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BURGESS ROAD/DAY ROAD-PINE FOREST DRIVE INTERSECTION

Existing Conditions and Alternatives Evaluation

Date:	July 15, 2016	**Project #: 19448**
To:	Chris Doty, PE, Deschutes County	
From:	Scott Beaird, PE, and Joel Amarillas	

This memorandum provides a summary of existing traffic conditions and identifies potential traffic control alternatives to improve traffic operations and safety at the Burgess Road/Day Road-Pine Forest Drive intersection.

PROJECT PURPOSE AND RECOMMENDATIONS

County staff identified the need for safety improvements at the Burgess Road/Day Road intersection to address observed safety deficiencies. The rural high-speed approaches, two-way stop control, and minor-street offset are potential contributing factors to the frequency and severity of crashes. County staff has identified this intersection as a priority location both in the County Transportation System Plan (TSP) and in the Capital Improvement Plan.

The purpose of this analysis is to further explore a range of potential improvement options and identify right-of-way needs and planning-level construction costs for a final recommended alternative. The intersection analysis includes a review of crash history, existing intersection operations, and field observations. Based on the issues identified, this memorandum identifies potential improvement alternatives to reduce crash potential and improve traffic flow.

EXISTING CONDITIONS

KAI conducted field reviews, evaluated historical crash data to identify trends, collected traffic count and speed data, and conducted intersection operations analysis at the Burgess Road/Day Road-Pine Forest Drive intersection. The existing conditions analysis is intended to inform the overall intersection needs and support the selection of treatment alternatives.

Existing Land Uses and Roadways

A convenience store is located in the southwest quadrant of the intersection and has access to Burgess Road (west of the intersection) and Pine Forest Drive (south of the intersection). A La Pine Rural Fire Protection District fire station is located in the northwest quadrant of the intersection. A frontage road parallels and intersects Burgess Road 150 feet east of Day Road along the north side of Burgess Road, providing access to rural residential properties. The property adjacent to the intersection in the southeast quadrant is currently undeveloped.

Burgess Road provides a connection from US 97 to Century Drive, serving rural residential uses and recreational traffic. Burgess Road is under the jurisdiction of Deschutes County, and has a posted speed of 45 miles per hour (mph).

Day Road (north of Burgess Road) has a posted speed of 45 mph and serves as a connection to rural residential areas northwest of La Pine and La Pine State Park. Pine Forest Drive has a posted speed of 35 mph and ends at a dead end one mile to the south of Burgess Road. Pine Forest Drive is offset, approximately 30 feet, to the west of where Day Road intersects Burgess Road. Due to the offset, left-turning vehicle paths from Burgess Road conflict.

East-west traffic at the intersection is uncontrolled, and north-south movements on Day Road and Pine Forest Drive are stop controlled. There are no turn lanes on Burgess Road at the study intersection. Exhibit 1 shows the existing geometric and traffic control conditions at the intersection.

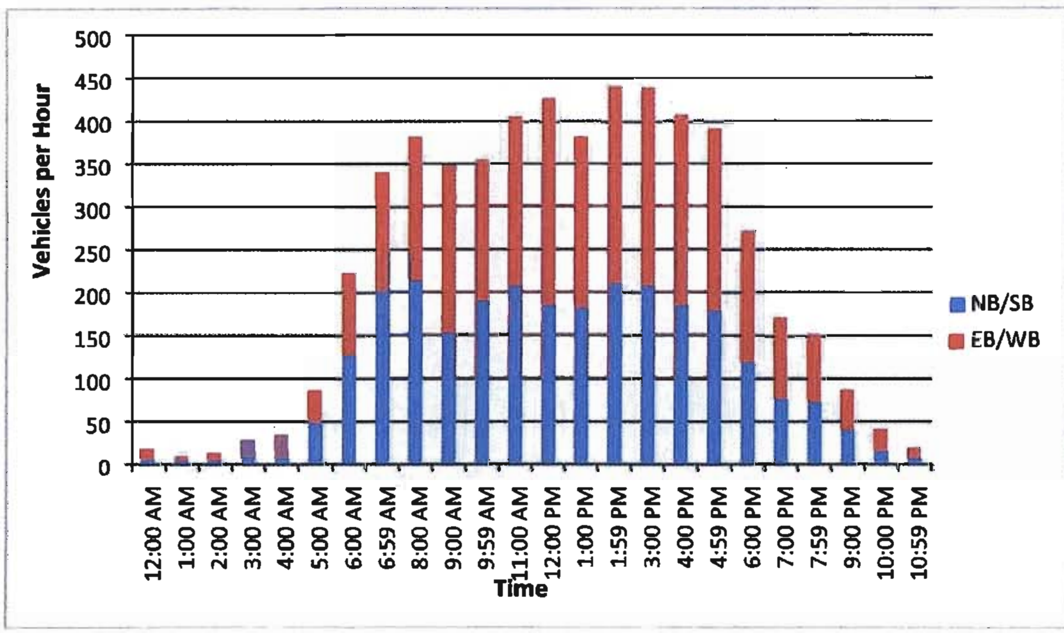
Exhibit 1. Burgess Road/Day Road-Pine Forest Drive – Existing Conditions

Data Collection

Information was collected at the intersection to document existing traffic flow and characteristics. Turning movement counts, daily traffic volumes, vehicle speed, and vehicle classification data were obtained during the third week of November 2015 and are included as *Appendix "A"*.

