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DRAFT MEMORANDUM

DATE: February 5th, 2015

TO: John Lewis, City of Oregon City
John Burrell, City of Oregon City
Dave Brokaw, Wallis Engineering

FROM: Nate Schroeder, P.E., PTOE
Jordin Ketelsen

SUBJECT: **Linn Ave Concept Plan – Intersection Control Analysis DRAFT** P#13220-000

The purpose of this memorandum is to provide a summary of the intersection control analysis that was completed for the intersections of Linn Ave/Warner Milne Rd/Leland Rd/Warner Parrott Rd and Central Point Rd/Warner Parrott Rd. The work completed as part of this analysis builds off of the previous work completed at these intersections in the Linn Avenue Concept Plan.[1] The project study area shown in Figure 1.

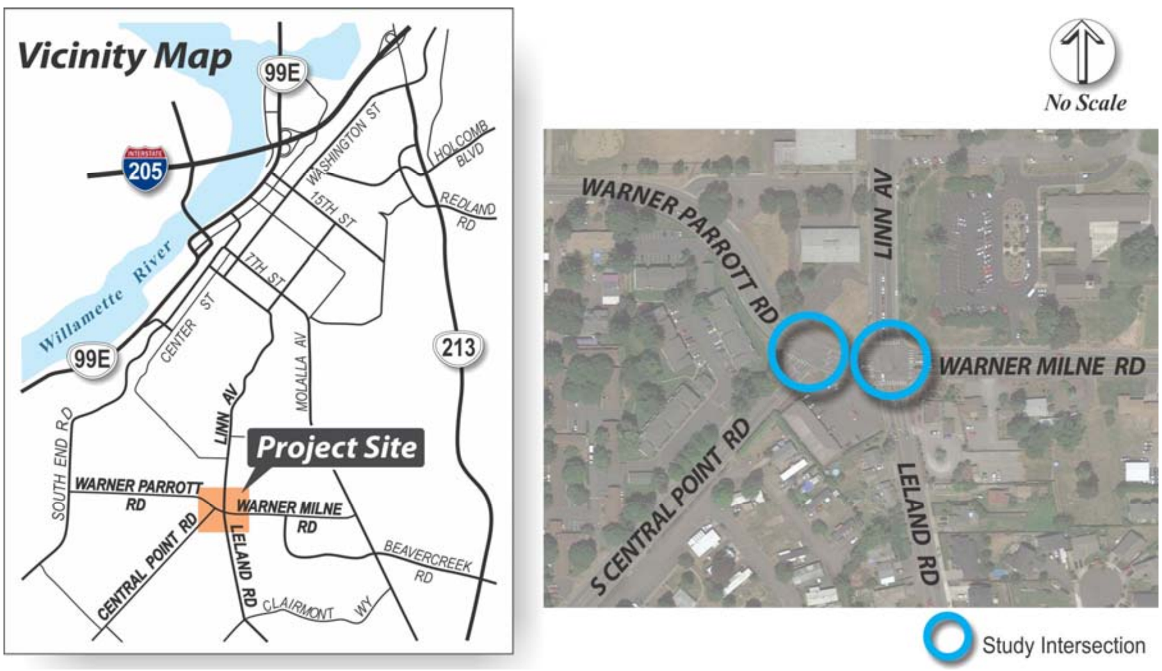

Figure 1: Project Study Area

The following sections discuss a summary of prior studies, system context, traffic volumes, a description of future alternatives, intersection operations analysis for each alternative, and a comparison summary.

[1] Oregon City, *Linn Avenue Concept Plan*, 2013-current.

SUMMARY OF PRIOR STUDIES

While these intersections have been the topic of discussion for quite some time, and even included as part of previous work, a comprehensive evaluation of intersection control alternatives was not conducted until this time. A summary of the past work involving these two study intersections is provided in the sections below.

Oregon City Transportation System Plan

Oregon City recently completed an update to their Transportation System Plan (TSP)[2] in an effort to prepare for and accommodate future transportation growth in the most efficient manner possible. As part of the update, it was determined that the intersection of Central Point Rd/Warner Parrott Rd would not meet the mobility targets identified in the adopted TSP. Based on input from key stakeholders, the selected improvement for addressing the deficiency at Central Point Rd/Warner Parrott Rd was a roundabout at the Warner Parrot Rd/Warner Milne Rd/Linn Ave/Leland Rd intersection, which is identified as project D34 in the adopted TSP. No detailed alternatives analysis was completed during the update, due to the high level nature of TSP analysis, support for the roundabout, and it's inclusion in the previous version of the TSP.

Oregon City Roundabout Alternatives & Linn Ave Concept Plan

The Oregon City Roundabout Alternatives project[3] provided preliminary hand drawn sketches of different roundabout configurations that could be constructed at the intersection of Warner Parrott Rd/Warner Milne Rd/Linn Ave/Leland Rd. The sketches were intended to be illustrative in nature, and no detailed operational analysis or evaluation was completed as part of this work. The concepts developed as part of this work provided a starting point for future analysis, and were later refined as part of the Linn Avenue Concept Plan project.[4] No alternatives evaluation was included as part of this work, as it was assumed that a roundabout was the preferred intersection control type based on its inclusion in the TSP.

SYSTEM CONTEXT

Identifying the system in which an intersection operates is important to determine the factors that contribute to its overall function. The existing and future contexts of the study intersections are discussed in the sections below, which include the roadway network, nearby intersections, pedestrian and bicycle facilities, transit facilities, intersection collision analysis, and a general discussion on alternative system context impacts.

Roadway Network

The transportation characteristics of the key roadways near the study area are shown in Table 1 and include jurisdiction, functional classification, posted speed, number of travel lanes, presence of sidewalks and/or bike lanes, as well as transit facilities.

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[2] Oregon City, *Transportation System Plan*, June 2013.
[3] *Oregon City Roundabout Alternatives*, DKS Associates, 2008.
[4] However, the work completed for the Linn Avenue Concept Plan was intended to verify the needed geometry for a roundabout at this location.

The functional classification is a key roadway characteristic because it specifies the purpose of the facility[5] and is a determining factor of applicable cross-section, access spacing, and intersection performance standards.

Table 1: Key Roadway Characteristics in Project Vicinity

Roadway	Jurisdiction	Functional Classification	Posted Speed	Number of Lanes	Sidewalks	Bike Lanes	Transit
Warner Parrott Road	Oregon City	Minor Arterial	30 mph	3-4[a]	Yes	Yes	No
Warner Milne Road	Oregon City	Minor Arterial	30 mph	2	Some	Yes	Route 33
Central Point Road	Oregon City	Collector	35 mph	2	Yes	Yes	No
Linn Avenue	Oregon City	Minor Arterial	35 mph	2	Yes	Yes	Route 33
Leland Road	Oregon City	Minor Arterial	35 mph	2	Some	Yes	No

[a] Warner Parrott Road is a four-lane cross section in between the Warner Parrott Rd/Warner Milne Rd/Linn Ave/Leland Rd and Central Point Rd/Warner Parrott Rd study intersections.

As shown, all of the key roadways are under the jurisdiction of Oregon City and the majority of the roadways are classified as minor arterials, with the exception of Central Point Rd that is classified as a collector. Most roadways are two-lane facilities, with the exception of Warner Parrott Rd that has two travel lanes and a center turn lane west of the Central Point Rd/Warner Parrott Rd intersection and one travel lane and one left-turn lane in each direction between the two study intersections.

Warner Milne Rd and Leland Rd have gaps in the sidewalk facilities near the study intersections, but all roadways have bike lanes. TriMet's Route 33 serves the study area along Warner Milne Rd and Linn Ave.

Nearby Intersections

Most of the intersections adjacent to the two study intersections are unsignalized including Linn Ave/AV Davis Rd/Ethel St to the north, Warner Parrott Rd/Canemah Rd to the west, Central Point Rd/Shenandoah Dr to the southwest, and Leland Rd/Pease Rd to the south. The Warner Milne Rd/Beavercreek Rd intersection to the east of the project study area is the only signalized intersection.

Pedestrian and Bicycle Facilities

Sidewalks are present near both study intersections except for some gaps on the southeast corner of the Warner Parrott Rd/Warner Milne Rd/Linn Ave/Leland Rd intersection. Pedestrian push-buttons and crosswalks are present along all four legs of the signalized Warner Parrott Rd/Warner Milne Rd/Linn Ave/Leland Rd intersection and only a single striped crosswalk is present on the southern leg of the Central Point Rd/Warner Parrott Rd intersection.

All roadways have bike lanes near the study intersections. Additionally, there are bicycle push-button detectors at all four corners of the Warner Parrott Rd/Warner Milne Rd/Linn Ave/Leland Rd intersection.

[5] The primary purpose of an arterial is to provide mobility, whereas at the opposite end of the spectrum, a local road is primarily concerned with site access. Collector roadways provide a transition between arterials and local roads.

Further understanding of the existing pedestrian and bicycle volumes at the study intersections was provided by intersection turn movement counts were taken on Tuesday, December 2nd, 2014. Table 2 displays the existing pedestrian and bicycle volumes at study intersections during the PM peak hour.

Table 2: PM Peak Hour Pedestrian and Bicycle Volumes at Study Intersections

Study Intersection	PM Peak Hour Volume	
	Pedestrian	*Bicycle*
Central Point Rd/Warner Parrott Rd	4	3
Warner Parrott Rd/Warner Milne Rd/Linn Ave/Leland Rd	10	2
Total	**14**	**5**

As shown, more pedestrians frequent the study are than bicyclists and the majority of pedestrians crossed at the Warner Parrott Rd/Warner Milne Rd/Linn Ave/Leland Rd intersection.

Transit Facilities

Route 33-McLoughlin travels bi-directionally along Linn Ave and Warner Milne Rd, turning at the Warner Parrott Rd/Warner Milne Rd/Linn Ave/Leland Rd intersection. This route has 15 minute headways on weekdays in the morning and afternoon and serves four bus stops in the project vicinity; two on Warner Milne Rd (TriMet Stop IDs 6121 and 6120) and two stops on Linn Ave (TriMet Stop IDs 3418 and 9559).

The First Presbyterian Church Park and Ride is located just north of the project vicinity on the southeast corner of the Linn Ave/Williams St intersection.

Intersection Collision Analysis

Collision analysis was performed for the study intersections to identify intersection-related trends. This analysis considered data from the past five years (2009-2013), which was obtained from the ODOT Crash and Analysis Reporting Unit and is located in the appendix.[6]

Table 3 shows a detailed crash rate compared to the published 90th percentile rates[7] in ODOT's Analysis Procedure Manual Table 4-1.[8] Intersections with crash rates close to or over the 90th percentiles rates should be flagged for further analysis. As shown, the intersection crash rate for the Warner Parrott Rd/Warner Milne Rd/Linn Ave/Leland Rd intersection is below the 90th percentile crash rates for other statewide urban, four-legged, signalized intersections. However, the Central Point Rd/Warner Parrott Rd intersection has a crash rate slightly higher than the statewide 90th percentile crash rate for urban, three-legged, unsignalized intersections.

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[6] Oregon Department of Transportation, Crash Analysis and Reporting Unit.
[7] The 90th percentile values represent 90th percentile crash rates from a study of 500 intersections in Oregon. The crash rates are grouped by rural/urban, signalized/unsignalized, and 3-leg/4-leg intersections.
[8] Analysis Procedures Manual, Version 2, February 2014, Chapter 4, Table 4-1.

Table 3: Study Intersection Collision Analysis (2009-2013)

Intersection	Collisions (by Severity)			Collisions per Year	Intersection Crash Rate	90th Percentile Rate
	Injury	*PDO*[a]	***Total***			
Central Point Rd/Warner Parrott Rd	5	6	11	2.2	**0.50**	0.47
Warner Parrott Rd/Warner Milne Rd/Linn Ave/Leland Rd	9	7	16	3.2	0.46	0.86

[a]PDO = Property damage only.
Bolded intersection crash rates indicate a value higher than the 90th percentile rates.

Further investigation was performed for the Central Point Rd/Warner Parrott Rd intersection to assess whether there are any clear trends in the collision data. Table 4 shows the collision data from 2009 through 2013 broken down by the type of collision. As shown, the most prevalent collision types were turning movement collisions as they make up 55 percent of the total collisions occurring at this intersection during the past five years. Furthermore, half of the turning collisions at this intersection involve the northbound left-turning movement. These turning collisions could be caused by the close proximity of the Warner Parrott Rd/Warner Milne Rd/Linn Ave/Leland Rd intersection, limited sight distance with the presence of queued vehicles, the intersection geometry itself (e.g. the curvature and skew of the roadways), or the requirement to cross three lanes of traffic to complete the left-turning movement.

Table 4: Collision Breakdown by Collision Type (2009 through 2013)

Intersection	Turn	Fixed Obj.	Bike[a]	Side-Swipe	Rear-End	Total
Central Point Rd/Warner Parrott Rd	6	3	1	1	1	11

[a] The collision involving a cyclist was a "Turn"-type collision and therefore is not included in the total.

Alternative System Context Impacts

All future alternatives include either unsignalized, signalized, or roundabout intersections. None of these intersection types are expected to significantly disrupt the system context of the surrounding area. Since this alternative evaluation category is not likely to aid in the alternatives comparison, a general system context discussion for the various alternatives are included in the sections below.

Alternatives Involving Signalized Intersection(s)

Although the majority of surrounding intersections are unsignalized, there are many other signalized intersections in Oregon City and drivers are expected to understand traffic laws regarding signalized intersections and to be familiar handling the intersection process. It is also anticipated that push-button detectors and marked cross-walks at the Warner Parrott Rd/Warner Milne Rd/Linn Ave/Leland Rd intersection will accommodate pedestrians at the intersection. Bike lanes that connect into the existing bicycle network in the area are easily accommodated with signalized intersections. Transit will be able to maneuver the intersection with relative ease due to prior experience with signalized and stop-controlled intersections and it is unlikely for alternatives involving signalized intersections to necessitate the modification of any existing transit facilities.

Alternatives Involving a Roundabout Intersection

The nearest existing roundabout in Oregon City is at the intersection of Washington St and Clackamas River Dr, but there are several other intersections identified in the Oregon City TSP that are planned to be roundabout controlled in the future. A roundabout in the study area is not anticipated to severely disrupt the current system context, but this option may not be as familiar to users as a signalized intersection. An effort to accommodate pedestrians and cyclists through clear signing and striping may be required for alternatives including roundabout intersections due to unfamiliarity with the multimodal aspects of roundabouts. Existing transit facilities may need modification due to the pull-up and pull-out space transit vehicles need to operate safely at a bus stop along a roadway, but transit should be able to maneuver the intersection.

TRAFFIC VOLUME DEVELOPMENT

For the Oregon City TSP update process, PM peak hour traffic counts were collected at both study intersections, but during different days. Those counts were collected in 2011 and 2012.[9] The 2035 future volumes were then developed based on those counts.

For this study, we wanted to both verify that the future counts developed for the Oregon City TSP update still apply, as well as collect data at both study intersections during the PM peak hour period (4 p.m.- 6 p.m.) to ensure consistency between the two intersections. On Tuesday, December 2nd 2014, PM peak hour turn movement counts were collected at both study intersections. These new counts were consistent with the 2011 and 2012 counts, which helped validate the development of the future 2035 traffic volumes. Collecting the counts during the same peak hour also verified that the volume distribution between the two intersections as developed for the 2035 future year volumes resembled existing conditions.

Based on the new PM peak hour counts collected in 2014, we concluded that the 2035 volumes developed for the Oregon City TSP update accurately capture projected future volumes and are the future volumes used in this study. All intersection volume data is located in the appendix.

Volume adjustments for each alternative were based on a qualitative assessment of the surrounding roadway network and an assumed origin and destination for the affected vehicles. The resolution of the regional travel demand model was too large to adequately reflect volume adjustments based on the relatively minor geometric change being proposed for each alternative.

FUTURE ALTERNATIVES

Five alternatives for addressing future transportation needs at the study intersections were considered as part of this analysis. These improvement alternatives were developed based on input received from key stakeholders, City staff, and the previously completed TSP. A description of the No-Build scenario and each alternative are included in the sections below. Conceptual drawings for each alternative developed by Wallis Engineering are provided in the appendix..

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[9] At the Warner Parrot Rd/Warner Milne Rd/Linn Ave/Leland Rd intersection counts were collected on Wednesday, October 3, 2012. At the Central Point/Warner Parrott Rd intersection counts were collected on Thursday, April 21, 2011.

No-Build

The No-Build scenario assumes that no changes to the study intersections will occur before the year 2035. Currently, the Warner Parrott Rd/Warner Milne Rd/Linn Ave/Leland Rd intersection is a four-leg, signalized intersection that allows all movements and the Central Point Rd/Warner Parrott Rd intersection is a three-leg, unsignalized intersection that allows all movements. The future 2035 volumes for the No-Build scenario are displayed in Figure 2.

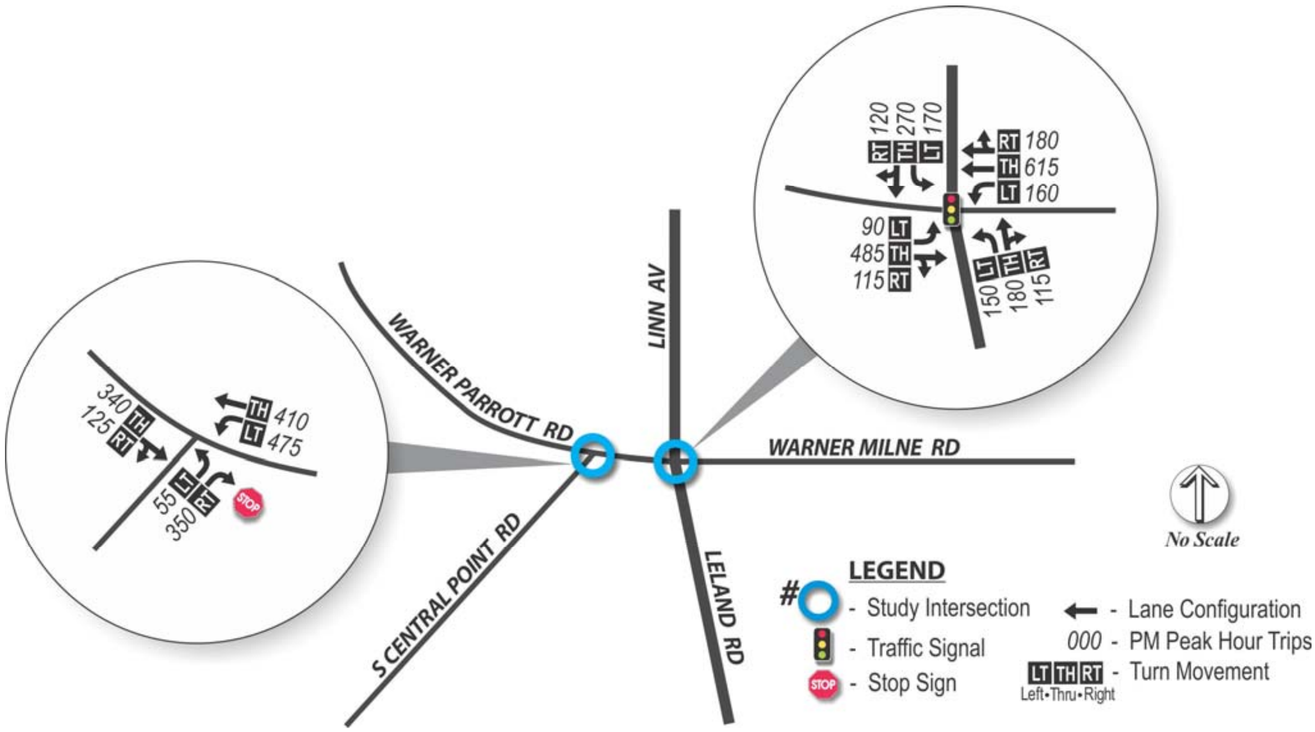

Figure 2: 2035 No-Build Intersection Volumes

Alternative 1: Unsignalized Left-Turn Restriction with Signalized U-Turn

This alternative includes the restriction of left-turns from Central Point Rd by the installation of a median along Warner Parrott Rd or a channelizing island at Central Point Rd. Left-turns onto Central Point Rd would still be allowed. The displaced left-turns would be accommodated by allowing an eastbound U-turn at the adjacent Warner Parrott Rd/Warner Milne Rd/Linn Ave/Leland Rd intersection. However, this movement would be restricted to passenger cars only since intersection widening required to accommodate larger vehicles would necessitate significant reconstruction and would have impacts to pedestrian crossing movements and vehicular operations.[10]

[10] An SU-30 design vehicle performing the eastbound U-turn movement at the Warner Parrott Rd/Warner Milne Rd/Linn Ave/Leland Rd intersection was simulated in Autoturn by Wallis Engineering and was found to require significant intersection widening.

As shown in Figure 2, 55 northbound left-turns are projected to occur at the Central Point Rd/Warner Parrott Rd intersection during the PM peak hour. Since this alternative restricts the northbound left-turn, volume adjustments were made to re-allocate these vehicles through the study area as shown in Figure 3.

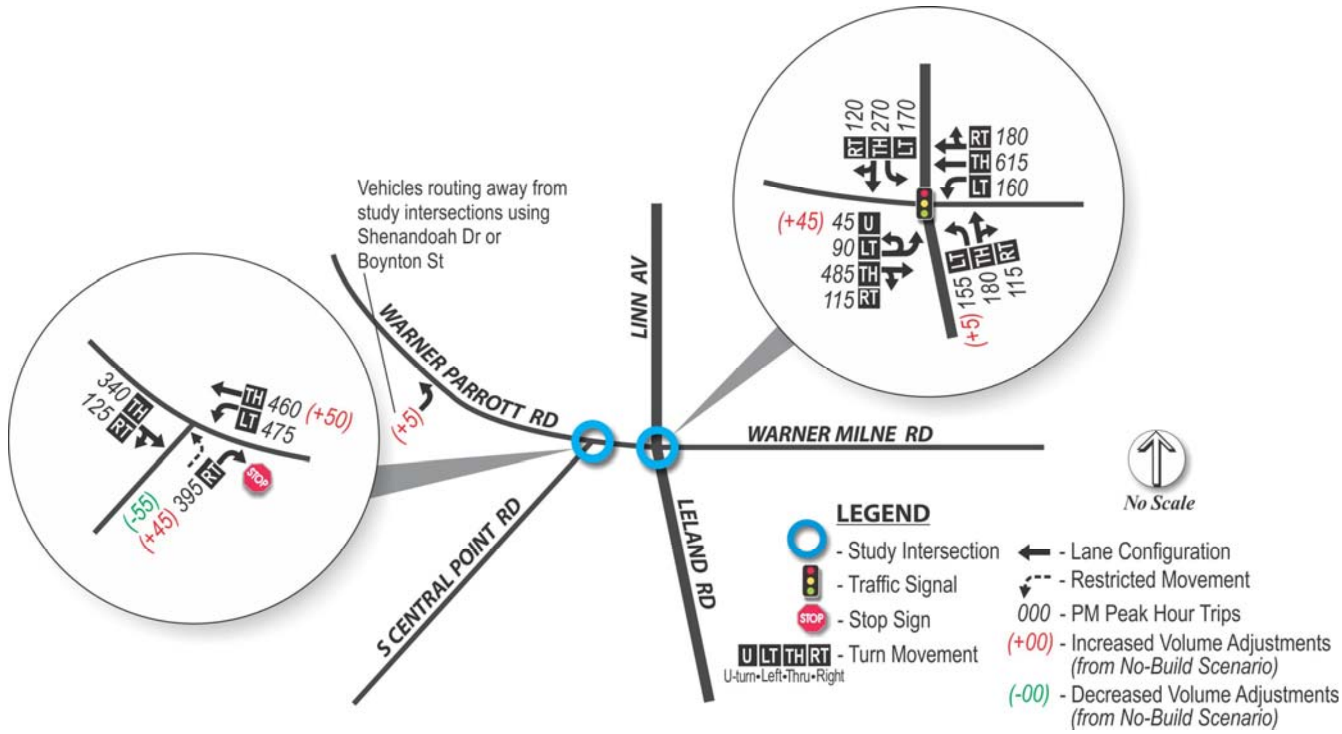

Figure 3: 2035 Intersection Volumes for Alt 1: Unsignalized Left-Turn Restriction with Signalized U-Turn

In this alternative, it was assumed that the majority of these displaced vehicles (45 during the PM peak) would simply utilize the U-turn at the adjacent signal (i.e. northbound vehicles turn right at the Central Point Rd/Warner Parrott Rd intersection then make a U-turn at the Warner Parrott Rd/Warner Milne Rd/Linn Ave/Leland Rd intersection), because of this movement is the most similar to the existing northbound left-turn movement. Five of the vehicles were assumed to avoid the Central Point Rd/Warner Parrott Rd intersection and instead use an alternate route, such as Pease Rd, to access Leland Rd to turn left at the adjacent Warner Parrott Rd/Warner Milne Rd/Linn Ave/Leland Rd intersection.

