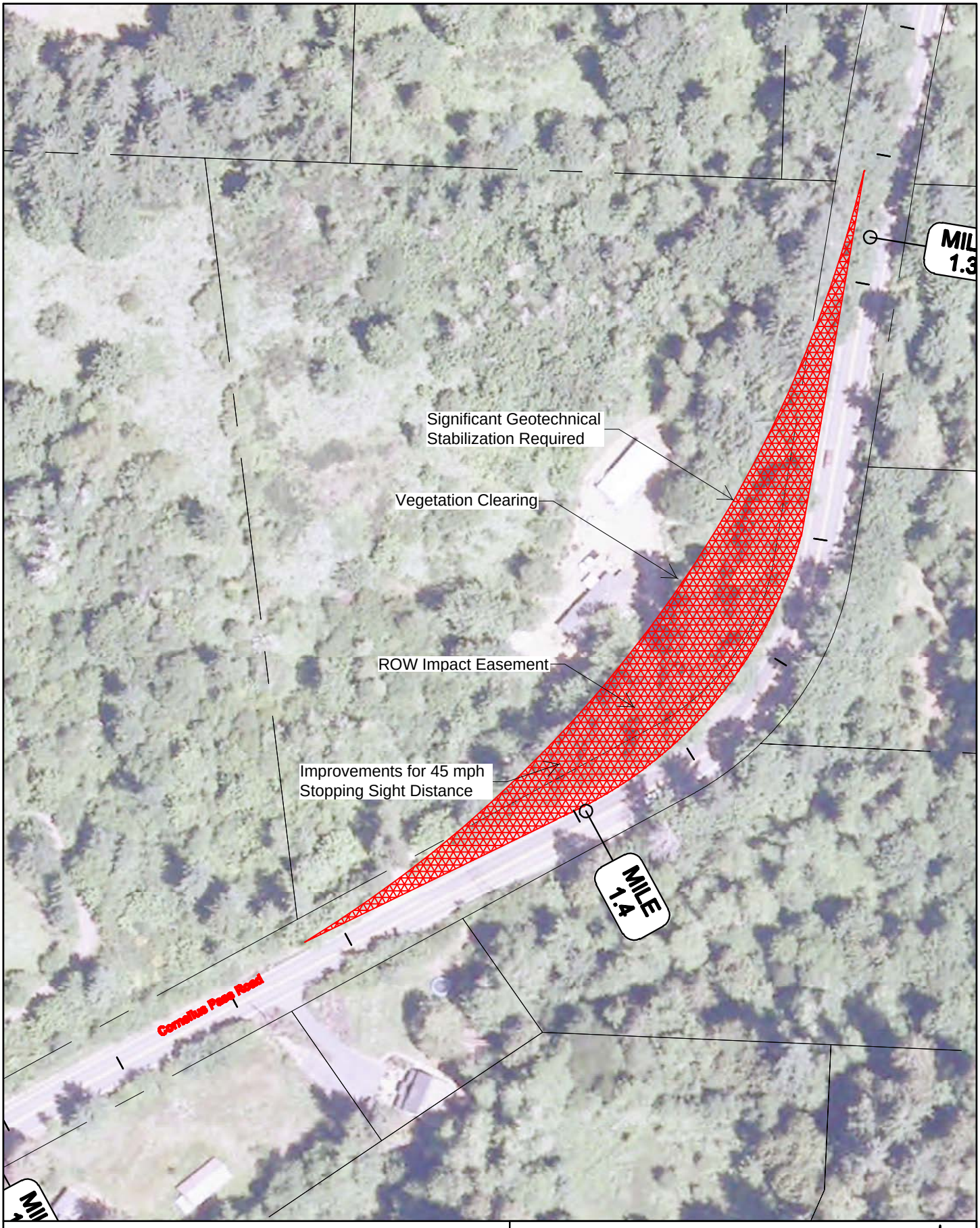
- Approximate minimum sight distance from the middle of the curve, northbound = 275 ft, southbound = 100 ft. This does not meet the required stopping sight distance (425 ft).
- No existing street lights along curve

Improvement Options	Benefits	Costs
Project 1: Improve the radius of this curve to meet 45 mph standards	• 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]	$1,500,000

[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.

Improvement Options	Benefits	Costs
Project 2: Increase stopping sight distance of the horizontal curve.	• The removal of material at this location will allow for the provision of recoverable clear zone as well as 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. [2]	$1,200,000
Other Considerations		
• Cornelius Pass Road is approximately 24 feet wide with one to eight foot wide gravel shoulders at this location. • Improving the curve radius and sightlines will require earthwork. • There are driveway accesses within 300 feet of the north and south end of the curve. • Curve warning signs, chevrons, and an active STOPPED VEHICLES AHEAD warning sign are present • There is a school bus stop south of the curve (and a "school bus stop ahead" warning sign for southbound traffic prior to entering the curve).		

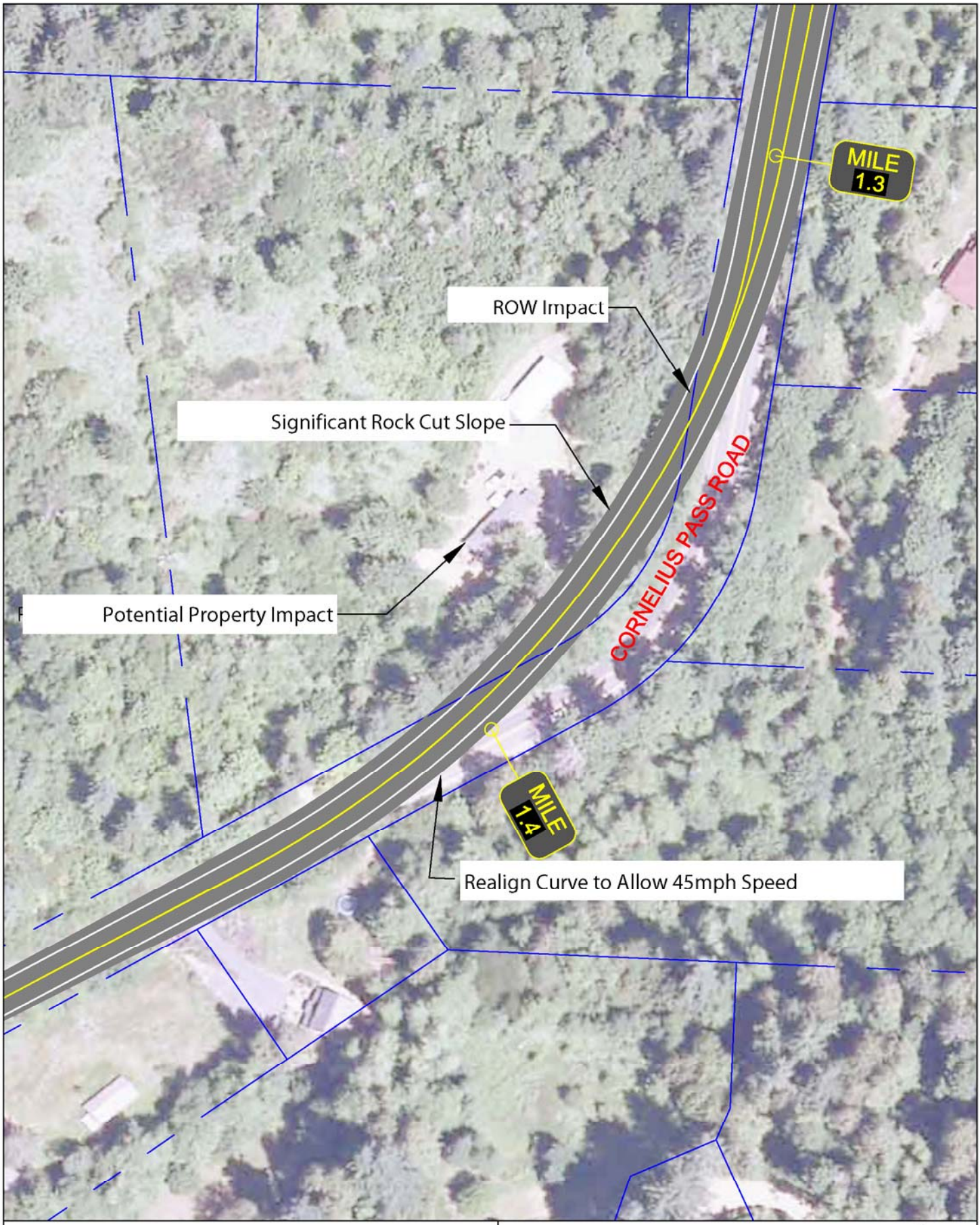
[2] Website: http://www.cmfclearinghouse.org/study_detail.cfm?stid=14 Site funded by US Department of Federal Highway Administration and maintained by the University of North Carolina Highway Safety Research Center. Accessed on November 24, 2010.



Project Area E: Project 1 - Horizontal Curve
MP 1.4 (Sight Distance Improvements)

Scale: 1 inch = 100 feet

100 50 0 50 100



Project Area E: Project 2- HORIZONTAL CURVE MP 1.4 (IMPROVE CURVE RADIUS)

Scale: 1 inch = 100 feet

100 50 0 50 100

N

Project Area F – 8th Avenue at MP 1.5

- **Project 1 – Improve Intersection and Stopping Sight Distance**
- **Project 2 – Improve Curve and Intersection**

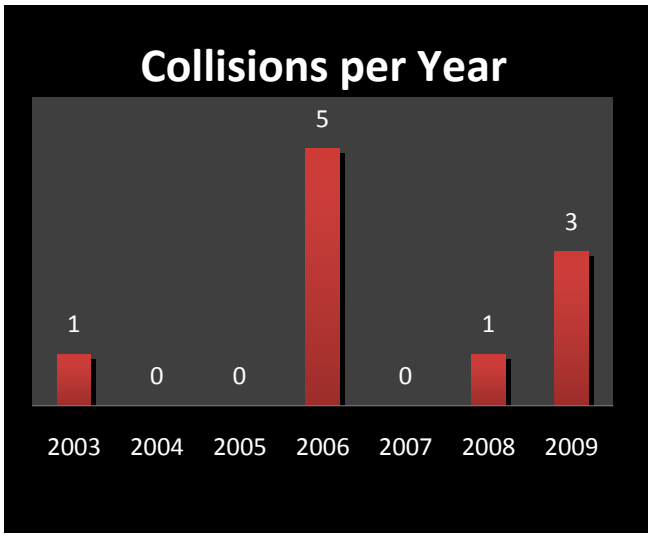
Collision Diagram
Project Area F (8th Ave at MP 1.5)

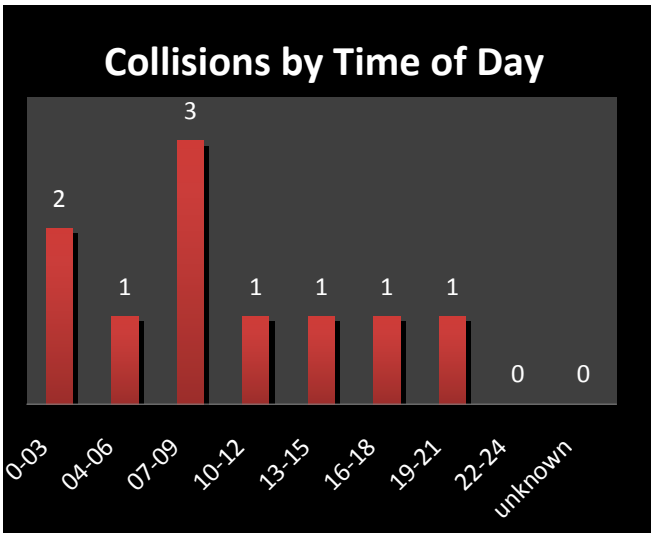
Scale: 1 inch = 100 feet

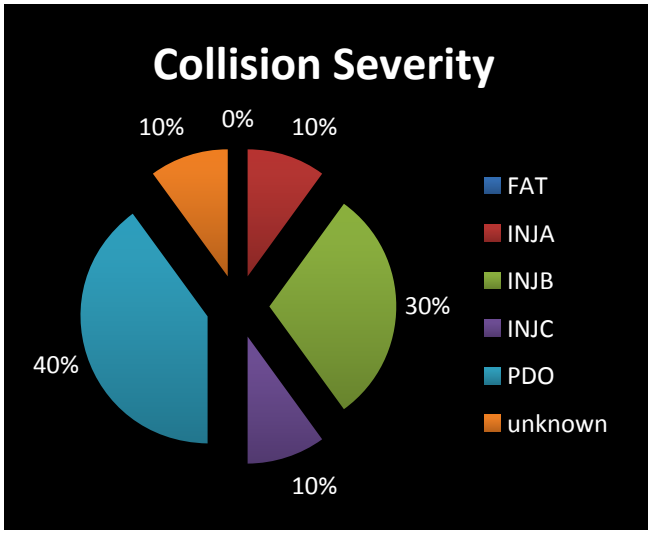
100 50 0 50 100

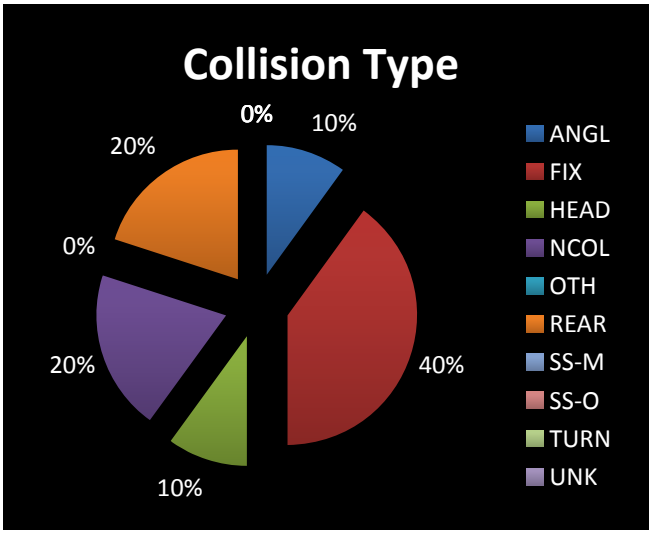
N

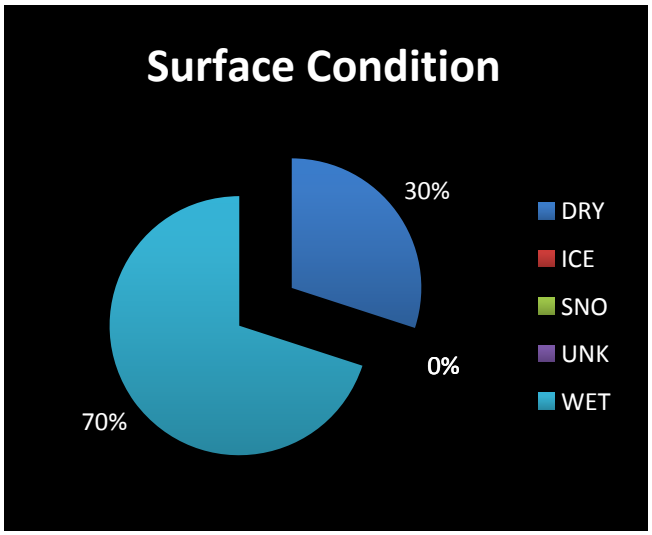
Cornelius Pass Road 2003 - 2009 Collisions
Project Area F: 8th Ave at MP 1.5

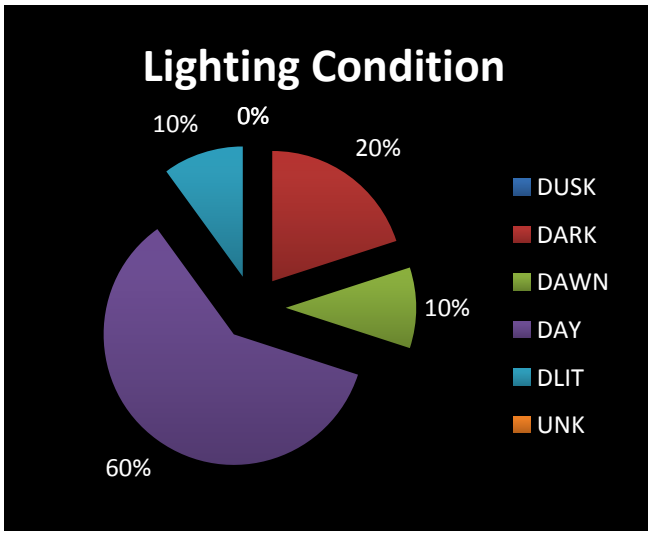






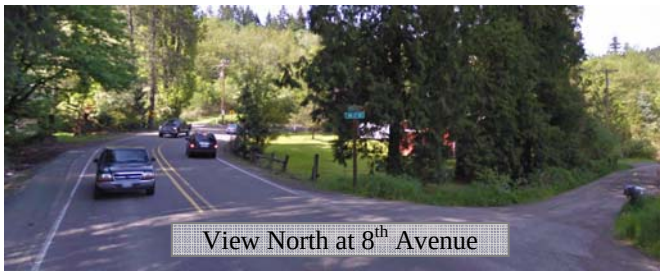






Project Area F: 8th Avenue at MP 1.5

Problem Statement: Sight distance (both intersection and stopping) at the 8th Avenue intersection is limited due to the existing curvature of the roadway and trees/vegetation. Over the past seven years, 10 collisions have been reported at this location.

Photographs	Proposed Improvement
 View North at 8th Avenue  View South	**Project 1:** Provide intersection sight distance (ISD) that complies with the posted speed of 45 mph (500 feet). If the 170-foot curve to the north remains, the ISD to the north could be reduced to comply with a 35 mph design speed (10 mph under the posted speed), because approaching speeds will be controlled by the 170-foot curve. At a minimum, 360 feet of stopping sight distance should be provided around the 170-foot curve. **Project 2:** Depending on the radius of the curve to the north (MP 1.35), introduce a 587-foot curve (45 mph design speed) to eliminate the existing S-curves. This project also includes realigning 8th Avenue to provide a 4-legged intersection with the driveway on the west side and providing the appropriate ISD in all corners.

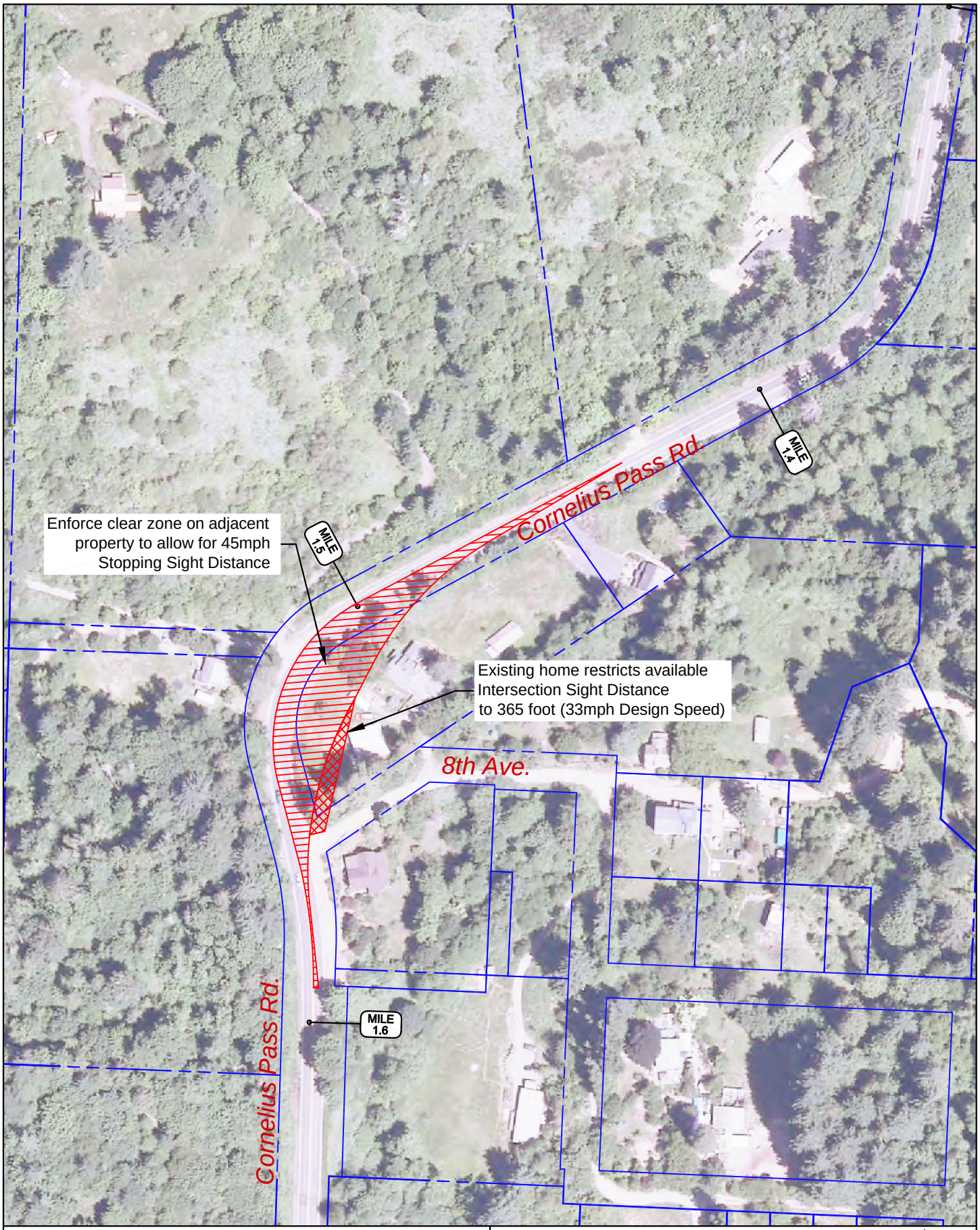
Supporting Data

- Total Collisions 2003- 2009 = 10
  - 60% "out of control" (collision type) resulting in a collision with a fixed object or ditch
  - 40% are either Injury A & B collisions
  - 70% on wet surface
  - 60% during day time
  - Intersection related collisions indicate 10% angle and 20% rear-end.
- See collision diagram and graphs for more details.