Automated tube counts were conducted over a 48-hour period from Wednesday, November 18, 2015 to Friday, November 20, 2015. The tube count data was used to identify daily travel patterns and peaking characteristics of the intersection. The tube counts were collected on all four approaches approximately 1,000 feet from the Burgess Road/Day Road-Pine Forest Drive intersection.

Exhibit 2. Bi-directional roadway volume profiles



As illustrated in Exhibit 2, the volume profile indicates that traffic flows peak between noon and 4 p.m., and east-west approach volumes are approximately equal to north-south approach volumes.

Vehicle classification data was obtained from the tube counts to identify the fleet mix passing through the intersection. Vehicles are classified from the tube counts based on the number and spacing of axles. A simplified summary of the classification data is provided in Table 1. As shown, the fleet mix is largely comprised of passenger cars and delivery trucks.

Table 1. Vehicle classification data

Roadway	Class 1 (Motorcycles)	Classes 2-4 (Passenger cars/buses)	Classes 5-7 (Delivery Trucks)	Class 8+ (Tractor Trailers)	Not Classified
Burgess Road	0.4%	81.8%	11.4%	0.8%	5.6%
Day Road/Pine Forest Drive	0.3%	86.8%	10.2%	0.6%	2.1%

Observed 85th-percentile speeds on Day Road, Pine Forest Drive, and Burgess Road are summarized in Table 2. It should be noted that the location of the tube counts near the intersection, where motorists may be decelerating to turn or slowing out of caution, may influence travel speeds.

Table 2. Summary of directional travel speed

Roadway	Direction	85th Percentile Speed
Pine Forest Drive	NB	28 mph
Day Road	SB	38 mph
Burgess Road	EB	48 mph
	WB	43 mph

Field Review

Kittelson & Associates, Inc. (KAI) and Deschutes County staff conducted a field visit to observe existing operations, geometry, and driver behavior during a weekday afternoon peak hour in December 2015. In addition to measuring available sight distance, as summarized in the following section, the following observations were made:

- The offset side-street approach geometry increases crash risk. Drivers were observed making concurrent left-turns from Burgess Road despite sight distance being limited by the opposing left-turn vehicle.
- Vehicles overtrack outside of the existing paved shoulder in all corners of the intersection, resulting in pavement deterioration and the potential for water ponding, as shown in Exhibits 3 and 4.

Exhibit 3: Vehicle overtracking in SW corner

Exhibit 4: Vehicle overtracking in NW Corner

Sight Distance Review

A Policy on Geometric Design of Highways and Streets, 6th Edition, published by the American Association of State Highway Transportation Officials (AASHTO), provides guidance on minimum sight distance. A comparison of the AASHTO recommended intersection sight distance (ISD) and available sight distance for vehicles on the stop-controlled northbound and southbound approaches is summarized in Table 3. The values in the table are based on an assumed speed of 50 mph on Burgess Road. This speed was assumed as a conservative estimate of actual speeds on Burgess Road and was developed by rounding up the observed 85th percentile speed.

Table 3. AASHTO Intersection sight distance review

Vehicle Movement	Design Speed for Passenger Vehicle	AASHTO Intersection Sight Distance[1]	Adequate?
Northbound Left-Turn	50 mph	555 ft	No
Northbound Right-Turn/Crossing		480 ft	Yes
Southbound Left-Turn		555 ft	Yes
Southbound Right-turn		480 ft	Yes

[1] *Based on AASHTO (6th Edition) Table 9-6, Table 9-8, and Table 9-14.*

Field measurements identified a sight distance restriction for northbound vehicles making a left-turn. Sight distance is limited for this movement by existing trees along the south side of Burgess Road. Exhibit 5 demonstrates this sight distance restriction. The restriction is marginal and is likely mitigated to some degree by vehicles pulling closer to Burgess Road. Improvements to this intersection should incorporate mitigation of this sight distance restriction.