The remaining five vehicles were anticipated to avoid both study intersections and find an alternate route such as Shenandoah Dr or Boynton St to access Warner Parrott Rd west of the project study area. Since a relatively small number of vehicles are anticipated to re-route away from both study intersections, the traffic operations at surrounding intersections are not likely to be severely impacted, but these drivers may experience extended travel time.

Alternative 2: Unsignalized Left-Turn Restriction without Signalized U-Turn

This alternative also includes the closure of the northbound left-turn at the Central Point Rd/Warner Parrott Rd intersection by the installation of a median along Warner Parrott Rd or a channelizing island at Central Point Rd. However, unlike Alternative 1, no U-turn would be available at the signalized Warner Parrott Rd/Warner Milne Rd/Linn Ave/Leland Rd intersection. Since this alternative also includes the closure of the northbound left-turns at the Central Point Rd/Warner Parrott Rd intersection, the volumes currently making this turn during the PM peak hour were re-distributed accordingly.

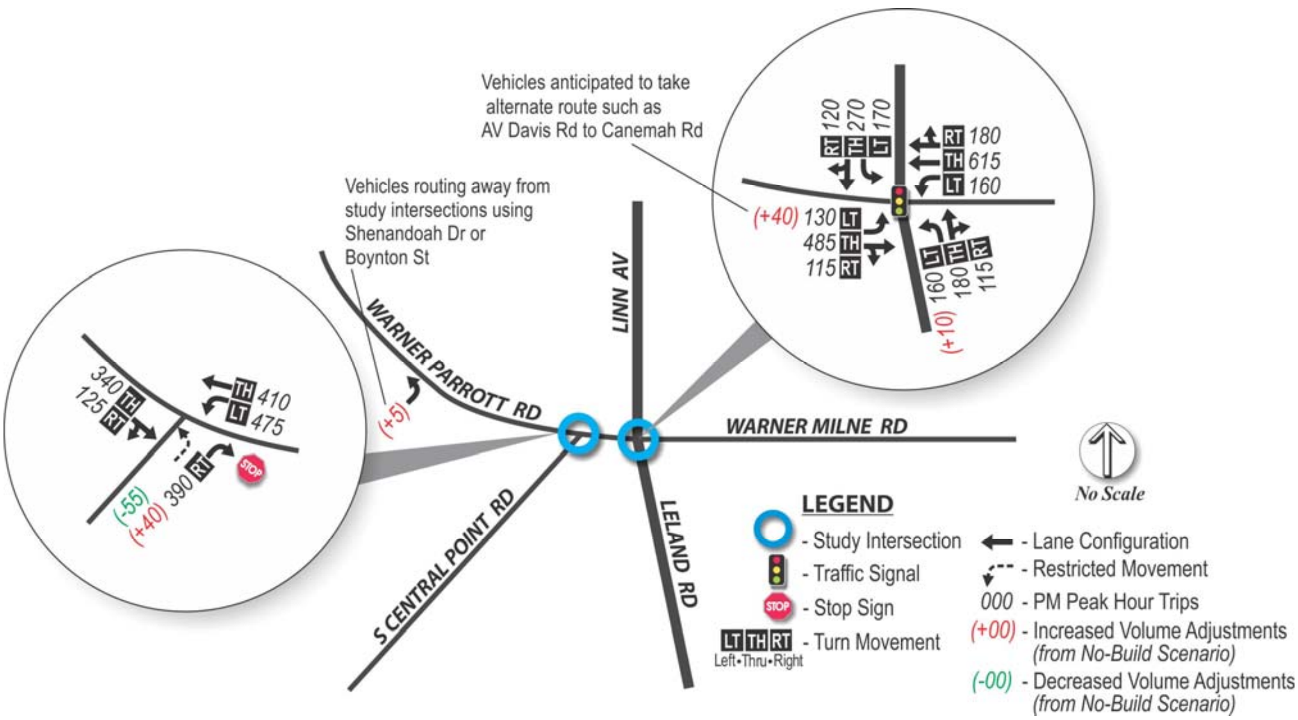

Figure 4: 2035 Intersection Volumes for Alt 2: Unsignalized Left-Turn Restriction without Signalized U-Turn

Forty of these northbound vehicles were assumed to turn right at the Central Point Rd/Warner Parrott Rd intersection, then turn left at the Warner Parrott Rd/Warner Milne Rd/Linn Ave/Leland Rd intersection, then take a parallel route (most likely AV Davis Rd onto Canemah Rd) to access Warner Parrott Rd west of the study area. Ten of the vehicles were assumed to forgo the Central Point Rd/Warner Parrott Rd intersection and instead use an alternate route, such as Pease Rd, to access Leland Rd and turn left at the adjacent Warner Parrott Rd/Warner Milne Rd/Linn Ave/Leland Rd intersection.

The remaining five vehicles are anticipated to avoid both study intersections and find an alternate route, such as Shenandoah Dr or Boynton St, to access Warner Parrott Rd west of the project study area. Since a relatively small amount of vehicles are anticipated to re-route away from both study intersections, the surrounding intersections are not likely to be severely impacted although these drivers may experience extended travel time.

Alternative 3: Both Intersections Signalized

In this alternative both study intersections are fully signalized, which allows for all movements to be accommodated. However, due to the close proximity of the study intersections, the two signals would need to operate as one intersection.

Due to the increased convenience of having a signalized northbound left-turn at the Central Point Rd/Warner Parrott Rd intersection, ten northbound vehicles turning left were assumed to migrate from the Warner Parrott Rd/Warner Milne Rd/Linn Ave/Leland Rd intersection to the Central Point Rd/Warner Parrott Rd intersection as shown below in Figure 5.

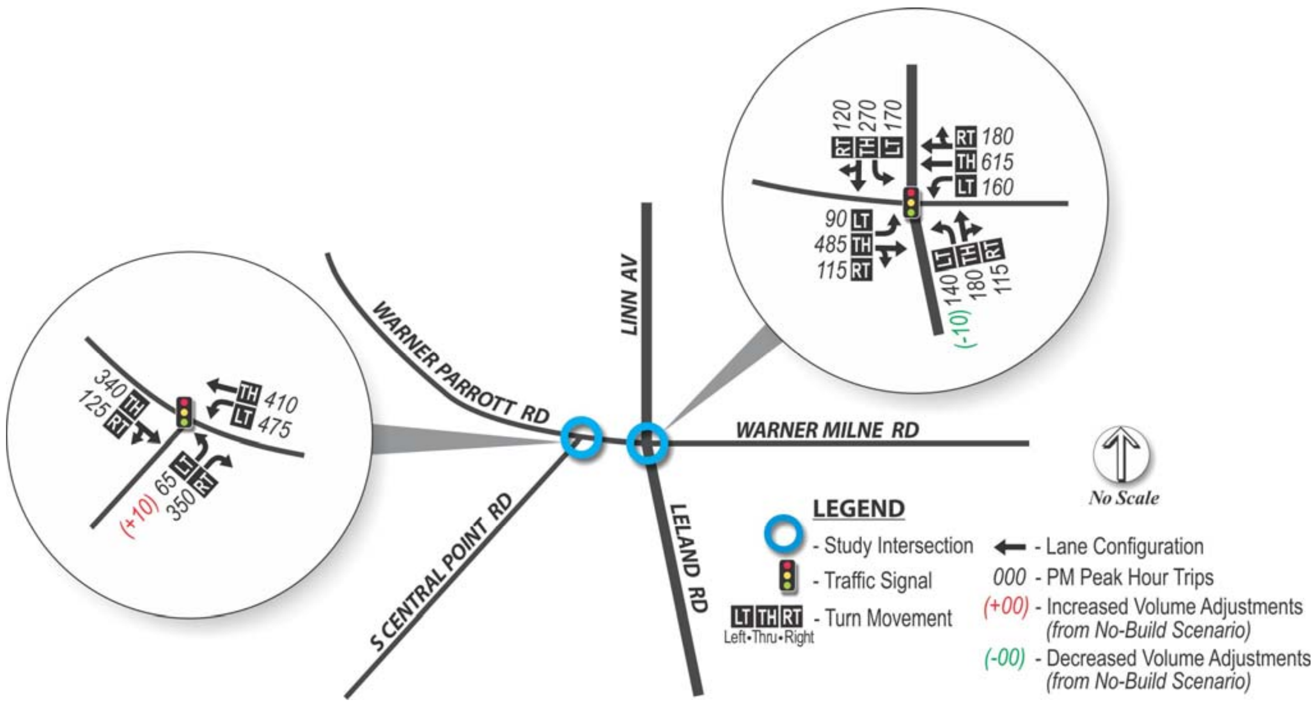

Figure 5: 2035 Intersection Volumes for Alt 3: Both Intersections Signalized

Alternative 4: Four-Leg Roundabout

In this alternative, northbound left-turns at the Central Point Rd/Warner Parrott Rd intersection would be restricted by the installation of a median along Warner Parrott Rd. Left-turns onto Central Point Rd would still be allowed. The Warner Parrott Rd/Warner Milne Rd/Linn Ave/Leland Rd intersection would be converted into a four-legged roundabout, which would accommodate the displaced northbound left-turning vehicles from Central Point Rd/Warner Parrott Rd via the eastbound U-turn movement.

The roundabout considered in this alternative includes two lane approaches for each of the legs. However, the removal of one approach lane on the south leg (Leland Ave) was also evaluated and is discussed further in the Intersection Operations section for Alternative 4.

Since this alternative also includes the closure of the northbound left-turns at the Central Point Rd/Warner Parrott Rd intersection, the volumes currently making this turn during the PM peak hour were re-distributed in a way that is identical to Alternative 1. The intersection volumes used for Alternative 4 are shown in Figure 6.

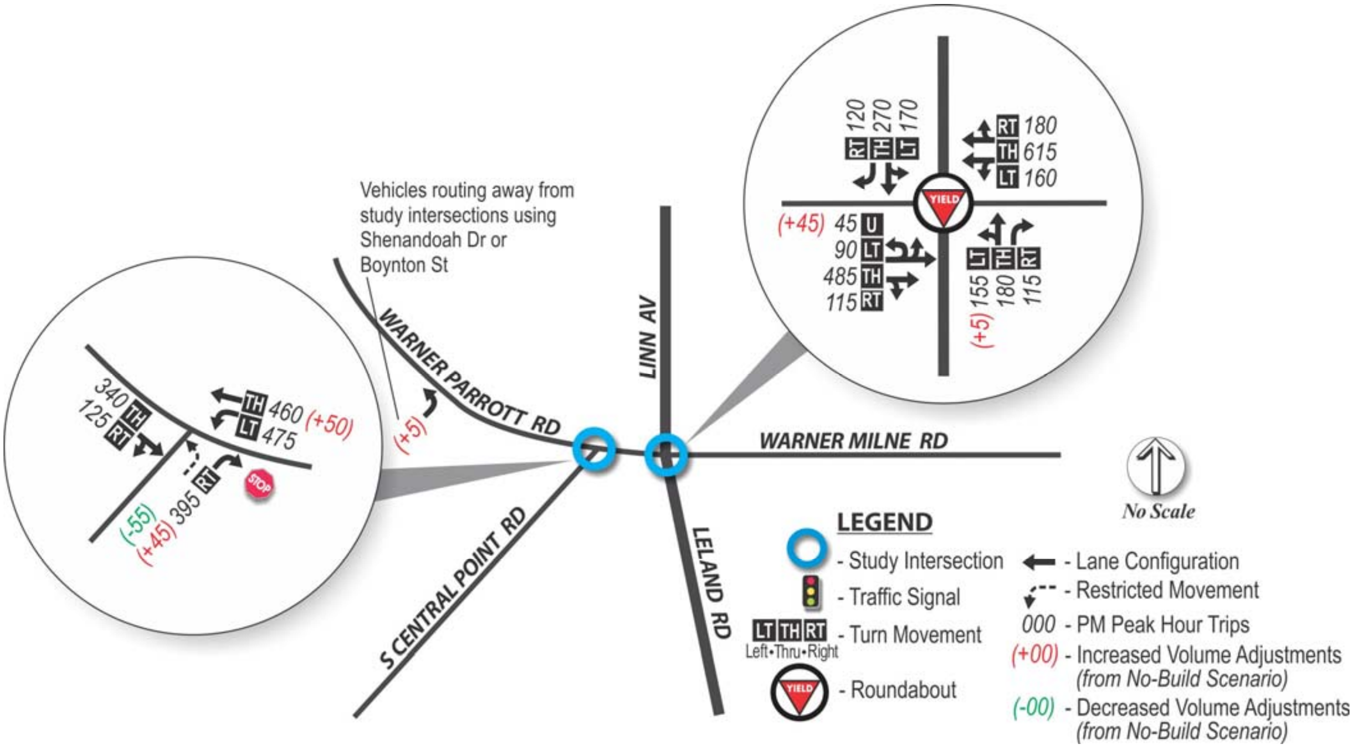

Figure 6: 2035 Intersection Volumes for Alt. 4: Four-Leg Roundabout

Alternative 5: Five-Leg Roundabout

In this alternative, a five-legged roundabout was considered that combined both study intersections into one. The five-legged roundabout results in a larger roundabout, but no turn movements are restricted. The approaches to the roundabout were all two-lane.

Since both intersections are merged into a single intersection in this alternative, the distribution of the 2035 PM peak hour volumes were determined by general destination and origin assumptions using the turn-movement counts collected as part of this analysis and are described in Figure 7.

Based on the distribution of westbound traffic at the Central Point Rd/Warner Parrott Rd intersection, 46 percent of traffic on that approach is destined for Warner Parrott Rd and the remaining 56 percent is destined for Central Point Rd. These percentages were then applied to the southbound right, westbound through, and northbound left movements at the Warner Parrott Rd/Warner Milne Rd/Linn Ave/Leland Rd intersection to estimate how these movements might re-distribute with the single intersection.

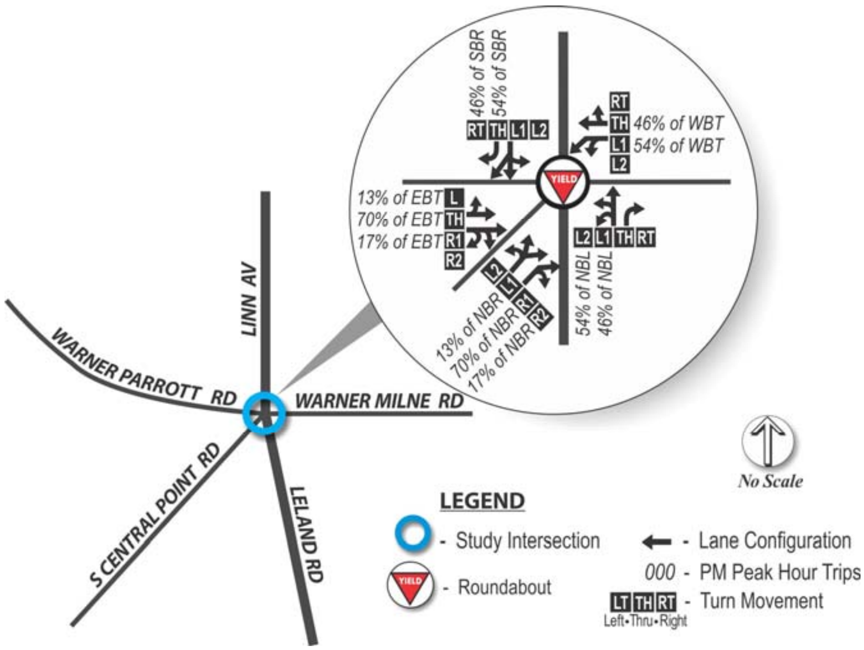

Figure 7: Intersection Volume Adjustments for Alt. 5: Five-Leg Roundabout

In the eastbound direction at Warner Parrott Rd/Warner Milne Rd/Linn Ave/Leland Rd, 70 percent of the traffic was determined to be destined for Warner Milne Rd, 17 percent destined for Linn Ave, and 13 percent destined for Leland Rd. These percentages were applied to the eastbound volume and northbound left-turn volume at Central Point Rd/Warner Parrott Rd to estimate how these movements might re-distribute with the single intersection. Figure 7 shows the combined intersection volumes that were used for Alternative 5.

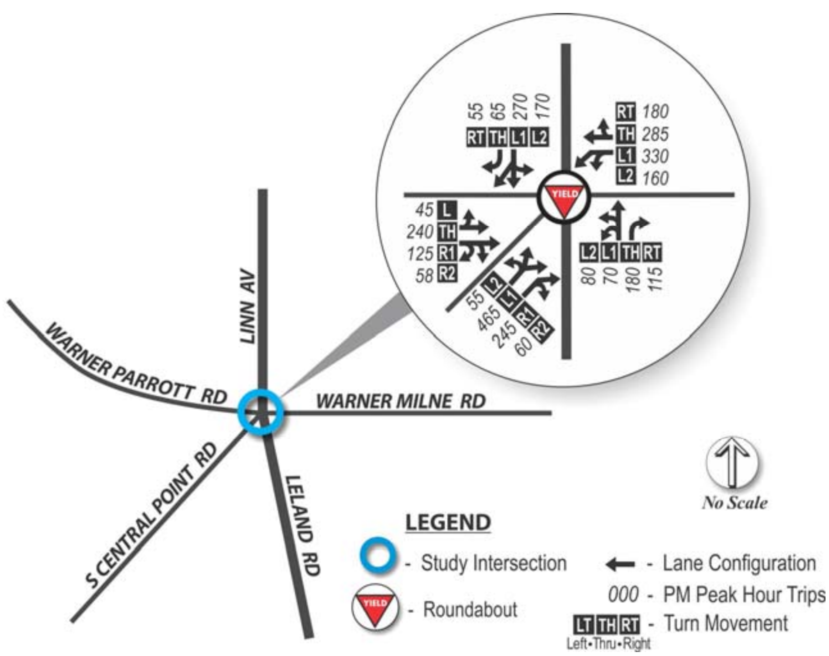

Figure 8: 2035 Intersection Volumes for Alt 5: Five-Leg Roundabout

FUTURE ALTERNATIVES EVALUATION

Each of the alternatives was evaluated based on several criteria to provide a comparison of the alternatives to each other, and to the No-Build scenario. These criteria included intersection operations, system context, right-of-way/access impacts, construction/maintenance costs, and safety. The following sections discuss the mobility standards for Oregon City, as well as a summary of the present worth analysis completed for each of the transportation alternatives.

Mobility Standards

Agency mobility standards often require intersections to meet level of service (LOS) or volume-to-capacity (v/c) intersection operation thresholds.

- The **intersection LOS** is similar to a "report card" rating based upon average vehicle delay. Level of service A, B, and C indicate conditions where traffic moves without significant delays over periods of peak hour travel demand. Level of service D and E are progressively worse operating conditions. Level of service F represents conditions where average vehicle delay has become excessive and demand has exceeded capacity. This condition is typically evident in long queues and delays.
- The **volume-to-capacity (v/c) ratio** represents the level of saturation of the intersection or individual movement. It is determined by dividing the peak hour traffic volume by the maximum hourly capacity of an intersection or turn movement. When the v/c ratio approaches 0.95, operations become unstable and small disruptions can cause the traffic flow to break down, as seen by the formation of excessive queues.

Two adopted documents contain language regarding the mobility standards for both signalized and unsignalized intersections in Oregon City. The first is Oregon City's TSP and the second is the Oregon City Municipal Code.[11] The language from both documents agrees that the mobility standard for signalized intersections as a whole requires a v/c ratio less than 0.99. However, the mobility standard language in both documents differs in regards to unsignalized intersections. According to the TSP, unsignalized mobility standards are given as v/c ratios that may not exceed 0.99 for the worst intersection movement, which is typically the side street. On the other hand, Oregon City's Municipal code refers to mobility standards for unsignalized intersections as a v/c ratio that may not exceed 0.99 for the main street movement and specifically states that there is no mobility standard for the side street movement.

In this document, mobility standards will be reported in accordance with Oregon City's TSP language. However, a discussion of the Oregon City Municipal Code mobility standards will be discussed as applicable. The mobility standards for signalized and unsignalized intersections from both the City's TSP and Municipal Code are summarized in Table 5.

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[11] Oregon City, Oregon - Code of Ordinances, August 25, 2014.

Table 5: Applicable Study Intersection Mobility Standards

Document	Traffic Control	Mobility Standard *v/c Ratio*	Applicable Intersection Movement
Oregon City's TSP	Signalized	0.99	Intersection as a whole
	Unsignalized	0.99	Worst intersection movement (Critical movement)
Oregon City Municipal Code	Signalized	0.99	Intersection as a whole
	Unsignalized	0.99	Worst major-street movement

No-Build

Table 6 provides the results of the intersection operations analysis completed for the future No-Build scenario. As shown, the critical movement of the Central Point Rd/Warner Parrott Rd intersection does not meet Oregon City's TSP v/c standard for unsignalized intersections although the major street v/c is below 0.99 and therefore does meet the Oregon City Municipal Code's mobility standards for unsignalized intersections. In light of differing mobility standards, it is important to note that motor vehicle queuing and overall intersection performance drastically decreases as the critical movement (northbound left) approaches a v/c above 0.99. The Warner Parrott Rd/Warner Milne Rd/Linn Ave/Leland Rd intersection does meet mobility standards in year 2035.[12]

Table 6: 2035 No-Build Intersection Operations

Intersection	Operating Standard	PM Peak Hour		
	v/c	*LOS*	*Delay*	*v/c*
Central Point Rd/Warner Parrott Rd	0.99	B/F	> 100s	1.38
Warner Parrott Rd/Warner Milne Rd/Linn Ave/Leland Rd	0.99	D	45.4	0.91

Signalized intersection:
Delay = Average Intersection Delay (sec.)
LOS = Level of Service
v/c= Intersection Volume-to-Capacity Ratio

Unsignalized intersection:
Delay = Critical Movement Approach Delay (sec.)
LOS = Major Street LOS/Minor Street LOS
v/c= Critical Movement Volume-to-Capacity Ratio

Alternative 1: Unsignalized Left-Turn Restriction with Signalized U-Turn

A discussion of the five areas of comparison; intersection operations, system context, right-of-way/access impacts, construction/maintenance costs, and safety are outlined in the sections below for Alternative 1: Unsignalized Left-Turn Restriction with Signalized U-Turn.

Intersection Operations

Intersection operations analysis was performed for both study intersections during the PM peak hour using the adjusted future 2035 traffic volumes shown in Figure 3. Due to the added eastbound U-turn at the Warner Parrott Rd/Warner Milne Rd/Linn Ave/Leland Rd intersection, a saturation flow adjustment was made to the

[12] Detailed reports for the HCM intersection analysis for the No-Build scenario as well as all five alternatives are provided in the appendix.

eastbound left turns as per research completed by the North Carolina State University for the North Carolina Department of Transportation.[13] The saturation flow adjustments are provided in the appendix. Table 7 provides the results of the intersection operation analysis.