Improvement Options	Benefits	Costs
Project 1: Improve intersection sight distance (ISD) and stopping sight distance (SSD)	• Provides appropriate SSD around existing curves to address "out of control" collisions giving motorists more opportunity to react to an obstruction in the road. • Improves ISD at the 8th Avenue intersection to address the intersection related collisions. • 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]	$100,000 to $200,000
Project 2: Improve curvature and provide conventional intersection	• Eliminates the tight S-curves and provides a more consistent travel path along a circular curve for motorists maintaining consistent driving speeds closer to the 45 mph corridor posted speed. • 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] • Provides appropriate ISD at the 8th Avenue intersection. • Consolidates existing approaches to Cornelius Pass Road to a single intersection.	$2,500,000 to $3,500,000
Other Considerations		
• Project 1 will likely require a sight triangle clearance to maintain clear vision triangles for intersection and stopping sight distance. • Project 2 will impact several residences and will require the relocation of utility poles, earthwork, and easements and/or right-of-way acquisition.		

[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.

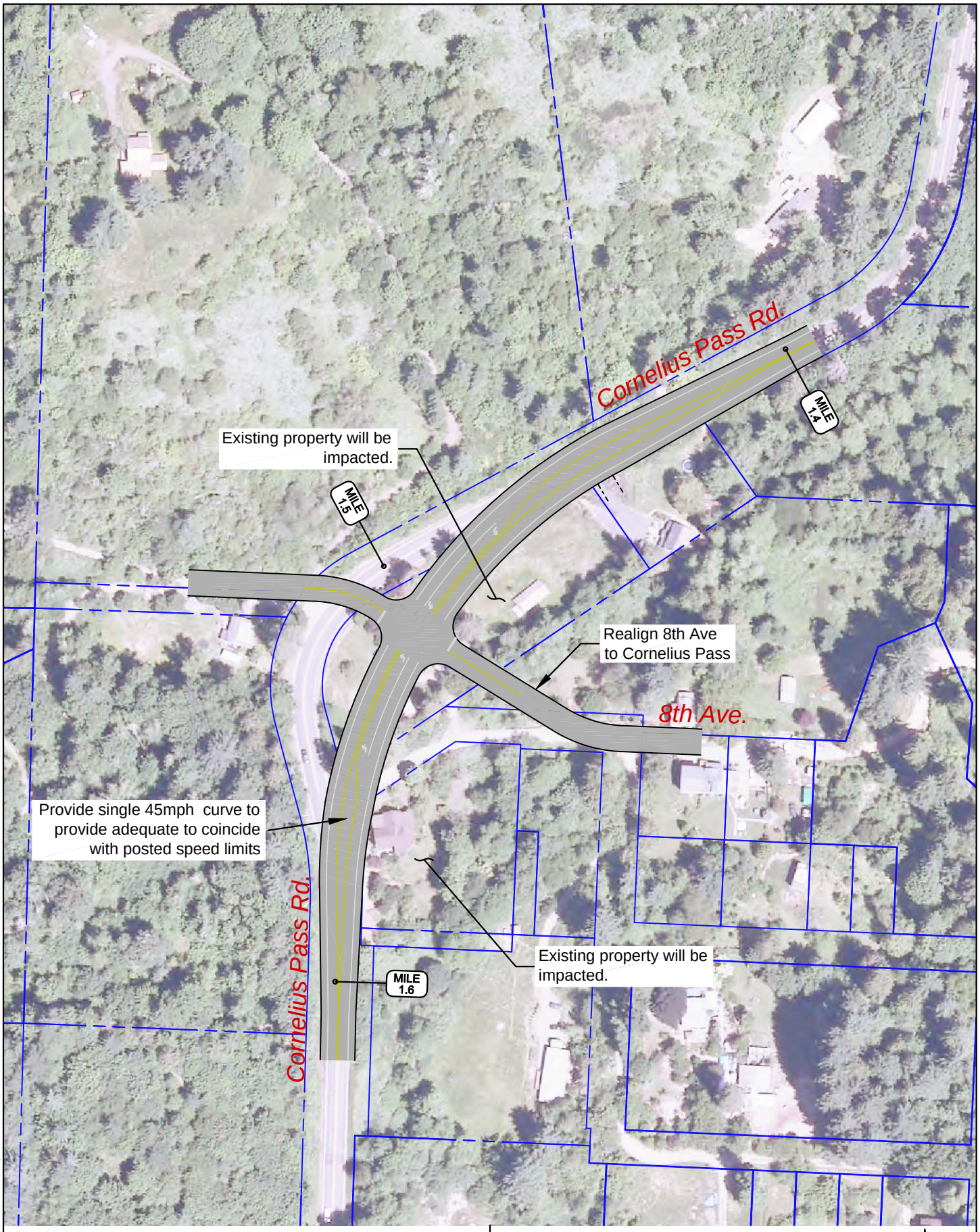
[2] Website: http://www.cmfclearinghouse.org/study_detail.cfm?stid=30 Site funded by US Department of Federal Highway Administration and maintained by the University of North Carolina Highway Safety Research Center. Accessed on November 24, 2010.



Project Area F: Project 1 - 8th Ave MP 1.5
(Vision Clearance Work Only)

Scale: 1 inch = 150 feet

150 75 0 75 150



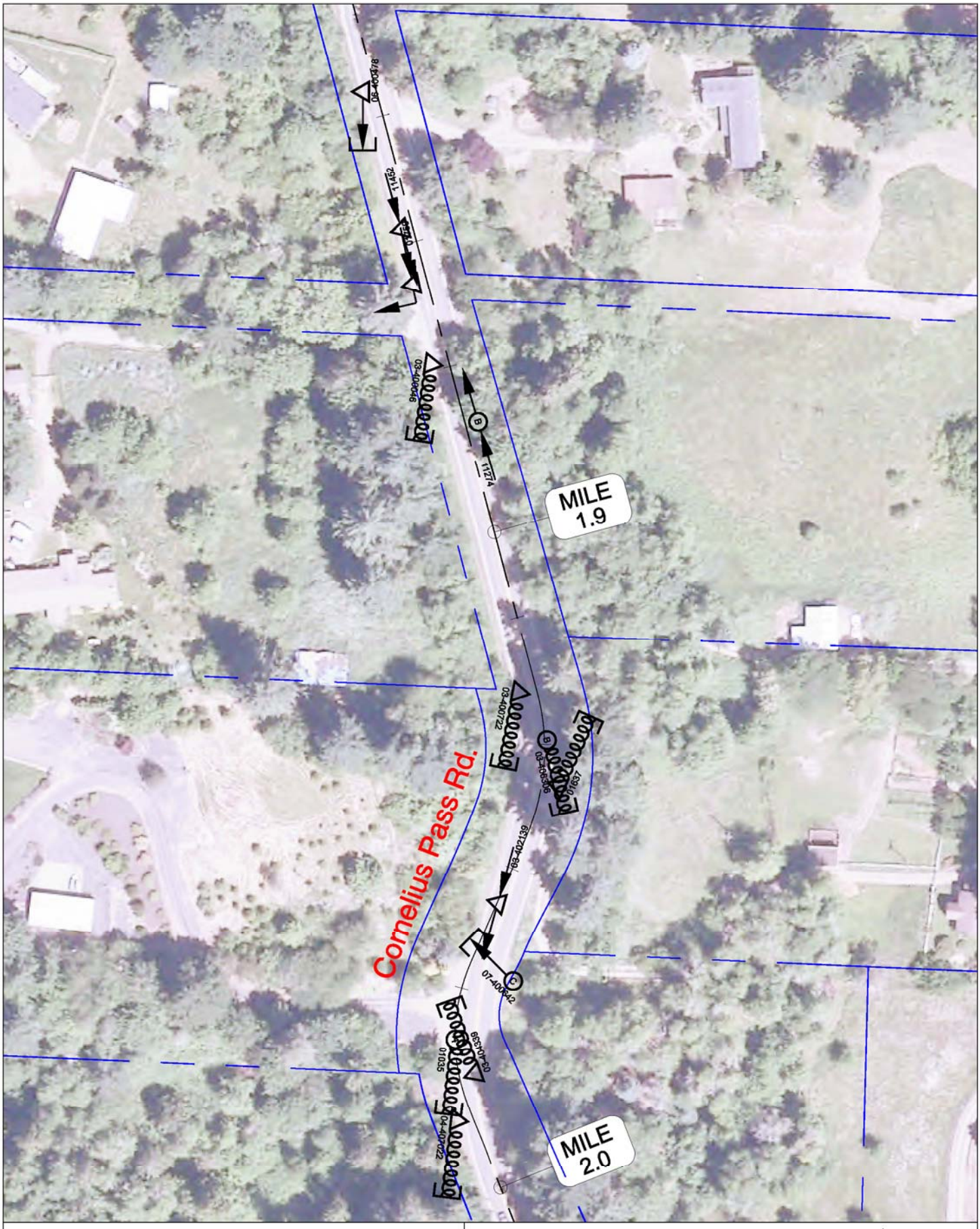
Project Area F: Project 2 - 8th Ave MP 1.5 (New Intersection Alignment)

Scale: 1 inch = 150 feet

150 75 0 75 150

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

- **Project 1 – Increase Stopping Sight Distance Through Curve**
- **Project 2 – Improve Curve Radius**

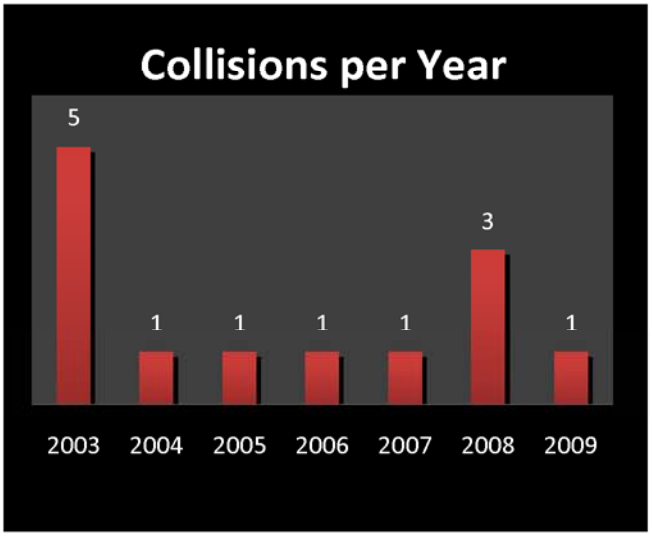


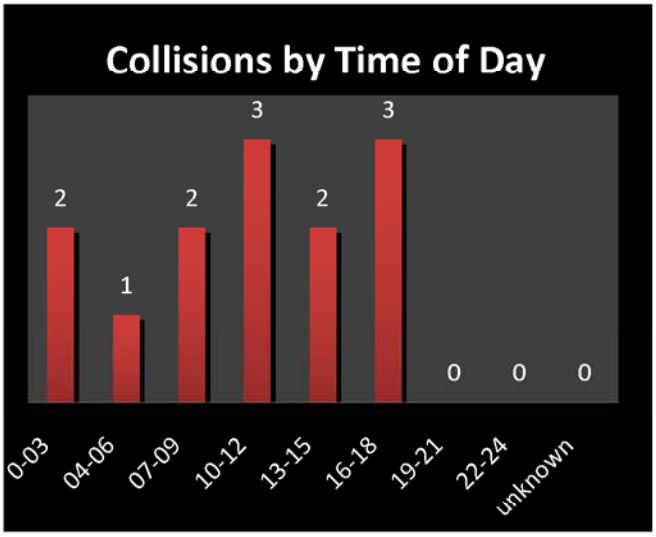
Collision Diagram
Project Area G (S-Curves at MP 1.8 - 2.0)

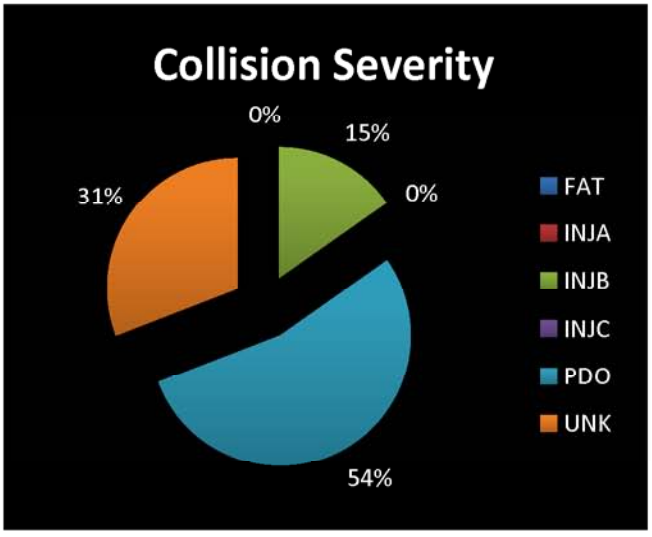
Scale: 1 inch = 100 feet

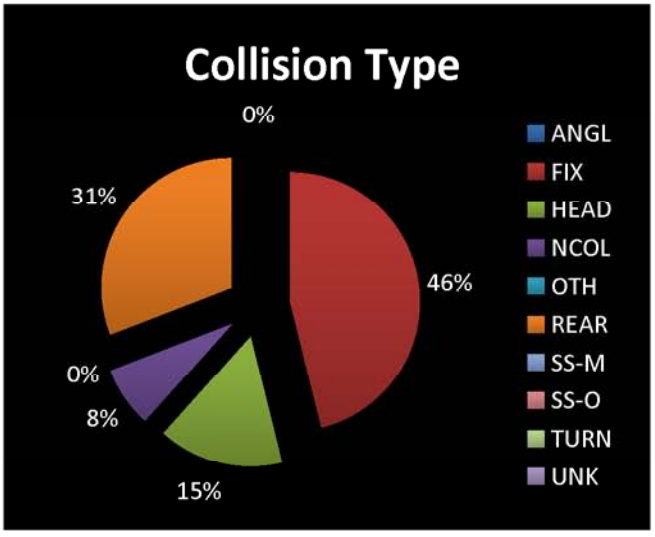
100 50 0 50 100

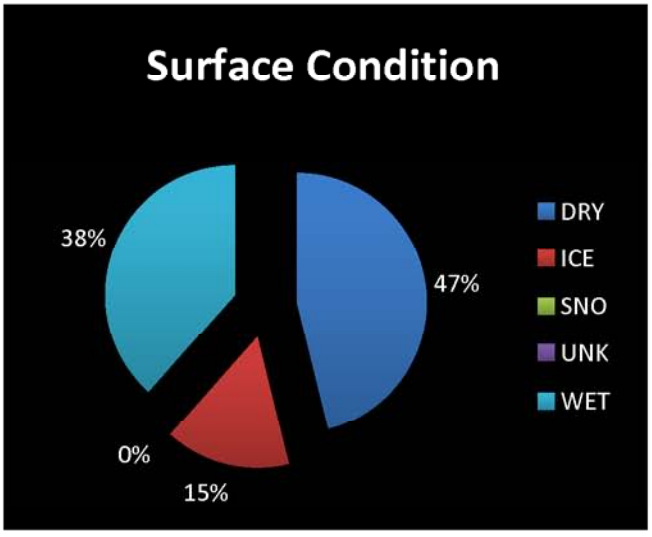
Cornelius Pass Road 2003 - 2009 Collisions
Project Area G: MP 1.8 - 2.1

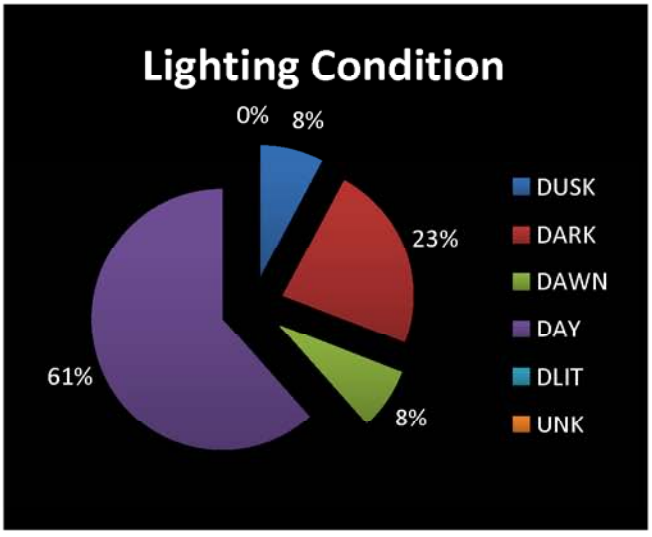






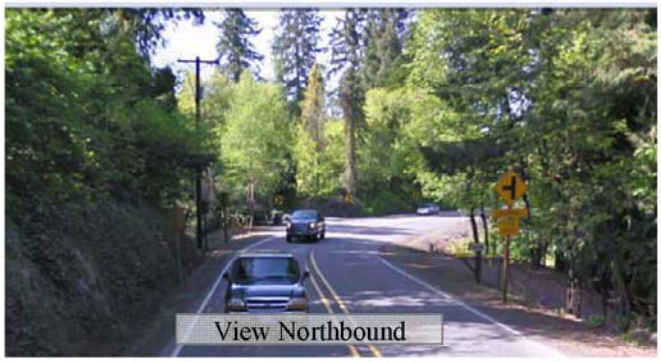






Project Area G: Roadway S-Curves at MP 1.8 to 2.1

Problem Statement: Existing curves have radii that range from 140-160 feet with a 105-foot tangent section in between, resulting in design speeds around 20 MPH.

Photographs	Proposed Improvement
 View Southbound  View Northbound	**Project 1:** Provide 360 feet of stopping sight distance along the existing curves that will comply with a design speed of approximately 45 mph (posted speed along this corridor).. **Project 2:** Provide flatter S-curves (approximately 590-foot radii) with a 250-foot tangent between the curves that will comply with a design speed of approximately 45 mph (posted speed along this corridor).

Supporting Data

- Total Collisions 2003- 2009 = 13
  - 38% of the collisions occur during morning and evening commute periods
  - 62% are either fixed object or head-on collisions
  - 54% of the collisions occurred under wet or icy conditions
- 8 collisions occurred within the S-curves (6 were "out of control" (collision type) resulting in a collision with a fixed object
- 5 collisions at the Columbia Street intersection (3 were either rear-end)
- See collision diagram and graphs for more details.

Improvement Options	Benefits	Costs
Project 1: Stopping sight distance (SSD) clearance	• Provides appropriate stopping sight distance (SSD) along S-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] • Provide intersection sight distance (ISD) at the Columbia Street intersection to address some of the intersection related collisions.	$100,000 to $200,000
Project 2: Realign the roadway to provide flatter S-curves	• Flattens the S-curves and provides a more consistent travel path for motorists maintaining consistent driving speeds closer to the 45 mph corridor posted speed. • 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] • Provides appropriate stopping sight distance along the new alignment • Provide intersection sight distance at the Columbia Street.	$1,500,000 to $2,500,000
Other Considerations		
• Project 2 will require earthworks; balancing cut and fill and minimizing environmental impact would be a critical component during the design phase. • Both projects may require public easements and/or right-of-way acquisition.		