Exhibit 5: Sight distance restriction

Existing Traffic Operations

The weekday p.m. peak period identified from the tube counts is from 2:55 p.m. to 3:55 p.m. Exhibit 6 identifies the weekday peak hour volumes and critical movement operations. Intersection operations were analyzed based on *Highway Capacity Manual 2000* methodology using Synchro 8 software. Deschutes County has a mobility target of Level of Service (LOS) D for existing roads. As shown in Exhibit 6, the existing intersection control results in acceptable operations during the weekday PM peak hour. However, the model does not account for operational deficiencies that result from the offset approach geometry, and actual operations may be not be fully reflected in this analysis. *Appendix "B" contains the existing conditions analysis worksheets.*

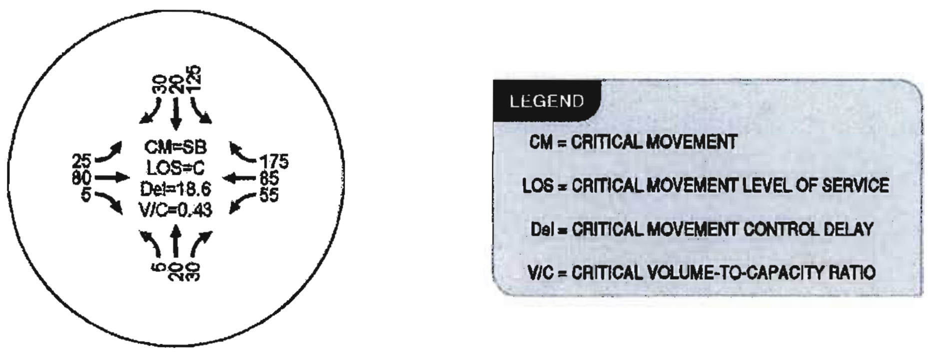


Exhibit 6. Existing weekday PM peak hour traffic conditions

Historical Crash Analysis

Historical crash data was obtained for the Burgess Road/Day Road-Pine Forest Drive intersection from the Oregon Department of Transportation (ODOT) crash database and from the Deschutes County Sheriff's Office. The data includes crashes reported over a six-year period from January 1, 2009 to December 31, 2014. *Appendix "C" contains the crash data.*

A total of 25 crashes were reported at or within the immediate vicinity of the intersection that resulted in 13 total injuries. No fatalities were reported within the study period. The number of crashes has been generally increasing annually, as shown in Exhibit 7.

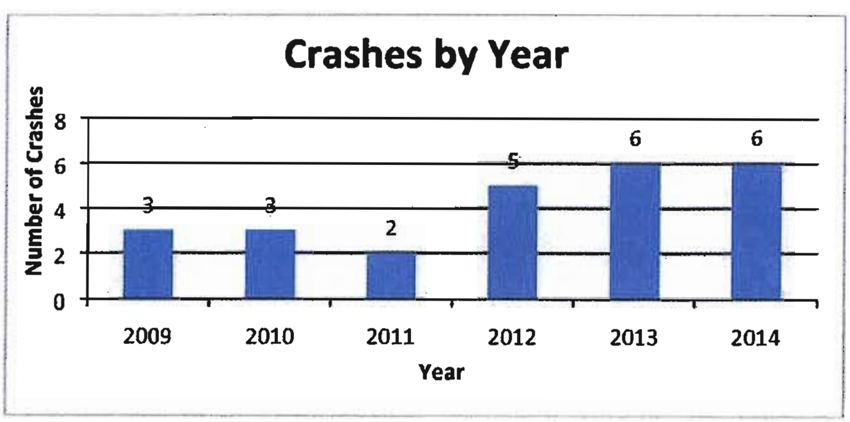


Exhibit 7. Crash frequency by year

Table 4 summarizes the reported crash history between 2009 and 2014 by crash type and severity. Note that cases are incidents where a deputy responds and requests a case number while an incident is an event where a crash is reported, but no report was filed.

Table 4. Burgess Road/Day Road-Pine Forest Drive Intersection Crash History (2009-2014)

	Collision Type					Crash Severity			
Year	Angle	Turning Movement	Rear End	Fixed Object	Unknown	Non-Injury	Injury	Fatality	Total
2009	1	1	1	0	0	2	1	0	**3**
2010	1	0	0	0	2	2	1	0	**3**
2011	1	1	0	0	0	0	2	0	**2**
2012	3	1	0	0	1	3	2	0	**5**
2013	1	1	3	1	0	3	3	0	**6**
2014	2	1	1	2	0	3	3	0	**6**
Total	**9**	**5**	**5**	**3**	**3**	**13**	**12**	**0**	**25**

Crash trends were reviewed by time of day, month of year, roadway surface, weather conditions, and other reported characteristics. Key findings of this review are summarized below:

- Thirteen of the reported crashes resulted in injury.
- Eight of the reported crashes were reported as "failure to yield right-of-way."
- Drugs or alcohol were cited as a factor in four of the reported crashes.
- Six of the nine angle crashes involved vehicles driving northbound on Pine Forest Drive
- Six of the nine angle crashes involved vehicles driving eastbound on Burgess Road

Table 5 compares the observed crash rate to the statewide 90th-percentile crash rate for the study intersection. Per the ODOT Analysis Procedures Manual (APM), the 90th-percentile crash rate is used as a means of comparison when the study area does not include more than five intersections.