Table 7: 2035 Intersection Operations for Alt. 1: Unsignalized Left-Turn Restriction with Signalized U-Turn

Intersection	Operating Standard	PM Peak Hour		
	v/c	*LOS*	*Delay*	*v/c*
Central Point Rd/Warner Parrott Rd	0.99	B/C	15.2	0.54
Warner Parrott Rd/Warner Milne Rd/Linn Ave/Leland Rd	0.99	D	52.8	0.92

Signalized intersection:
Delay = Average Intersection Delay (sec.)
LOS = Level of Service
v/c= Intersection Volume-to-Capacity Ratio

Unsignalized intersection:
Delay = Critical Movement Approach Delay (sec.)
LOS = Major Street LOS/Minor Street LOS
v/c= Critical Movement Volume-to-Capacity Ratio

As shown, both intersections meet the mobility standards under future year conditions during the PM peak hour. Compared to the No-Build scenario, an increase of over 30 seconds of delay from the No-Build scenario at the Warner Parrott Rd/Warner Milne Rd/Linn Ave/Leland Rd intersection is expected under this alternative.

Under this alternative, the delay of the critical movement approach for the Central Point Rd/Warner Parrott Rd intersection significantly decreases from the No-Build scenario which is due to the restriction of the northbound left-turn movement on the Central Point Rd intersection leg (critical movement).

Right-of-way/Access Impacts

Limited impacts to accesses are anticipated under this alternative. All existing access to adjacent businesses will remain open, but the Central Point Rd northbound left-turn will be restricted. However, the added U-turn movement at the adjacent intersection should help minimize the impact of removing that turn movement. No right-of-way acquisition is expected for this alternative. The two study intersections are spaced less than 150 feet in this alternative, thus, it does not meet the City's intersection minimum access spacing requirements for minor arterials.[14]

Construction/Maintenance Costs

Construction costs for this alternative would likely be relatively minor. Costs would include the construction of the center median along Warner Parrott Rd, and signal modifications to accommodate for the added eastbound U-turn movement. There would also be ongoing maintenance costs affiliated with the signalized intersection, which is expected to be similar to the existing maintenance costs for this intersection and typically include equipment replacement, signal timing updates, power, etc.

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[13] *Effects of Increased U-Turns at Intersections of Divided Facilities and Median Divided Versus Five Lane Undivided Benefits*, North Carolina State University, August 2004. (Research conducted for the North Carolina Department of Transportation).
[14] Oregon City Transportation System Plan, Volume I, Page 36, Table 1, June 2013.

A construction cost estimate for this alternative was developed by Wallis Engineering, and found to be approximately $115,000.[15]

Safety

The poor traffic operations expected at the Warner Parrott Rd/Warner Milne Rd/Linn Ave/Leland Rd intersection and the anticipated queuing on the northbound approach of the Central Point Rd/Warner Parrott Rd intersection and eastbound approach between the intersections may cause an increase in collisions within the study intersections. When an intersection is over capacity (has a v/c ratio greater than 1.0) and experiences a significant amount of delay, the potential for drivers to become impatient and act more recklessly (e.g. running-red lights) increases.

Since the U-turn movement isn't especially common in the State of Oregon, drivers may be unfamiliar with the practice and the added conflict point. For instance, drivers making a southbound right from Linn Ave during a red-light are used to yielding for either the westbound through movement or northbound left-turn movement. In this alternative, drivers wanting to make a southbound right must also yield to the eastbound U-turn movement, which may require additional signage or operational changes (e.g. no turn on red) to help drivers understand how to navigate each intersection turning movement safely.

Although the current crash rate at the Warner Parrott Rd/Warner Milne Rd/Linn Ave/Leland Rd intersection isn't expected to change drastically under this alternative, the Central Point Rd/Warner Parrott Rd intersection could expect a decrease in accidents arising from northbound vehicles making left-turns due to the movement restriction.

Typically, a wide variety of collision types occur at signalized intersections, the most severe of which are head-on, turning, and "T-bone" collisions. These collision types often have a higher frequency of injuries and fatalities than other types of collisions such as side-swipe or rear-end collisions. However, signalized intersections would provide a protected crossing for pedestrians using the intersection.

Alternative 2: Unsignalized Left-Turn Restriction without Signalized U-Turn

A discussion of the five areas of comparison; intersection operations, system context, right-of-way/access impacts, construction/maintenance costs, and safety are outlined in the sections below for Alternative 2: Unsignalized Left-Turn Restriction without Signalized U-Turn.

Intersection operations analysis was performed for both study intersections during the PM peak hour using the adjusted future 2035 traffic volumes shown in Figure 4. Table 8 provides the results of the intersection operations analysis.

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[15] Planning level construction costs estimates for all five alternatives are provided in the appendix.

Table 8: 2035 Intersection Operations for Alt 2: Unsignalized Left-Turn Restriction without Signalized U-Turn

Intersection	Operating Standard	PM Peak Hour		
	v/c	*LOS*	*Delay*	*v/c*
Central Point Rd/Warner Parrott Rd	0.99	B/C	15.1	0.53
Warner Parrott Rd/Warner Milne Rd/Linn Ave/Leland Rd	0.99	D	46.8	0.92

Signalized intersection:
Delay = Average Intersection Delay (sec.)
LOS = Level of Service
v/c= Intersection Volume-to-Capacity Ratio

Unsignalized intersection:
Delay = Critical Movement Approach Delay (sec.)
LOS = Major Street LOS/Minor Street LOS
v/c= Critical Movement Volume-to-Capacity Ratio

As shown, both study intersections meet mobility standards under 2035 PM peak hour conditions. It is important to note that this alternative causes minor rerouting through other intersections (see the *Volumes Adjustment Summary* section in this memorandum). Those impacts are not assessed in this study, but are expected to be minor.

Under this alternative, the intersection delay at the Warner Parrott Rd/Warner Milne Rd/Linn Ave/Leland Rd intersection is projected to stay similar to that of the No-Build scenario and the delay of the critical movement approach for the Central Point Rd/Warner Parrott Rd intersection significantly decreases from the No-Build scenario which is due to the restriction of the northbound left-turn movement on the Central Point Rd intersection leg (critical movement).

Right-of-way/Access Impacts

Limited, if any, accesses are anticipated to be adversely affected for this alternative. All existing access to adjacent businesses will remain open, however, the Central Point Rd northbound left-turn will be restricted. Right-of-way acquisition is not expected for this alternative. Additionally, the two study intersections are spaced less than 150 feet in this alternative, thus, it does not meet the City's intersection minimum access spacing requirements for minor arterials.[16]

Construction/Maintenance Costs

Construction costs for this alternative are expected to be minimal, and would be limited to the construction of the center median along Warner Parrott Rd. No modifications to the existing traffic signal are anticipated as part of this alternative. The ongoing maintenance costs affiliated with signalized intersections are expected to be similar to existing maintenance costs for this intersection and typically include equipment replacement, signal timing updates, power, etc.

A construction cost estimate for this alternative was developed by Wallis Engineering, and was found to be approximately $45,000.

[16] Oregon City Transportation System Plan, Volume I, Page 36, Table 1, June 2013.

Safety

This alternative is not expected to change the safety of the study intersections significantly from existing conditions. However, it is important to note that the main types of collisions occurring at signalized intersections have a greater incidence of injury than other types of collisions. Although the current crash rate at the Warner Parrott Rd/Warner Milne Rd/Linn Ave/Leland Rd intersection isn't expected to change drastically under this alternative, the Central Point Rd/Warner Parrott Rd intersection could expect a decrease in accidents arising from northbound vehicles making left-turns due to the movement restriction.

Alternative 3: Both Intersections Signalized

A discussion of the coordinated signal phasing used for this alternative as well as the five areas of comparison; intersection operations, system context, right-of-way/access impacts, construction/maintenance costs, and safety are outlined in the sections below for Alternative 3: Both Intersections Signalized.

Coordinated Signal Phasing

Signalizing two intersections in such close proximity to each other create challenges in providing adequate through movement and not trapping vehicles between the two intersections. To help address these challenges, the two intersections will need to operate as one intersection, with signal phases carefully coordinated to allow for through movement and to prevent conflicts. To maintain a clear area between the two intersections, the eastbound and westbound phases need to operate using split phase timing. Split phase timing allows all the movements from one approach to flow through the intersection, instead of allowing through movements in two directions. This type of signal timing is typically less efficient than other types, but necessary in this case to provide adequate time for the through movement. The analysis maintained all four pedestrian crossings at the Warner Parrott Rd/Warner Milne Rd/Linn Ave/Leland Rd intersection, and includes two pedestrian crossings at the Central Point Rd/Warner Parrott Rd intersection. The proposed signal phasing is shown below in Figure 9.

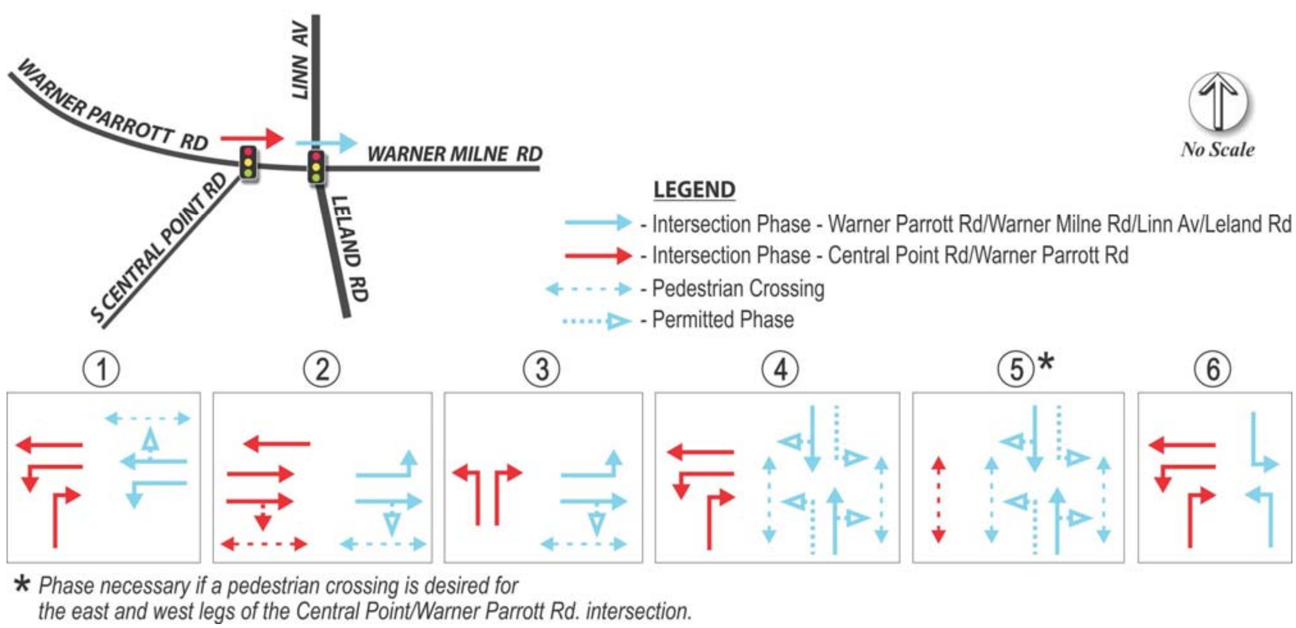

Figure 9: Proposed Signal Phasing for Alternative 3 (Both Intersections Signalized)

Intersection Operations

Intersection operations analysis was performed for both study intersections during the PM peak hour using the adjusted future 2035 traffic volumes shown in Figure 5. Table 9 provides the results of the intersection operations analysis.

Table 9: 2035 Intersection Operations for Alt. 3: Both Intersections Signalized

Intersection	Operating Standard	PM Peak Hour		
	v/c	*LOS*	*Delay*	*v/c*
Maintaining all Pedestrian Crossings				
Central Point Rd/Warner Parrott Rd	0.99	C	20.2	0.53
Warner Parrott Rd/Warner Milne Rd/Linn Ave/Leland Rd	0.99	F	151.1	1.12
Without Pedestrian Crossings on the East and West Legs of Central Point Rd/Warner Parrott Rd				
Central Point Rd/Warner Parrott Rd	0.99	B	16.8	0.49
Warner Parrott Rd/Warner Milne Rd/Linn Ave/Leland Rd	0.99	E	67.1	1.02

Signalized intersection:
Delay = Average Intersection Delay (sec.)
LOS = Level of Service
v/c = Intersection Volume-to-Capacity Ratio

Unsignalized intersection:
Delay = Critical Movement Approach Delay (sec.)
LOS = Major Street LOS/Minor Street LOS
v/c = Critical Movement Volume-to-Capacity Ratio

As shown, the Warner Parrott Rd/Warner Milne Rd/Linn Av/Leland Rd intersection does not meet mobility standards under this alternative. Furthermore, an increase of over 20 seconds of delay from the No-Build scenario at the Warner Parrott Rd/Warner Milne Rd/Linn Ave/Leland Rd intersection is expected under this alternative. This alternative was also analyzed without the pedestrian crossing on the east leg of Central Point Rd/Warner Parrott Rd. By eliminating this pedestrian crossing, more green time can be allocated to other movements and operations improve, but still do not meet mobility standards.

The split phase timing works well keeping the westbound area between the two intersections clear because the westbound through movement at Central Point Rd is served during four of the five phases shown in the proposed signal phasing. However, in the eastbound direction the block between the two intersections can become fully queued. Due to the northbound and southbound traffic demands at Warner Parrott Rd/Warner Milne Rd/Linn Ave/Leland Rd, as well as the split phase eastbound-westbound signal timing, there is limited green time for the eastbound movement. The northbound right from Central Point Rd continuously fills that block, yet cannot proceed through the Warner Parrott Rd/Warner Milne Rd/Linn Ave/Leland Rd intersection. This scenario creates a significant northbound vehicle queue on Central Point Rd although the delay of the critical movement approach is projected to significantly increase from the No-Build scenario at this location.

Since the intersection operations for this alternative fails to meet Oregon City's mobility standards, it is excluded from any further evaluation.

Alternative 4: Four-Leg Roundabout

A discussion of the five areas of comparison; intersection operations, system context, right-of-way/access impacts, construction/maintenance costs, and safety are outlined in the sections below for Alternative 4: Four-Leg Roundabout.

Intersection Operations

Intersection operations analysis was performed for both study intersections during the PM peak hour using the adjusted future 2035 traffic volumes shown in Figure 6. Table 10 provides the results of the intersection operations analysis.

Table 10: 2035 Intersection Operations for Alt. 4: Four-Leg Roundabout

Intersection	Operating Standard	PM Peak Hour		
	v/c	*LOS*	*Delay*	*v/c*
Two-Lane Approach for all Four Roundabout Legs				
Central Point Rd/Warner Parrott Rd	0.99	B/C	15.2	0.54
Warner Parrott Rd/Warner Milne Rd/Linn Ave/Leland Rd	0.99	C	26.6	0.77
Two-Lane Approach for all but the South Leg (Leland Ave)				
Central Point Rd/Warner Parrott Rd	0.99	B/C	15.2	0.54
Warner Parrott Rd/Warner Milne Rd/Linn Ave/Leland Rd	0.99	D	49.3	0.91

Roundabout intersection:
Delay = Critical Movement Approach Delay (sec.)
LOS = Level of Service
v/c = Critical Movement Volume-to-Capacity Ratio

Unsignalized intersection:
Delay = Critical Movement Approach Delay (sec.)
LOS = Major Street LOS/Minor Street LOS
v/c = Critical Movement Volume-to-Capacity Ratio

As shown, the two study intersections operate with v/c ratios well below the mobility standard for Oregon City, in both four-legged options. However, at the conceptual stage, it is recommended that the scenario including a two-lane approach for all legs be carried forward for the evaluation. Taking this approach is likely to result in a conservative estimate of the potential impacts associated with this alternative. The possibility of phased construction could be considered as part of the final design process if needed.

The critical movement delays at both study intersections are expected to decrease at both study intersections under this alternative when compared with the No-Build scenario.

Right-of-way/Access Impacts

The Central Point Rd northbound left-turn will be restricted in this alternative and all existing accesses to adjacent businesses will remain open. However, the east and west driveways accessing the strip mall have the potential to be restricted to right-in, right-out only depending on the final configuration and design of the roundabout. These decisions would be made as part of the final design phase of the project, which is not expected to occur until funding is secured for the project. Even with these potential access restrictions, all movements from both intersections would be able to enter/exit the strip mall without going beyond the two study intersections.

This alternative would require right-of-way acquisitions to construct the proposed roundabout and realigned roadways. Based on the current concept for this alternative, approximately 5,000 square feet of right-of-way would need to be acquired. Additionally, the two study intersections are spaced less than 150 feet in this alternative, thus, it does not meet the City's intersection minimum access spacing requirements for minor arterials.[17]

Construction/Maintenance Costs

The cost of construction for this alternative is expected to be significantly higher than the construction costs other alternatives with signalized intersections. The major reason for this is the significant amount of new road construction and changes to roadway alignment that are needed to initially construct the roundabout. The cost associated with acquiring right-of-way is also a factor in the higher cost for this alternative as compared to the traffic signal alternatives.

Ongoing maintenance cost of a roundabout controlled intersection is highly dependent on the landscaping treatment. Options can range from high maintenance costs that include irrigation, regular pruning, and cleaning statues or other art work, to low maintenance cost options that may include a simple concrete island or pavers. Other ongoing costs could include lighting, maintaining signs related to the roundabout, and pedestrian crossing treatments.

A construction cost estimate for this alternative was developed by Wallis Engineering, and was found to be approximately $3,220,000.

Safety

Vehicles at roundabouts generally travel at slower speeds, which results in less severe collisions. Furthermore, the main collision types that occur at roundabout intersections (side-swipe or rear-end) typically have a lesser incidence of injury than other collision types. Studies show that roundabouts can reduce injury crashes by 72% to 80%[18,19].

Current guidance is to provide pedestrian crossing treatments for multi-lane approaches to roundabouts, as it can be difficult for visually impaired pedestrians to cross multiple lanes of an unsignalized facility. Therefore, pedestrian-activated flashers were assumed to be necessary at each crossing. The type of crossing treatment will need further review during the final design phase. Cyclists have the option to travel on the sidewalk or to circulate with traffic at an intersection with a roundabout configuration. For cyclists that choose to circulate with traffic, the relative speed between the cyclist and the adjacent motor vehicles is likely to be similar thus reducing the risk of high-impact collisions.

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[17] Oregon City Transportation System Plan, Volume I, Page 36, Table 1, June 2013.
[18] Insurance Institute for Highway Safety. Website Accessed 1/12/2015 : http://www.iihs.org/iihs/topics/t/roundabouts/qanda
[19] Eisenman, S.; Josselyn, J.; List, G.; Persaud, B.; Lyon, C.; Robinson, B.; Blogg, M.; Waltman, E.; and Troutbeck, R. 2004. Operational and safety performance of modern roundabouts and other intersection types. Final Report, SPR Project C-01-47. Albany, NY: New York State Department of Transportation.

Another safety consideration for this alternative is the vehicle queue created by the westbound left turn movement at Warner Parrott Rd/Central Point Rd. Existing observations revealed that vehicles making this movement queue through the adjacent signalized intersection occasionally during the PM peak hour. With volumes increasing by 2035, the queuing would likely grow more frequent. This vehicle queueing would likely be similar in Alternatives 1 and 2. However, with a roundabout there is some added complexity to the vehicle queue. With a signalized intersection at Warner Parrott Rd/Warner Milne Rd/Linn Ave/Leland Rd, drivers can see the vehicle queue as they approach and choose not to enter the intersection. In the case of a roundabout, a driver might not be aware of the vehicle queue until they are in the roundabout, causing them to stop in the circulating roadway, which would then impact other movements through the roundabout as well.

Alternative 5: Five-Leg Roundabout

A discussion of the five areas of comparison; intersection operations, system context, right-of-way/access impacts, construction/maintenance costs, and safety are outlined in the sections below for Alternative 5: Five-Leg Roundabout.

Intersection Operations

Intersection operations analysis was performed for the combined study intersection during the PM peak hour using the adjusted future 2035 traffic volumes shown in Figure 8. Table 11 provides the results of the intersection operations analysis.

Table 11: 2035 Intersection Operations for Alt. 5: Five-Leg Roundabout

Intersection	Operating Standard	PM Peak Hour		
	v/c	*LOS*	*Delay*	*v/c*
Two-Lane Approach for all Five Roundabout Legs				
Warner Parrott Rd/Warner Milne Rd/Linn Ave/Leland Rd/Central Point Rd	0.99	C	31.1	0.83
Two-Lane Approach for all but the South Leg (Leland Ave) and the South-East Leg (Central Point Rd)				
Warner Parrott Rd/Warner Milne Rd/Linn Ave/Leland Rd/Central Point Rd	0.99	E	62.5	0.97

Roundabout intersection:
Delay = Critical Movement Approach Delay (sec.)
LOS = Level of Service
v/c = Critical Movement Volume-to-Capacity Ratio

Unsignalized intersection:
Delay = Critical Movement Approach Delay (sec.)
LOS = Major Street LOS/Minor Street LOS
v/c = Critical Movement Volume-to-Capacity Ratio

As shown, both roundabout scenarios have v/c ratios under the maximum standard for Oregon City. Similar to what was stated for Alternative 4, at the conceptual stage it is recommended that the scenario including a two-lane approach for all legs be carried forward for the evaluation. Furthermore, taking this approach is likely to result in a conservative estimate of the potential impacts associated with this alternative. The possibility of phased construction could be considered as part of the final design process if needed.

Under this alternative, the intersection delay at the Rd/Warner Milne Rd/Linn Ave/Leland Rd intersection is projected to increase slightly when compared to the No-Build scenario and the delay of the critical movement approach for the Central Point Rd/Warner Parrott Rd intersection significantly decreases from the No-Build scenario.

Right-of-way/Access Impacts

No motor vehicle movements will be restricted in this alternative and all existing accesses to adjacent businesses will remain open, however, the east and west driveways for the strip mall has the potential to be restricted to right-in, right-out only and would require further analysis in the design phase. Even though this access restriction is not definite, all movements from both intersections would be able to enter and exit the site without going beyond the adjacent roundabout.

This alternative would require a significant amount of right-of-way acquisitions to construct the proposed roundabout and realigned roadways. Based on the current concept for this alternative, approximately 7,000 square feet of right-of-way would need to be acquired.

Construction/Maintenance Costs

The cost of construction for this alternative is expected to be significantly higher than the construction costs other alternatives with signalized intersections. The major reason for this is the significant amount of road construction and changes to roadway alignment that are needed to initially construct the roundabout. It is also anticipated that this alternative would be slightly more expensive than the four-legged roundabout in Alternative 4, due to the increased size of the roundabout required to accommodate the fifth leg. There is also more roadway alignment modifications required for this alternative compared to Alternative 4. The cost associated with acquiring right-of-way is also a factor in the higher cost for this alternative as compared to the traffic signal alternatives.

Similar to Alternative 4, the ongoing maintenance cost of a roundabout controlled intersection is highly dependent on the landscaping treatment. Options can range from high maintenance costs that include irrigation, regular pruning, and cleaning statues or other art work, to low maintenance cost options that may include a simple concrete island or pavers. Other ongoing costs could include lighting, maintaining signs related to the roundabout, and pedestrian crossing treatments.

A construction cost estimate for this alternative was developed by Wallis Engineering, and found to be approximately $3,350,000.

Safety

Similar to Alternative 4, a roundabout is expected to decrease the number of injury crashes by about 70%. Since this alternative includes a five-leg roundabout with complex lane geometry, driver confusion may occur and more conflict points for potential collisions exist for this alternative compared to others.

However, conflict points are not the only important factor in analyzing intersection safety. It is also important to discuss the general collision-types associated with roundabout intersections. The main collision types that occur at roundabouts (side-swipe, rear-end) typically have a lesser incidence of injury than other collision types. Furthermore, vehicles at roundabouts generally travel at slower speeds which results in less severe collisions.