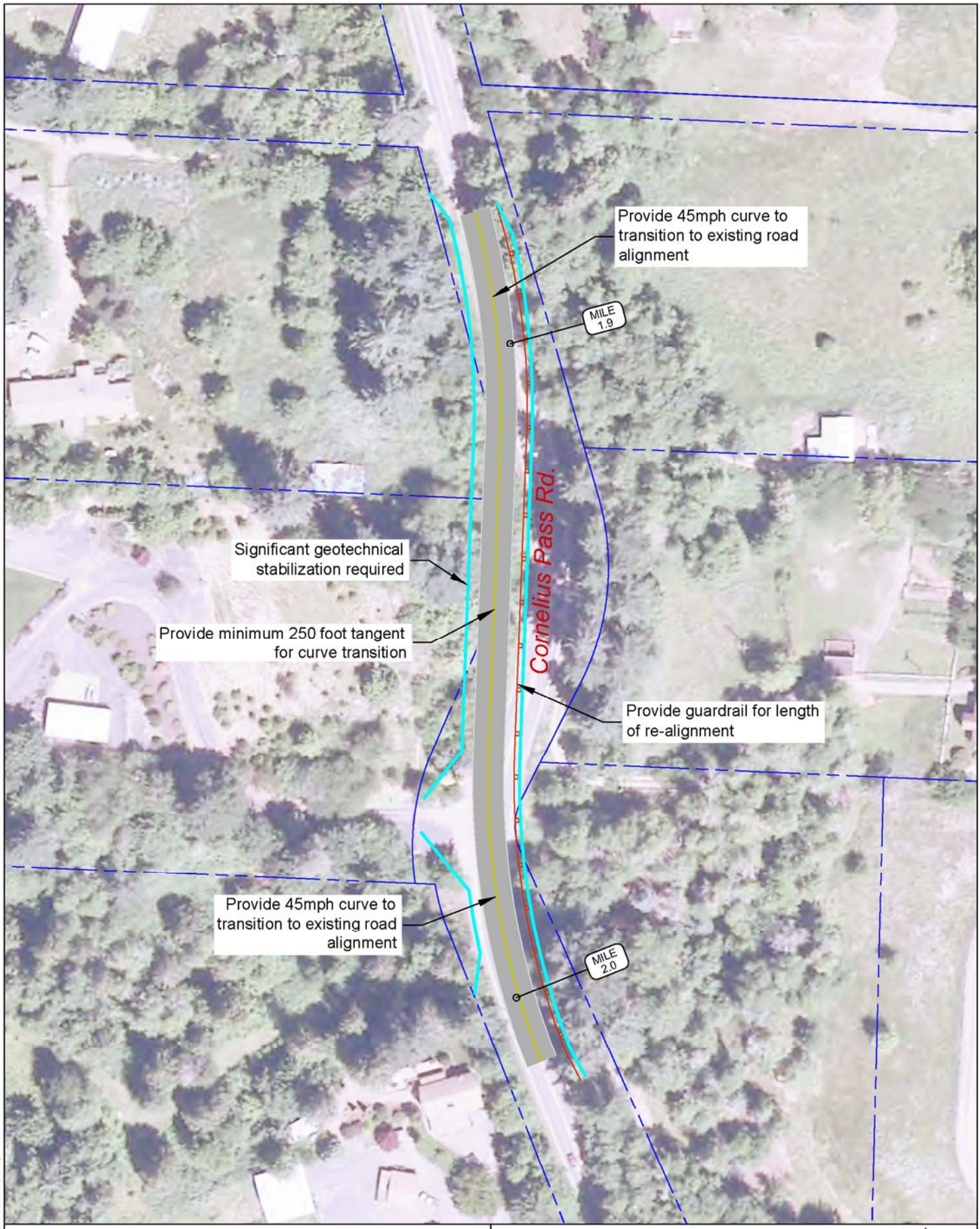
[1] Website: http://www.cmfclearinghouse.org/study_detail.cfm?stid=14 Site funded by US Department of Federal Highway Administration and maintained by the University of North Carolina Highway Safety Research Center. Accessed on November 24, 2010.

[2] 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.

Project Area G: Project 1 - S-Curves
MP 1.8-2.1 (Sight Distance Clearance Only)

Scale: 1 inch = 100 feet

100 50 0 50 100



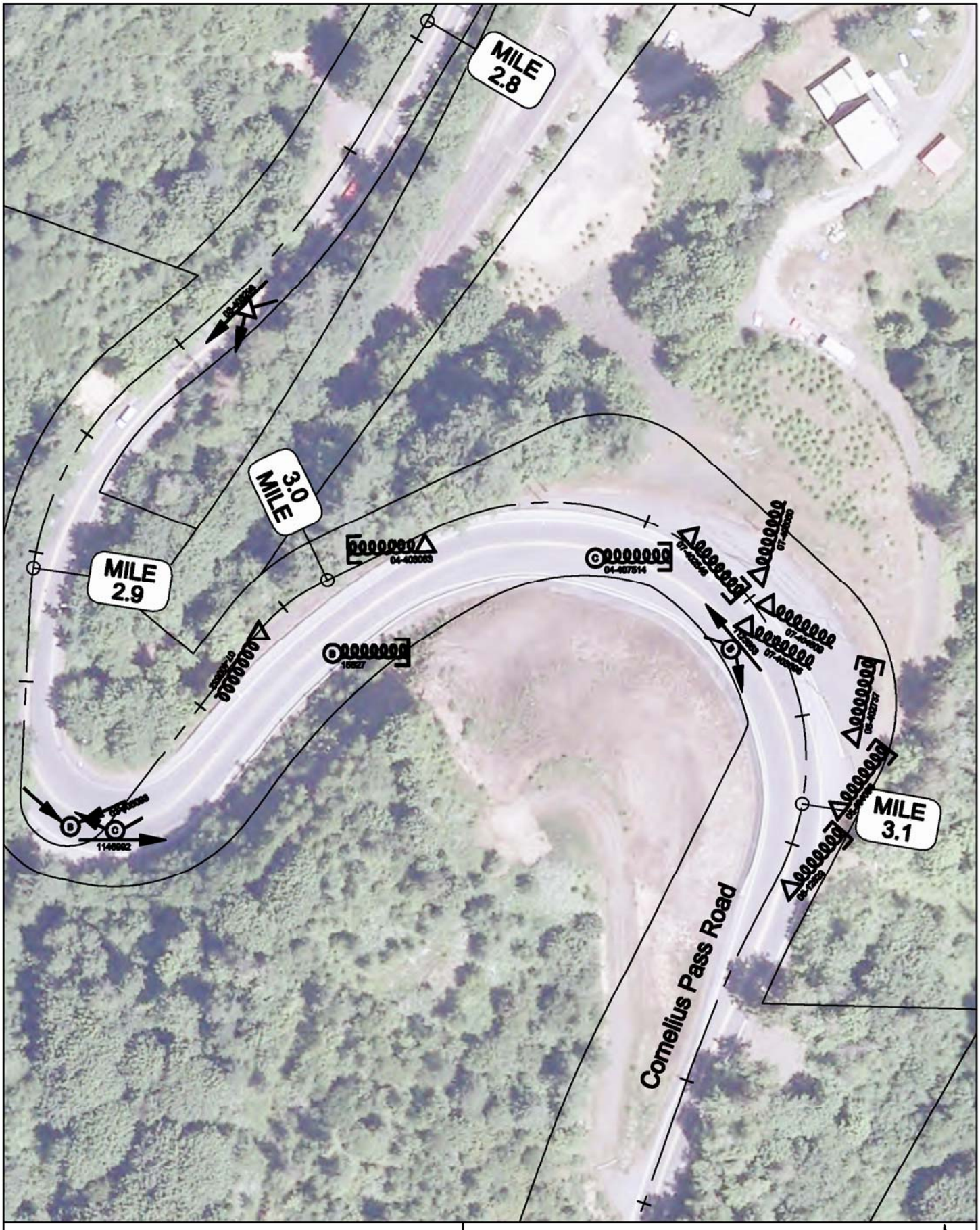
Project Area G: Project 2 - S-Curves
MP 1.8-2.1 (Curve Realignment)

Scale: 1 inch = 100 feet

100 50 0 50 100

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

- **Project 1 – Widen Shoulders**
- **Project 2 – Construct a Bridge Structure**
- **Project 3 – Realign Road to West**

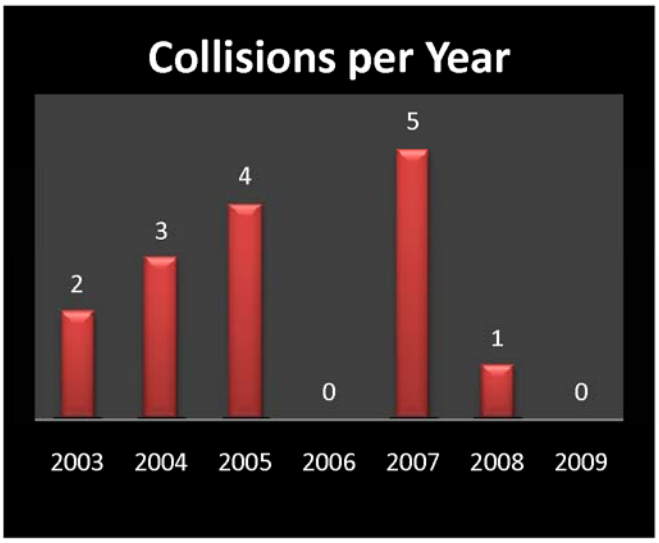


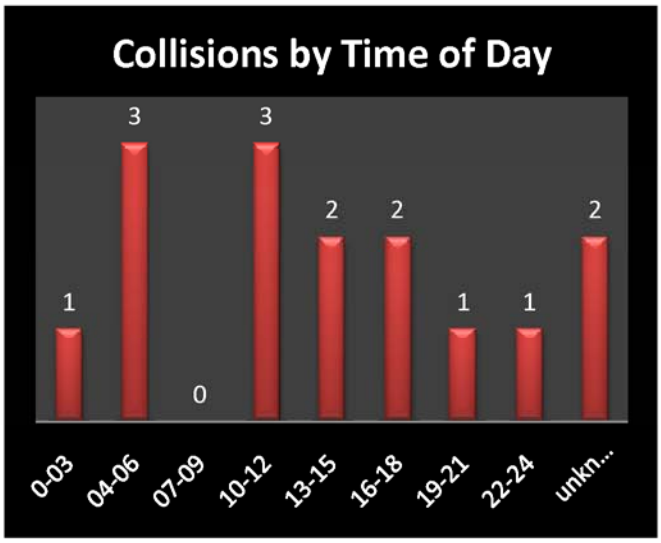
Collision Diagram
Project Area H (S-Curves at MP 2.8 to 3.3)

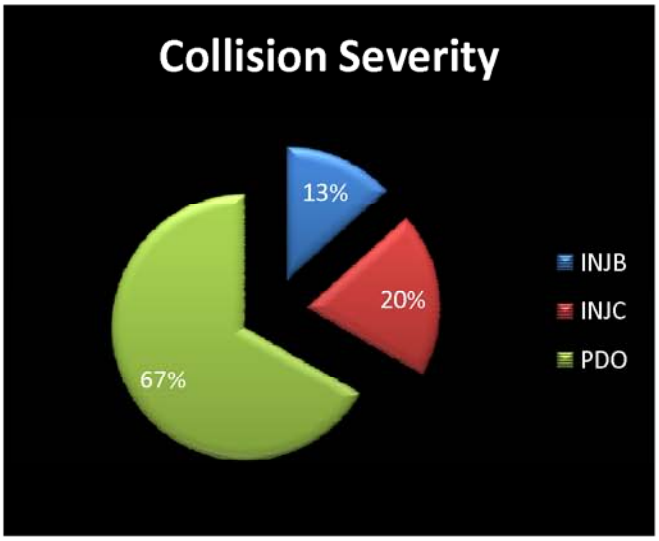
Scale: 1 inch = 100 feet

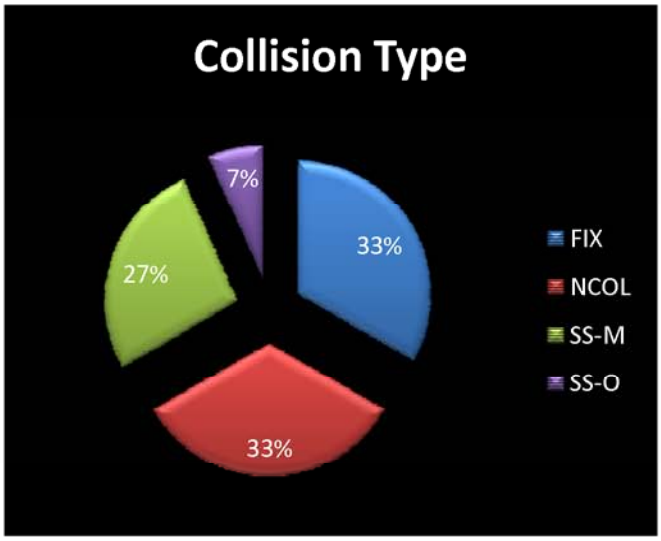
100 50 **0** 50 100

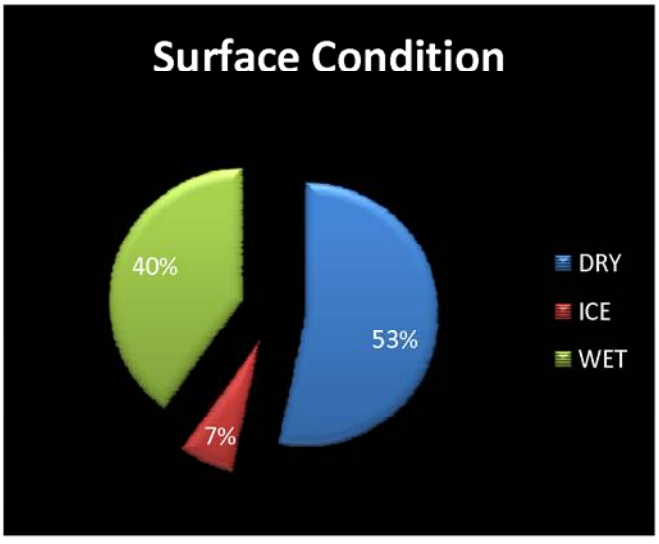
Cornelius Pass Road 2003 - 2009 Collisions
Project Area H: MP 2.85-3.15

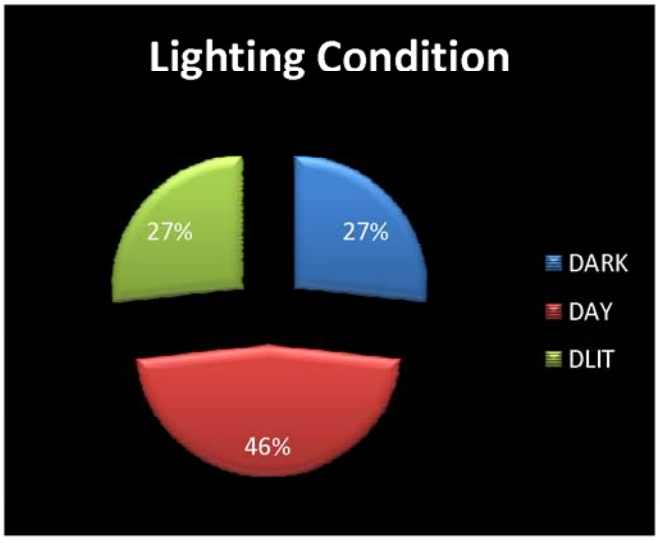






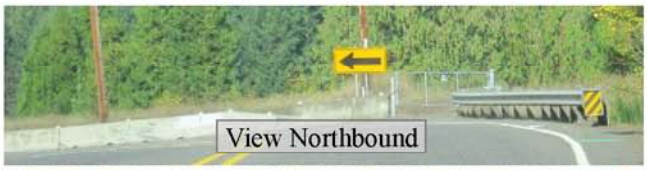






Project Area H - MP 2.8-3.3 (Tight Curves)

Problem Statement: 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. These sharp curves continue to present a risk for drivers.

Photos	Proposed Projects
 View Southbound  View Northbound  View Northbound	Project 1: 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: This project would replace the 25 mph and 15 mph curves with a structure that is designed for 45 mph. The bridge would span the valley and railroad tracks between the beginning of the 25 mph curve and the tangent section of the road directly north of this curve. Project 3: 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.

Supporting Data

Total Collisions 2003-2009 = 15
ADT = 10,575
Collision Rate = 1.85 per million VMT
By type:
- 33% overturn, 33% fixed object, 33% sideswipe

By severity:
- B 13%, C 20%, PDO 67%

Other collision factors:
- 53% on dry surface
- 47% during daylight conditions

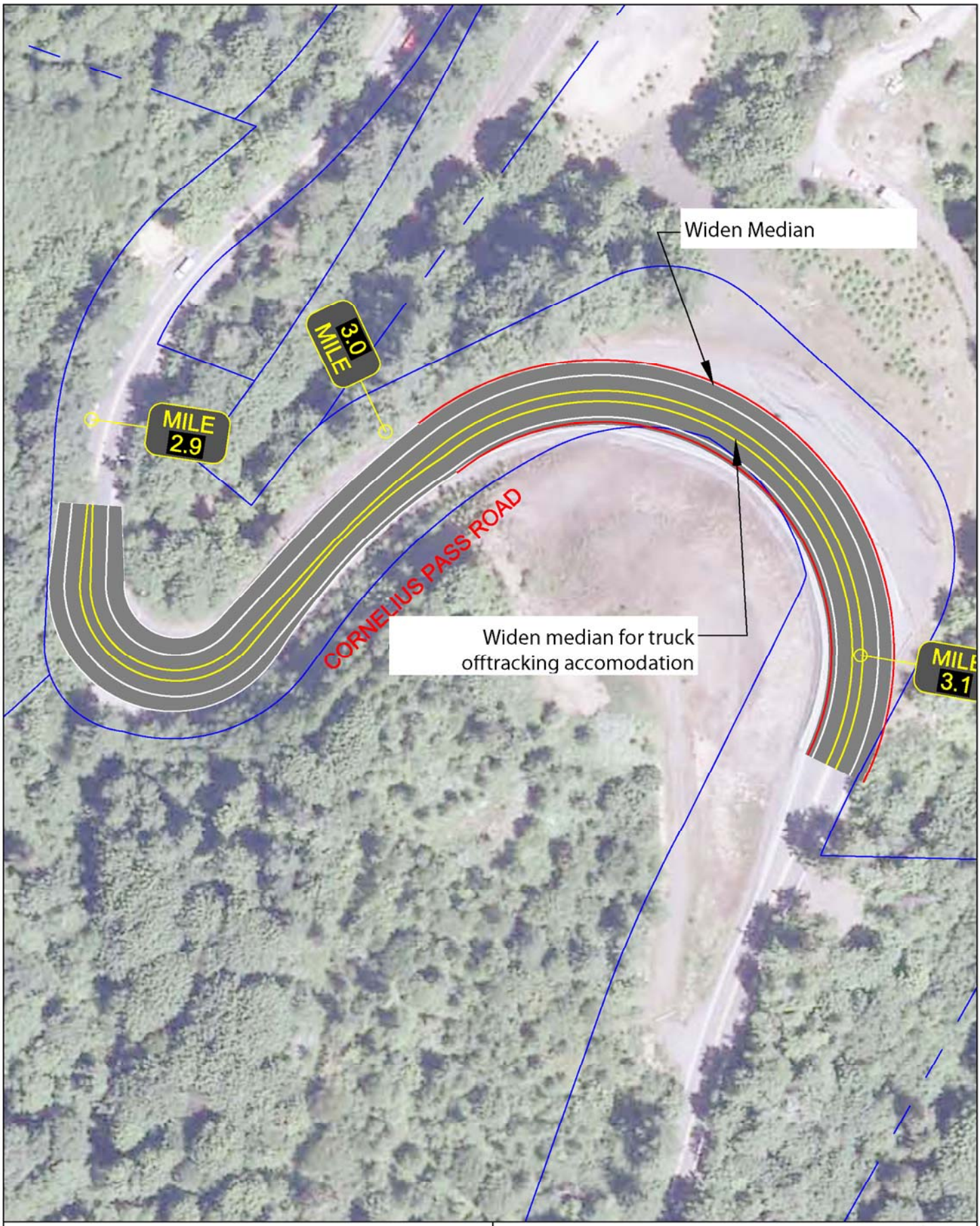
- Approximate minimum sight distance from the middle of the 25mph curve is 175 ft in each direction. This meets the required stopping sight distances (227 ft westbound and 179 ft southbound, assuming a design speed of 30 mph and grade of 9%).
- There is a street light and other utility poles along the west side of the road.
- Curve warning signs and concrete guardrails are present.

Improvement Options	Benefits	Costs
Project 1: Widen Shoulders	• 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]	$50,000

[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.

Improvement Options	Benefits	Costs
Project 2: Bridge Structure	• Provide a gentler curve in the road, reducing the likelihood that cars and trucks will leave their lane or overturn on or off the road. • 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]	$25,000,000
Project 3: Realign roadway to the west by clearing embankment	• 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]	$5,000,000
Other Considerations		
• Cornelius Pass Road is approximately 24 feet wide on either side of the curves and 48 ft wide in the middle of the curves; there are also paved shoulders approximately 5 feet wide along the curve. • This project will require the relocation of utility poles and the guardrail along the east side of the road. • This project may require earthwork. • This project may require right of way easements or purchase.		