Table 5. Intersection Crash Rate Analysis (2009-2014)

Intersection	Number of Crashes	Million Entering Vehicles (MEV)	Crash Rate (crash per MEV)	Statewide 90th Percentile Rate
Burgess Road/Day Road	25	13.7	1.82	1.08[1]

[1]From APM, Table 4.1: Intersection Crash Rates by Land Type and Traffic Control

As shown in Table 5, this intersection has a crash rate above the statewide 90th-percentile rate for similar intersection types (rural four-legged stop-controlled intersections).

Predictive Crash Analysis

Review of historical crash records provided an indication of past trends and potential geometric issues. Crash prediction methods estimate the crashes that are statistically likely to occur over the long term, for a given set of geometric and volume characteristics. This analysis reduces the potential for statistical bias and provides a baseline crash prediction for use in identifying crash reduction potential of various alternatives.

The predictive crash method for estimating average crash frequency for intersections on rural two-lane, two-way roads, is found in Chapter 10 of the *Highway Safety Manual (HSM)*. The crash prediction models in the HSM are based on national studies and were calibrated to reflect Oregon-specific conditions. The crash prediction method results in an estimate of expected average crash frequency that reflects a statistical average of observed and predicted values to provide the most statistically-rigorous long-term estimate.

If no changes are made to the existing Burgess Road/Day Road-Pine Forest Drive intersection, the predictive analysis forecasts 4.2 fatal or injury (FI) crashes and a total of 9.9 crashes will occur every 5 years, based on observed crash history and crash prediction methods from the HSM. Calibration factors developed for rural, four-leg, stop-controlled intersections in Oregon were applied to reflect existing conditions.

PRELIMINARY CONCEPTS

Based on the existing conditions review, three intersection improvement concepts were developed. These improvements considered how the existing intersection control could be retained with improved geometrics, or other types of control that would improve safety while still meeting the long-term operational needs. The following section summarizes the development and preliminary evaluations of these alternatives based on future operations, safety, right-of-way impacts, and construction costs.

Conceptual Design Development

Three intersection concepts were developed to reduce specific crash types, simplify the intersection geometry, and improve sight distance. The concepts include various traffic control alternatives that consider adding dedicated turn lanes, signalization, or construction of a roundabout. Each of these alternatives would require treatments along the intersection approaches to further alert drivers of the intersection. These approach treatments could consider cross-sectional changes, improvements to sight distance, illumination, advance signing and striping, and a variety of treatments to increase driver awareness and manage approach speeds.

For this preliminary evaluation, the concepts were developed in sketch format over scaled aerial imagery. These concepts represent reasonable dimensions and general right-of-way impacts to appropriately assess the magnitude of impact from the layout. This high-level analysis provides a cost-effective method of assessing feasibility of the three alternatives.

Preliminary Concept A - Realign Minor Street Approaches and Provide Major Street Left-Turn Lanes

Figure 1 illustrates Preliminary Concept A, which adds left-turn lanes on Burgess Road in combination with realignment of the Day Road and Pine Forest Drive approaches to reduce the crash potential associated with the intersection offset. This concept will also reduce the potential for rear-end crashes and reduce delay to through traffic on the uncontrolled approaches. This alternative can also serve as the first phase of a two-phase improvement that would ultimately result in signalization when warrants are met. As shown in Figure 1, the addition of left-turn lanes on Burgess Road could be accomplished by widening the road on both sides.

Preliminary Concept B – Construct Signalized Intersection

Preliminary Concept B is shown in Figure 2. This concept builds upon Preliminary Concept A by providing left-turn lanes and realigning the side street approaches while changing the intersection control to a traffic signal and adding minor-street left-turn lanes.