Current guidance is to provide pedestrian crossing treatments for multi-lane approaches to roundabouts, as it can be difficult for visually impaired pedestrians to cross multiple lanes of an unsignalized facility. Therefore, pedestrian-activated flashers were assumed to be necessary at each crossing. The type of crossing treatment will need further review during the final design phase. Cyclists have the option to travel on the sidewalk or to circulate with traffic at an intersection with a roundabout configuration. For cyclists that choose to circulate with traffic, the relative speed between the cyclist and the adjacent motor vehicles is likely to be similar thus reducing the risk of high-impact collisions.

Present Worth Analysis

A present worth analysis was completed in order to determine the relative, present-day cost of each of the five alternatives. This analysis is included in the appendix. While the present worth analysis includes only those costs which are quantifiable, unquantifiable costs should also be considered.

Quantifiable Costs

Costs associated with construction delay, crashes, construction, and maintenance were estimated for each alternative. A short discussion of each of these quantifiable costs is included below.

Delay Costs

Traffic operations are based on the 2035 PM peak year analysis completed for each alternative. The cost associated with PM peak hour delay incorporates the average hourly cost of a passenger vehicle ($26.68) and for a heavy truck ($31.80)[20]. Using the hourly costs, along with existing traffic data (to establish the percent of passenger vehicles and heavy trucks), the average cost of PM peak hour delay for each alternative can be computed using the following equation:

$$Annual\ PM\ Peak\ Hour\ Delay\ Cost =$$
$$Total\ Peak\ Hour\ Delay\ (hrs) \times Adjusted\ Hourly\ Value\ Based\ on\ Percentages\ of\ Vehicle\ Types\ \times$$
$$261\ (Total\ Weekdays\ in\ a\ Year)$$

These hourly costs can then be converted to an annual cost by multiplying them by the number of weekdays in a year. Using this methodology represents a conservative annual cost, because it excludes any delay that might occur outside of the weekday PM peak hour (i.e. weekends, AM peak hour).

Safety Costs

Annual safety benefits were calculated based on which crashes, over a five year period, could be prevented with the geometric changes of each alternative. The cost of a crash is associated with the level of severity. For the purposes of this evaluation, the following AASHTO[21] established costs for the various severity levels were used:

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[20] The Value of Time-Travel: Estimates of the Hourly Value of Time for Vehicles in Oregon 2011. Oregon Department of Transportation Programs and Economic Analysis Unit. November 2012.
[21] American Association of State Highway and Transportation Officials (AASHTO). Highway Safety Manual. 1st Edition. 2010. Table 7-1.

- Property damage only = $7,400
- Injury crash = $79,000
- Fatal crash = $4,008,900

Five years of crash data was analyzed, so the savings is divided by five to obtain annual crash savings. The general equation used to compute the crash savings for each alternative is displayed below:

$$Annual\ Crash\ Savings = \frac{[\#of\ Fatal\ Crashes\ Reduced\ \times \$4{,}008{,}900]}{5} + \frac{[\#of\ Injury\ Crashes\ Reduced\ \times \$79{,}000]}{5} + \frac{[\#\ of\ PDO\ Crashes\ Reduced\ \times \$7{,}400]}{5}$$

For each alternative, the northbound left turn from Central Point Road to Warner Parrot Road is eliminated, which prevents one injury and two PDO crashes (over five years). For alternatives 1 and 2, these are the only crashes prevented.

Roundabouts typically result in less severe crashes than a typical traffic signal, with studies documenting a 72% to 80% reduction in injury crashes. This present worth analysis applied a conservative estimate, reducing 70% of injury crashes to PDO crashes at the roundabout intersections. For alternative 4, converting 70% of the injury crashes at the Warner Parrott Rd/Warner Milne Rd/Linn Ave/Leland Rd intersection to PDO crashes, equated to five crashes. For alternative 5, a 70% reduction in injury crashes was applied to both intersections (after accounting for the crashes prevented by eliminating the northbound left turn movement from Central Point Road to prevent double counting). For the five lane roundabout the 70% reduction equated to eight injury crashes being reduced to PDO crashes.

Construction Costs

A preliminary cost estimate was completed for all alternatives except the No-Build Alternative, with a planning-level approach to costs. The estimates include costs associated with design, construction, permitting, and Right-of-Way acquisition. Each cost estimate is included in the appendix.

Maintenance Costs

Maintenance costs for each alternative were also estimated. For Alternatives 1, 2, and 3, these are from signal maintenance. For Alternatives 4 and 5, costs are associated with landscaping maintenance. Maintenance of pavement or utilities within the intersection was not included, because these would be relatively the same for all alternatives.

Unquantifiable Costs

There are a number of significant costs which are not addressed in the present worth analysis. However difficult to quantify, these costs should be considered when determining the most optimal design solution.

Opportunity

There are significant costs for each project resulting from lost opportunities. Construction of each alternative would require funds. These funds, applied elsewhere, represent opportunities for improvements elsewhere. The greater the cost of the alternative, the larger the loss of opportunity to construct other improvements. For example, the construction of Alternative 5 (the 5-leg roundabout) would require a large amount of funds that could alternatively be used to construct other, perhaps greater-needed improvements.

Construction Delay

The traffic delays associated with construction are difficult to quantify, but represent significant costs to users – and to destination businesses within the project area. The more extensive the scope of work for each alternative, the greater the construction delay impacts - and their associated costs.

Impacts to Private Businesses

The construction impacts to private businesses and roadway users would vary substantially between the various alternatives. The significant reconfiguration of the intersection as required by Alternatives 4 and 5 would necessitate the reconfiguration of private properties within the intersection, such as driveways and roadway frontages. These costs to private property owners are not quantifiable at this level of planning.

Public Right-of-Way

The construction of Alternatives 4 or 5 would require a portion of Right-of-Way at the northwest corner of the intersection. Though this property is owned by the City, its use for a roundabout would have an associated cost to the City due to the inability to use it for another purpose.

COMPARISON SUMMARY

A summary table comparing each of the five alternatives plus the No-Build scenario is displayed in Table 12. The table is color coded, with light green shading indicating a more favorable factor (such as lower cost, or better traffic operations), yellow shading indicating a less favorable factor, and orange indicating the least favorable outcome (such as higher cost, lower safety improvements, etc).

Overall, the roundabout alternatives (alternatives 4 and 5) show the greatest benefit for operations and safety, but also have the largest construction cost, which includes right-of-way acquisition. Alternatives 1 and 2 have a much more modest construction cost, yet the operational benefits and safety benefits are not nearly what can be achieved with the roundabout options. Alternative 3, where both intersections are signalized, does not meet operational standards. Based on future traffic operations and potential savings related to safety, Alternative 5 is recommended as the long-term preferred alternative for these study intersections. If a short-term solution is desired, Alternative 1 or 2 could be implemented at a significantly lower cost.

Table 12: Future Alternatives Evaluation Summary Table

		TRAFFIC OPERATIONS				CONSTRUCTION COSTS		SAFETY			
Alternative	Alternative Description	v/c ratio at Central Point	v/c ratio at Linn Ave	Annual Weekday PM Peak Hour Delay Cost	Queuing Between Intersections	Construction Assumptions	Estimated Construction Cost	Safety Elements	Annual Savings due to crash reduction	System Context	Right-of-way/Access Impacts
No Build	Maintain existing lane configuration	1.38	0.91	$316,610	There is currently queuing between the study intersections due to the close proximity	None	$0	No changes	$0	Similar to other signalized intersections throughout the Oregon City area. Pedestrian, bicycle, and transit connections can be provided.	Does not meet Oregon City's intersection access spacing standards.
1	Unsignalized northbound left-turn restriction at the Central Point Rd/Warner Parrott Rd intersection with an eastbound U-turn option for passenger vehicles at the signalized Warner Parrott Rd/Warner Milne Rd/Linn Ave/Leland Rd intersection.	0.54	0.92	$279,361	Queuing between the two study intersections due to their close proximity could have a similar impact to existing conditions	Key costs for this alternative include: • modifications to signal due to added U-Turn • channelizing island	$115,000	PROS • Restricting the northbound left at Central Point removes a conflict point - reduces 2 PDO and 1 injury crash CONS • U-turn movement adds conflict points, and is only allowed for passenger vehicles • Traffic signals generally result in more severe crashes	$18,760	Similar to other signalized intersections throughout the Oregon City area. Pedestrian, bicycle, and transit connections can be provided.	ROW acquisition - none Accesses Closed - none Accesses Modified - 1 (restricts northbound left from Central Point Road) Out of Direction Travel - some Does not meet Oregon City's intersection access spacing standards.
2	Unsignalized northbound left-turn restriction at the Central Point Rd/Warner Parrott Rd intersection without an eastbound U-turn option at the signalized Warner Parrott Rd/Warner Milne Rd/Linn Ave/Leland Rd intersection.	0.53	0.92	$254,529	Queuing between the two study intersections due to their close proximity could have a similar impact to existing conditions	Key costs for this alternative include: • channelizing island	$45,000	PROS • Restricting the northbound left at Central Point removes a conflict point - reduces 2 PDO and 1 injury crash CONS • Traffic signals generally result in more severe crashes • Requires an alternate route	$18,760	Similar to other signalized intersections throughout the Oregon City area. Pedestrian, bicycle, and transit connections can be provided.	ROW acquisition - none Accesses Closed - none Accesses Modified - 1 (restricts northbound left from Central Point Road) Out of Direction Travel - some Does not meet Oregon City's intersection access spacing standards.
3	No movements are restricted and both study intersections are fully signalized. Due to the close proximity of the study intersections, the two signals would essentially need to operate as one intersection.	0.53	1.12	This alternative does not meet mobility standards and is not considered for further evaluation and comparison.							
4	The Warner Parrott Rd/Warner Milne Rd/Linn Ave/Leland Rd intersection would be converted into a four-legged roundabout that allows U-turns for all vehicle types. Northbound left turns at the Central Point Rd/Warner Parrott Rd intersection would be restricted by the installation of a median along Warner Parrott Road.	0.54	0.77	$98,708	Queuing due to the close intersectionproximity could have a greater impact to existing conditions because of the roundabout configuration at the Warner Parrott Rd/Warner Milne Rd/Linn Ave/Leland Rd intersection	Key costs for this alternative include: • construction of roundabout • right-of-way acquisition • lighting	$3,220,000	PROS • Restricting the northbound left at Central Point removes a conflict point - reduces 2 PDO and 1 injury crash • Roundabouts generally result in less severe crashes than a traffic signal. Studies show a 72-80% reduction in injury crashes. This evaluation assumes a 70% reduction in injury crashes at Linn Ave (After accounting for the injury crashes eliminated due to restricted movements, 5 more injury crashes are reduced to PDO crashes) CONS • Pedestrian crossings more challenging especially for impaired pedestrians • Complex roundabout • Queuing into roundabout is likely to occur	$90,360	A roundabout may be less familiar to Oregon City area drivers than a traffic signal. Pedestrian, bicycle, and transit connections can be provided.	ROW acquisition - 4,590 square feet Accesses Closed - none Accesses Modified - 3 (restricts northbound left from Central Point Road and relocates driveways to businesses between Central Point Rd and Leland Rd. Both driveways would be right-in/right-out. Out of Direction Travel - some Does not meet Oregon City's intersection access spacing standards.
5	A single five-legged roundabout that includes the Central Point Road approach with no motor vehicle movement restrictions.	n/a	0.83	$91,879	No queuing between intersections will occur under this alternative (the two intersections will become one)	Key costs for this alternative include: • construction of roundabout • right-of-way acquisition (slightly more than Alternative 4) • lighting	$3,350,000	PROS • Restricting the northbound left at Central Point removes a conflict point - reduces 2 PDO and 1 injury crash • Removal of the westbound left at Central Point eliminates 1 injury crash • Roundabouts generally result in less severe crashes than a traffic signal. Studies show a 72-80% reduction in injury crashes. This evaluation assumes a 70% reduction in injury crashes at Linn Ave and Central Point Rd (After accounting for the injury crashes that were eliminated due to restricted movements, 8 more INJ crashes are reduced to PDO crashes) CONS • Pedestrian crossings more challenging especially for impaired pedestrians • Complex two lane roundabout	$149,120	A roundabout may be less familiar to Oregon City area drivers than a traffic signal. Pedestrian, bicycle, and transit connections can be provided.	ROW acquisition - 6,980 square feet Accesses Closed - none Accesses Modified - 2 (relocates driveways to businesses between Central Point Rd and Leland Rd. Both driveways would be right-in/right-out.) Out of Direction Travel - none Meets Oregon City's intersection access spacing standards.

KEY

Green =

Yellow =

Orange =

720 SW Washington St.
Suite 500
Portland, OR 97205
503.243.3500
www.dksassociates.com

Appendix

Peak Hour Turn Movement Counts

HCM Intersection Analysis (Synchro)

HCM Intersection Analysis (SIDRA)

ODOT Collision Data

Alternative Conceptual Drawings

Cost Estimates

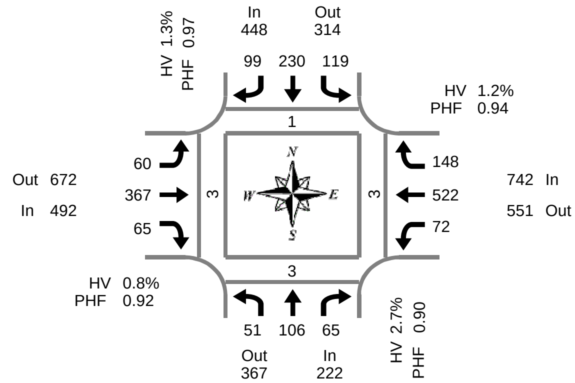
Present Worth Analysis

Peak Hour Turn Movement Counts

Total Vehicle Summary

All Traffic Data Services Inc.

Clay Carney
(503) 833-2740



Peak Hour Summary
4:45 PM to 5:45 PM

Leland Rd & Warner Parrott Rd

Tuesday, December 02, 2014
4:00 PM to 6:00 PM

15-Minute Interval Summary
4:00 PM to 6:00 PM

Interval Start Time	Northbound Leland Rd				Southbound Leland Rd				Eastbound Warner Parrott Rd				Westbound Warner Parrott Rd				Interval Total
	L	T	R	Bikes	L	T	R	Bikes	L	T	R	Bikes	L	T	R	Bikes	
4:00 PM	11	24	12	0	32	51	19	0	12	81	12	0	21	113	38	0	426
4:15 PM	9	29	15	0	27	56	19	0	16	85	16	0	18	125	32	0	447
4:30 PM	13	24	17	0	27	60	26	0	17	77	18	0	24	131	27	1	461
4:45 PM	9	21	20	0	33	52	23	0	13	94	18	0	20	125	34	1	462
5:00 PM	12	28	13	0	33	57	26	0	15	81	19	0	17	139	42	1	482
5:15 PM	14	28	15	0	27	60	23	0	19	101	13	0	17	119	36	0	472
5:30 PM	16	29	17	0	26	61	27	0	13	91	15	0	18	139	36	0	488
5:45 PM	13	25	11	0	23	53	22	0	15	87	16	0	20	114	32	0	431
Total Survey	97	208	120	0	228	450	185	0	120	697	127	0	155	1,005	277	3	3,669

Pedestrians Crosswalk			
North	South	East	West
2	0	0	0
1	0	0	1
0	2	0	0
0	0	2	1
0	0	1	0
1	1	0	2
0	2	0	0
1	1	0	0
5	6	3	4

Peak Hour Summary
4:45 PM to 5:45 PM

By Approach	Northbound Leland Rd				Southbound Leland Rd				Eastbound Warner Parrott Rd				Westbound Warner Parrott Rd				Total
	In	Out	Total	Bikes	In	Out	Total	Bikes	In	Out	Total	Bikes	In	Out	Total	Bikes	
Volume	222	367	589	0	448	314	762	0	492	672	1,164	0	742	551	1,293	2	1,904
%HV	2.7%				1.3%				0.8%				1.2%				1.3%
PHF	0.90				0.97				0.92				0.94				0.98

Pedestrians Crosswalk			
North	South	East	West
1	3	3	3

By Movement	Northbound Leland Rd				Southbound Leland Rd				Eastbound Warner Parrott Rd				Westbound Warner Parrott Rd				Total
	L	T	R	Total	L	T	R	Total	L	T	R	Total	L	T	R	Total	
Volume	51	106	65	222	119	230	99	448	60	367	65	492	72	522	148	742	1,904
%HV	2.0%	2.8%	3.1%	2.7%	2.5%	0.9%	1.0%	1.3%	1.7%	0.5%	1.5%	0.8%	2.8%	1.0%	1.4%	1.2%	1.3%
PHF	0.80	0.91	0.81	0.90	0.90	0.94	0.92	0.97	0.79	0.91	0.86	0.92	0.90	0.94	0.88	0.94	0.98

Rolling Hour Summary
4:00 PM to 6:00 PM

Interval Start Time	Northbound Leland Rd				Southbound Leland Rd				Eastbound Warner Parrott Rd				Westbound Warner Parrott Rd				Interval Total
	L	T	R	Bikes	L	T	R	Bikes	L	T	R	Bikes	L	T	R	Bikes	
4:00 PM	42	98	64	0	119	219	87	0	58	337	64	0	83	494	131	2	1,796
4:15 PM	43	102	65	0	120	225	94	0	61	337	71	0	79	520	135	3	1,852
4:30 PM	48	101	65	0	120	229	98	0	64	353	68	0	78	514	139	3	1,877
4:45 PM	51	106	65	0	119	230	99	0	60	367	65	0	72	522	148	2	1,904
5:00 PM	55	110	56	0	109	231	98	0	62	360	63	0	72	511	146	1	1,873

Pedestrians Crosswalk			
North	South	East	West
3	2	2	2
1	2	3	2
1	3	3	3
1	3	3	3
2	4	1	2

Heavy Vehicle Summary

All Traffic Data Services Inc.

Clay Carney
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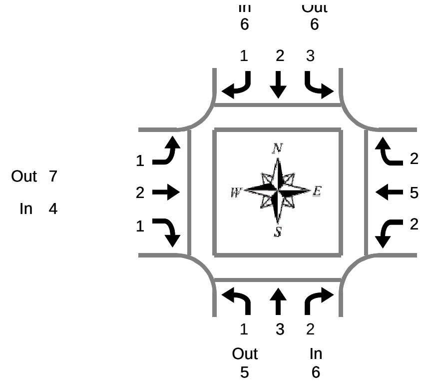

Leland Rd & Warner Parrott Rd

Tuesday, December 02, 2014

4:00 PM to 6:00 PM

Peak Hour Summary
4:45 PM to 5:45 PM

Heavy Vehicle 15-Minute Interval Summary
4:00 PM to 6:00 PM

Interval Start Time	Northbound Leland Rd				Southbound Leland Rd				Eastbound Warner Parrott Rd				Westbound Warner Parrott Rd				Interval Total
	L	T	R	Total	L	T	R	Total	L	T	R	Total	L	T	R	Total	
4:00 PM	1	0	1	2	2	0	0	2	0	2	0	2	1	2	0	3	9
4:15 PM	0	1	0	1	0	1	1	2	2	1	1	4	0	1	1	2	9
4:30 PM	2	1	0	3	1	0	2	3	1	2	0	3	2	0	0	2	11
4:45 PM	0	0	1	1	2	0	0	2	0	1	1	2	1	3	0	4	9
5:00 PM	0	2	0	2	0	0	1	1	0	0	0	0	0	1	1	2	5
5:15 PM	0	1	0	1	0	1	0	1	1	0	0	1	1	0	1	2	5
5:30 PM	1	0	1	2	1	1	0	2	0	1	0	1	0	1	0	1	6
5:45 PM	0	1	0	1	0	0	0	0	0	0	0	0	0	2	1	3	4
Total Survey	4	6	3	13	6	3	4	13	4	7	2	13	5	10	4	19	58

Heavy Vehicle Peak Hour Summary
4:45 PM to 5:45 PM

By Approach	Northbound Leland Rd			Southbound Leland Rd			Eastbound Warner Parrott Rd			Westbound Warner Parrott Rd			Total
	In	Out	Total	In	Out	Total	In	Out	Total	In	Out	Total	
Volume	6	5	11	6	6	12	4	7	11	9	7	16	25
PHF	0.25			0.21			0.11			0.28			0.22

By Movement	Northbound Leland Rd				Southbound Leland Rd				Eastbound Warner Parrott Rd				Westbound Warner Parrott Rd				Total
	L	T	R	Total	L	T	R	Total	L	T	R	Total	L	T	R	Total	
Volume	1	3	2	6	3	2	1	6	1	2	1	4	2	5	2	9	25
PHF	0.08	0.25	0.50	0.25	0.25	0.25	0.08	0.21	0.08	0.10	0.13	0.11	0.17	0.31	0.25	0.28	0.22

Heavy Vehicle Rolling Hour Summary
4:00 PM to 6:00 PM

Interval Start Time	Northbound Leland Rd				Southbound Leland Rd				Eastbound Warner Parrott Rd				Westbound Warner Parrott Rd				Interval Total
	L	T	R	Total	L	T	R	Total	L	T	R	Total	L	T	R	Total	
4:00 PM	3	2	2	7	5	1	3	9	3	6	2	11	4	6	1	11	38
4:15 PM	2	4	1	7	3	1	4	8	3	4	2	9	3	5	2	10	34
4:30 PM	2	4	1	7	3	1	3	7	2	3	1	6	4	4	2	10	30
4:45 PM	1	3	2	6	3	2	1	6	1	2	1	4	2	5	2	9	25
5:00 PM	1	4	1	6	1	2	1	4	1	1	0	2	1	4	3	8	20

Peak Hour Summary

Clay Carney
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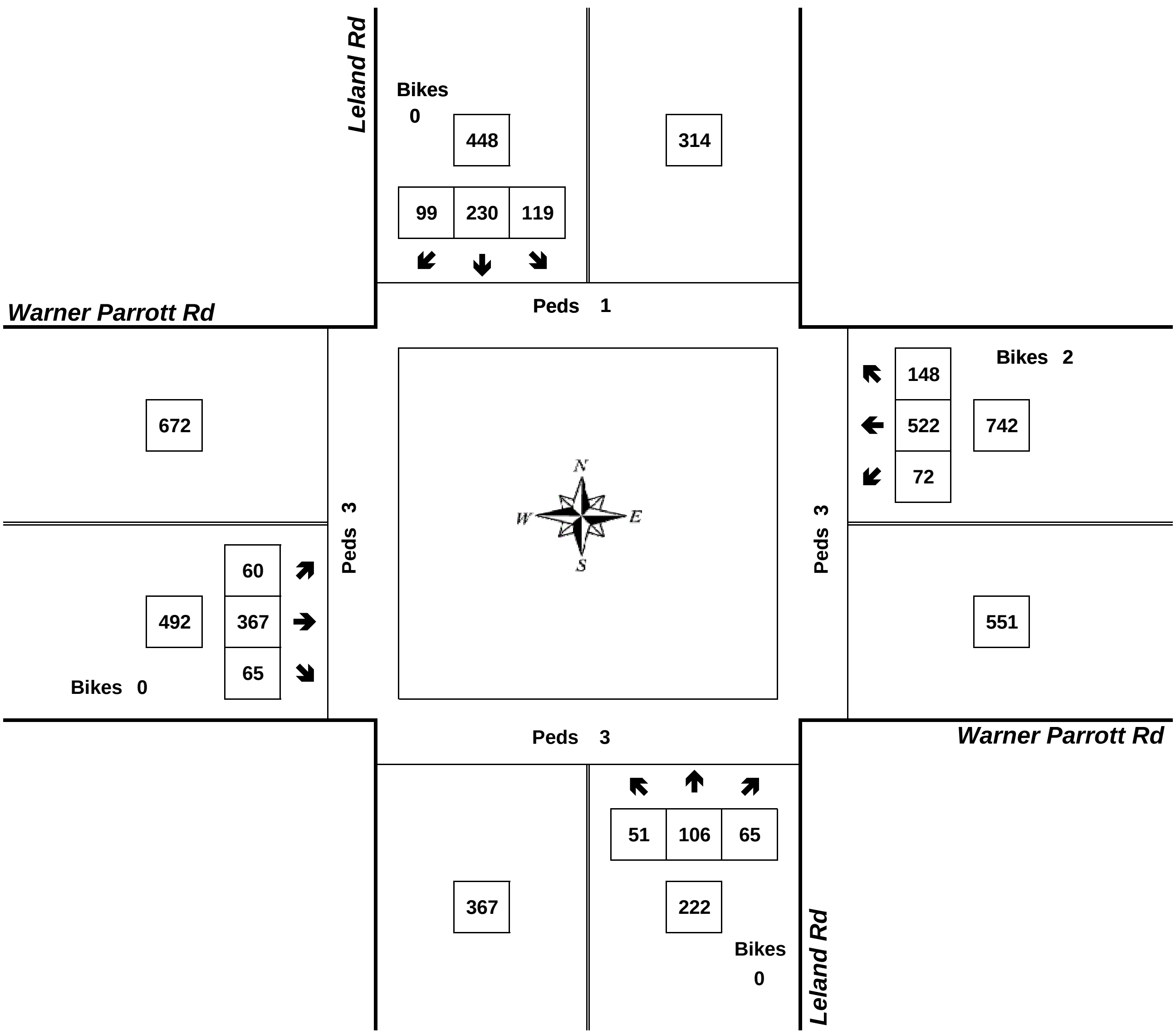
Leland Rd & Warner Parrott Rd