[2] 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.

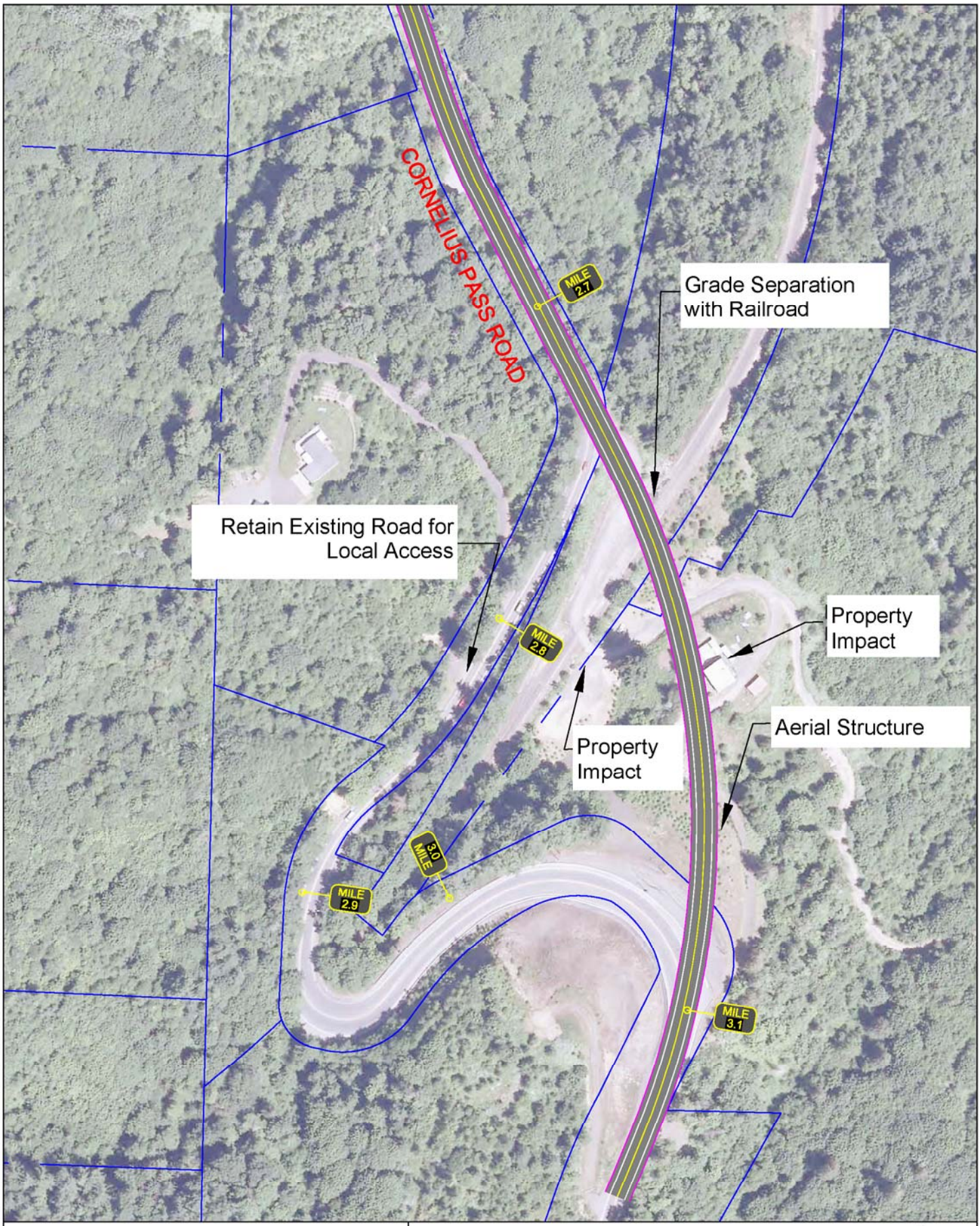


Project Area H : Project 1- S-Curve
MP 2.8-3.3 (widen Shoulders)

Scale: 1 inch = 100 feet

100 50 0 50 100

N

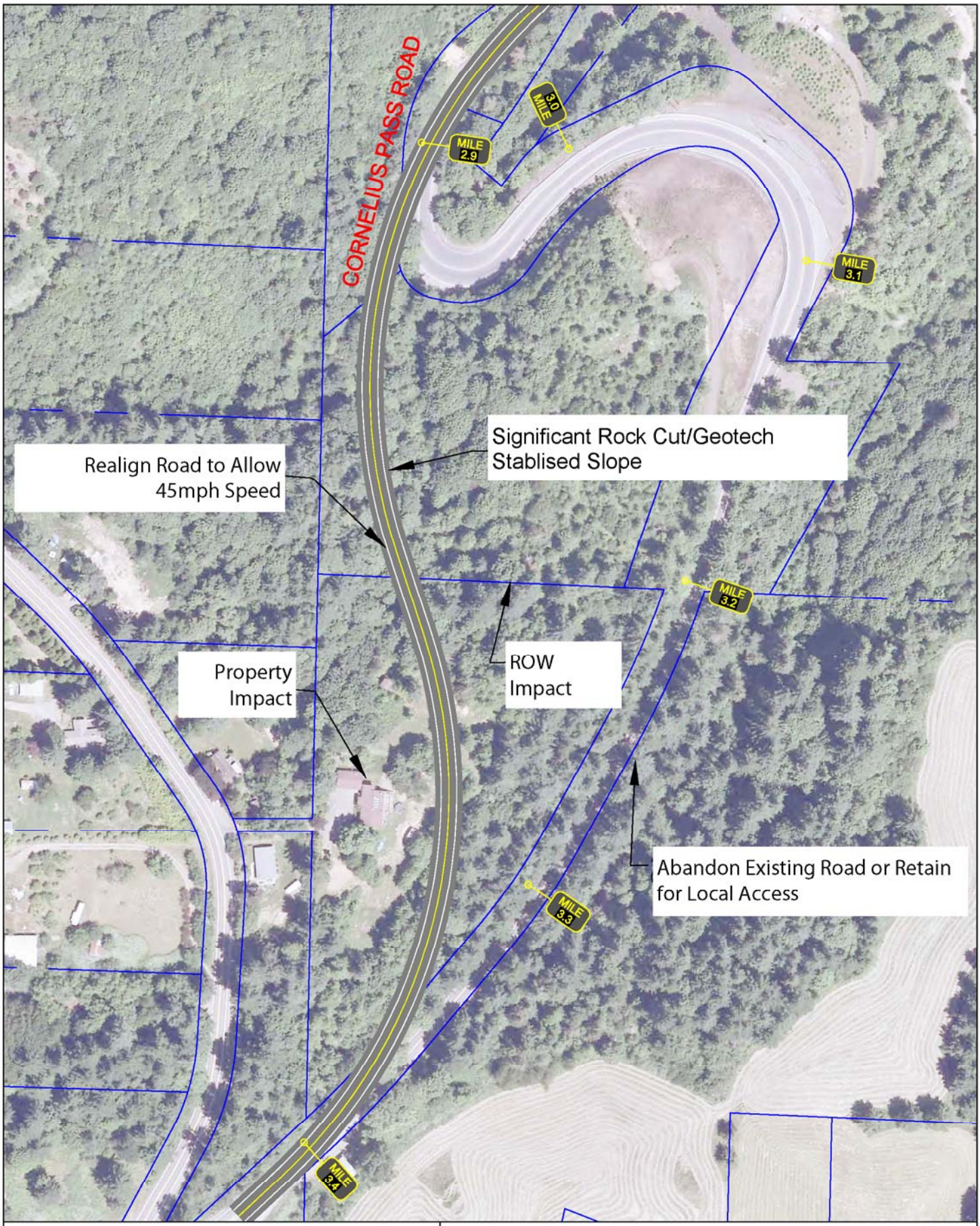


Project Area H: Project 2- S-Curve
MP 2.8-3.3 (Bridge Structure)

Scale: 1 inch = 200 feet

200 100 0 100 200

N



Project Area H: Project 3- S-Curve
MP 2.8-3.3 (Realign Road to West)

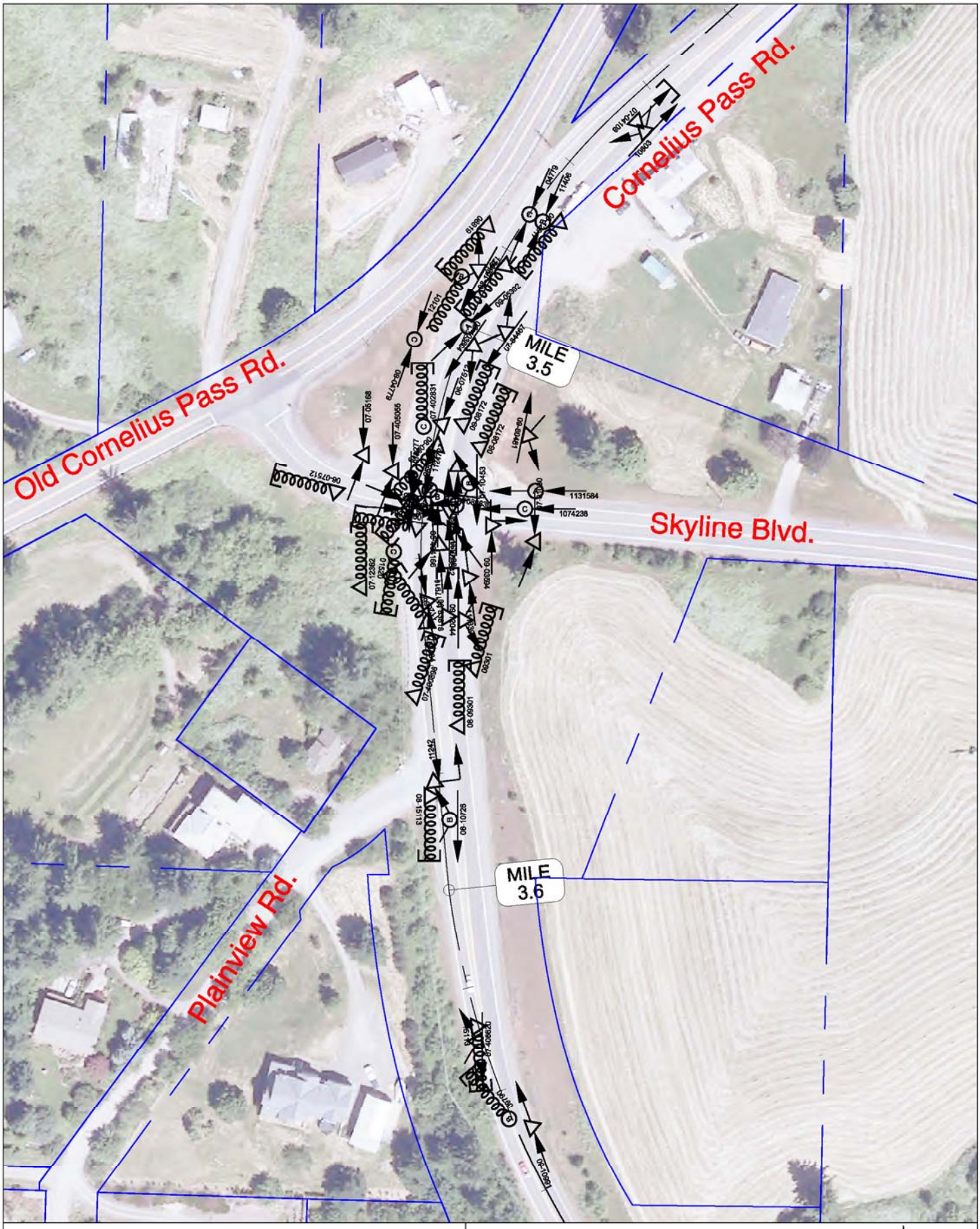
Scale: 1 inch = 200 feet

200 100 0 100 200

N

Project Area I – Skyline Boulevard Intersection

- **Project 1 – Access Management and Improve Intersection Sight Distance**
- **Project 2 – Realignment of Cornelius Pass Road and Plainview Road**
- **Project 3 – Realignment of Cornelius Pass Road and Introduce Southbound Passing Lane**
- **Project 4 – Construct a Single Lane Roundabout**

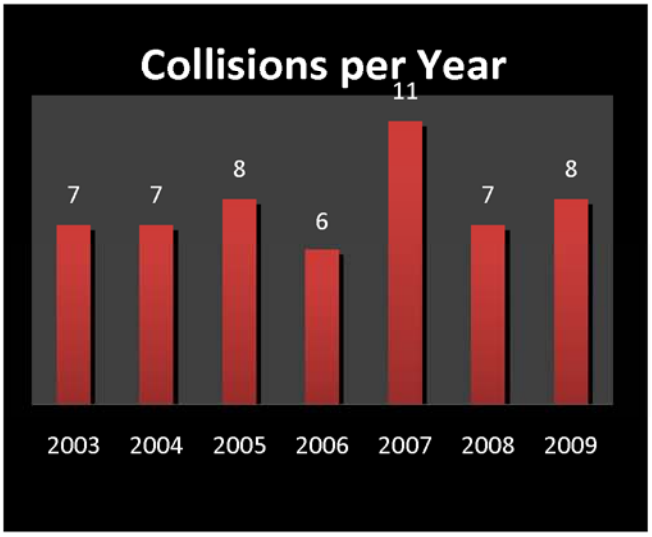


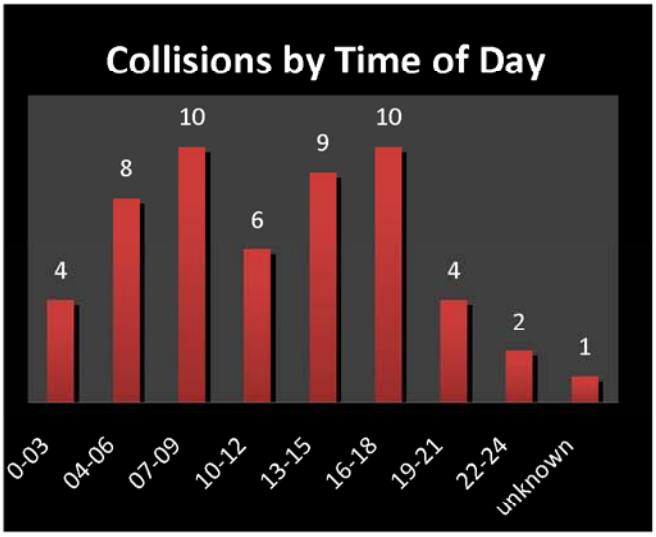
Collision Diagram
Project Area I (Skyline Blvd Intersection)

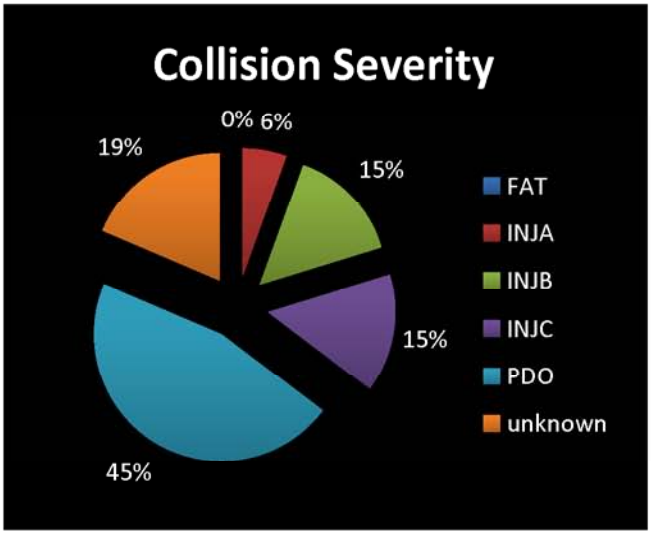
Scale: 1 inch = 120 feet

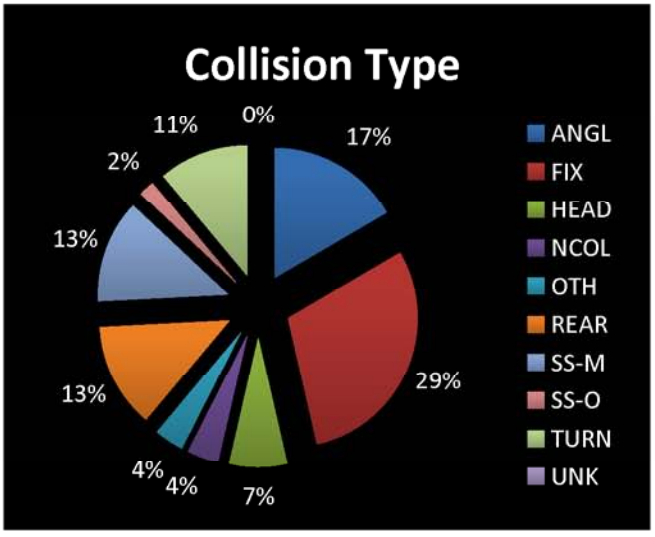
120 60 0 60 120

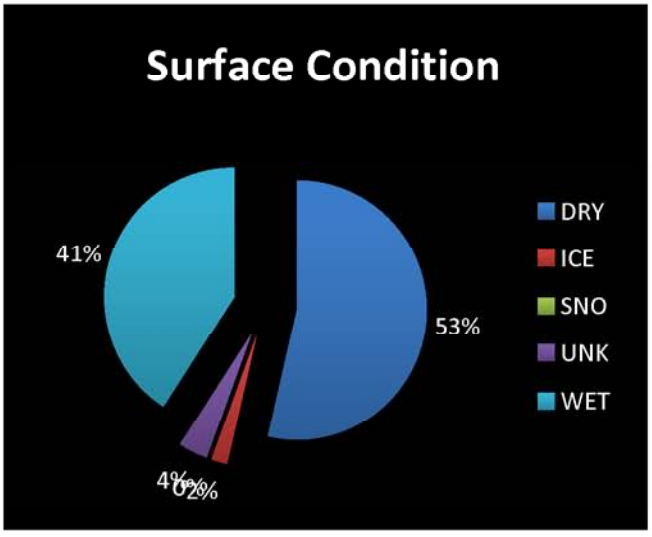
Cornelius Pass Road 2003 - 2009 Collisions
Project Area I: Skyline Boulevard, MP 3.45 - 3.65

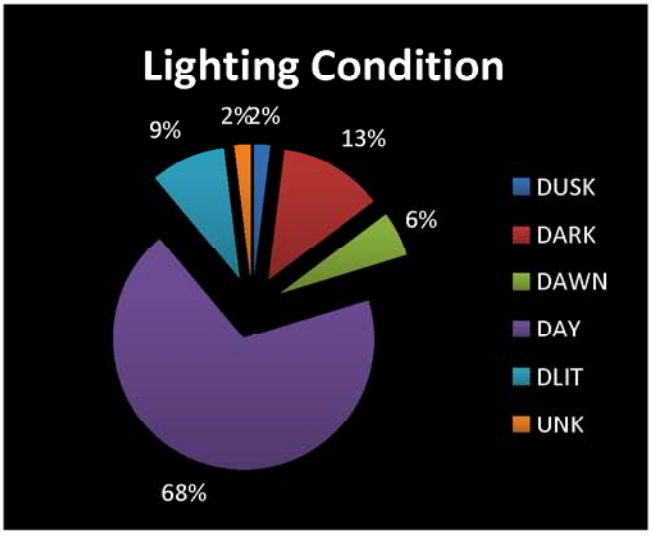












Project Area I: Skyline Boulevard Intersection

Problem Statement: At the Skyline Boulevard intersection there is a high occurrence (54) of collisions over a seven-year period (2003 – 2009). 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 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.

Photographs	Proposed Improvement
 View Southbound  View Northbound	**Project 1:** Provide only one driveway to the grocery store in the northeast corner of the intersection immediately south of the building. This would require modifications to the on-site circulation of the property. Improve intersection and stopping sight distance at the Skyline Boulevard intersection. **Project 2:** Realign Cornelius Pass Road with a circular curve to eliminate broken-back arrangement of curves and extend Plainview Road to Old Cornelius Pass Road by creating an offset T-intersection on Cornelius Pass Road. **Project 3:** Realign Cornelius Pass Road with compound curves to eliminate broken-back arrangement of curves and provide a southbound passing lane. **Project 4:** Introduce a single-lane roundabout as an alternative intersection control.