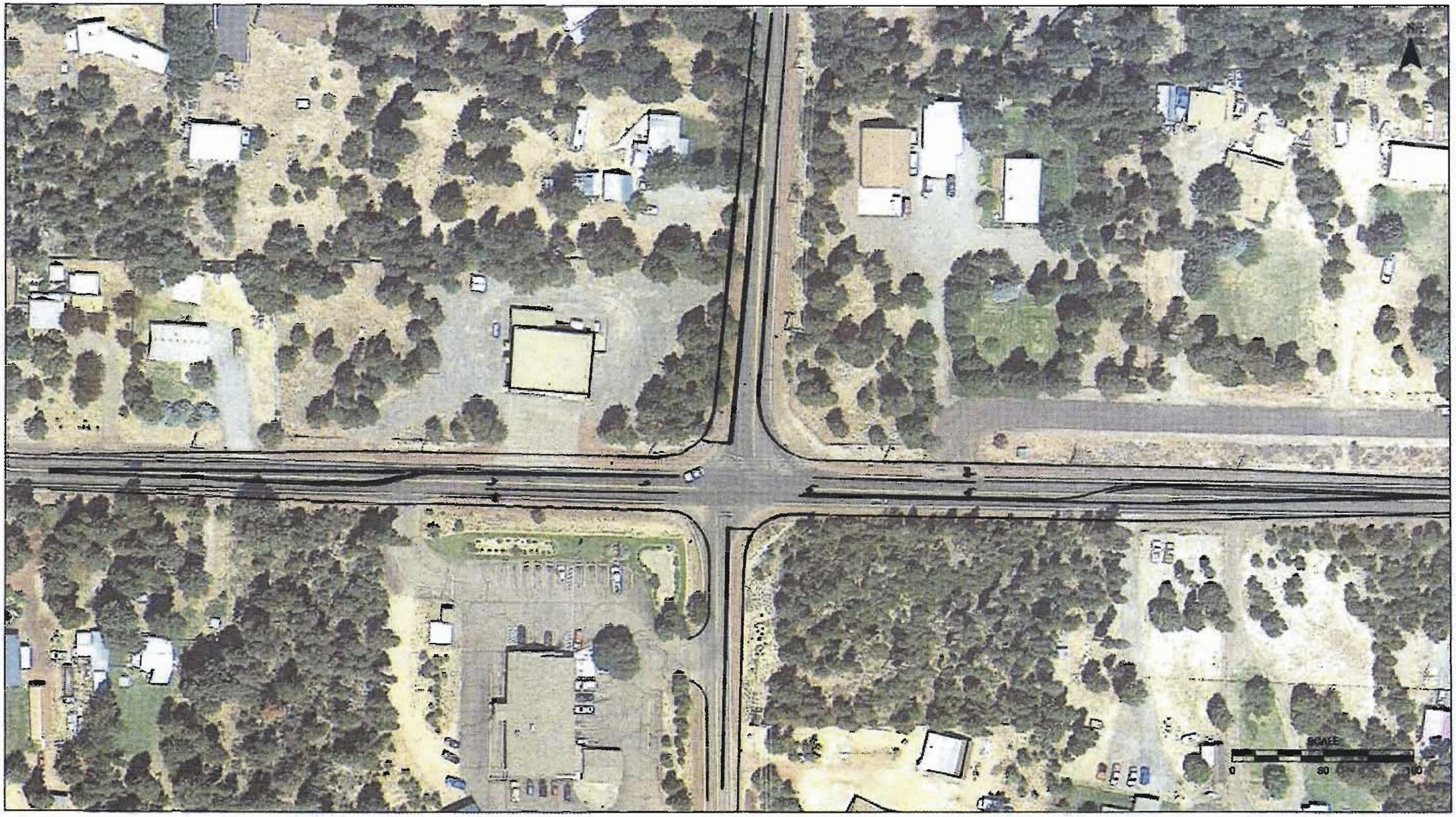
A traffic signal would provide dedicated phases for minor-street traffic, which would be effective in addressing a subset of the reported crashes (e.g., "did not yield right-of-way"). However, empirical studies have found that, while converting stop control to signal control may result in a reduced number of angle and/or turning movement crashes, the intersection may experience an increase in rear-end crashes. Traffic signal warrants were established to assess the tradeoffs made between safety, delays, and installation capital costs. Traffic signal warrants are the minimum criteria by which a traffic signal should be installed. Guidance provided in Chapter 4C of the *Manual of Uniform Traffic Control Devices (MUTCD)* indicates a traffic control signal should not be installed unless one or more of the warrants are met.

An evaluation of the MUTCD signal warrants indicates the volume-based warrants (peak-hour, 4-hour, and 8-hour) are not met under the existing volume conditions. To meet the crash warrant, an intersection must have experienced at least five reportable crashes in a single year that were susceptible to mitigation with signalization and meet the 80% volume thresholds identified under Warrant 1. The condition also states that adequate trial of other crash mitigation strategies must also have failed to improve safety. There have not been five reported crashes in a 12-month period susceptible to mitigation with a traffic signal and the 80% traffic volume thresholds are not met. As such, minimum thresholds for the volume and crash experience signal warrants are not currently met, and are unlikely to be met in the near term. *Appendix "D" contains the signal warrant summary.*