4:45 PM to 5:45 PM

Tuesday, December 02, 2014



Approach	PHF	HV%	Volume
EB	0.92	0.8%	492
WB	0.94	1.2%	742
NB	0.90	2.7%	222
SB	0.97	1.3%	448
Intersection	0.98	1.3%	1,904

Count Period: 4:00 PM to 6:00 PM

Total Vehicle Summary

All Traffic Data Services Inc.
Clay Carney
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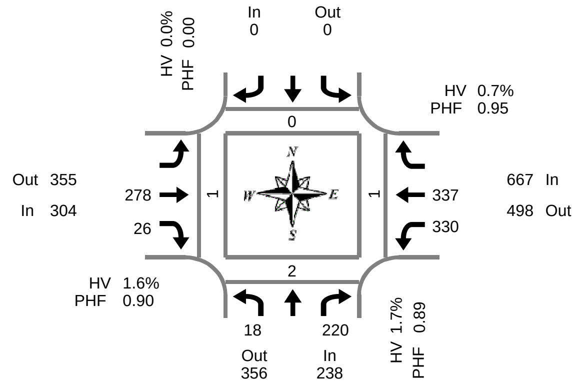


Peak Hour Summary
4:45 PM to 5:45 PM

Central Point Rd & Warner Parrott Rd

Tuesday, December 02, 2014
4:00 PM to 6:00 PM

15-Minute Interval Summary
4:00 PM to 6:00 PM

Interval Start Time	Northbound Central Point Rd				Southbound Central Point Rd				Eastbound Warner Parrott Rd				Westbound Warner Parrott Rd				Interval Total
	L		R	Bikes				Bikes		T	R	Bikes	L	T		Bikes	
4:00 PM	5		50	0				0		60	8	0	80	69		0	272
4:15 PM	5		55	0				0		62	5	0	68	81		0	276
4:30 PM	4		45	0				0		67	7	0	84	82		1	289
4:45 PM	2		52	0				0		75	9	0	80	79		0	297
5:00 PM	6		56	0				0		61	6	0	75	91		0	295
5:15 PM	6		61	0				0		72	7	0	85	82		0	313
5:30 PM	4		51	0				0		70	4	1	90	85		2	304
5:45 PM	6		42	0				0		71	6	0	74	77		0	276
Total Survey	38		412	0				0		538	52	1	636	646		3	2,322

Interval Start Time	Pedestrians Crosswalk			
	North	South	East	West
4:00 PM	0	2	0	0
4:15 PM	0	1	0	0
4:30 PM	0	0	2	0
4:45 PM	0	0	0	0
5:00 PM	0	0	0	1
5:15 PM	0	2	1	0
5:30 PM	0	0	0	0
5:45 PM	0	0	0	0
Total Survey	0	5	3	1

Peak Hour Summary
4:45 PM to 5:45 PM

By Approach	Northbound Central Point Rd				Southbound Central Point Rd				Eastbound Warner Parrott Rd				Westbound Warner Parrott Rd				Total
	In	Out	Total	Bikes	In	Out	Total	Bikes	In	Out	Total	Bikes	In	Out	Total	Bikes	
Volume	238	356	594	0	0	0	0	0	304	355	659	1	667	498	1,165	2	1,209
%HV	1.7%				0.0%				1.6%				0.7%				1.2%
PHF	0.89				0.00				0.90				0.95				0.97

	Pedestrians Crosswalk			
	North	South	East	West
Volume	0	2	1	1

By Movement	Northbound Central Point Rd				Southbound Central Point Rd				Eastbound Warner Parrott Rd				Westbound Warner Parrott Rd				Total
	L		R	Total				Total		T	R	Total	L	T		Total	
Volume	18		220	238				0		278	26	304	330	337		667	1,209
%HV	11.1%	NA	0.9%	1.7%	NA	NA	NA	0.0%	NA	1.1%	7.7%	1.6%	0.6%	0.9%	NA	0.7%	1.2%
PHF	0.75		0.90	0.89				0.00		0.93	0.72	0.90	0.92	0.93		0.95	0.97

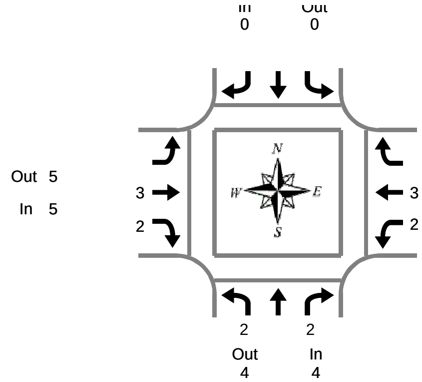
Rolling Hour Summary
4:00 PM to 6:00 PM

Interval Start Time	Northbound Central Point Rd				Southbound Central Point Rd				Eastbound Warner Parrott Rd				Westbound Warner Parrott Rd				Interval Total
	L		R	Bikes				Bikes		T	R	Bikes	L	T		Bikes	
4:00 PM	16		202	0				0		264	29	0	312	311		1	1,134
4:15 PM	17		208	0				0		265	27	0	307	333		1	1,157
4:30 PM	18		214	0				0		275	29	0	324	334		1	1,194
4:45 PM	18		220	0				0		278	26	1	330	337		2	1,209
5:00 PM	22		210	0				0		274	23	1	324	335		2	1,188

Interval Start Time	Pedestrians Crosswalk			
	North	South	East	West
4:00 PM	0	3	2	0
4:15 PM	0	1	2	1
4:30 PM	0	2	3	1
4:45 PM	0	2	1	1
5:00 PM	0	2	1	1

Heavy Vehicle Summary

All Traffic Data Services Inc.
Clay Carney
(503) 833-2740



Peak Hour Summary
4:45 PM to 5:45 PM

Central Point Rd & Warner Parrott Rd

Tuesday, December 02, 2014
4:00 PM to 6:00 PM

Heavy Vehicle 15-Minute Interval Summary
4:00 PM to 6:00 PM

Interval Start Time	**Northbound** Central Point Rd L		R	Total	**Southbound** Central Point Rd			Total	**Eastbound** Warner Parrott Rd	T	R	Total	**Westbound** Warner Parrott Rd L	T		Total	Interval Total
4:00 PM	1		1	2				0		2	1	3	2	1		3	8
4:15 PM	2		0	2				0		1	0	1	1	2		3	6
4:30 PM	0		2	2				0		1	1	2	3	1		4	8
4:45 PM	0		1	1				0		2	0	2	1	2		3	6
5:00 PM	0		0	0				0		0	1	1	0	1		1	2
5:15 PM	1		1	2				0		0	1	1	1	0		1	4
5:30 PM	1		0	1				0		1	0	1	0	0		0	2
5:45 PM	0		0	0				0		0	0	0	1	1		2	2
Total Survey	5		5	10				0		7	4	11	9	8		17	38

Heavy Vehicle Peak Hour Summary
4:45 PM to 5:45 PM

By Approach	**Northbound** Central Point Rd In	Out	Total	**Southbound** Central Point Rd In	Out	Total	**Eastbound** Warner Parrott Rd In	Out	Total	**Westbound** Warner Parrott Rd In	Out	Total	Total
Volume	4	4	8	0	0	0	5	5	10	5	5	10	14
PHF	0.17			0.00			0.21			0.13			0.16

By Movement	**Northbound** Central Point Rd L		R	Total	**Southbound** Central Point Rd			Total	**Eastbound** Warner Parrott Rd	T	R	Total	**Westbound** Warner Parrott Rd L	T		Total	Total
Volume	2		2	4				0		3	2	5	2	3		5	14
PHF	0.17		0.17	0.17				0.00		0.19	0.25	0.21	0.08	0.15		0.13	0.16

Heavy Vehicle Rolling Hour Summary
4:00 PM to 6:00 PM

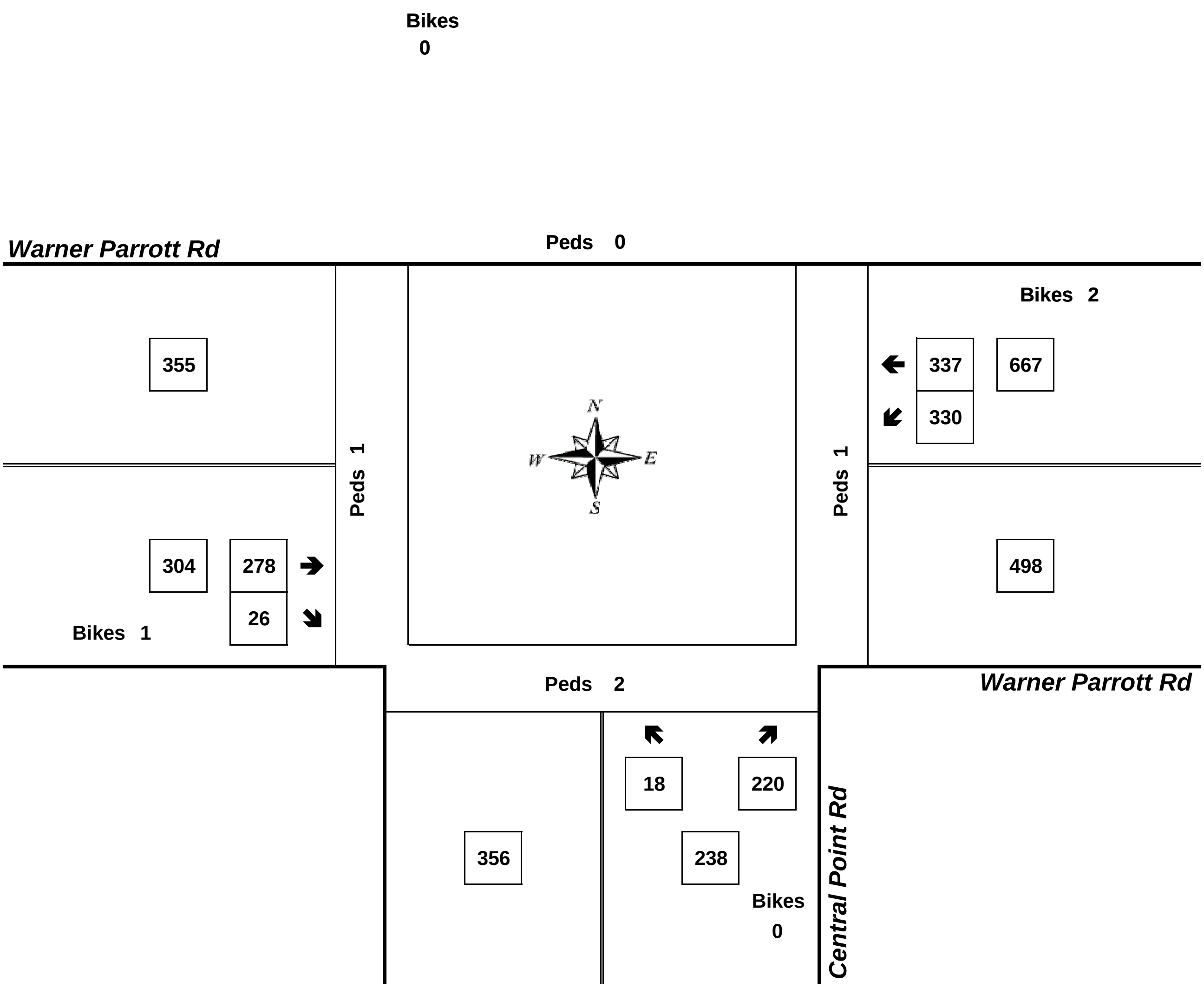
Interval Start Time	**Northbound** Central Point Rd L		R	Total	**Southbound** Central Point Rd			Total	**Eastbound** Warner Parrott Rd	T	R	Total	**Westbound** Warner Parrott Rd L	T		Total	Interval Total
4:00 PM	3		4	7				0		6	2	8	7	6		13	28
4:15 PM	2		3	5				0		4	2	6	5	6		11	22
4:30 PM	1		4	5				0		3	3	6	5	4		9	20
4:45 PM	2		2	4				0		3	2	5	2	3		5	14
5:00 PM	2		1	3				0		1	2	3	2	2		4	10

Peak Hour Summary

All Traffic Data Services Inc.
Clay Carney
(503) 833-2740

Central Point Rd & Warner Parrott Rd

4:45 PM to 5:45 PM
Tuesday, December 02, 2014



Approach	PHF	HV%	Volume
EB	0.90	1.6%	304
WB	0.95	0.7%	667
NB	0.89	1.7%	238
SB	0.00	0.0%	0
Intersection	0.97	1.2%	1,209

Count Period: 4:00 PM to 6:00 PM

HCM Intersection Analysis (Synchro)

Movement	WBL	WBR	SEL	SER	NEL	NER
Lane Configurations						
Volume (vph)	400	475	340	125	65	350
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.5	4.5	4.5		4.0	4.5
Lane Util. Factor	1.00	1.00	0.97		1.00	1.00
Frpb, ped/bikes	1.00	1.00	0.99		1.00	1.00
Flpb, ped/bikes	1.00	1.00	1.00		1.00	1.00
Frt	1.00	0.85	0.96		1.00	0.85
Flt Protected	0.95	1.00	0.96		0.95	1.00
Satd. Flow (prot)	1805	1615	3296		1719	1599
Flt Permitted	0.95	1.00	0.96		0.95	1.00
Satd. Flow (perm)	1805	1615	3296		1719	1599
Peak-hour factor, PHF	0.97	0.97	0.97	0.97	0.97	0.97
Adj. Flow (vph)	412	490	351	129	67	361
RTOR Reduction (vph)	0	38	32	0	0	61
Lane Group Flow (vph)	412	452	448	0	67	300
Confl. Peds. (#/hr)	5			5		1
Heavy Vehicles (%)	0%	0%	2%	4%	5%	1%
Turn Type	Prot	custom	Prot		Prot	custom
Protected Phases	1 3 4	1 2 3 4	2		5	1 3 4 5
Permitted Phases						
Actuated Green, G (s)	70.4	104.4	29.5		7.0	81.4
Effective Green, g (s)	66.4	100.4	29.5		7.0	73.4
Actuated g/C Ratio	0.55	0.84	0.25		0.06	0.61
Clearance Time (s)			4.5		4.0	
Vehicle Extension (s)			3.0		3.0	
Lane Grp Cap (vph)	999	1352	810		100	978
v/s Ratio Prot	c0.23	0.28	c0.14		c0.04	0.19
v/s Ratio Perm						
v/c Ratio	0.41	0.33	0.55		0.67	0.31
Uniform Delay, d1	15.5	2.2	39.4		55.3	11.1
Progression Factor	0.25	0.55	1.00		1.00	1.00
Incremental Delay, d2	0.1	0.0	0.8		16.2	0.2
Delay (s)	3.9	1.3	40.3		71.5	11.3
Level of Service	A	A	D		E	B
Approach Delay (s)	2.5		40.3		20.7	
Approach LOS	A		D		C	

Intersection Summary			
HCM 2000 Control Delay	16.8	HCM 2000 Level of Service	B
HCM 2000 Volume to Capacity ratio	0.49		
Actuated Cycle Length (s)	119.9	Sum of lost time (s)	21.5
Intersection Capacity Utilization	50.7%	ICU Level of Service	A
Analysis Period (min)	15		
c Critical Lane Group			

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	90	485	115	160	615	180	140	180	115	170	270	120
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.5	4.5		4.5	4.5		4.0	4.5		4.0	4.5	
Lane Util. Factor	1.00	1.00		1.00	0.95		1.00	1.00		1.00	1.00	
Frpb, ped/bikes	1.00	0.99		1.00	0.99		1.00	0.98		1.00	1.00	
Flpb, ped/bikes	1.00	1.00		1.00	1.00		1.00	1.00		1.00	1.00	
Frt	1.00	0.97		1.00	0.97		1.00	0.94		1.00	0.95	
Flt Protected	0.95	1.00		0.95	1.00		0.95	1.00		0.95	1.00	
Satd. Flow (prot)	1770	1793		1770	3391		1770	1725		1767	1769	
Flt Permitted	0.95	1.00		0.95	1.00		0.16	1.00		0.25	1.00	
Satd. Flow (perm)	1770	1793		1770	3391		292	1725		464	1769	
Peak-hour factor, PHF	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98
Adj. Flow (vph)	92	495	117	163	628	184	143	184	117	173	276	122
RTOR Reduction (vph)	0	7	0	0	23	0	0	19	0	0	13	0
Lane Group Flow (vph)	92	605	0	163	789	0	143	282	0	173	385	0
Confl. Peds. (#/hr)	5		8	8		5			6	6		
Confl. Bikes (#/hr)			1						4			2
Turn Type	Split	NA		Split	NA		pm+pt	NA		pm+pt	NA	
Protected Phases	2 5	2 5		1	1		3	4		3	4	
Permitted Phases							4			4		
Actuated Green, G (s)	41.0	41.0		28.5	28.5		33.4	25.5		33.4	25.5	
Effective Green, g (s)	41.0	41.0		28.5	28.5		33.4	25.5		33.4	25.5	
Actuated g/C Ratio	0.34	0.34		0.24	0.24		0.28	0.21		0.28	0.21	
Clearance Time (s)				4.5	4.5		4.0	4.5		4.0	4.5	
Vehicle Extension (s)				3.0	3.0		3.0	3.0		3.0	3.0	
Lane Grp Cap (vph)	605	613		420	806		178	366		215	376	
v/s Ratio Prot	0.05	c0.34		0.09	c0.23		0.05	0.16		c0.05	c0.22	
v/s Ratio Perm							0.17			0.17		
v/c Ratio	0.15	0.99		0.39	0.98		0.80	0.77		0.80	1.02	
Uniform Delay, d1	27.4	39.2		38.4	45.4		51.8	44.4		48.1	47.2	
Progression Factor	0.70	0.72		1.00	1.00		1.00	1.00		1.00	1.00	
Incremental Delay, d2	0.1	31.0		0.6	26.3		22.4	9.6		19.2	52.4	
Delay (s)	19.2	59.1		39.0	71.7		74.2	54.1		67.3	99.6	
Level of Service	B	E		D	E		E	D		E	F	
Approach Delay (s)		53.9			66.2			60.6			89.8	
Approach LOS		D			E			E			F	

Intersection Summary			
HCM 2000 Control Delay	67.1	HCM 2000 Level of Service	E
HCM 2000 Volume to Capacity ratio	1.02		
Actuated Cycle Length (s)	119.9	Sum of lost time (s)	21.5
Intersection Capacity Utilization	85.4%	ICU Level of Service	E
Analysis Period (min)	15		
c Critical Lane Group			

Movement	WBL	WBR	SEL	SER	NEL	NER
Lane Configurations						
Volume (vph)	400	475	340	125	65	350
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.5	4.5	4.5		4.0	4.5
Lane Util. Factor	1.00	1.00	0.97		1.00	1.00
Frpb, ped/bikes	1.00	1.00	0.99		1.00	1.00
Flpb, ped/bikes	1.00	1.00	1.00		1.00	1.00
Frt	1.00	0.85	0.96		1.00	0.85
Flt Protected	0.95	1.00	0.96		0.95	1.00
Satd. Flow (prot)	1805	1615	3298		1719	1599
Flt Permitted	0.95	1.00	0.96		0.95	1.00
Satd. Flow (perm)	1805	1615	3298		1719	1599
Peak-hour factor, PHF	0.97	0.97	0.97	0.97	0.97	0.97
Adj. Flow (vph)	412	490	351	129	67	361
RTOR Reduction (vph)	0	150	32	0	0	165
Lane Group Flow (vph)	412	340	448	0	67	196
Confl. Peds. (#/hr)	5			5		1
Heavy Vehicles (%)	0%	0%	2%	4%	5%	1%
Turn Type	Prot	custom	Prot		Prot	custom
Protected Phases	1 3 4	1 2 3 4	2		5	1 3 4 5
Permitted Phases						
Actuated Green, G (s)	51.5	78.5	22.5		11.0	62.5
Effective Green, g (s)	47.5	74.5	22.5		11.0	58.5
Actuated g/C Ratio	0.44	0.69	0.21		0.10	0.54
Clearance Time (s)			4.5		4.0	
Vehicle Extension (s)			3.0		3.0	
Lane Grp Cap (vph)	797	1119	690		175	870
v/s Ratio Prot	c0.23	0.21	c0.14		c0.04	0.12
v/s Ratio Perm						
v/c Ratio	0.52	0.30	0.65		0.38	0.23
Uniform Delay, d1	21.7	6.4	38.9		45.1	12.7
Progression Factor	0.31	2.04	1.00		1.00	1.00
Incremental Delay, d2	0.1	0.0	2.1		1.4	0.1
Delay (s)	6.7	13.1	41.0		46.5	12.9
Level of Service	A	B	D		D	B
Approach Delay (s)	10.2		41.0		18.1	
Approach LOS	B		D		B	

Intersection Summary			
HCM 2000 Control Delay	20.2	HCM 2000 Level of Service	C
HCM 2000 Volume to Capacity ratio	0.53		
Actuated Cycle Length (s)	107.5	Sum of lost time (s)	25.5
Intersection Capacity Utilization	50.7%	ICU Level of Service	A
Analysis Period (min)	15		
c Critical Lane Group			