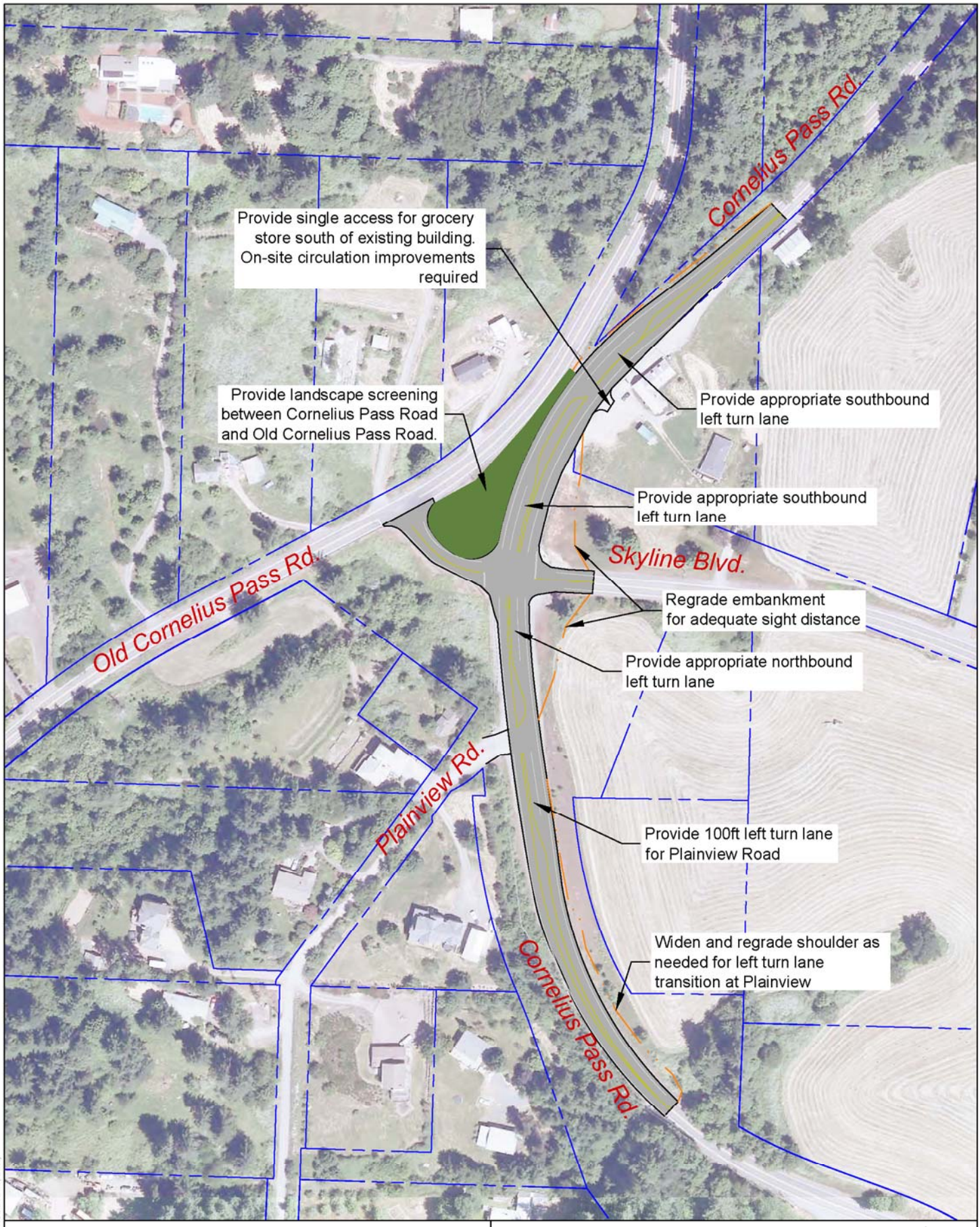
Supporting Data

- Total collisions 2003- 2009 = 54
  - 21% Injury A & B crashes
  - 21% during dusk, dark and dawn
  - 41% angle/rear/turn intersection related crashes
  - 68% of the collisions occur during morning and evening commute periods
  - 37% out-of-control type collisions
  - 12% side-swipe related collisions
- Several turning movements
  - Skyline Boulevard intersection
  - Plainview Road intersection (200' south)
  - Two grocery driveways (200' & 400' north)
- Limited intersection sight distance for westbound approach
- See collision diagram and graphs for more details.

Improvement Options	Benefits	Costs
Project 1: Access management and improve intersection and stopping sight distance	• Reduces the number of conflict points by consolidating access points. • Improve intersection sight distance (ISD) by cutting back the embankments in the northeast and southeast corners of the intersection. • Improve stopping sight distance (SSD) by cutting back the embankment of the curve immediately south of the intersection. 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]	$3,500,000 to $5,000,000
Project 2: Realignment of Cornelius Pass Road and Plainview Road extension	• Provides a travel path along a circular curve for motorists by eliminating the existing broken-back arrangement of curves along Cornelius Pass Road addressing the "out-of-control" type crashes. • Create two offset T-intersections and extend Plainview Road to Old Cornelius Pass Road by separating the conflict points along Cornelius Pass Road. • Provides for adequate ISD at the intersections. • Provide SSD along the inside of the new circular curve.	$4,500,000 to $7,000,000
Project 3: Realignment of Cornelius Pass Road and introduce a southbound passing lane	• Introduces a compound arrangement of curves (ratio 1.5:1) to eliminate the existing broken-back arrangement of curves along Cornelius Pass Road addressing the "out-of-control" type crashes. • Provide a ¼ mile southbound passing lane to provide an opportunity for vehicles to pass at the summit. Providing a passing lane through an intersection may cause other safety concerns. • Provides for adequate ISD at the intersections. • Provide SSD along the inside of the circular curve.	$4,000,000 to $6,000,000
Project 4: Construct a single-lane roundabout	• National research shows that the conversion of two-way stop controlled intersections to roundabouts results in a decrease in total crashes of approximately 71% and a reduction in injury/fatal crashes by approximately 87%. [2]	$3,000,000 to $4,500,000
Other Considerations		
• All projects will likely require the relocation of utility poles. • All projects will require earthworks; balancing cut and fill and minimizing environmental impact. • All projects will require negotiations with the property owner in the northeast corner of the intersection. • All projects may require public easements and/or right-of-way acquisition.		

[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.

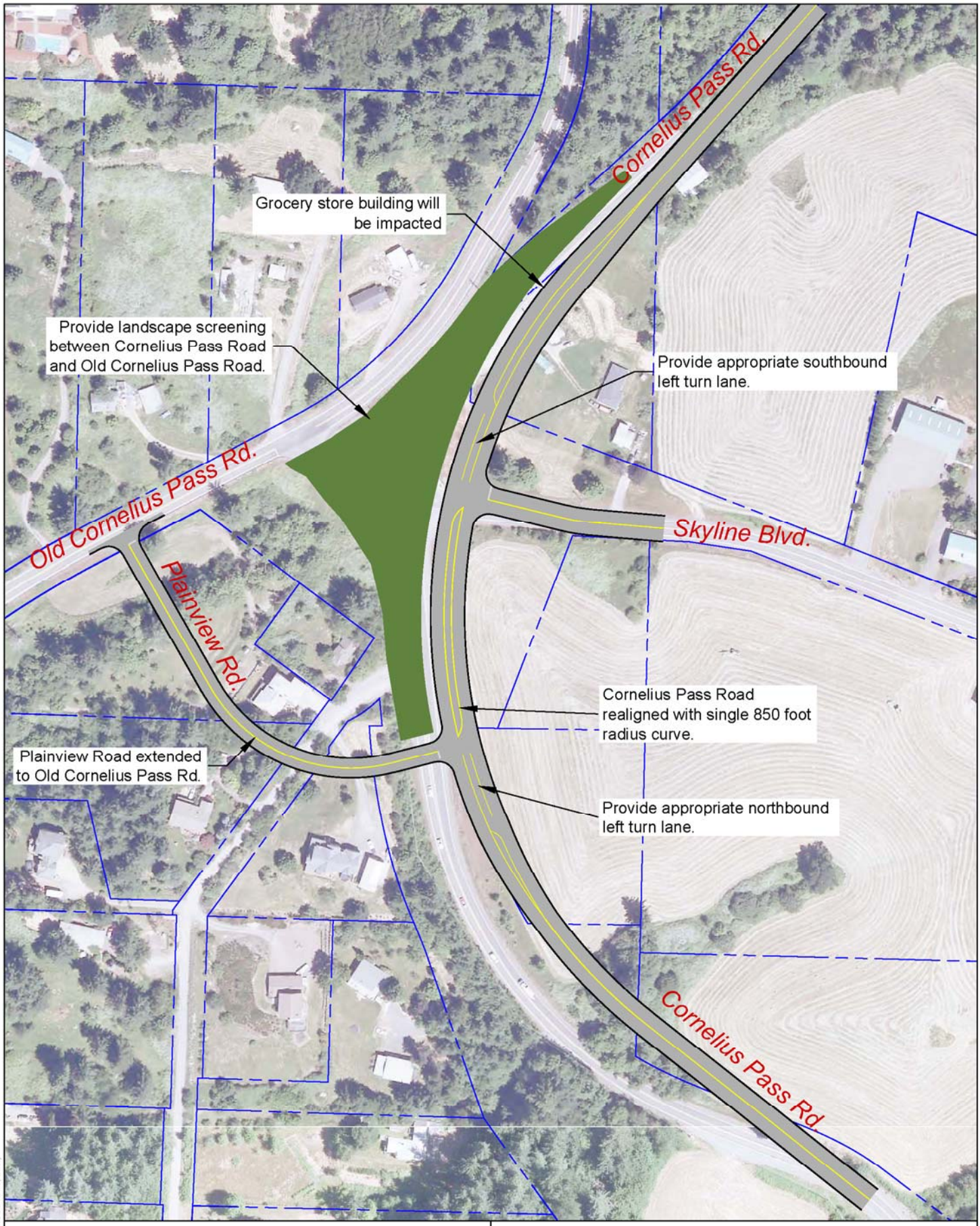
[2] Website: http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_rpt_572.pdf NCHRP Report 572, Roundabouts in the United States, 2007, Table 28.



Project Area I: Project 1 - Skyline Blvd (Access Control & Sight Distance)

Scale: 1 inch = 200 feet

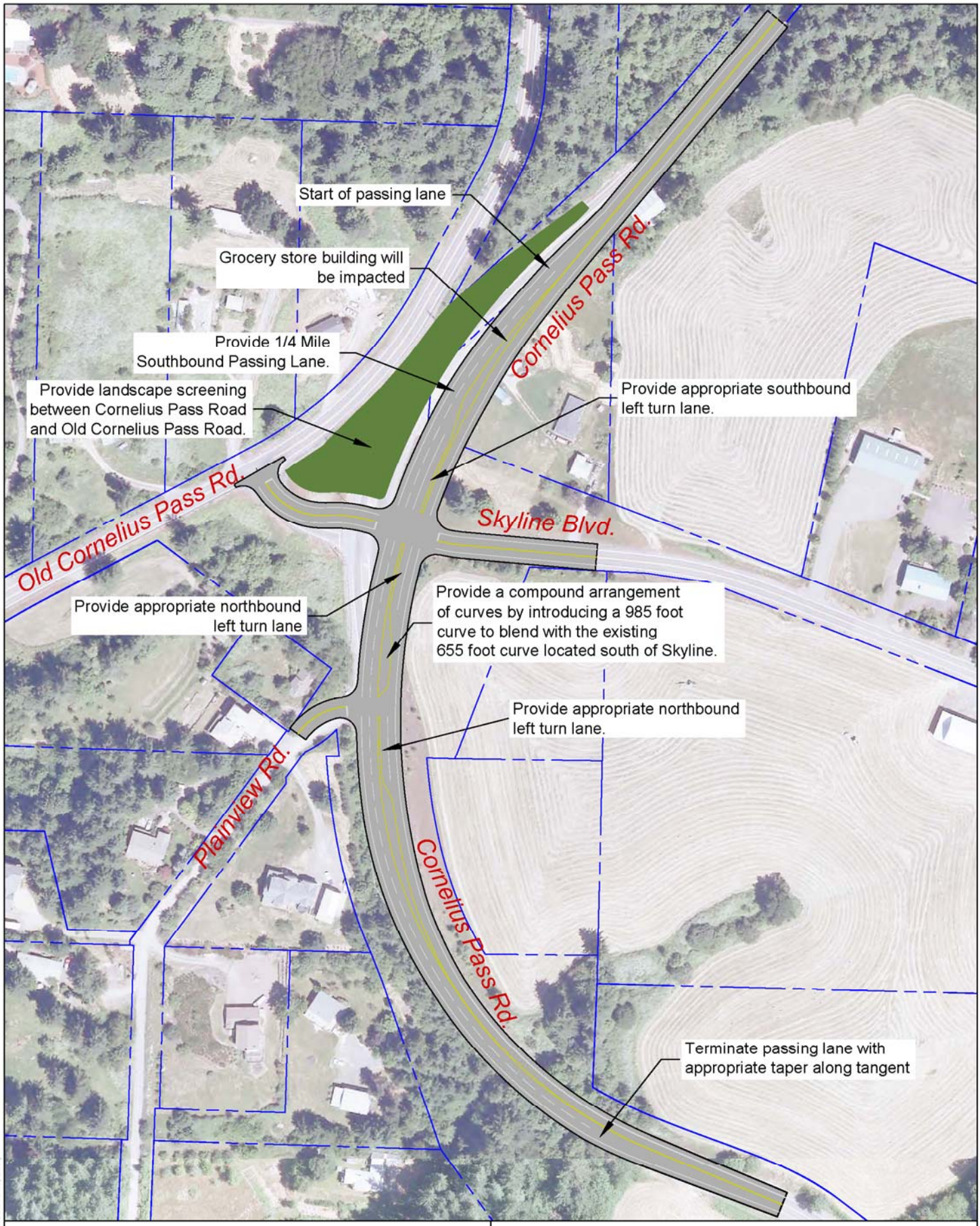
200 100 0 100 200



Project Area I: Project 2 - Skyline Blvd (Plainview Realignment)

Scale: 1 inch = 200 feet

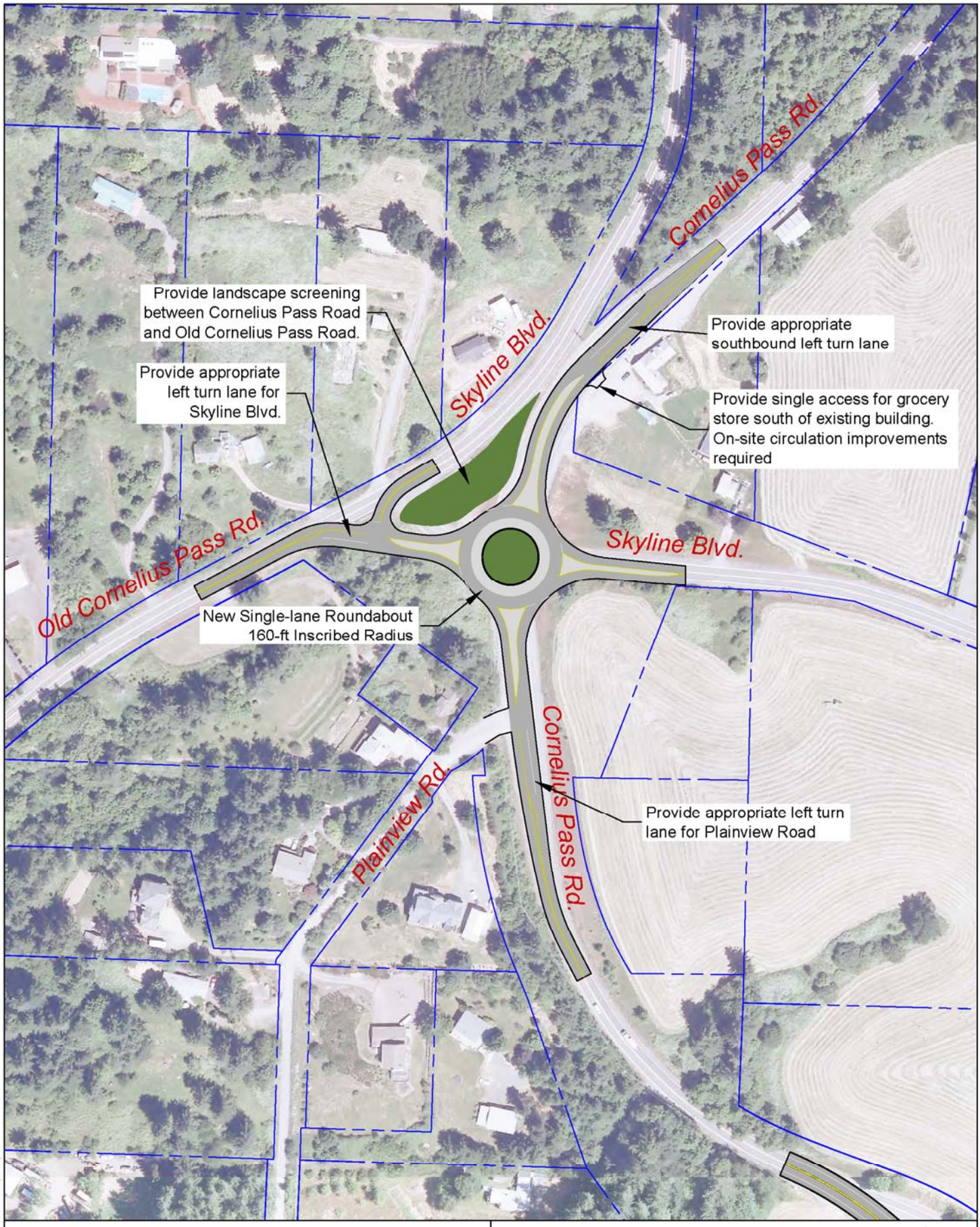
200 100 0 100 200



Project Area I: Project 3 - Skyline Blvd (Southbound Passing Lane)

Scale: 1 inch = 200 feet

200 100 0 100 200



Project Area I: Project 4 - Skyline Blvd (Single Lane Roundabout)

Scale: 1 inch = 200 feet

200 100 0 100 200

Project Area J –Roadway Curve, MP 3.8

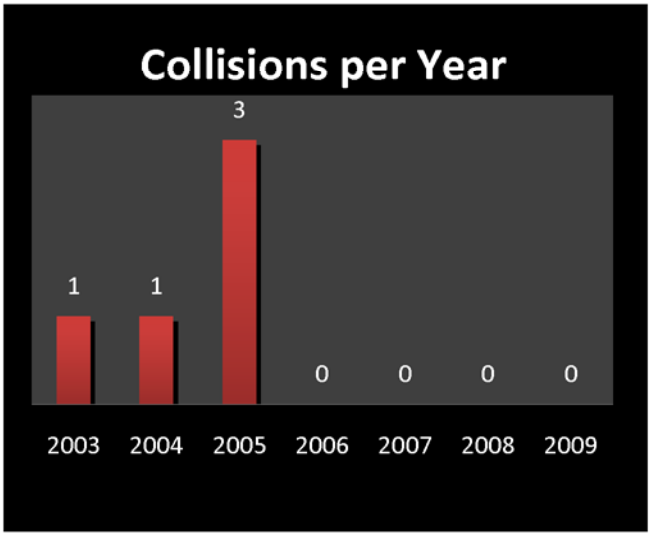
- **Project 1 – Increase Stopping Sight Distance Through Curve**
- **Project 2 – Improve Curve Radius**

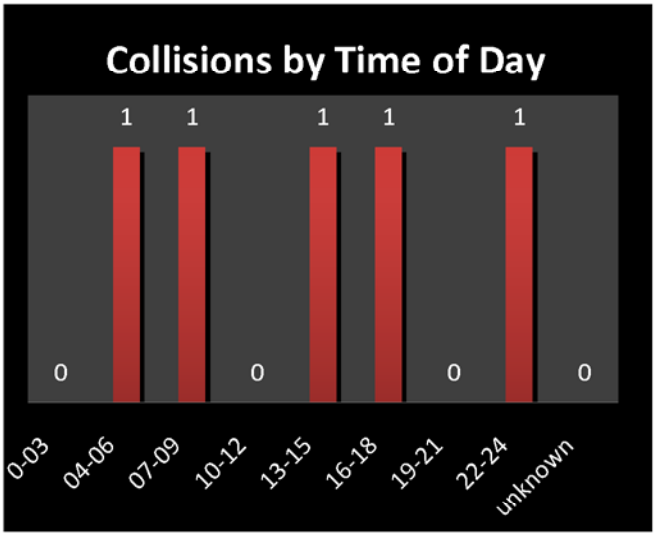
Collision Diagram
Project Area J (Curve at MP 3.8)