Preliminary Concept C – Construct Single-Lane Roundabout

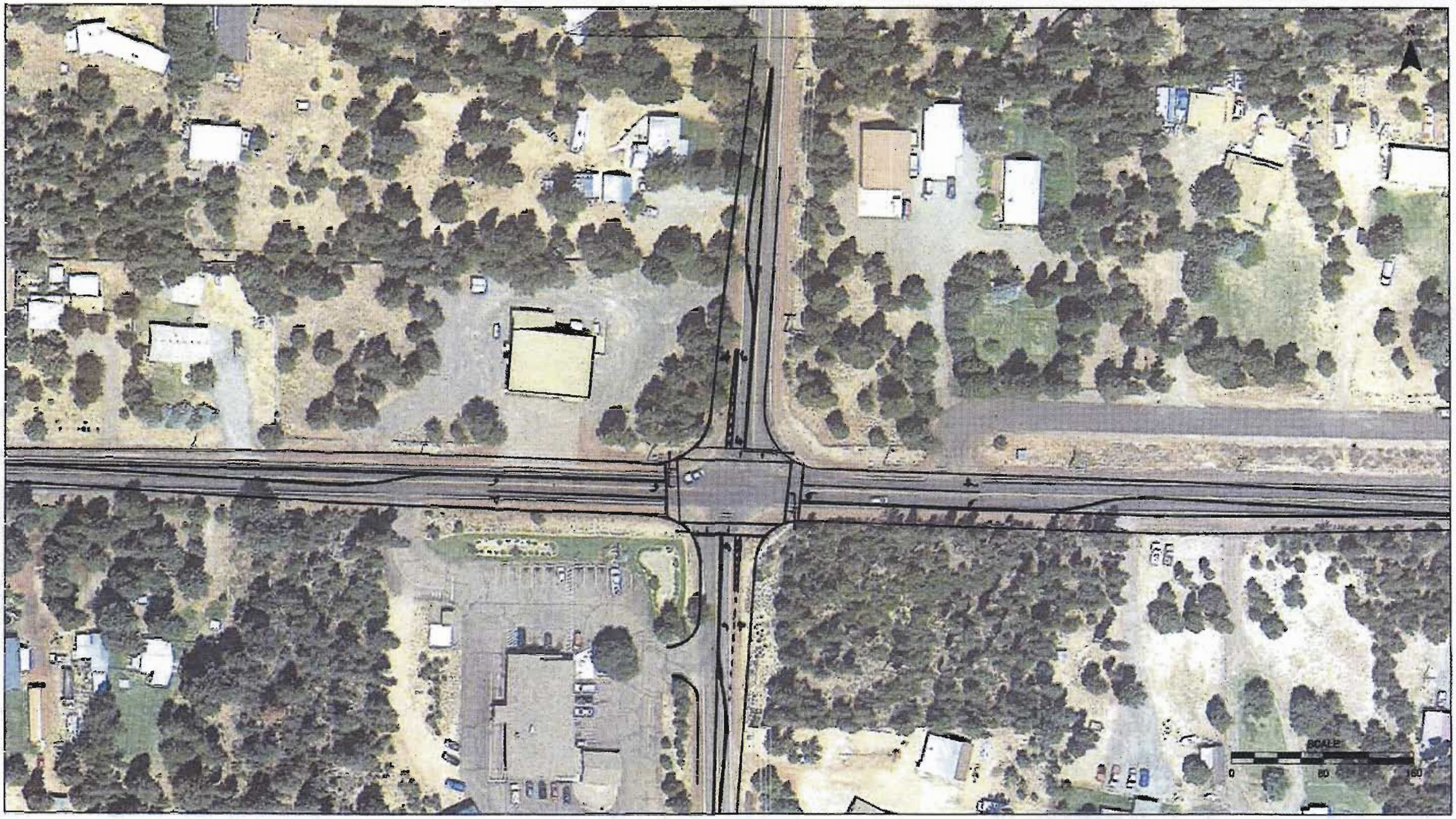
A single-lane roundabout concept was developed as Preliminary Concept C, as illustrated in Figure 3. The roundabout concept presented represents a possible option for the roundabout horizontal geometry. Roundabout design is based upon a set of fundamental principles outlined in *NCHRP Report 672: Roundabouts: An Informational Guide – 2nd Edition*. These principles include: (1) achieving speed control at entry, (2) providing appropriate lane numbers and arrangements, (3) appropriately aligning the natural path of vehicles, (4) accommodating the design vehicle, (5) accommodating non-motorized users, and (6) providing adequate sight distance and visibility. Alternative sizes, shapes, placement, and approach alignments may also be acceptable provided that they result in a design that meets these fundamental principles.

To minimize private property impacts in the southwest quadrant of the intersection, the center of the roundabout was shifted to the north. The inscribed circle diameter is 150 feet. The roundabout maintains all turning movements while minimizing the number of conflict points. The reduction in conflict points and speeds on the approaches reduces the crash potential and severity.