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	90	485	115	160	615	180	140	180	115	170	270	120
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.5	4.5		4.5	4.5		4.0	4.5		4.0	4.5	
Lane Util. Factor	1.00	1.00		1.00	0.95		1.00	1.00		1.00	1.00	
Frpb, ped/bikes	1.00	0.99		1.00	0.99		1.00	0.98		1.00	1.00	
Flpb, ped/bikes	1.00	1.00		1.00	1.00		1.00	1.00		1.00	1.00	
Frt	1.00	0.97		1.00	0.97		1.00	0.94		1.00	0.95	
Flt Protected	0.95	1.00		0.95	1.00		0.95	1.00		0.95	1.00	
Satd. Flow (prot)	1770	1794		1770	3393		1770	1723		1766	1768	
Flt Permitted	0.95	1.00		0.95	1.00		0.32	1.00		0.32	1.00	
Satd. Flow (perm)	1770	1794		1770	3393		596	1723		595	1768	
Peak-hour factor, PHF	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98
Adj. Flow (vph)	92	495	117	163	628	184	143	184	117	173	276	122
RTOR Reduction (vph)	0	6	0	0	22	0	0	19	0	0	13	0
Lane Group Flow (vph)	92	606	0	163	790	0	143	282	0	173	385	0
Confl. Peds. (#/hr)	5		8	8		5			6	6		
Confl. Bikes (#/hr)			1						4			2
Turn Type	Split	NA		Split	NA		pm+pt	NA		pm+pt	NA	
Protected Phases	2 5	2 5		1	1		3	4		3	4	
Permitted Phases							4			4		
Actuated Green, G (s)	38.0	38.0		22.5	22.5		20.5	12.5		20.5	12.5	
Effective Green, g (s)	38.0	38.0		22.5	22.5		20.5	12.5		20.5	12.5	
Actuated g/C Ratio	0.35	0.35		0.21	0.21		0.19	0.12		0.19	0.12	
Clearance Time (s)				4.5	4.5		4.0	4.5		4.0	4.5	
Vehicle Extension (s)				3.0	3.0		3.0	3.0		3.0	3.0	
Lane Grp Cap (vph)	625	634		370	710		201	200		200	205	
v/s Ratio Prot	0.05	c0.34		0.09	c0.23		0.05	0.16		c0.06	c0.22	
v/s Ratio Perm							0.08			0.10		
v/c Ratio	0.15	0.96		0.44	1.11		0.71	1.41		0.86	1.88	
Uniform Delay, d1	23.7	33.9		37.0	42.5		45.1	47.5		45.8	47.5	
Progression Factor	0.53	0.61		1.00	1.00		1.00	1.00		1.00	1.00	
Incremental Delay, d2	0.1	22.9		0.8	69.0		11.3	212.4		30.0	412.5	
Delay (s)	12.6	43.7		37.9	111.5		56.4	259.9		75.8	460.0	
Level of Service	B	D		D	F		E	F		E	F	
Approach Delay (s)		39.6			99.2			194.4			343.6	
Approach LOS		D			F			F			F	

Intersection Summary			
HCM 2000 Control Delay	151.1	HCM 2000 Level of Service	F
HCM 2000 Volume to Capacity ratio	1.12		
Actuated Cycle Length (s)	107.5	Sum of lost time (s)	25.5
Intersection Capacity Utilization	85.4%	ICU Level of Service	E
Analysis Period (min)	15		
c Critical Lane Group			

Intersection	
Int Delay, s/veh	6.2

Movement	EBT	EBR	WBL	WBT	NEL	NER
Vol, veh/h	340	125	475	460	0	390
Conflicting Peds, #/hr	0	5	5	0	0	1
Sign Control	Free	Free	Free	Free	Stop	Stop
RT Channelized	-	None	-	None	-	None
Storage Length	-	-	0	-	-	0
Veh in Median Storage, #	0	-	-	0	0	-
Grade, %	0	-	-	0	0	-
Peak Hour Factor	97	97	97	97	97	97
Heavy Vehicles, %	2	4	0	0	5	1
Mvmt Flow	351	129	490	474	0	402

Major/Minor	Major1		Major2		Minor1	
Conflicting Flow All	0	0	480	0	1870	246
Stage 1	-	-	-	-	416	-
Stage 2	-	-	-	-	1454	-
Critical Hdwy	-	-	4.1	-	6.675	6.915
Critical Hdwy Stg 1	-	-	-	-	5.875	-
Critical Hdwy Stg 2	-	-	-	-	5.475	-
Follow-up Hdwy	-	-	2.2	-	3.5475	3.3095
Pot Cap-1 Maneuver	-	-	1093	-	69	758
Stage 1	-	-	-	-	627	-
Stage 2	-	-	-	-	209	-
Platoon blocked, %	-	-		-		
Mov Cap-1 Maneuver	-	-	1088	-	38	754
Mov Cap-2 Maneuver	-	-	-	-	38	-
Stage 1	-	-	-	-	626	-
Stage 2	-	-	-	-	114	-

Approach	EB	WB	NE
HCM Control Delay, s	0	5.6	15.1
HCM LOS			C

Minor Lane/Major Mvmt	NELn1	EBT	EBR	WBL	WBT
Capacity (veh/h)	754	-	-	1088	-
HCM Lane V/C Ratio	0.533	-	-	0.45	-
HCM Control Delay (s)	15.1	-	-	11	-
HCM Lane LOS	C	-	-	B	-
HCM 95th %tile Q(veh)	3.2	-	-	2.4	-

HCM Signalized Intersection Capacity Analysis
98: Leland Rd/Linn Ave & Warner Milne Rd

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	130	485	115	160	615	180	160	180	115	170	270	120
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	4.5		4.0	4.5		4.0	4.5		4.0	4.5	
Lane Util. Factor	1.00	1.00		1.00	0.95		1.00	1.00		1.00	1.00	
Frpb, ped/bikes	1.00	0.99		1.00	0.99		1.00	0.99		1.00	1.00	
Flpb, ped/bikes	1.00	1.00		1.00	1.00		1.00	1.00		1.00	1.00	
Frt	1.00	0.97		1.00	0.97		1.00	0.94		1.00	0.95	
Flt Protected	0.95	1.00		0.95	1.00		0.95	1.00		0.95	1.00	
Satd. Flow (prot)	1770	1796		1770	3395		1770	1729		1770	1770	
Flt Permitted	0.95	1.00		0.95	1.00		0.95	1.00		0.95	1.00	
Satd. Flow (perm)	1770	1796		1770	3395		1770	1729		1770	1770	
Peak-hour factor, PHF	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98
Adj. Flow (vph)	133	495	117	163	628	184	163	184	117	173	276	122
RTOR Reduction (vph)	0	10	0	0	30	0	0	26	0	0	18	0
Lane Group Flow (vph)	133	602	0	163	782	0	163	275	0	173	380	0
Confl. Peds. (#/hr)	5		8	8		5			6	6		
Confl. Bikes (#/hr)			1						4			2
Turn Type	Prot	NA		Prot	NA		Prot	NA		Prot	NA	
Protected Phases	5	2		1	6		3	8		7	4	
Permitted Phases												
Actuated Green, G (s)	8.8	30.9		9.0	31.1		9.0	21.4		9.0	21.4	
Effective Green, g (s)	8.8	30.9		9.0	31.1		9.0	21.4		9.0	21.4	
Actuated g/C Ratio	0.10	0.35		0.10	0.36		0.10	0.25		0.10	0.25	
Clearance Time (s)	4.0	4.5		4.0	4.5		4.0	4.5		4.0	4.5	
Vehicle Extension (s)	3.0	3.0		3.0	3.0		3.0	3.0		3.0	3.0	
Lane Grp Cap (vph)	178	635		182	1209		182	423		182	433	
v/s Ratio Prot	0.08	c0.34		c0.09	0.23		0.09	0.16		c0.10	c0.21	
v/s Ratio Perm												
v/c Ratio	0.75	0.95		0.90	0.65		0.90	0.65		0.95	0.88	
Uniform Delay, d1	38.2	27.4		38.7	23.5		38.7	29.6		38.9	31.7	
Progression Factor	1.00	1.00		1.00	1.00		1.00	1.00		1.00	1.00	
Incremental Delay, d2	15.7	23.5		38.4	1.2		38.4	3.6		52.2	17.8	
Delay (s)	53.8	50.9		77.1	24.7		77.1	33.2		91.2	49.5	
Level of Service	D	D		E	C		E	C		F	D	
Approach Delay (s)		51.4			33.5			48.6			62.1	
Approach LOS		D			C			D			E	

Intersection Summary			
HCM 2000 Control Delay	46.8	HCM 2000 Level of Service	D
HCM 2000 Volume to Capacity ratio	0.92		
Actuated Cycle Length (s)	87.3	Sum of lost time (s)	17.0
Intersection Capacity Utilization	86.1%	ICU Level of Service	E
Analysis Period (min)	15		
c Critical Lane Group			

Intersection	
Int Delay, s/veh	6.3

Movement	EBT	EBR	WBL	WBT	NBL	NBR
Vol, veh/h	340	125	475	460	0	395
Conflicting Peds, #/hr	0	5	5	0	0	1
Sign Control	Free	Free	Free	Free	Stop	Stop
RT Channelized	-	None	-	None	-	None
Storage Length	-	-	0	-	-	0
Veh in Median Storage, #	0	-	-	0	0	-
Grade, %	0	-	-	0	0	-
Peak Hour Factor	97	97	97	97	97	97
Heavy Vehicles, %	2	4	0	0	5	1
Mvmt Flow	351	129	490	474	0	407

Major/Minor	Major1		Major2		Minor1	
Conflicting Flow All	0	0	480	0	1870	246
Stage 1	-	-	-	-	416	-
Stage 2	-	-	-	-	1454	-
Critical Hdwy	-	-	4.1	-	6.675	6.915
Critical Hdwy Stg 1	-	-	-	-	5.875	-
Critical Hdwy Stg 2	-	-	-	-	5.475	-
Follow-up Hdwy	-	-	2.2	-	3.5475	3.3095
Pot Cap-1 Maneuver	-	-	1093	-	69	758
Stage 1	-	-	-	-	627	-
Stage 2	-	-	-	-	209	-
Platoon blocked, %	-	-		-		
Mov Cap-1 Maneuver	-	-	1088	-	38	754
Mov Cap-2 Maneuver	-	-	-	-	38	-
Stage 1	-	-	-	-	626	-
Stage 2	-	-	-	-	114	-

Approach	EB	WB	NB
HCM Control Delay, s	0	5.6	15.2
HCM LOS			C

Minor Lane/Major Mvmt	NBLn1	EBT	EBR	WBL	WBT
Capacity (veh/h)	754	-	-	1088	-
HCM Lane V/C Ratio	0.54	-	-	0.45	-
HCM Control Delay (s)	15.2	-	-	11	-
HCM Lane LOS	C	-	-	B	-
HCM 95th %tile Q(veh)	3.3	-	-	2.4	-

Movement	EBU	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT
Lane Configurations												
Volume (vph)	45	90	485	115	160	615	180	155	180	115	170	270
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)		4.0	4.5		4.0	4.5		4.0	4.5		4.0	4.5
Lane Util. Factor		1.00	1.00		1.00	0.95		1.00	1.00		1.00	1.00
Frpb, ped/bikes		1.00	0.99		1.00	0.99		1.00	0.99		1.00	1.00
Flpb, ped/bikes		1.00	1.00		1.00	1.00		1.00	1.00		1.00	1.00
Frt		1.00	0.97		1.00	0.97		1.00	0.94		1.00	0.95
Flt Protected		0.95	1.00		0.95	1.00		0.95	1.00		0.95	1.00
Satd. Flow (prot)		1566	1796		1770	3395		1770	1729		1770	1770
Flt Permitted		0.95	1.00		0.95	1.00		0.95	1.00		0.95	1.00
Satd. Flow (perm)		1566	1796		1770	3395		1770	1729		1770	1770
Peak-hour factor, PHF	0.92	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98
Adj. Flow (vph)	49	92	495	117	163	628	184	158	184	117	173	276
RTOR Reduction (vph)	0	0	9	0	0	27	0	0	26	0	0	18
Lane Group Flow (vph)	0	141	603	0	163	785	0	158	275	0	173	380
Confl. Peds. (#/hr)		5		8	8		5			6	6	
Confl. Bikes (#/hr)				1						4		
Turn Type	Prot	Prot	NA		Prot	NA		Prot	NA		Prot	NA
Protected Phases	5	5	2		1	6		3	8		7	4
Permitted Phases												
Actuated Green, G (s)		13.1	31.5		9.1	27.5		7.1	21.2		7.1	21.2
Effective Green, g (s)		13.1	31.5		9.1	27.5		7.1	21.2		7.1	21.2
Actuated g/C Ratio		0.15	0.37		0.11	0.32		0.08	0.25		0.08	0.25
Clearance Time (s)		4.0	4.5		4.0	4.5		4.0	4.5		4.0	4.5
Vehicle Extension (s)		3.0	3.0		3.0	3.0		3.0	3.0		3.0	3.0
Lane Grp Cap (vph)		238	658		187	1086		146	426		146	436
v/s Ratio Prot		0.09	c0.34		c0.09	0.23		0.09	0.16		c0.10	c0.21
v/s Ratio Perm												
v/c Ratio		0.59	0.92		0.87	0.72		1.08	0.65		1.18	0.87
Uniform Delay, d1		33.9	25.9		37.8	25.8		39.4	29.0		39.4	31.0
Progression Factor		1.00	1.00		1.00	1.00		1.00	1.00		1.00	1.00
Incremental Delay, d2		3.9	17.4		33.0	2.4		98.2	3.4		132.7	17.1
Delay (s)		37.8	43.4		70.8	28.2		137.6	32.4		172.1	48.1
Level of Service		D	D		E	C		F	C		F	D
Approach Delay (s)			42.3			35.4			68.6			85.7
Approach LOS			D			D			E			F

Intersection Summary			
HCM 2000 Control Delay	53.2	HCM 2000 Level of Service	D
HCM 2000 Volume to Capacity ratio	0.92		
Actuated Cycle Length (s)	85.9	Sum of lost time (s)	17.0
Intersection Capacity Utilization	85.8%	ICU Level of Service	E
Analysis Period (min)	15		
c Critical Lane Group			

Movement	SBR
Lane Configurations	
Volume (vph)	120
Ideal Flow (vphpl)	1900
Total Lost time (s)	
Lane Util. Factor	
Frpb, ped/bikes	
Flpb, ped/bikes	
Frt	
Flt Protected	
Satd. Flow (prot)	
Flt Permitted	
Satd. Flow (perm)	
Peak-hour factor, PHF	0.98
Adj. Flow (vph)	122
RTOR Reduction (vph)	0
Lane Group Flow (vph)	0
Confl. Peds. (#/hr)	
Confl. Bikes (#/hr)	2
Turn Type	
Protected Phases	
Permitted Phases	
Actuated Green, G (s)	
Effective Green, g (s)	
Actuated g/C Ratio	
Clearance Time (s)	
Vehicle Extension (s)	
Lane Grp Cap (vph)	
v/s Ratio Prot	
v/s Ratio Perm	
v/c Ratio	
Uniform Delay, d1	
Progression Factor	
Incremental Delay, d2	
Delay (s)	
Level of Service	
Approach Delay (s)	
Approach LOS	

Intersection Summary

Intersection	
Int Delay, s/veh	19.2

Movement	EBT	EBR	WBL	WBT	NEL	NER
Vol, veh/h	340	125	475	410	55	350
Conflicting Peds, #/hr	0	5	5	0	0	1
Sign Control	Free	Free	Free	Free	Stop	Stop
RT Channelized	-	None	-	None	-	None
Storage Length	-	-	0	-	100	0
Veh in Median Storage, #	0	-	-	0	0	-
Grade, %	0	-	-	0	0	-
Peak Hour Factor	97	97	97	97	97	97
Heavy Vehicles, %	2	4	0	0	5	1
Mvmt Flow	351	129	490	423	57	361

Major/Minor	Major1		Major2		Minor1	
Conflicting Flow All	0	0	480	0	1818	246
Stage 1	-	-	-	-	416	-
Stage 2	-	-	-	-	1402	-
Critical Hdwy	-	-	4.1	-	6.675	6.915
Critical Hdwy Stg 1	-	-	-	-	5.875	-
Critical Hdwy Stg 2	-	-	-	-	5.475	-
Follow-up Hdwy	-	-	2.2	-	3.5475	3.3095
Pot Cap-1 Maneuver	-	-	1093	-	75	758
Stage 1	-	-	-	-	627	-
Stage 2	-	-	-	-	222	-
Platoon blocked, %	-	-		-		
Mov Cap-1 Maneuver	-	-	1088	-	~ 41	754
Mov Cap-2 Maneuver	-	-	-	-	~ 41	-
Stage 1	-	-	-	-	626	-
Stage 2	-	-	-	-	122	-

Approach	EB	WB	NE
HCM Control Delay, s	0	5.9	70.3
HCM LOS			F

Minor Lane/Major Mvmt	NELn1	NELn2	EBT	EBR	WBL	WBT
Capacity (veh/h)	41	754	-	-	1088	-
HCM Lane V/C Ratio	1.383	0.479	-	-	0.45	-
HCM Control Delay (s)	$ 428.1	14.1	-	-	11	-
HCM Lane LOS	F	B	-	-	B	-
HCM 95th %tile Q(veh)	5.7	2.6	-	-	2.4	-

Notes

~: Volume exceeds capacity $: Delay exceeds 300s +: Computation Not Defined *: All major volume in platoon

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (vph)	90	485	115	160	615	180	150	180	115	170	270	120
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Total Lost time (s)	4.0	4.5		4.0	4.5		4.0	4.5		4.0	4.5	
Lane Util. Factor	1.00	1.00		1.00	0.95		1.00	1.00		1.00	1.00	
Frpb, ped/bikes	1.00	0.99		1.00	0.99		1.00	0.99		1.00	1.00	
Flpb, ped/bikes	1.00	1.00		1.00	1.00		1.00	1.00		1.00	1.00	
Frt	1.00	0.97		1.00	0.97		1.00	0.94		1.00	0.95	
Flt Protected	0.95	1.00		0.95	1.00		0.95	1.00		0.95	1.00	
Satd. Flow (prot)	1770	1796		1770	3395		1770	1729		1770	1770	
Flt Permitted	0.95	1.00		0.95	1.00		0.95	1.00		0.95	1.00	
Satd. Flow (perm)	1770	1796		1770	3395		1770	1729		1770	1770	
Peak-hour factor, PHF	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98
Adj. Flow (vph)	92	495	117	163	628	184	153	184	117	173	276	122
RTOR Reduction (vph)	0	10	0	0	29	0	0	26	0	0	18	0
Lane Group Flow (vph)	92	602	0	163	783	0	153	275	0	173	380	0
Confl. Peds. (#/hr)	5		8	8		5			6	6		
Confl. Bikes (#/hr)			1						4			2
Turn Type	Prot	NA		Prot	NA		Prot	NA		Prot	NA	
Protected Phases	5	2		1	6		3	8		7	4	
Permitted Phases												
Actuated Green, G (s)	6.8	31.7		9.0	33.9		8.0	20.6		9.0	21.6	
Effective Green, g (s)	6.8	31.7		9.0	33.9		8.0	20.6		9.0	21.6	
Actuated g/C Ratio	0.08	0.36		0.10	0.39		0.09	0.24		0.10	0.25	
Clearance Time (s)	4.0	4.5		4.0	4.5		4.0	4.5		4.0	4.5	
Vehicle Extension (s)	3.0	3.0		3.0	3.0		3.0	3.0		3.0	3.0	
Lane Grp Cap (vph)	137	652		182	1318		162	407		182	437	
v/s Ratio Prot	0.05	c0.34		c0.09	0.23		0.09	0.16		c0.10	c0.21	
v/s Ratio Perm												
v/c Ratio	0.67	0.92		0.90	0.59		0.94	0.68		0.95	0.87	
Uniform Delay, d1	39.2	26.6		38.7	21.2		39.4	30.3		38.9	31.5	
Progression Factor	1.00	1.00		1.00	1.00		1.00	1.00		1.00	1.00	
Incremental Delay, d2	12.2	18.9		38.4	0.7		54.0	4.4		52.2	16.6	
Delay (s)	51.4	45.5		77.1	22.0		93.5	34.7		91.2	48.1	
Level of Service	D	D		E	C		F	C		F	D	
Approach Delay (s)		46.3			31.2			54.5			61.1	
Approach LOS		D			C			D			E	

Intersection Summary			
HCM 2000 Control Delay	45.4	HCM 2000 Level of Service	D
HCM 2000 Volume to Capacity ratio	0.91		
Actuated Cycle Length (s)	87.3	Sum of lost time (s)	17.0
Intersection Capacity Utilization	85.5%	ICU Level of Service	E
Analysis Period (min)	15		
c Critical Lane Group			

Documentation: Effects of Increased U-Turns at Intersections of Divided Facilities and Median Divided Versus Five Lane Undivided Benefits. North Carolina State University. August 2004. Research conducted for the North Carolina Department of Transporation.

1.8% sat flow rate loss in the left turn lane for every 10% incrase in the U-Turn percentage
And an additional 1.5% loss for every 10% U-turns if the U-turning movement is opposed by protected right turn overlap from the cross street.

Warner Parrott

EBT	EBLT	EB U-turn
485	90	45

Sat flow adjustment

loss per 10% U-turns	BASE left turn sat flow
3.3%	1770

Use left turn saturation flow rate of 1566

Percent of u-turners		multiplier	% loss of sat flow	sat flow loss	final sat flow
33%		3	9.90%	175.23	1595
		4	13.20%	233.64	1536

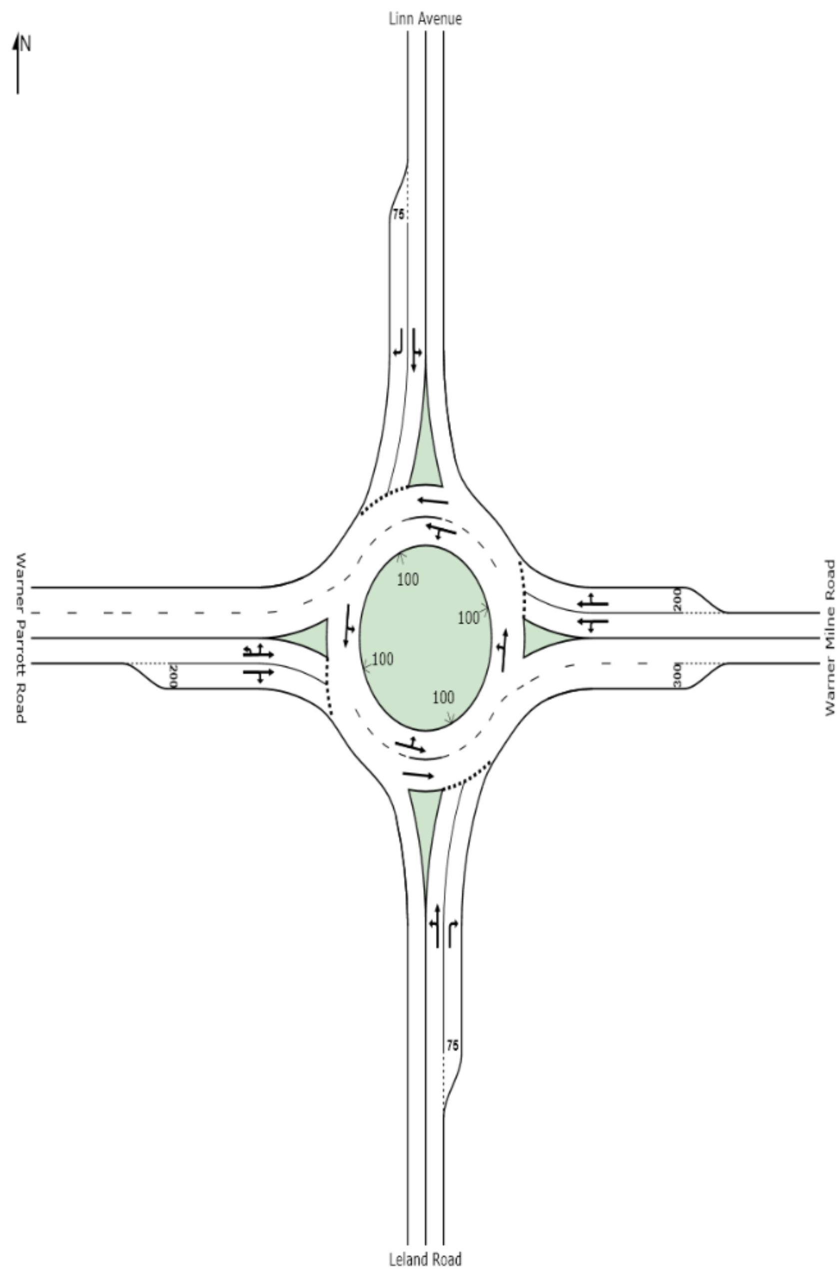
Average
1566

HCM Intersection Analysis (SIDRA)

SITE LAYOUT

Site: Warner Milne/Linn - Planned System

Warner Milne Road/Linn Avenue
2035 Planned System - PM Peak



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SIDRA INTERSECTION 6

MOVEMENT SUMMARY

Site: Warner Milne/Linn - Planned System

Warner Milne Road/Linn Avenue
4-Legged RAB Option
2035 Planned System - PM Peak
Roundabout

Movement Performance - Vehicles

Mov ID	OD Mov	Demand Flows Total veh/h	Demand Flows HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance ft	Prop. Queued	Effective Stop Rate per veh	Average Speed mph
South: Leland Road											
3	L2	158	2.0	0.537	14.5	LOS B	3.7	93.7	0.82	1.77	24.3
8	T1	189	1.0	0.537	14.5	LOS B	3.7	93.7	0.82	1.77	24.3
18	R2	121	0.0	0.281	13.0	LOS B	1.3	32.5	0.73	1.46	25.5
Approach		468	1.1	0.537	14.1	LOS B	3.7	93.7	0.80	0.85	24.6
East: Warner Milne Road											
1	L2	168	0.0	0.582	13.3	LOS B	5.4	136.4	0.84	1.66	25.1
6	T1	647	2.0	0.582	12.7	LOS B	5.5	139.9	0.84	1.63	25.7
16	R2	189	0.0	0.582	12.2	LOS B	5.5	139.9	0.84	1.60	26.3
Approach		1005	1.3	0.582	12.7	LOS B	5.5	139.9	0.84	0.81	25.7
North: Linn Avenue											
7	L2	179	0.0	0.766	26.6	LOS C	6.7	168.2	0.92	2.17	20.2
4	T1	284	1.0	0.766	26.6	LOS C	6.7	168.2	0.92	2.17	20.2
14	R2	126	2.0	0.388	19.9	LOS B	1.8	45.2	0.77	1.62	22.6
Approach		589	0.9	0.766	25.2	LOS C	6.7	168.2	0.89	1.03	20.7
West: Warner Parrott Road											
5u	U	58	2.0	0.672	16.9	LOS B	7.7	195.1	0.96	2.07	23.6
5	L2	95	2.0	0.672	16.9	LOS B	7.7	195.1	0.96	2.07	23.6
2	T1	511	2.0	0.672	15.7	LOS B	7.7	195.1	0.93	1.96	24.2
12	R2	120	2.0	0.433	12.7	LOS B	3.1	78.2	0.83	1.67	26.0
Approach		783	2.0	0.672	15.5	LOS B	7.7	195.1	0.92	0.97	24.4
All Vehicles		2846	1.4	0.766	16.3	LOS B	7.7	195.1	0.86	0.91	23.9

Level of Service (LOS) Method: Delay (HCM 2000).
Roundabout LOS Method: Same as Signalised Intersections.
Vehicle movement LOS values are based on average delay per movement
Intersection and Approach LOS values are based on average delay for all vehicle movements.
Roundabout Capacity Model: SIDRA Standard.
HCM Delay Formula option is used. Control Delay does not include Geometric Delay since Exclude Geometric Delay option applies.
Gap-Acceptance Capacity: SIDRA Standard (Akçelik M3D).
HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.