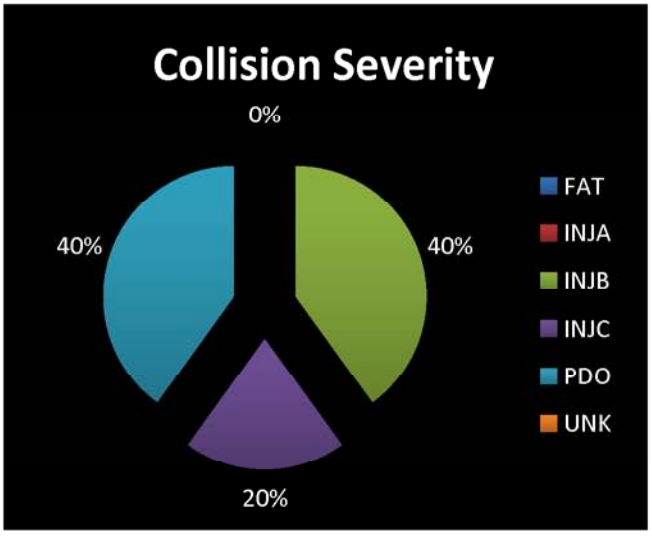
Scale: 1 inch = 100 feet

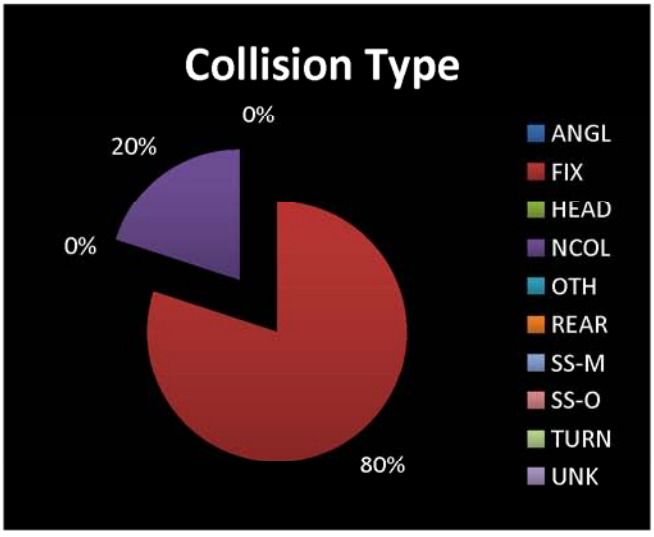
100 50 0 50 100

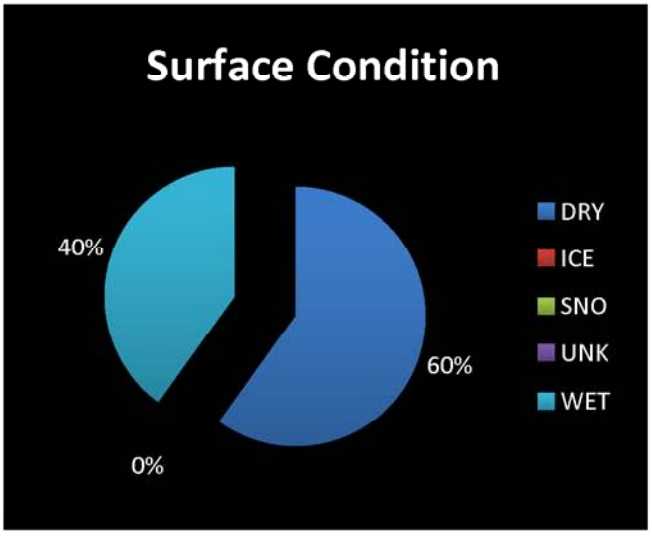
Cornelius Pass Road 2003 - 2009 Collisions
Project Area J: MP 3.8

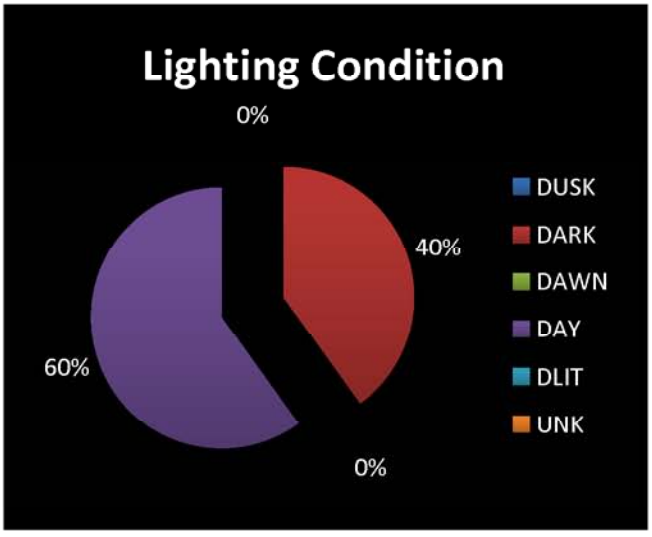






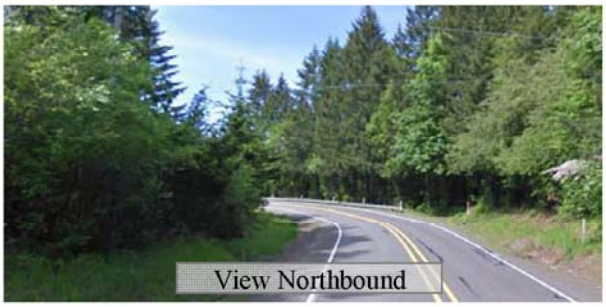






Project Area J: Roadway Curve at Milepost 3.8

Problem Statement: There were five "out of control" collisions reported with fixed objects over a seven-year period (2003 – 2009) along a curved section of Cornelius Pass Road near milepost 3.8.

Photographs	Proposed Improvement
 View Southbound  View Northbound	**Project 1:** Improve stopping sight distance (SSD) around the roadway curve to comply with a design speed of 45 mph and a wider vehicle recovery area. **Project 2:** Improve the existing 30-35 mph curve to comply with a 45 mph curve to be consistent with posted speed along corridor. In addition, provide appropriate stopping sight distance (SSD) around the roadway curve.

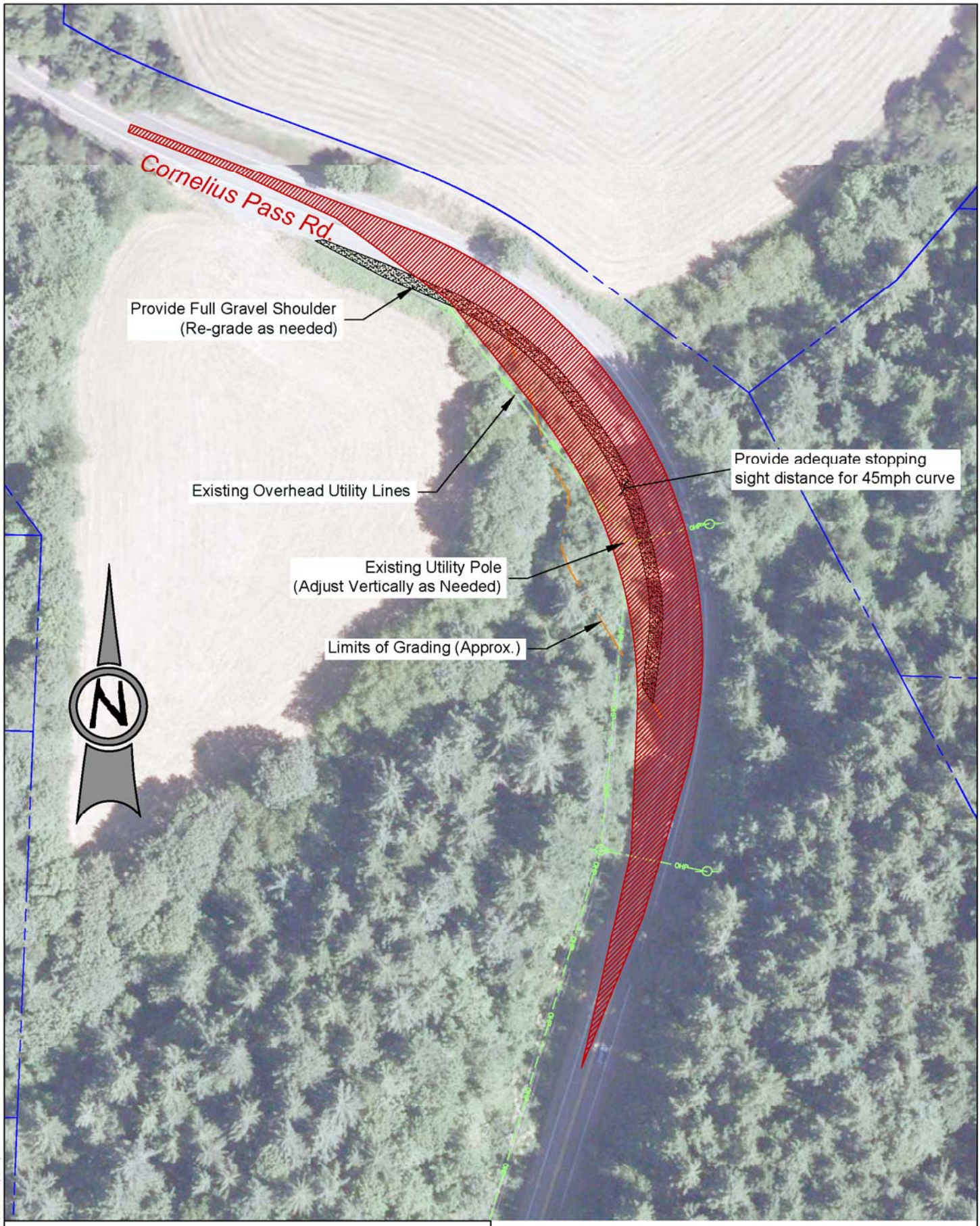
Supporting Data

- Total Collisions 2003- 2009 = 5
  - 40% Injury A & B collisions
  - 40% during dark
  - 100% "out of control" (collision type) resulting in a collision with a fixed object
  - 40% of the collisions occur during morning and evening commute periods
- Limited sight distance for both northbound and southbound approaches around roadway curve due to trees and other vegetation
- Narrow shoulders along the inside curve
- See collisions diagram and graphs for more details.

Improvement Options	Benefits	Costs
Project 1: Clear trees and other vegetation within inside roadway curve.	• Provides appropriate sight distance around curve (at a minimum it needs to meet minimum stopping sight distance for 45 mph). 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] • Provides additional recovery area for vehicles	$300,000 to $400,000
Project 2: Provide 45-mph curve.	• Improve curvature to provide a more consistent travel path for motorists. • 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] • Provides appropriate stopping sight distances. • Provides appropriate recovery area for vehicles.	$1,500,000 to $2,500,000
Other Considerations		
• Both projects will likely require the relocation of utility poles. • Both projects will require earthworks; balancing cut and fill and minimizing environmental impact would be a critical component during the design phase. • Both projects may require public easements and/or right-of-way acquisition.		

[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.

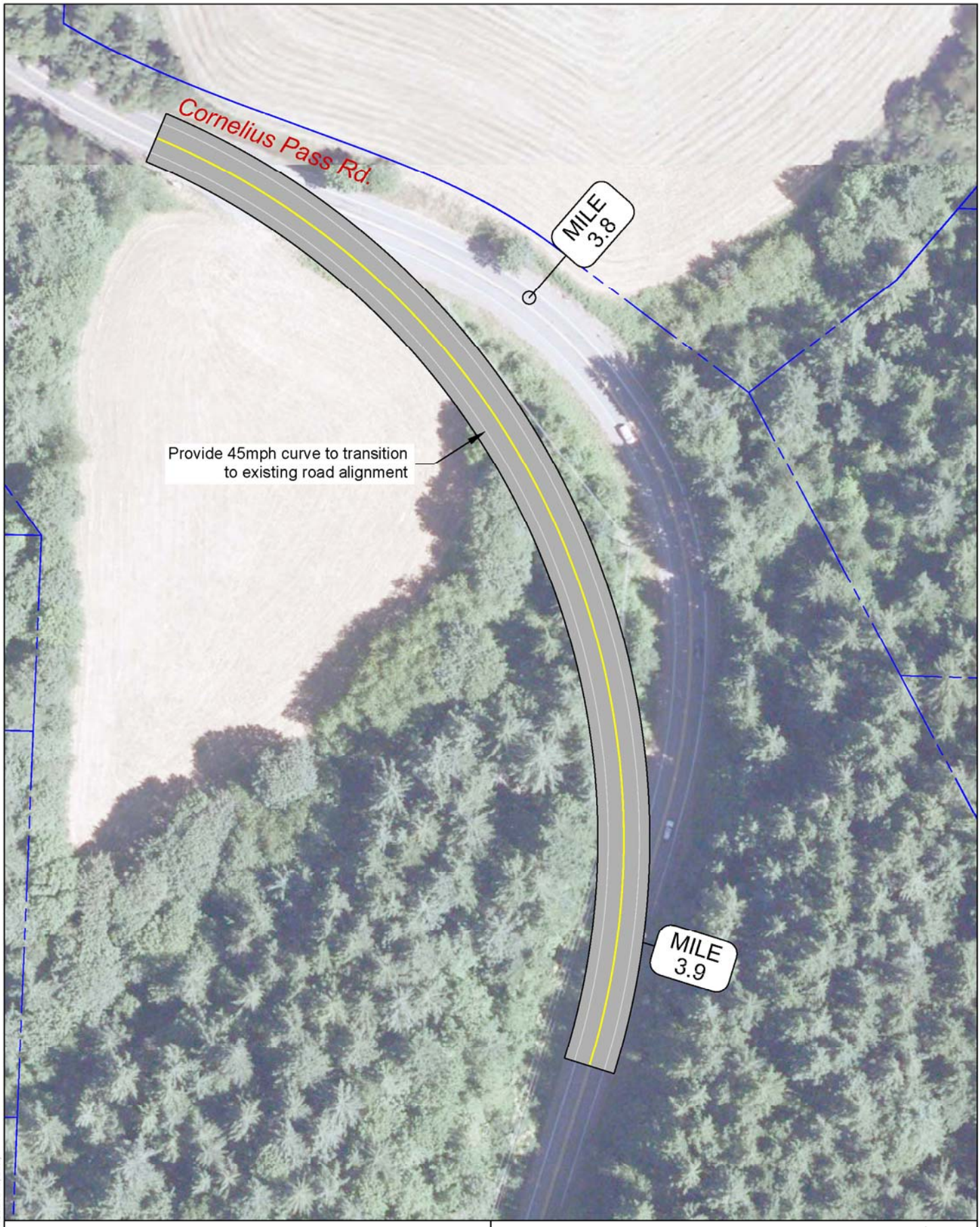
[2] Website: http://www.cmfclearinghouse.org/study_detail.cfm?stid=30 Site funded by US Department of Federal Highway Administration and maintained by the University of North Carolina Highway Safety Research Center. Accessed on November 24, 2010.



Project Area J: Project 1 - Curve at MP 3.8
(Site Distance Improvements)

Scale: 1 inch = 100 feet

100 50 0 50 100



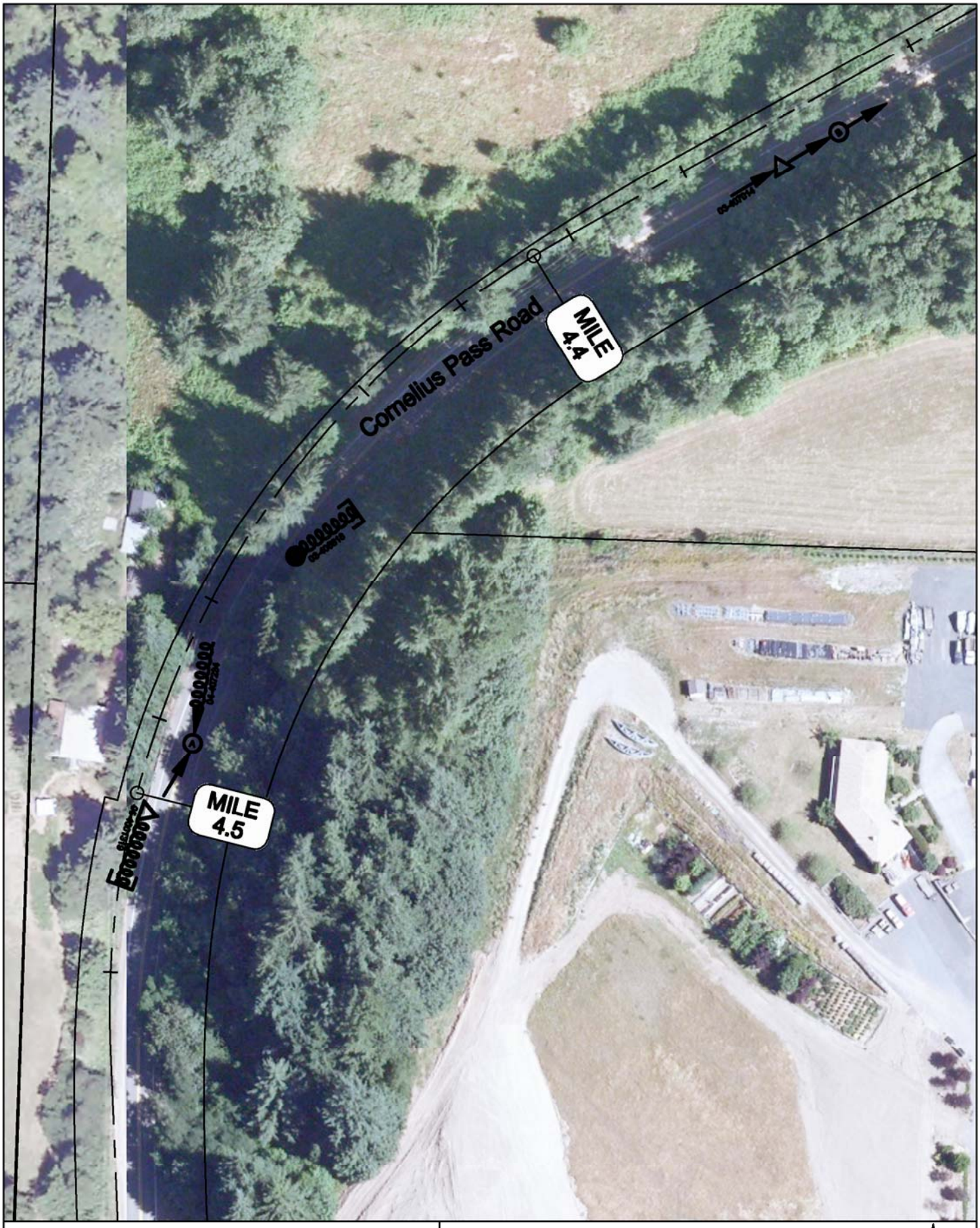
Project Area J: Project 2 - Curve at MP 3.8 (45 MPH Curve)

Scale: 1 inch = 100 feet

100 50 0 50 100

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

- **Project 1 – Increase Stopping Sight Distance Through Curve**
- **Project 2 – Improve Curve Radius**



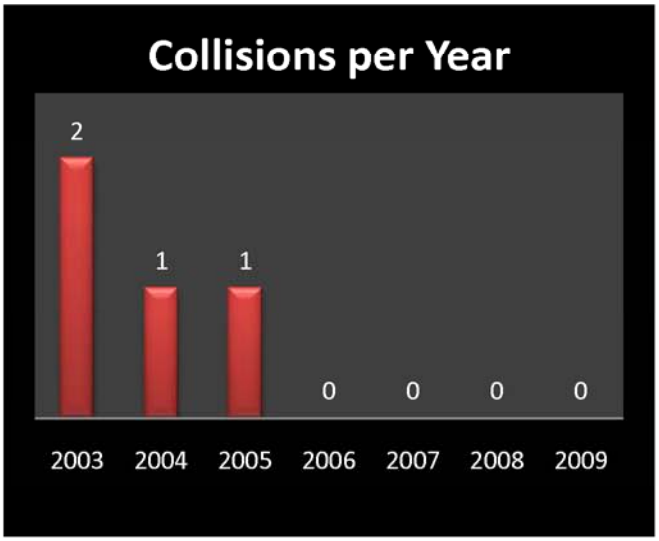
Collision Diagram
Project Area K (Curve at MP 4.5)