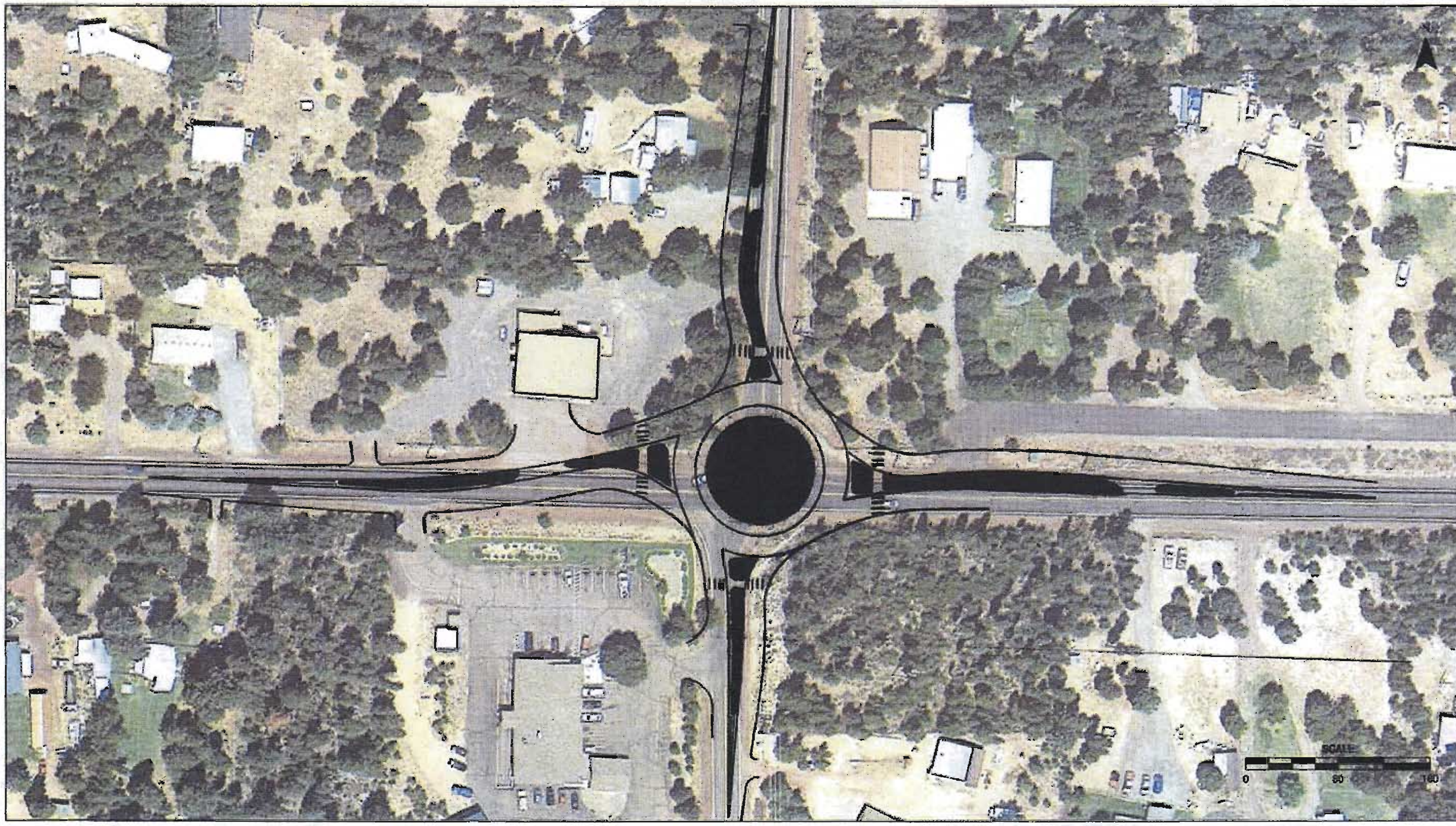
PRELIMINARY CONCEPT A: UNSIGNALIZED INTERSECTION
BURGESS RD/DAY RD-PINE FOREST DR
LAPINE, OR

Figure
1



PRELIMINARY CONCEPT B: SIGNALIZED INTERSECTION
BURGESS RD/DAY RD-PINE FOREST DR
LAPINE, OR

Figure
2



PRELIMINARY CONCEPT C: SINGLE-LANE ROUNDABOUT
BURGESS RD/DAY RD-PINE FOREST DR
LAPINE, OR

Figure 3

PRELIMINARY CONCEPTS EVALUATION

The identified alternatives were evaluated based on their ability to address the project needs and overall feasibility. A summary of the screening criteria is provided in this section.

Operations

The traffic operational analysis considers whether the alternative can adequately serve the existing traffic demand based on Deschutes County LOS thresholds. Operations were assessed for each alternative during the weekday p.m. peak hour to inform this initial screening. Table 6 contains a summary of operational results by alternative.