INTERSECTION SUMMARY

Site: Warner Milne/Linn - Planned System

Warner Milne Road/Linn Avenue
4-Legged RAB Option
2035 Planned System - PM Peak
Roundabout

Intersection Performance - Hourly Values

Performance Measure	Vehicles		Persons	
Travel Speed (Average)	29.4	mph	29.4	mph
Travel Distance (Total)	1805.7	veh-mi/h	2166.9	pers-mi/h
Travel Time (Total)	61.5	veh-h/h	73.8	pers-h/h
Demand Flows (Total)	2846	veh/h	3416	pers/h
Percent Heavy Vehicles (Demand)	1.4	%		
Degree of Saturation	0.766			
Practical Spare Capacity	10.9	%		
Effective Intersection Capacity	3714	veh/h		
Control Delay (Total)	12.89	veh-h/h	15.47	pers-h/h
Control Delay (Average)	16.3	sec	16.3	sec
Control Delay (Worst Lane)	26.6	sec		
Control Delay (Worst Movement)	26.6	sec	26.6	sec
Geometric Delay (Average)	0.0	sec		
Stop-Line Delay (Average)	16.3	sec		
Idling Time (Average)	10.3	sec		
Intersection Level of Service (LOS)	LOS B			
95% Back of Queue - Vehicles (Worst Lane)	7.7	veh		
95% Back of Queue - Distance (Worst Lane)	195.1	ft		
Queue Storage Ratio (Worst Lane)	0.16			
Total Effective Stops	2581	veh/h	3097	pers/h
Effective Stop Rate	0.91	per veh	0.91	per pers
Proportion Queued	0.86		0.86	
Performance Index	117.2		117.2	
Cost (Total)	740.52	$/h	740.52	$/h
Fuel Consumption (Total)	75.2	gal/h		
Carbon Dioxide (Total)	671.0	kg/h		
Hydrocarbons (Total)	0.251	kg/h		
Carbon Monoxide (Total)	3.322	kg/h		
NOx (Total)	0.952	kg/h		

Level of Service (LOS) Method: Delay (HCM 2000).
Roundabout LOS Method: Same as Signalised Intersections.
Intersection LOS value for Vehicles is based on average delay for all vehicle movements.
Roundabout Capacity Model: SIDRA Standard.
HCM Delay Formula option is used. Control Delay does not include Geometric Delay since Exclude Geometric Delay option applies.

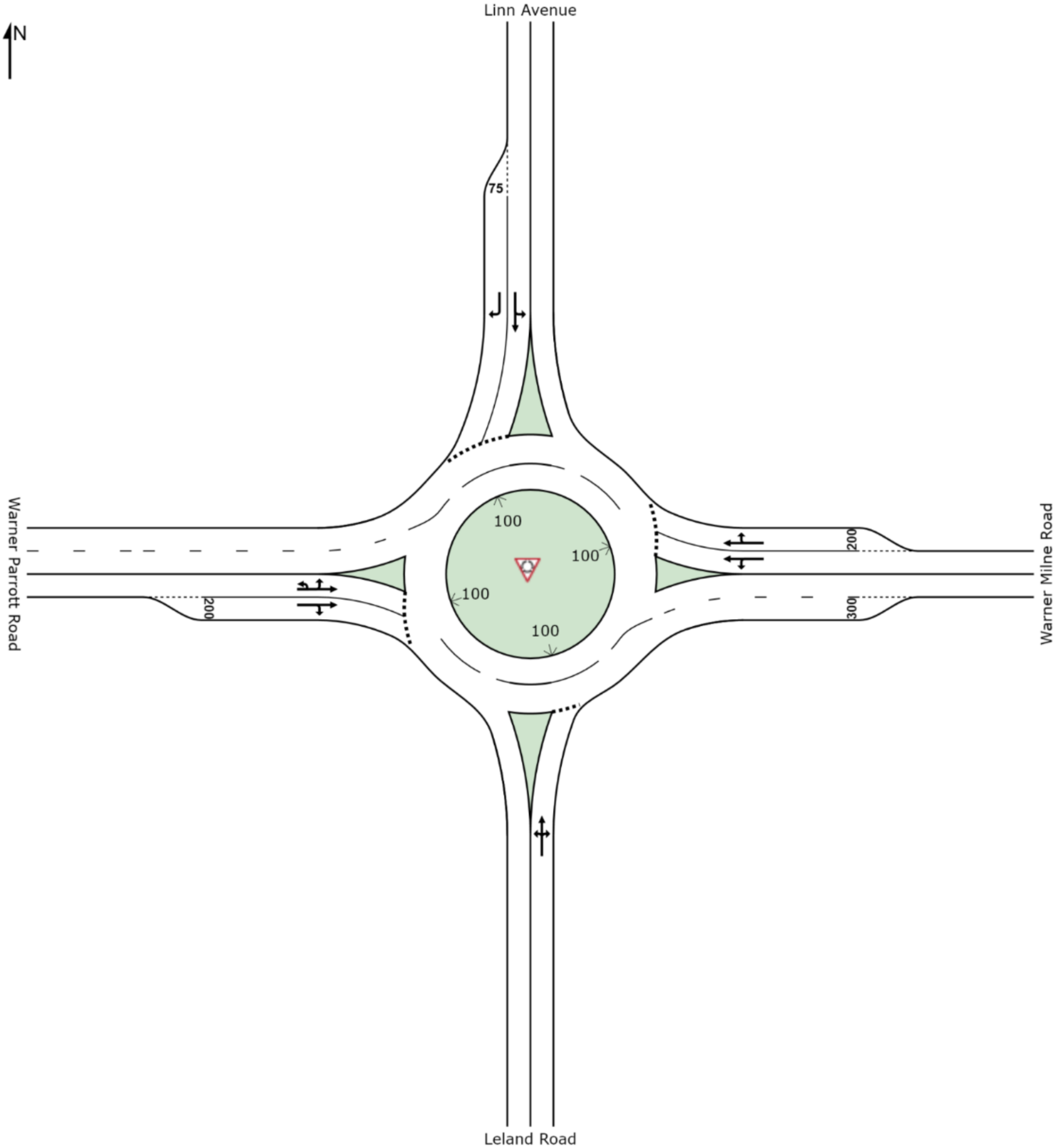
Intersection Performance - Annual Values

Performance Measure	Vehicles		Persons	
Demand Flows (Total)	1,366,231	veh/y	1,639,478	pers/y
Delay	6,187	veh-h/y	7,424	pers-h/y
Effective Stops	1,238,765	veh/y	1,486,518	pers/y
Travel Distance	866,744	veh-mi/y	1,040,093	pers-mi/y
Travel Time	29,512	veh-h/y	35,415	pers-h/y
Cost	355,449	$/y	355,449	$/y
Fuel Consumption	36,083	gal/y		
Carbon Dioxide	322,101	kg/y		
Hydrocarbons	121	kg/y		
Carbon Monoxide	1,594	kg/y		
NOx	457	kg/y		

SITE LAYOUT

Site: Warner Milne/Linn - Planned System

Warner Milne Road/Linn Avenue
4-Legged RAB Option
2035 Planned System - PM Peak
Roundabout



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MOVEMENT SUMMARY

Site: Warner Milne/Linn - Planned System

Warner Milne Road/Linn Avenue
4-Legged RAB Option
2035 Planned System - PM Peak
Roundabout

Movement Performance - Vehicles

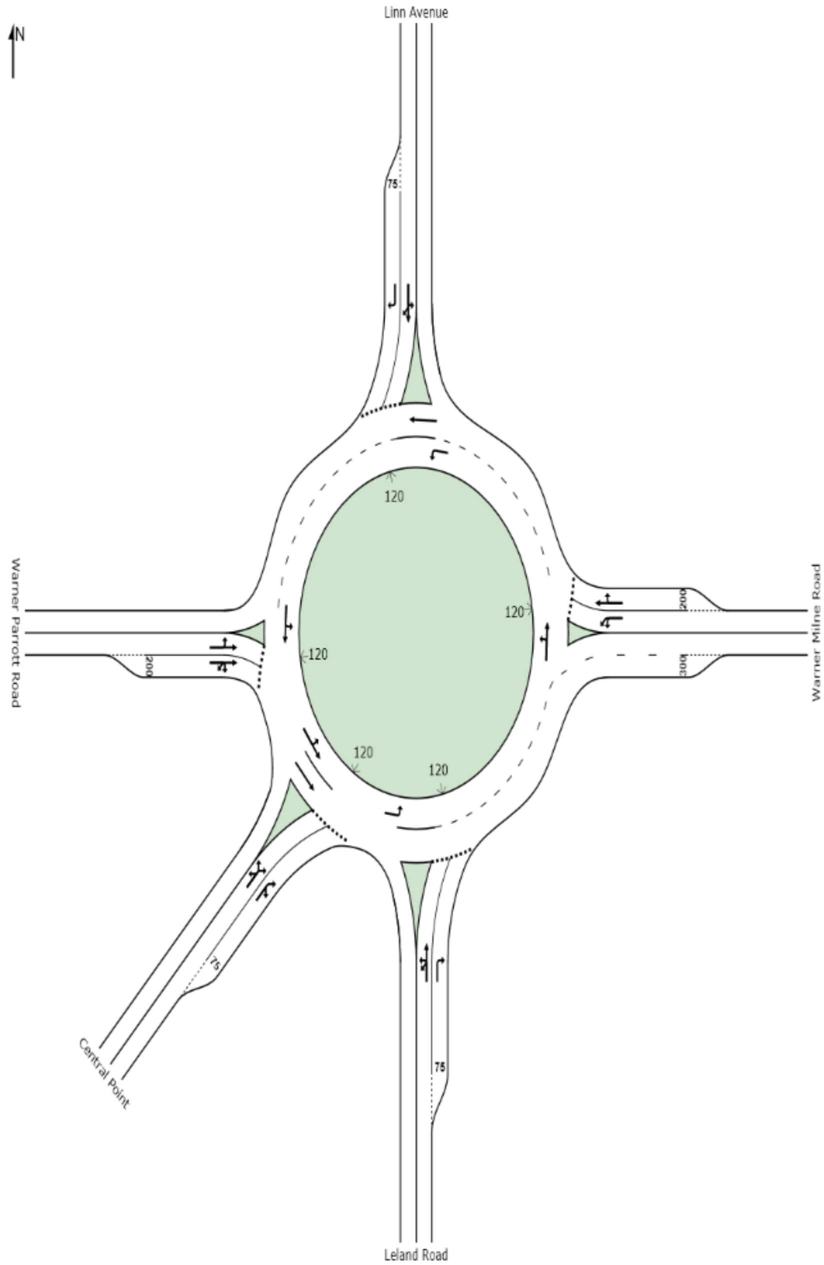
Mov ID	OD Mov	Demand Flows Total veh/h	Demand Flows HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance ft	Prop. Queued	Effective Stop Rate per veh	Average Speed mph
South: Leland Road											
3	L2	158	2.0	0.914	49.3	LOS D	12.0	301.5	1.00	1.38	20.6
8	T1	189	1.0	0.914	49.3	LOS D	12.0	301.5	1.00	1.38	20.6
18	R2	121	0.0	0.914	49.3	LOS D	12.0	301.5	1.00	1.38	20.3
Approach		468	1.1	0.914	49.3	LOS D	12.0	301.5	1.00	1.38	20.5
East: Warner Milne Road											
1	L2	168	0.0	0.593	13.8	LOS B	5.7	143.2	0.86	0.86	30.4
6	T1	647	2.0	0.593	13.2	LOS B	5.8	147.3	0.86	0.84	30.9
16	R2	189	0.0	0.593	12.7	LOS B	5.8	147.3	0.86	0.82	30.5
Approach		1005	1.3	0.593	13.2	LOS B	5.8	147.3	0.86	0.84	30.7
North: Linn Avenue											
7	L2	179	0.0	0.771	27.2	LOS C	6.8	170.7	0.92	1.09	25.8
4	T1	284	1.0	0.771	27.2	LOS C	6.8	170.7	0.92	1.09	25.7
14	R2	126	2.0	0.391	20.1	LOS C	1.8	45.7	0.78	0.81	27.7
Approach		589	0.9	0.771	25.6	LOS C	6.8	170.7	0.89	1.03	26.1
West: Warner Parrott Road											
5u	U	58	2.0	0.672	16.9	LOS B	7.7	195.4	0.96	1.04	29.8
5	L2	95	2.0	0.672	16.9	LOS B	7.7	195.4	0.96	1.04	29.2
2	T1	511	2.0	0.672	15.8	LOS B	7.7	195.4	0.93	0.98	29.7
12	R2	120	2.0	0.433	12.7	LOS B	3.1	78.3	0.84	0.83	30.5
Approach		783	2.0	0.672	15.5	LOS B	7.7	195.4	0.92	0.97	29.8
All Vehicles		2846	1.4	0.914	22.4	LOS C	12.0	301.5	0.91	1.00	27.3

Level of Service (LOS) Method: Delay (HCM 2000).
Roundabout LOS Method: Same as Signalised Intersections.
Vehicle movement LOS values are based on average delay per movement
Intersection and Approach LOS values are based on average delay for all vehicle movements.
Roundabout Capacity Model: SIDRA Standard.
HCM Delay Formula option is used. Control Delay does not include Geometric Delay since Exclude Geometric Delay option applies.
Gap-Acceptance Capacity: SIDRA Standard (Akçelik M3D).
HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.

SITE LAYOUT

Site: Warner Milne/Linn - Planned System

Warner Milne Road/Linn Avenue
2035 Planned System - PM Peak



SIDRA INTERSECTION 6

MOVEMENT SUMMARY

Site: Warner Milne/Linn - Planned System

Warner Milne Road/Linn Avenue
5-Legged RAB Option
2035 Planned System - PM Peak
Roundabout

Movement Performance - Vehicles

Mov ID	OD Mov	Demand Flows Total veh/h	Demand Flows HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance ft	Prop. Queued	Effective Stop Rate per veh	Average Speed mph
South: Leland Road											
3b	L3	88	2.0	0.499	12.4	LOS B	3.4	84.8	0.78	1.68	25.4
3	L2	75	2.0	0.499	12.4	LOS B	3.4	84.8	0.78	1.68	25.4
8	T1	196	1.0	0.499	12.4	LOS B	3.4	84.8	0.78	1.68	25.4
18	R2	125	0.0	0.258	11.3	LOS B	1.2	29.4	0.70	1.40	26.6
Approach		484	1.1	0.499	12.1	LOS B	3.4	84.8	0.76	0.81	25.7
East: Warner Milne Road											
1	L2	174	0.0	0.561	11.3	LOS B	5.2	131.1	0.83	1.54	24.7
1a	L1	359	2.0	0.561	11.3	LOS B	5.2	131.1	0.83	1.54	24.7
6	T1	300	2.0	0.587	13.2	LOS B	5.5	139.7	0.85	1.68	26.1
16	R2	189	0.0	0.587	13.2	LOS B	5.5	139.7	0.85	1.68	26.1
Approach		1022	1.3	0.587	12.2	LOS B	5.5	139.7	0.84	0.80	25.3
North: Linn Avenue											
7	L2	179	0.0	0.833	31.1	LOS C	7.8	195.6	0.92	2.26	19.2
4	T1	293	1.0	0.833	31.1	LOS C	7.8	195.6	0.92	2.26	19.2
14a	R1	70	2.0	0.833	31.1	LOS C	7.8	195.6	0.92	2.26	19.2
14	R2	59	2.0	0.176	13.9	LOS B	0.7	17.0	0.71	1.43	25.3
Approach		601	0.9	0.833	29.5	LOS C	7.8	195.6	0.90	1.09	19.7
West: Warner Parrott Road											
5	L2	46	2.0	0.634	23.3	LOS C	7.3	185.6	1.00	2.45	21.8
2	T1	251	2.0	0.634	23.3	LOS C	7.3	185.6	1.00	2.45	21.8
12	R2	63	2.0	0.557	24.9	LOS C	5.0	126.5	1.00	2.31	20.8
12b	R3	136	2.0	0.557	24.9	LOS C	5.0	126.5	1.00	2.31	20.8
Approach		496	2.0	0.634	23.9	LOS C	7.3	185.6	1.00	1.20	21.4
SouthWest: Central Point											
5bx	L3	60	2.0	0.467	12.7	LOS B	2.7	69.6	0.78	1.65	25.5
5ax	L1	50	2.0	0.467	12.7	LOS B	2.7	69.6	0.78	1.65	25.5
12ax	R1	266	2.0	0.467	12.5	LOS B	2.7	69.6	0.76	1.59	25.8
12bx	R3	64	2.0	0.290	12.0	LOS B	1.3	33.0	0.72	1.44	26.4
Approach		440	2.0	0.467	12.5	LOS B	2.7	69.6	0.76	0.79	25.8
All Vehicles		3043	1.4	0.833	17.6	LOS B	7.8	195.6	0.85	0.92	23.4

Level of Service (LOS) Method: Delay (HCM 2000).
Roundabout LOS Method: Same as Signalised Intersections.
Vehicle movement LOS values are based on average delay per movement
Intersection and Approach LOS values are based on average delay for all vehicle movements.
Roundabout Capacity Model: SIDRA Standard.
HCM Delay Formula option is used. Control Delay does not include Geometric Delay since Exclude Geometric Delay option applies.
Gap-Acceptance Capacity: SIDRA Standard (Akçelik M3D).
HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.

INTERSECTION SUMMARY

Site: Warner Milne/Linn - Planned System

Warner Milne Road/Linn Avenue
5-Legged RAB Option
2035 Planned System - PM Peak
Roundabout

Intersection Performance - Hourly Values

Performance Measure	Vehicles	Persons
Travel Speed (Average)	23.4 mph	23.4 mph
Travel Distance (Total)	1191.1 veh-mi/h	1429.3 pers-mi/h
Travel Time (Total)	50.9 veh-h/h	61.0 pers-h/h
Demand Flows (Total)	3043 veh/h	3651 pers/h
Percent Heavy Vehicles (Demand)	1.4 %	
Degree of Saturation	0.833	
Practical Spare Capacity	2.1 %	
Effective Intersection Capacity	3653 veh/h	
Control Delay (Total)	14.83 veh-h/h	17.80 pers-h/h
Control Delay (Average)	17.6 sec	17.6 sec
Control Delay (Worst Lane)	31.1 sec	
Control Delay (Worst Movement)	31.1 sec	31.1 sec
Geometric Delay (Average)	0.0 sec	
Stop-Line Delay (Average)	17.6 sec	
Idling Time (Average)	10.9 sec	
Intersection Level of Service (LOS)	LOS B	
95% Back of Queue - Vehicles (Worst Lane)	7.8 veh	
95% Back of Queue - Distance (Worst Lane)	195.6 ft	
Queue Storage Ratio (Worst Lane)	0.16	
Total Effective Stops	2809 veh/h	3370 pers/h
Effective Stop Rate	0.92 per veh	0.92 per pers
Proportion Queued	0.85	0.85
Performance Index	125.0	125.0
Cost (Total)	601.30 $/h	601.30 $/h
Fuel Consumption (Total)	26.5 gal/h	
Carbon Dioxide (Total)	236.3 kg/h	
Hydrocarbons (Total)	0.124 kg/h	
Carbon Monoxide (Total)	0.872 kg/h	
NOx (Total)	0.169 kg/h	

Level of Service (LOS) Method: Delay (HCM 2000).
Roundabout LOS Method: Same as Signalised Intersections.
Intersection LOS value for Vehicles is based on average delay for all vehicle movements.
Roundabout Capacity Model: SIDRA Standard.
HCM Delay Formula option is used. Control Delay does not include Geometric Delay since Exclude Geometric Delay option applies.