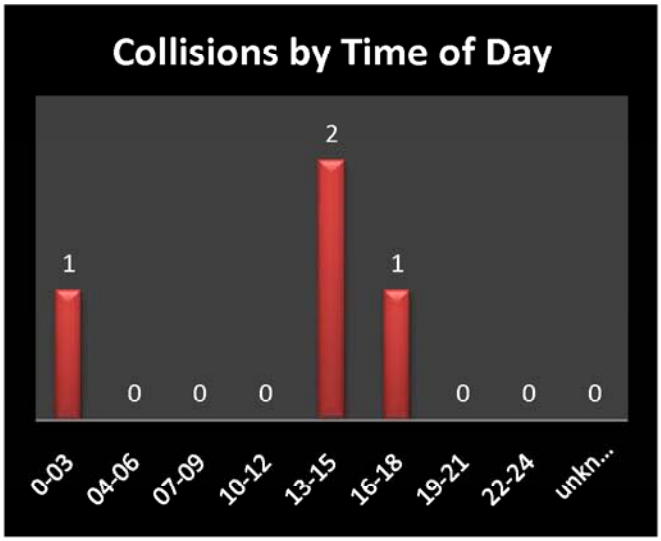
Scale: 1 inch = 100 feet

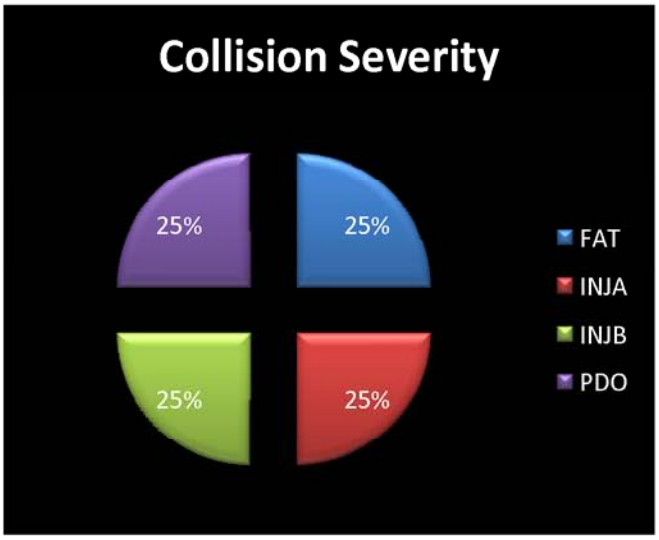
100 50 **0** 50 100

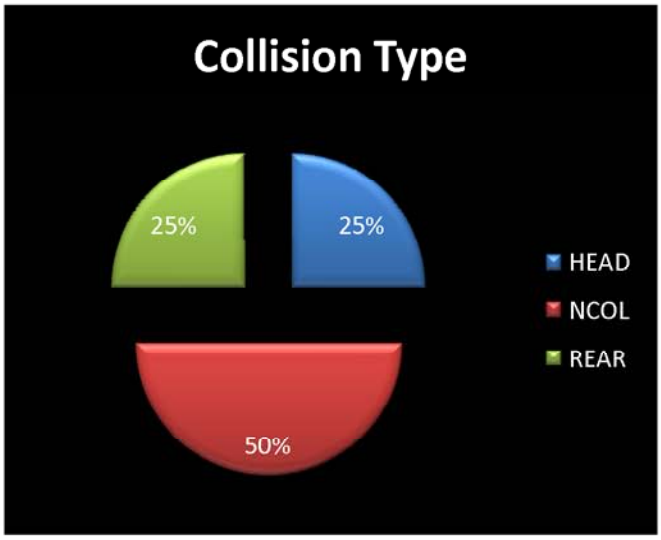
Cornelius Pass Road 2003 - 2009 Collisions

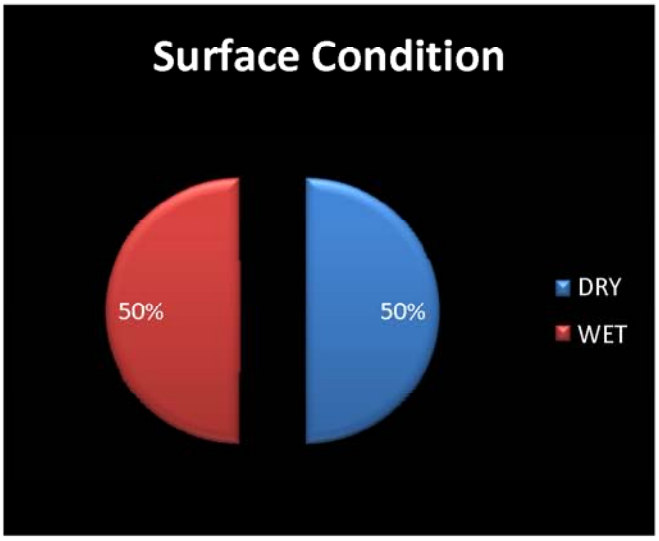
Project Area K: MP 4.3-4.55

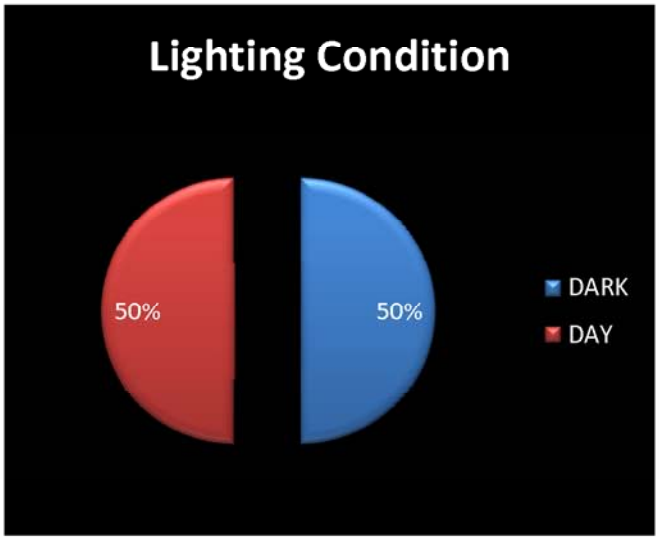






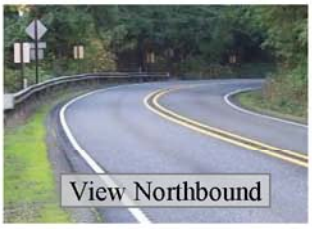






Project Area K: Horizontal Curve north of Kaiser Road

Problem Statement: On the horizontal curve approximately 500 feet north of the Kaiser Road intersection, there have been four collisions that resulted in a severe injury, a debilitating injury, as well as a fatality over the last seven years. The embankment and vegetation on the curve north of Kaiser Road limit stopping sight distances through the curve, creating a potential hazard for drivers.

Photos	Proposed Project
 View Southbound  View Northbound  View Southbound	**Project 1:** 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). **Project 2:** This project improves the horizontal alignment of the curve to meet standards for a 45 mph roadway design.

Supporting Data

Total Collisions 2003-2009 = 4
ADT = 10,570
Collision Rate = 0.74 per million VMT
By type:
- 25% rear end, 25% head-on, 50% overturn

By severity:
- Fatal 25%, A 25%, B 25%, PDO 25%

Other collision factors:
- 50% on Dry surface (50% on wet surface)
- 50% during daylight conditions (50% during dark conditions)
- Approximate minimum sight distance from the middle of the curve, northbound = 260 ft, southbound = 275 ft. This does not meet the required stopping sight distances (305 ft to 380ft).
- No existing street lights along curve
- Curve warning signs and guardrail are present

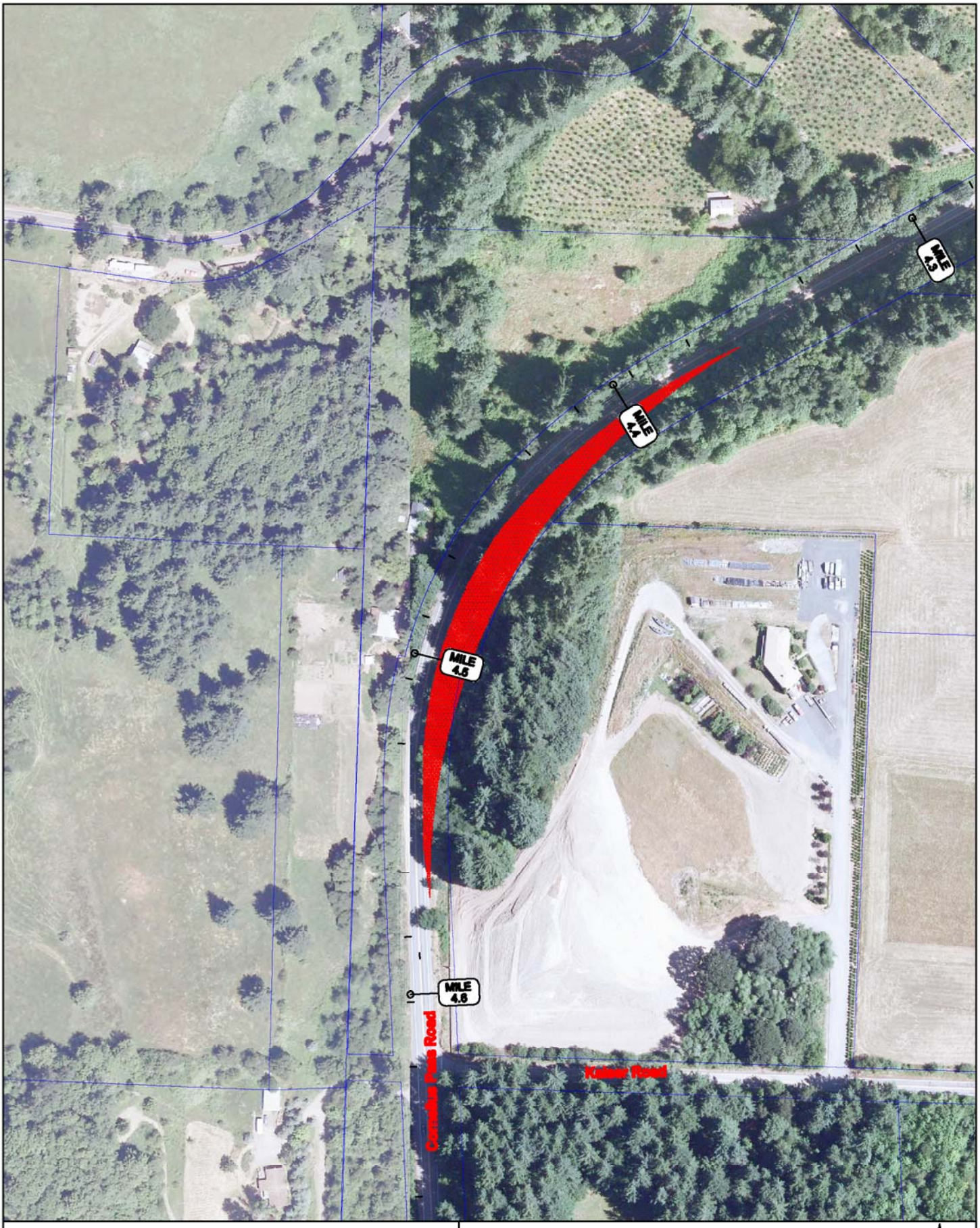
Improvement Options	Benefits	Costs
Project 1: Remove vegetation and embankment to meet sight distance standards.	• The removal of material at this location will allow for the provision of recoverable clear zone as well as stopping sight distance along the curve. • National research shows that the removal of roadside obstacles in the clear zone can reduce collisions by 22% to 44% depending on the increase in clear zone. [1]	$ 1,500,000
Project 2: Realign horizontal curve to meet 45 mph standards.	• National research shows that increasing horizontal curvature by one degree increases run off the road collisions by approximatcly 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]	> $ 3,000,000

Other Considerations

- Cornelius Pass Road is approximately 24 feet wide with one to three foot wide gravel shoulders at this location.
- There is dense vegetation along the inside of the curve (east side of the road) that may need to be removed.
- Improving sightlines along the curve may require earthwork.
- There is a guardrail along part of the outside of the curve (west side of the road).
- There is a driveway access on the west side of the road, near the middle of the curve.

[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.

[2] 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.

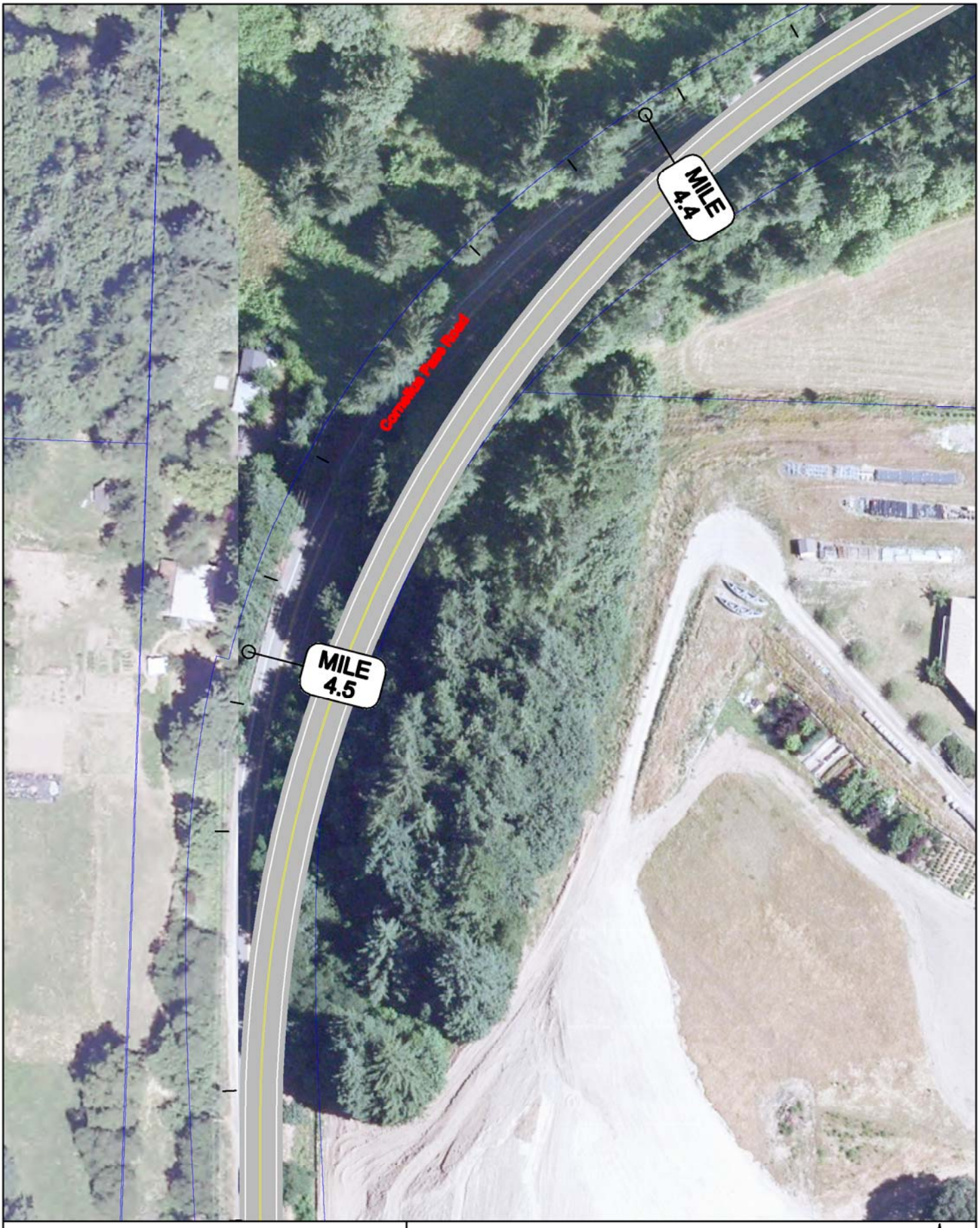


Project Area K: Project 1- Curve
MP 4.5 (Sight Distance Improvements)

Scale: 1 inch = 200 feet

200 100 0 100 200

N



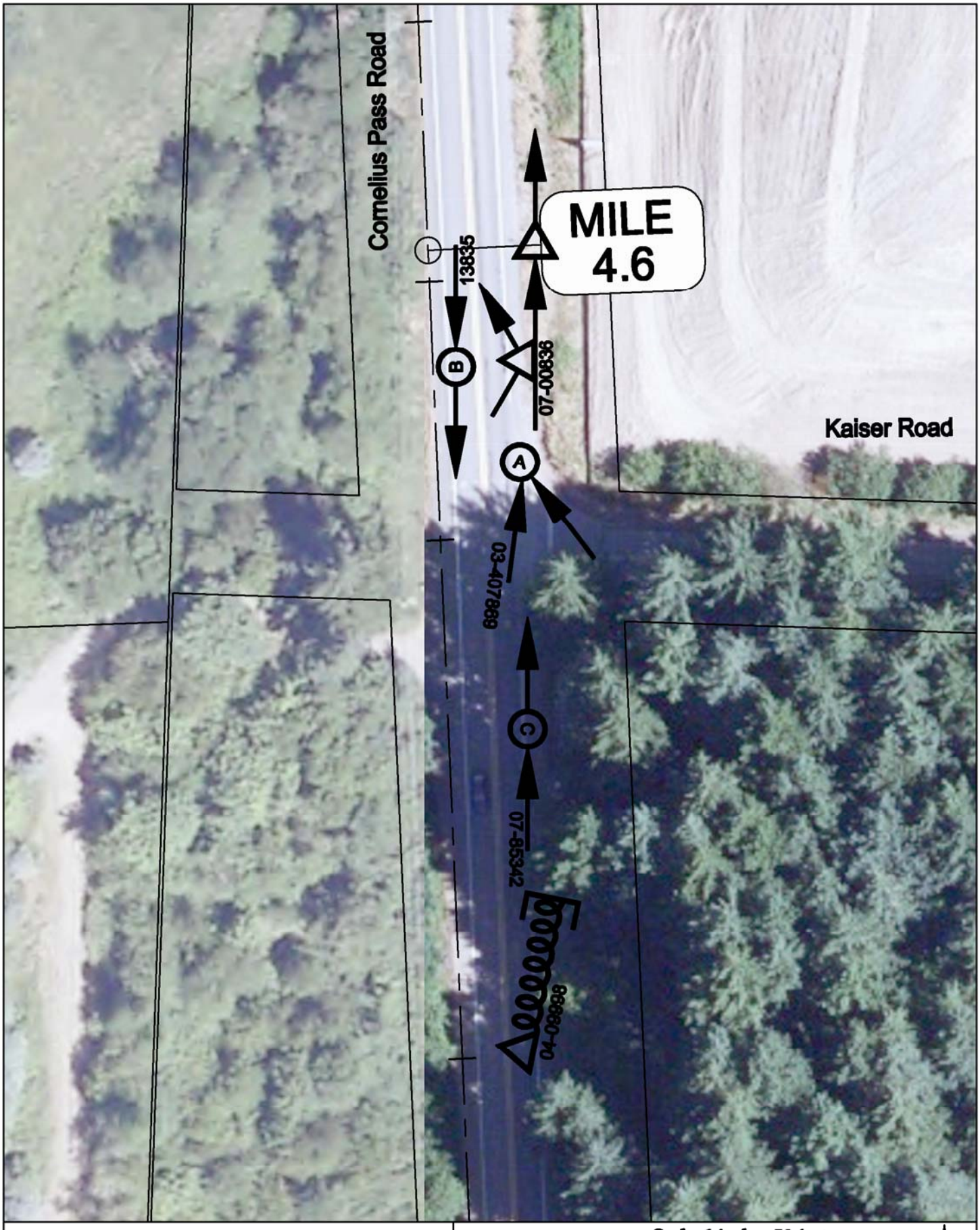
Project Area K: Project 2 - Curve MP 4.5 (Improve Curve Radius)

Scale: 1 inch = 100 feet

100 50 **0** 50 100

Project Area L – Kaiser Road Intersection, MP 4.6

- **Project 1 – Construct a Southbound left turn pocket**
- **Project 2 – Construct a Northbound right turn pocket/widen shoulder**



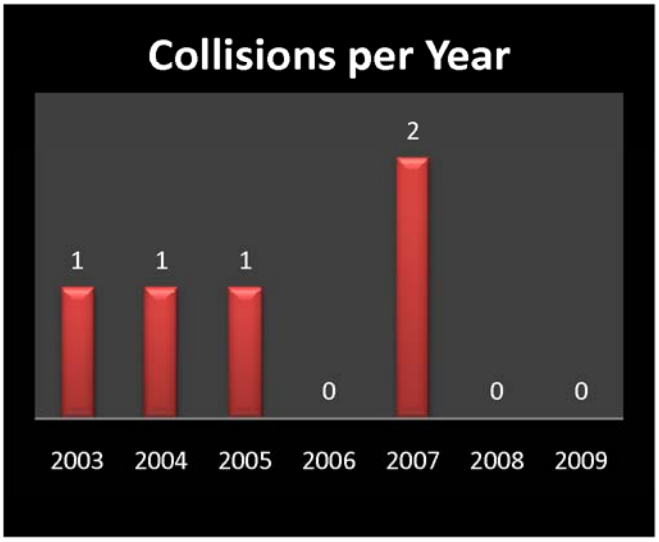
Collision Diagram
Project Area L (Kaiser Road Intersection)