As shown in Table 6, Concept A is forecast to operate with essentially the same traffic operations as under the existing conditions. However, as previously mentioned, the model does not account for operational inefficiencies associated with the existing intersection geometry and offset alignment. Both Concept B (traffic signal) and Concept C (roundabout) improve intersection operations. *Appendix "E" contains the traffic analysis worksheets for each of the concepts.*

Table 6. Summary of traffic operational analysis

	Weekday PM Peak Hour Traffic Conditions			
	No Mitigation[1]	Concept A: Add Left-Turn Lanes[1]	Concept B: Install Traffic Signal[2]	Concept C: Install Roundabout[3]
Delay (seconds)	18.6	18.5	11.6	4.9
Level of Service	C	C	B	A
Volume-to-Capacity Ratio	0.43	0.42	0.23	0.28

[1] Stop-controlled HCM analysis results reflect critical approach or movement
[2] Signal analysis based on average for intersection
[3] Roundabout analysis based on average for intersection for delay and LOS and critical approach for volume-to-capacity ratio

Safety

This criterion is intended to address the escalating crash experience identified through review of the reported crash history. Crash reduction potential is based on review of crash modification factors developed from studies of similar projects in rural areas and Oregon-specific calibrations.

The expected change in crashes associated with converting a rural two-way stop-controlled (TWSC) intersection to a TWSC with protected left-turn lanes along the major road is summarized in Table 7, based on crash prediction methods from the HSM. Signalized intersection crash prediction results are summarized in Table 8 and roundabout crash prediction results are shown in Table 9.

Table 7. Crash prediction results for adding left-turn lanes

Intersection	No-Build		Add LT Lanes		Crashes Reduced		Percent Reduction	
	Fatal and Injury Crashes	All Crashes	Fatal and Injury Crashes	All Crashes	Fatal and Injury Crashes	All Crashes	Fatal and Injury Crashes	All Crashes
Annual	0.8	2.0	0.4	0.8	0.5	1.2	58%	59%
5-year Total	4.2	9.9	1.8	4.1	2.5	5.8		

Table 8. Crash prediction results for installing a traffic signal

Intersection	No-Build		Signal		Crashes Reduced		Percent Reduction	
	Fatal and Injury Crashes	All Crashes	Fatal and Injury Crashes	All Crashes	Fatal and Injury Crashes	All Crashes	Fatal and Injury Crashes	All Crashes
Annual	0.8	2.0	0.3	1.0	0.5	1.0	61%	50%
5-year Total	4.2	9.9	1.7	4.9	2.6	5.0		

Table 9. Crash prediction results for constructing a single-lane roundabout

Intersection	No-Build		Roundabout		Crashes Reduced		Percent Reduction	
	Fatal and Injury Crashes	All Crashes	Fatal and Injury Crashes	All Crashes	Fatal and Injury Crashes	All Crashes	Fatal and Injury Crashes	All Crashes
Annual	0.8	2.0	0.1	0.6	0.7	1.4	88%	72%
5-year Total	4.2	9.9	0.5	2.8	3.7	7.1		

As shown in Tables 7 through 9, each of the preliminary concepts are forecast to reduce the total number of crashes and the number of fatal and injury crashes at the intersection.

Cost

The following planning-level cost estimates were developed for each of the preliminary concepts:

- Concept A: Realign/Install Left-Turn Lanes = $975,000
- Concept B: Install Traffic Signal = $2,150,000
- Concept C: Construct Single-Lane Roundabout = $2,375,000

These planning-level cost estimates include construction costs, design and construction administration, and a 30-percent contingency. The estimates do not include right-of-way costs or utility relocations. *Appendix "F" contains the planning-level cost estimate worksheets.*

SUMMARY OF FINDINGS

Table 10 presents a qualitative summary of the concept analysis documented in this report. Following the table is a brief summary of findings for each concept.

Table 10. Concept evaluation summary

Concept	Cost	Operations	Safety
Concept A: Realign/Install Turn Lanes	◒	○	◒
Concept B: Install Traffic Signal	●	●	◒
Concept C: Construct Roundabout	●	●	●
	○ = Low cost ◒ = Medium cost ● = High cost	○ = Little improvement over existing ◒ = Marginal improvement over existing ● = Significant improvement over existing	

Preliminary Concept A - Realign Minor Street Approaches and Provide Major Street Left-Turn Lanes

Concept A is the lowest cost of the three alternatives and has the potential to addresses the primary factors that are contributing to a majority of the reported crashes. Given the existing volumes, the cost of Concept A compared to Concepts B and C, the potential crash reduction associated with the improvements in Concept A, we recommend this concept be advanced for further consideration. Additional speed control and visibility treatments on the intersection approaches should also be considered to further improve the crash reduction potential.

Preliminary Concept B – Construct Signalized Intersection

As indicated previously, a signal is not warranted based on existing volumes and crash history. Although the signal is not warranted and is, therefore, not recommended in the near-term, it could be considered as a long-term improvement if volume increases or crash experience warrant a signal.

Preliminary Concept C – Construct Single-Lane Roundabout

The roundabout is expected to have the greatest crash reduction potential of the alternatives based on empirical studies conducted in rural, high-speed environments. However, a roundabout is similar in cost to a traffic signal. If future volumes or crash experience warrant a traffic signal, a roundabout should be further considered at the same time.