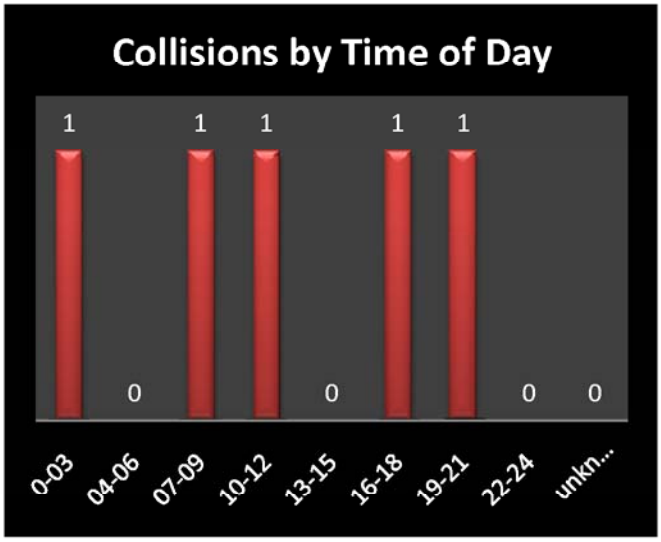
Scale: 1 inch = 50 feet

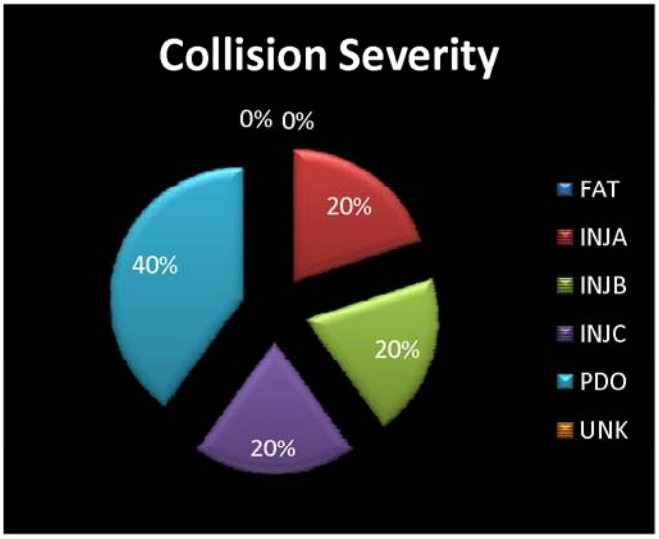
50 25 **0** 25 50

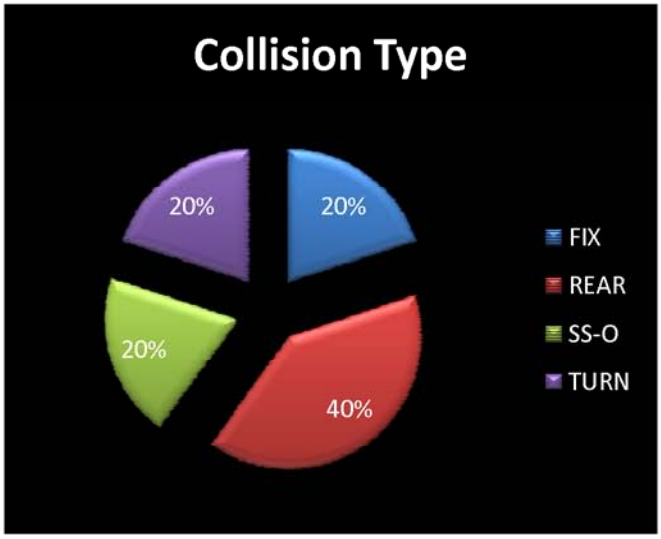
N

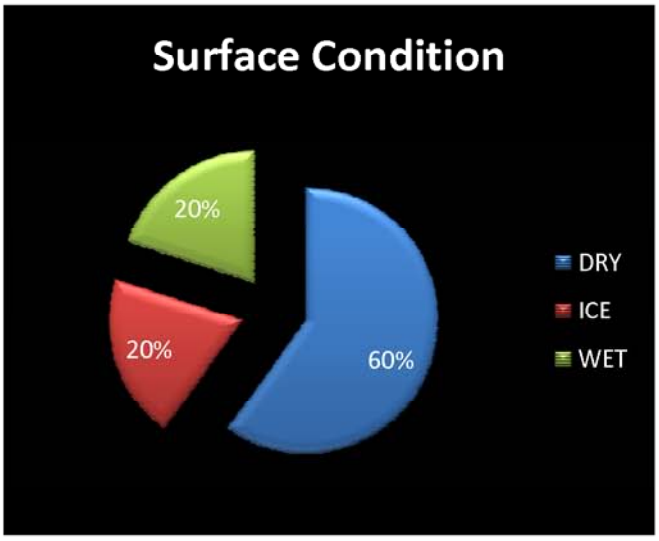
Cornelius Pass Road 2003 - 2009 Collisions
Project Area L: Kaiser Road, MP 4.6-4.65

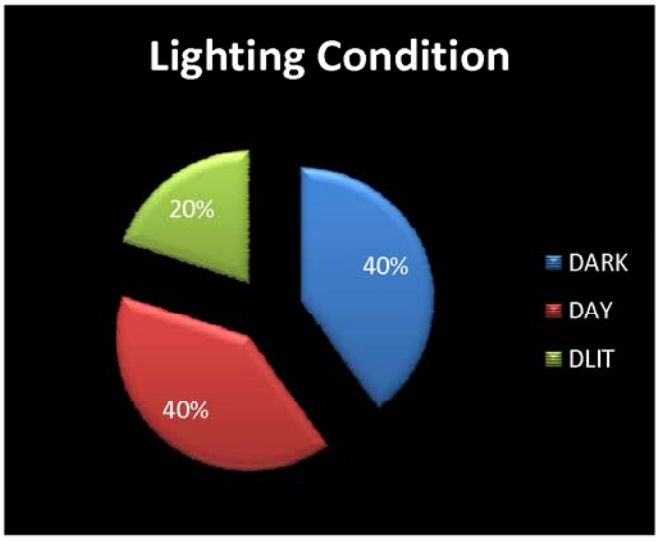












Project Area L: Kaiser Road Intersection

Problem Statement: There have been five collisions that have resulted in a severe injury and a debilitating injury at the Kaiser Road intersection with Cornelius Pass Road over the last seven years. The majority of these collisions occurred during dry conditions in the daylight, suggesting that driver behavior and the roadside environment may have a greater impact on the collisions than other environmental conditions.

Collision Diagram	Proposed Project
 View Southbound  View Northbound  View Eastbound	**Project 1:** The proposed project adds a 75 ft long southbound left turn lane (14 feet in width) at Kaiser Road. Following Multnomah County design standards, this improvement would require approach and departure tapers of 630 feet (assuming a design speed of 45 mph). **Project 2:** 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.

Supporting Data

Total collisions 2003-2009 = 5
ADT = 10,570
Collision rate = 0.19 (per MEV at Kaiser Rd)
By type:

- 40% rear end, 20% sideswipe, 20% turning, 20% fixed object

By severity:

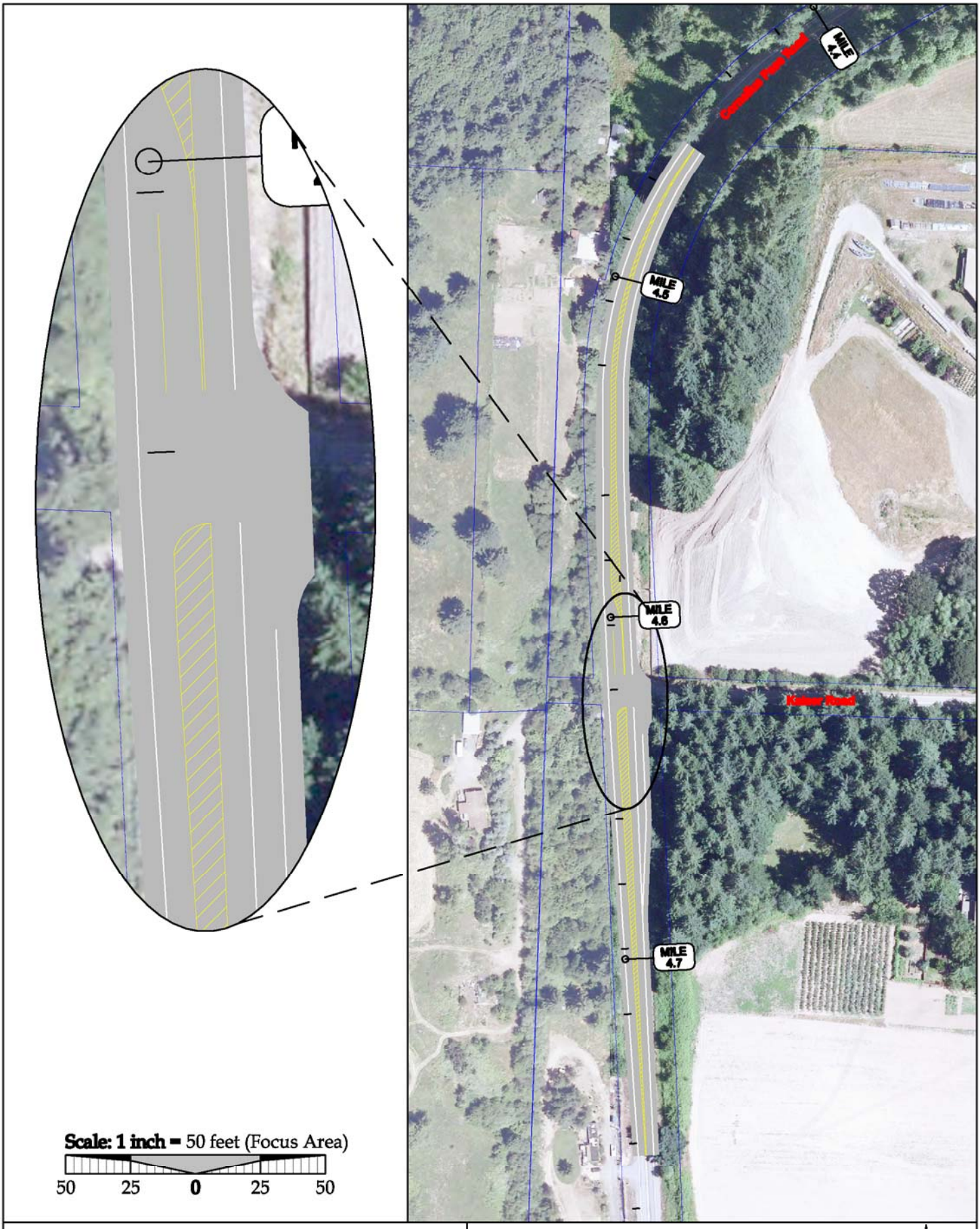
- A 20%, B 20%, C 20%, PDO 40%

Other collision factors:

- 60% on dry surface
- 40% during daylight conditions
- Approximate sight distance from Kaiser Road, northbound = 450 ft, southbound = over 1,000 ft. The intersection sight distance for left turning vehicles (from Kaiser Road to Cornelius Pass Road) does not meet standards (500 ft assuming a design speed of 45 mph).
- No existing street lights near intersection

Improvement Options	Benefits	Costs
Project 1: Install a southbound left turn lane	• National research shows installation of a left turn lane on a single major approach (on rural roads) results in a decrease of all collision types by 44%, and injury collisions by 35%.[1] • Reduces potential for southbound rear end collisions by creating storage space.	$ 600,000
Project 2: Create a northbound right storage pocket/wider shoulder	• 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]	$ 200,000
Other Considerations		
• Cornelius Pass Road is approximately 24 feet wide with one to five foot wide gravel shoulders near Kaiser Road. • Widening may require relocating utility poles along the west side of the roadway. • Widening Cornelius Pass Road north of Kaiser Road may require earthwork fill and/or retaining structure. However, widening the roadway south of Kaiser Road could require less earthwork. • There is a driveway access on the west side of Cornelius Pass Road, just south of Kaiser Road.		

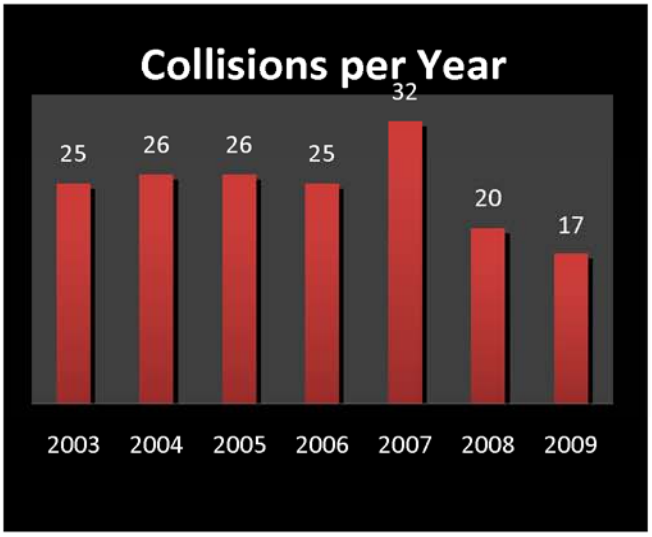
[1] Website: http://www.cmfclearinghouse.org/study_detail.cfm?stid=24 Site funded by US Department of Federal Highway Administration and maintained by the University of North Carolina Highway Safety Research Center. Accessed on November 24, 2010.

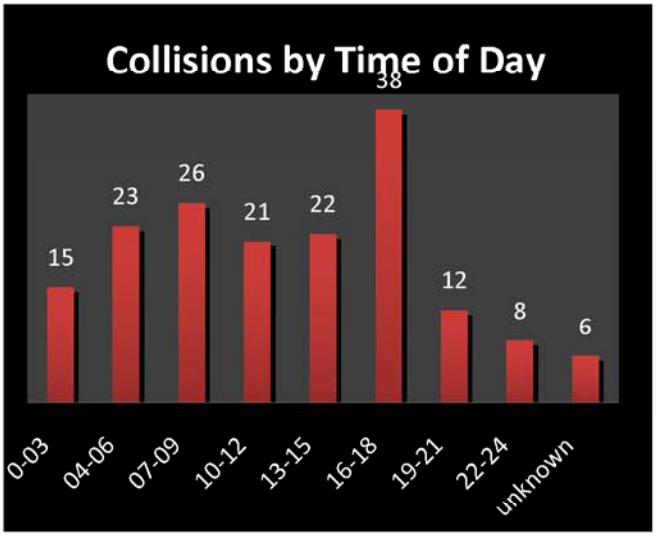


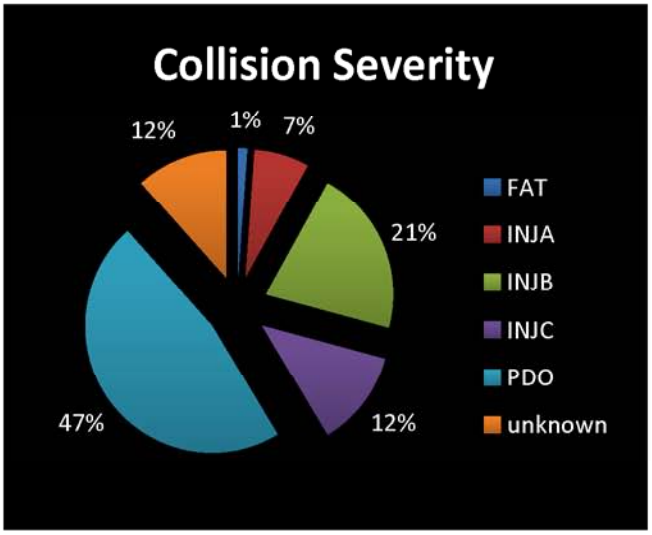
Project Area L: Projects 1 & 2
Kaiser Road - MP 4.6 (Add Turn Lanes)

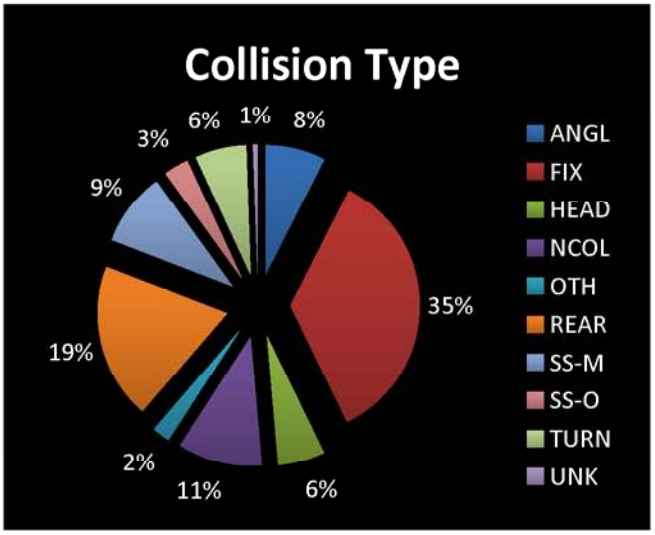
Project M – Cornelius Pass Road Specific Design Guide

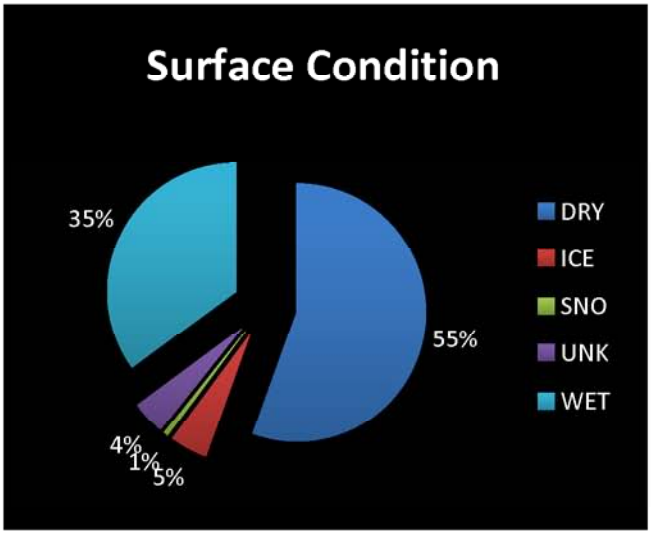
Cornelius Pass Road 2003 - 2009 Collisions
Project M: Entire Corridor MP 0.0 - 5.0

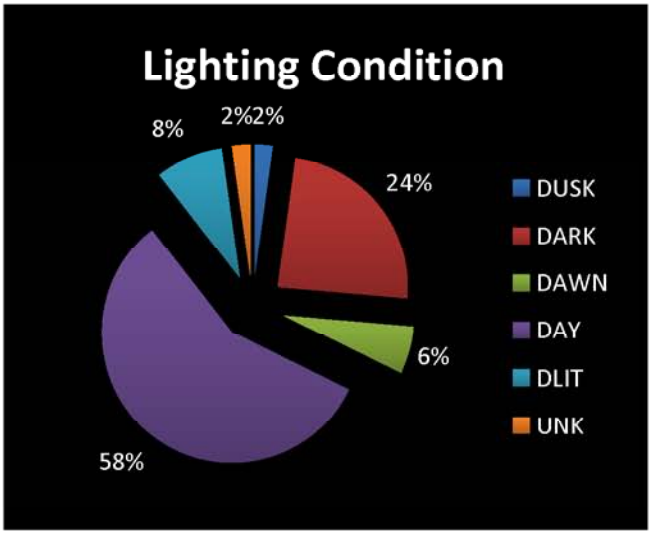












Project M – Design Guide

Problem Statement: 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 topographical nature of this corridor is dynamic with significant horizontal and vertical curvature north of Skyline Boulevard.

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
Other Considerations	
•	

Project N – Cornelius Pass Road Specific Policies

Project N – Policies

Problem Statement: The Multnomah County portion of Cornelius Pass Road has a history of collisions related to the narrow roadway width, limited shoulders, restricted sight distances, horizontal and vertical curves, and differing user needs. The demands placed on this rural arterial come from the adjacent rural land users and the urban commuters, who are traveling between the employment centers of Washington County and the communities adjacent to the Columbia River. While site specific improvements are useful for high collision locations, policy level improvements are useful to address the needs and demands placed on the road by different user groups. These policy recommendations are needed to address the need for safety improvements along the entire corridor.

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).

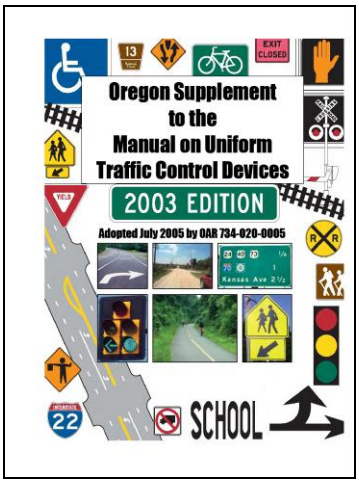
Photo	Proposed Policy: Appropriate Sign Guidelines
 *Source: 2003 Oregon Supplement to MUTCD*	Implementing appropriate sign guidelines would provide a consistency throughout the corridor to reduce driver confusion. • Complete an inventory and plan that identifies existing signs that may be removed or 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).