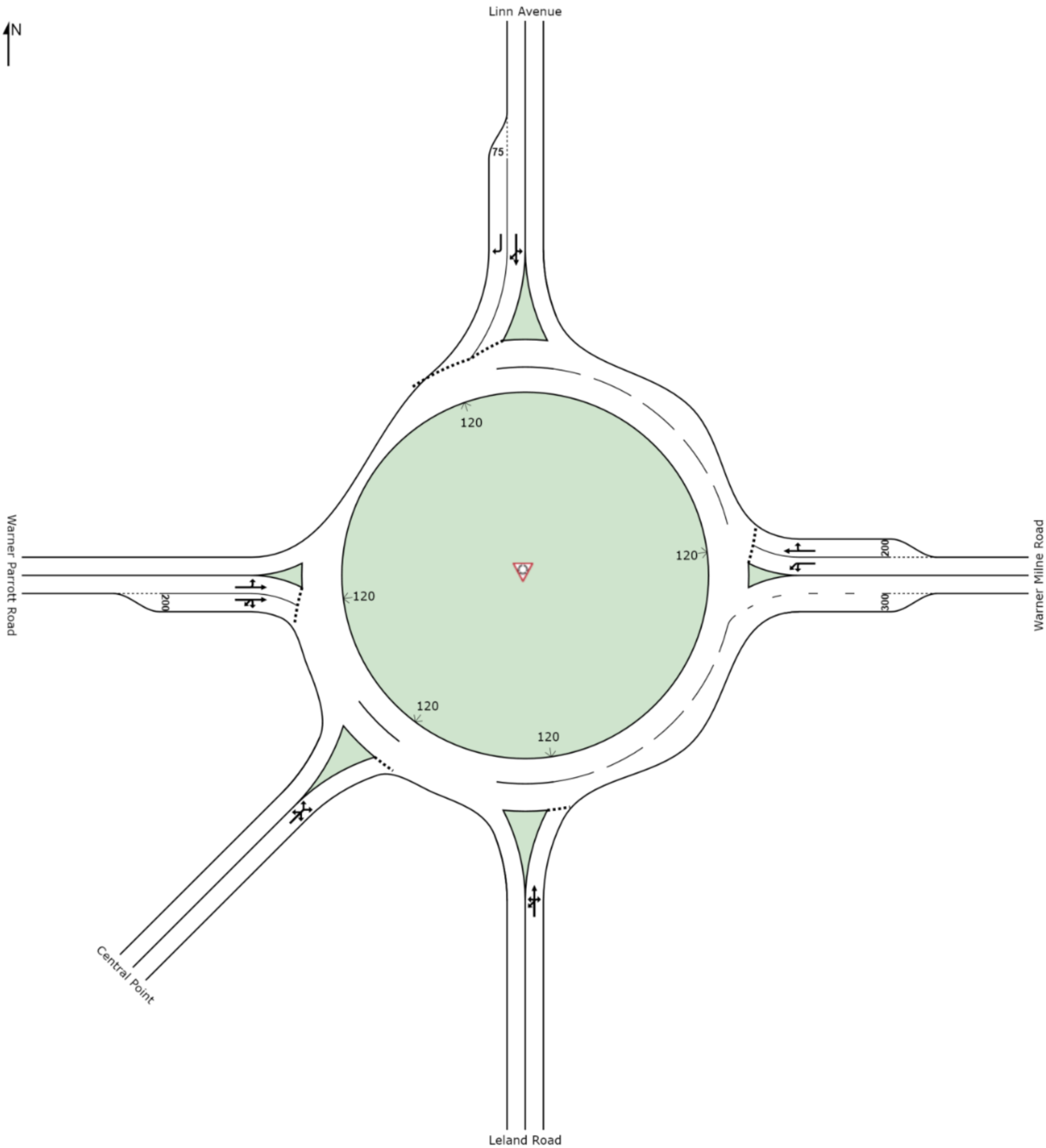
Intersection Performance - Annual Values

Performance Measure	Vehicles	Persons
Demand Flows (Total)	1,460,491 veh/y	1,752,589 pers/y
Delay	7,121 veh-h/y	8,545 pers-h/y
Effective Stops	1,348,088 veh/y	1,617,706 pers/y
Travel Distance	571,736 veh-mi/y	686,083 pers-mi/y
Travel Time	24,413 veh-h/y	29,295 pers-h/y
Cost	288,624 $/y	288,624 $/y
Fuel Consumption	12,727 gal/y	
Carbon Dioxide	113,404 kg/y	
Hydrocarbons	59 kg/y	
Carbon Monoxide	419 kg/y	
NOx	81 kg/y	

SITE LAYOUT

Site: Warner Milne/Linn - Planned System

Warner Milne Road/Linn Avenue
5-Legged RAB Option
2035 Planned System - PM Peak
Roundabout



MOVEMENT SUMMARY

Site: Warner Milne/Linn - Planned System

Warner Milne Road/Linn Avenue
5-Legged RAB Option
2035 Planned System - PM Peak
Roundabout

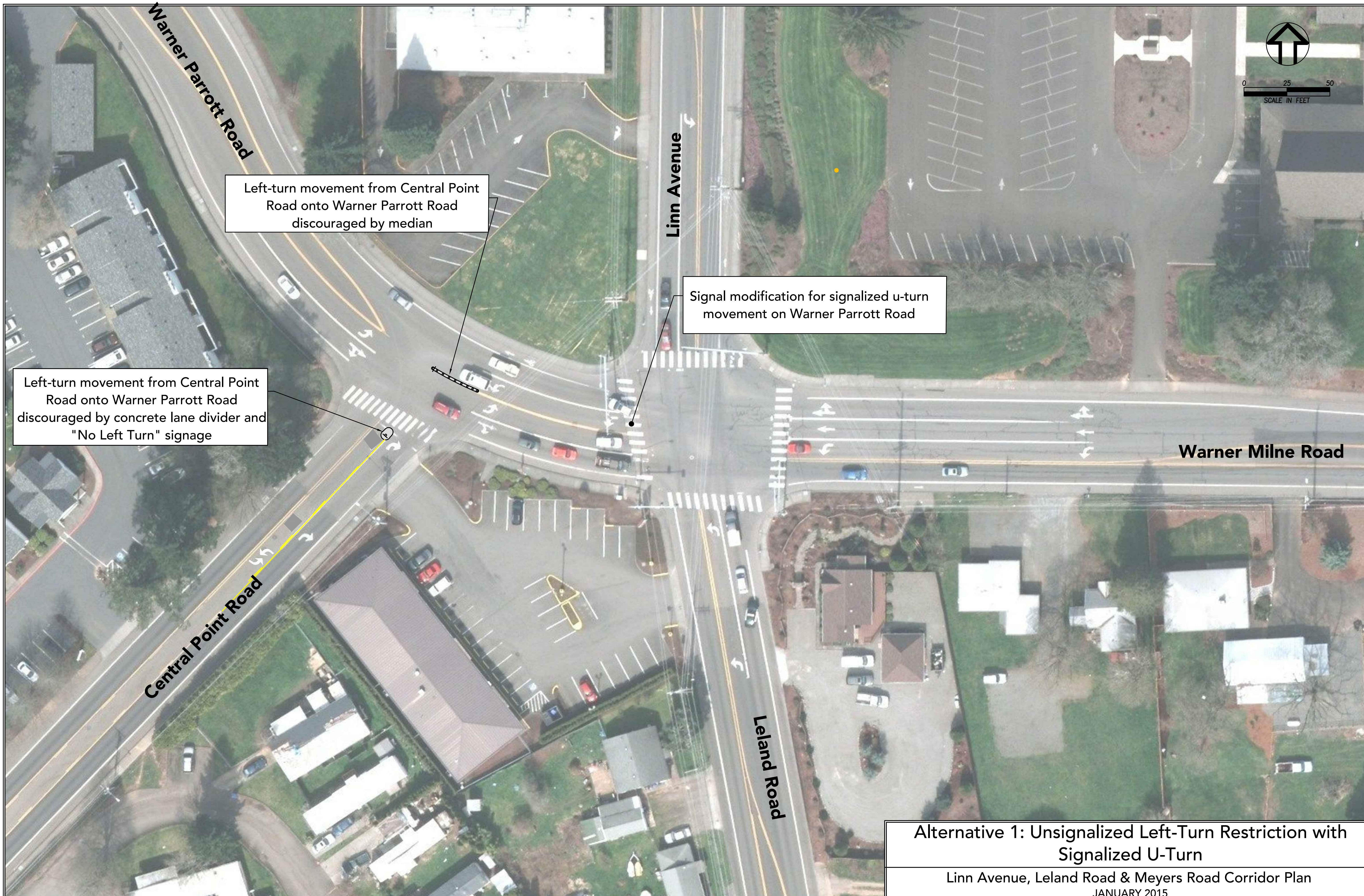
Movement Performance - Vehicles											
Mov ID	OD Mov	Demand Flows Total veh/h	Demand Flows HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance ft	Prop. Queued	Effective Stop Rate per veh	Average Speed mph
South: Leland Road											
3b	L3	88	2.0	0.973	62.5	LOS E	19.3	487.4	1.00	3.31	13.4
3	L2	75	2.0	0.973	62.5	LOS E	19.3	487.4	1.00	3.31	13.4
8	T1	196	1.0	0.973	62.5	LOS E	19.3	487.4	1.00	3.31	13.4
18	R2	125	0.0	0.973	62.5	LOS E	19.3	487.4	1.00	3.31	13.4
Approach		484	1.1	0.973	62.5	LOS E	19.3	487.4	1.00	1.66	13.4
East: Warner Milne Road											
1	L2	174	0.0	0.575	11.9	LOS B	5.5	140.1	0.85	1.61	24.5
1a	L1	359	2.0	0.575	11.9	LOS B	5.5	140.1	0.85	1.61	24.5
6	T1	300	2.0	0.602	13.9	LOS B	5.9	148.6	0.87	1.74	25.7
16	R2	189	0.0	0.602	13.9	LOS B	5.9	148.6	0.87	1.74	25.7
Approach		1022	1.3	0.602	12.8	LOS B	5.9	148.6	0.86	0.84	25.1
North: Linn Avenue											
7	L2	179	0.0	0.840	32.2	LOS C	8.0	200.4	0.93	2.29	19.0
4	T1	293	1.0	0.840	32.2	LOS C	8.0	200.4	0.93	2.29	19.0
14a	R1	70	2.0	0.840	32.2	LOS C	8.0	200.4	0.93	2.29	19.0
14	R2	59	2.0	0.177	14.0	LOS B	0.7	17.2	0.72	1.43	25.3
Approach		601	0.9	0.840	30.4	LOS C	8.0	200.4	0.91	1.10	19.4
West: Warner Parrott Road											
5	L2	46	2.0	0.636	23.4	LOS C	7.3	186.2	1.00	2.45	21.8
2	T1	251	2.0	0.636	23.4	LOS C	7.3	186.2	1.00	2.45	21.8
12	R2	63	2.0	0.558	24.9	LOS C	5.0	126.8	1.00	2.31	20.8
12b	R3	136	2.0	0.558	24.9	LOS C	5.0	126.8	1.00	2.31	20.8
Approach		496	2.0	0.636	24.0	LOS C	7.3	186.2	1.00	1.20	21.4
SouthWest: Central Point											
5bx	L3	60	2.0	0.885	45.3	LOS D	9.6	244.0	0.95	2.56	16.1
5ax	L1	50	2.0	0.885	45.3	LOS D	9.6	244.0	0.95	2.56	16.1
12ax	R1	266	2.0	0.885	45.3	LOS D	9.6	244.0	0.95	2.56	16.1
12bx	R3	64	2.0	0.885	45.3	LOS D	9.6	244.0	0.95	2.56	16.1
Approach		440	2.0	0.885	45.3	LOS D	9.6	244.0	0.95	1.28	16.1
All Vehicles		3043	1.4	0.973	30.7	LOS C	19.3	487.4	0.93	1.14	19.2

Level of Service (LOS) Method: Delay (HCM 2000).
Roundabout LOS Method: Same as Signalised Intersections.
Vehicle movement LOS values are based on average delay per movement
Intersection and Approach LOS values are based on average delay for all vehicle movements.
Roundabout Capacity Model: SIDRA Standard.
HCM Delay Formula option is used. Control Delay does not include Geometric Delay since Exclude Geometric Delay option applies.
Gap-Acceptance Capacity: SIDRA Standard (Akçelik M3D).
HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.

ODOT Collision Data

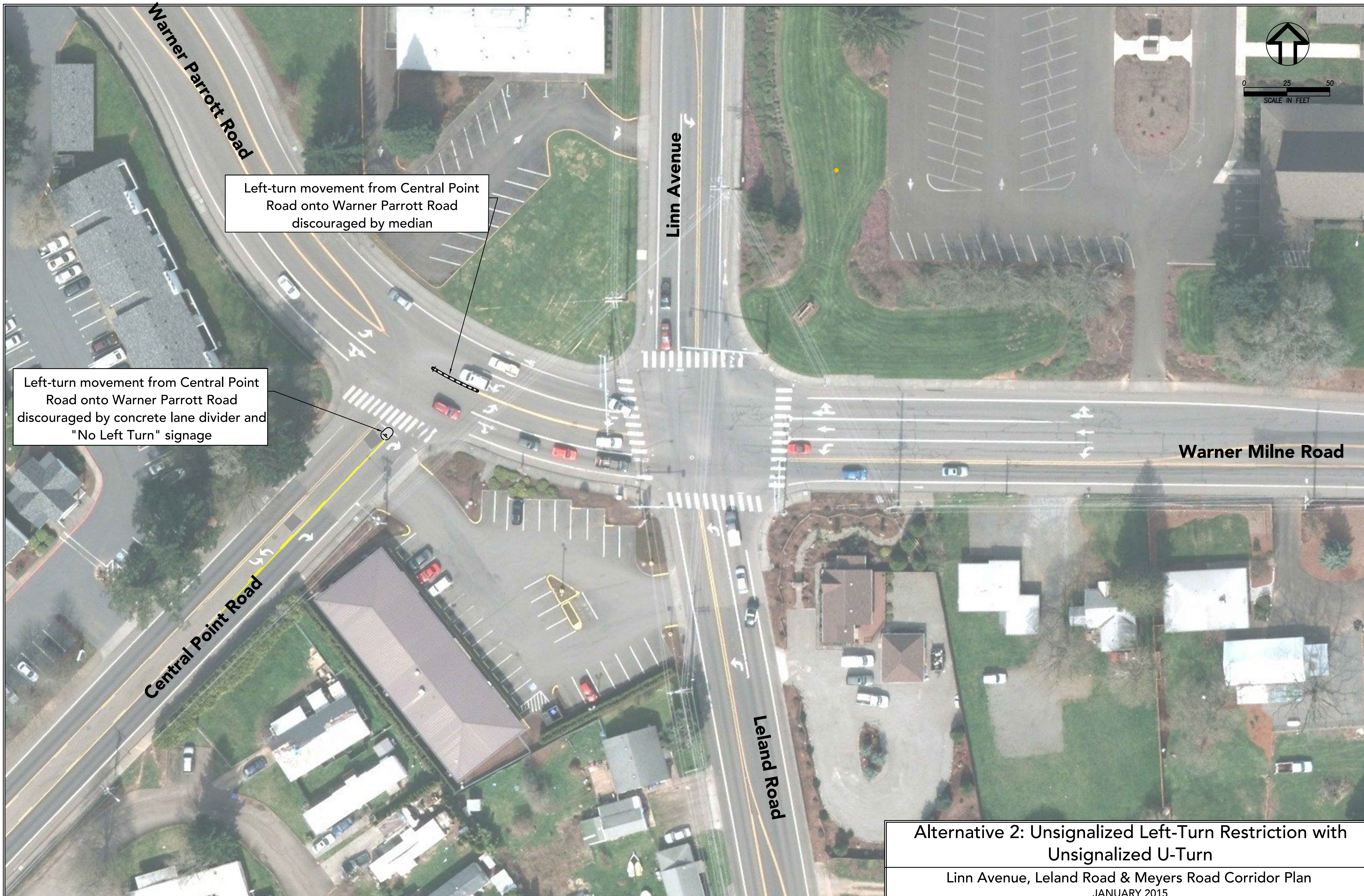
Crash ID	Serial #	Crash Date	Hour	1st Street	2nd Street	Dist.	Dir.	Lat	Long	Road Character	Crash Type	Col. Type	Veh Count	Veh Occu	Tot Per	Crash Sev	Weather	Road Surface	Light	Vehicle Movement	From - To	Vehicle Action	Vehicle Moveme	From - To	Vehicle Action
1323506	1439	4/16/2009	16	CENTRAL POINT RD	WARNER-PARROTT RD	0	CN	45.336497	-122.605533	INTER	ANGL-OTH	TURN	2	4	4	INJ C	CLEAR	DRY	DAYLIGHT	TURN-R	SW to SE	GO A/STOP	STRGHT	NW to SE	NONE
1356752	198	1/19/2010	6	LELAND RD	WARNER-MILNE RD	0	CN	45.336417	-122.604946	INTER	S-1STOP	REAR	2	8	8	INJ C	CLEAR	DRY	DARK-NO ST LIGHTS	STRGHT	W to E	NONE	STOP	W to E	STOPPED
1359936	639	2/23/2010	11	LINN AVE	WARNER-PARROTT RD	0	CN	45.336417	-122.604946	INTER	ANGL-OTH	ANGL	2	3	3	INJ C	RAIN	WET	DAYLIGHT	STRGHT	N to S	NONE	STRGHT	E to W	NONE
1356414	83	1/9/2010	18	CENTRAL POINT RD	WARNER-PARROTT RD	0	CN	45.336497	-122.605533	INTER	O-1TURN	TURN	2	3	3	INJ C	CLEAR	DRY	DARK-NO ST LIGHTS	STRGHT	NW to SE	NONE	TURN-L	SE to SW	NONE
1368969	1214	4/12/2010	9	CENTRAL POINT RD	WARNER-MILNE RD	0	CN	45.336497	-122.605533	INTER	ANGL-OTH	TURN	2	4	4	INJ C	CLEAR	DRY	DAYLIGHT	TURN-L	SW to NW	GO A/STOP	STRGHT	NW to SE	NONE
1376031	2537	7/21/2010	15	LINN AVE	WARNER-MILNE RD	20	N	45.336480	-122.604947	STRGHT	S-1STOP	REAR	2	2	2	INJ C	CLEAR	DRY	DAYLIGHT	STRGHT	N to S	NONE	STOP	N to S	STOPPED
1387492	3511	9/28/2010	13	LELAND RD	WARNER-MILNE RD	1000	SE	45.333720	-122.604165	STRGHT	S-1TURN	TURN	2	2	2	PDO	CLEAR	DRY	DAYLIGHT	STRGHT	NW to SE	NONE	U-TURN	NW to NW	ENT OFFRD
1375822	2437	7/14/2010	14	CENTRAL POINT RD	WARNER-PARROTT RD	0	CN	45.336497	-122.605533	INTER	ANGL-OTH	TURN	2	4	4	PDO	CLEAR	DRY	DAYLIGHT	STRGHT	NW to SE	NONE	TURN-L	SW to NW	GO A/STOP
1399462	4763	12/13/2010	7	WARNER-PARROTT RD	CENTRAL POINT RD	218	NW	45.336911	-122.606136	CURVE	FIX OBJ	FIX	1	1	1	PDO	RAIN	WET	DAYLIGHT	STRGHT	SE to NW	NONE			
1409679	711	2/27/2011	12	LINN AVE	WARNER-MILNE RD	0	E	45.336411	-122.604946	INTER	S-1STOP	SS-O	2	2	2	PDO	CLEAR	DRY	DAYLIGHT	STRGHT	E to W	AVOIDING	STOP	E to W	STOPPED
1439776	3858	10/14/2011	11	LINN AVE	WARNER-MILNE RD	0	CN	45.336417	-122.604939	INTER	O-1TURN	TURN	2	2	2	INJ C	CLOUDY	DRY	DAYLIGHT	STRGHT	E to W	NONE	TURN-L	W to N	NONE
1445677	4694	12/5/2011	7	LINN AVE	WARNER-MILNE RD	0	N	45.336417	-122.604939	INTER	ANGL-STP	TURN	2	2	2	PDO	FOG	ICE	DAWN	TURN-R	E to N	NONE	STOP	N to S	STOPPED
1469715	1720	5/10/2012	7	LELAND RD	WARNER-MILNE RD	137	S	45.336043	-122.604867	STRGHT	S-1STOP	REAR	2	3	3	INJ C	CLEAR	DRY	DAYLIGHT	STRGHT	S to N	NONE	STOP	S to N	STOPPED
1471585	1973	5/30/2012	15	LINN AVE	WARNER-MILNE RD	95	N	45.336686	-122.604952	STRGHT	S-1STOP	REAR	2	4	4	INJ C	CLEAR	DRY	DAYLIGHT	STRGHT	N to S	NONE	STOP	N to S	STOPPED
1480291	2866	8/4/2012	12	LINN AVE	WARNER-MILNE RD	100	N	45.336686	-122.604952	STRGHT	S-1STOP	REAR	2	2	2	PDO	CLEAR	DRY	DAYLIGHT	STRGHT	S to N	NONE	STOP	S to N	STOPPED
1486129	3422	9/14/2012	11	WARNER-MILNE RD	LELAND RD	100	E	45.336420	-122.604545	STRGHT	S-1STOP	REAR	2	2	2	PDO	CLEAR	DRY	DAYLIGHT	STRGHT	W to E	NONE	STOP	W to E	STOPPED
1488339	3639	10/1/2012	15	CENTRAL POINT RD	WARNER-PARROTT RD	0	SW	45.336497	-122.605533	INTER	BIKE	TURN	1	1	2	INJ B	CLEAR	DRY	DAYLIGHT	TURN-L	SE to SW	NONE	STRGHT	SW to NE	NONE
1490401	3835	10/15/2012	17	LELAND RD	WARNER-MILNE RD	0	CN	45.336417	-122.604946	INTER	ANGL-OTH	ANGL	2	4	4	INJ C	RAIN	WET	DUSK	STRGHT	E to W	NONE	STRGHT	S to N	NONE
1499513	4405	11/17/2012	20	LELAND RD	WARNER-PARROTT RD	31	S	45.336226	-122.604923	STRGHT	FIX OBJ	FIX	1	1	1	INJ B	RAIN	WET	DARK-NO ST LIGHTS	STRGHT	N to S	NONE	PRKD-P	NE to SW	PAR PARK
1499760	4652	12/1/2012	13	WARNER-PARROTT RD	CENTRAL POINT RD	473	NW	45.337400	-122.606825	CURVE	FIX OBJ	FIX	1	1	1	INJ C	CLOUDY	DRY	DAYLIGHT	STRGHT	W to E	NONE			
1506878	720	3/2/2013	20	LELAND RD	WARNER-PARROTT RD	0	SW	45.336417	-122.604946	INTER	PED	PED	1	1	2	INJ B	RAIN	WET	DUSK	TURN-R	W to S	NONE	STOP	SE to NW	STOPPED
1512521	1308	4/17/2013	14	WARNER-PARROTT RD	CENTRAL POINT RD	100	E	45.337289	-122.622501	STRGHT	S-1STOP	SS-O	4	2	2	PDO	CLEAR	DRY	DAYLIGHT	STRGHT	W to E	AVOIDING	STOP	W to E	STOPPED
1519476	2048	6/5/2013	15	WARNER-PARROTT RD	CENTRAL POINT RD	500	NW	45.337401	-122.606909	STRGHT	S-1STOP	REAR	2	2	2	PDO	CLEAR	DRY	DAYLIGHT	STRGHT	NW to SE	NONE	STOP	NW to SE	STOPPED
1519762	2086	6/12/2013	7	LELAND RD	WARNER-MILNE RD	0	S	45.336417	-122.604946	INTER	S-1STOP	REAR	2	2	2	PDO	CLEAR	DRY	DAYLIGHT	STRGHT	S to N	NONE	STOP	S to N	STOPPED
1533493	3616	9/25/2013	16	CENTRAL POINT RD	WARNER-PARROTT RD	0	CN	45.336540	-122.605573	INTER	ANGL-OTH	TURN	2	2	2	PDO	CLOUDY	DRY	DAYLIGHT	TURN-L	SW to NW	GO A/STOP	STRGHT	NW to SE	NONE
1537350	4120	10/26/2013	17	LELAND RD	WARNER-PARROTT RD	0	CN	45.336417	-122.604946	INTER	ANGL-OTH	ANGL	2	5	5	PDO	CLEAR	DRY	DAYLIGHT	STRGHT	S to N	NONE	STRGHT	E to W	NONE
1544482	4879	12/17/2013	4	WARNER-PARROTT RD	CENTRAL POINT RD	96	NW	45.336680	-122.605795	STRGHT	FIX OBJ	FIX	1	2	2	PDO	CLOUDY	WET	DARK-ST LIGHTS	STRGHT	SE to NW	NONE	STOP	W to E	STOPPED

Alternative Conceptual Drawings



Alternative 1: Unsignalized Left-Turn Restriction with Signalized U-Turn

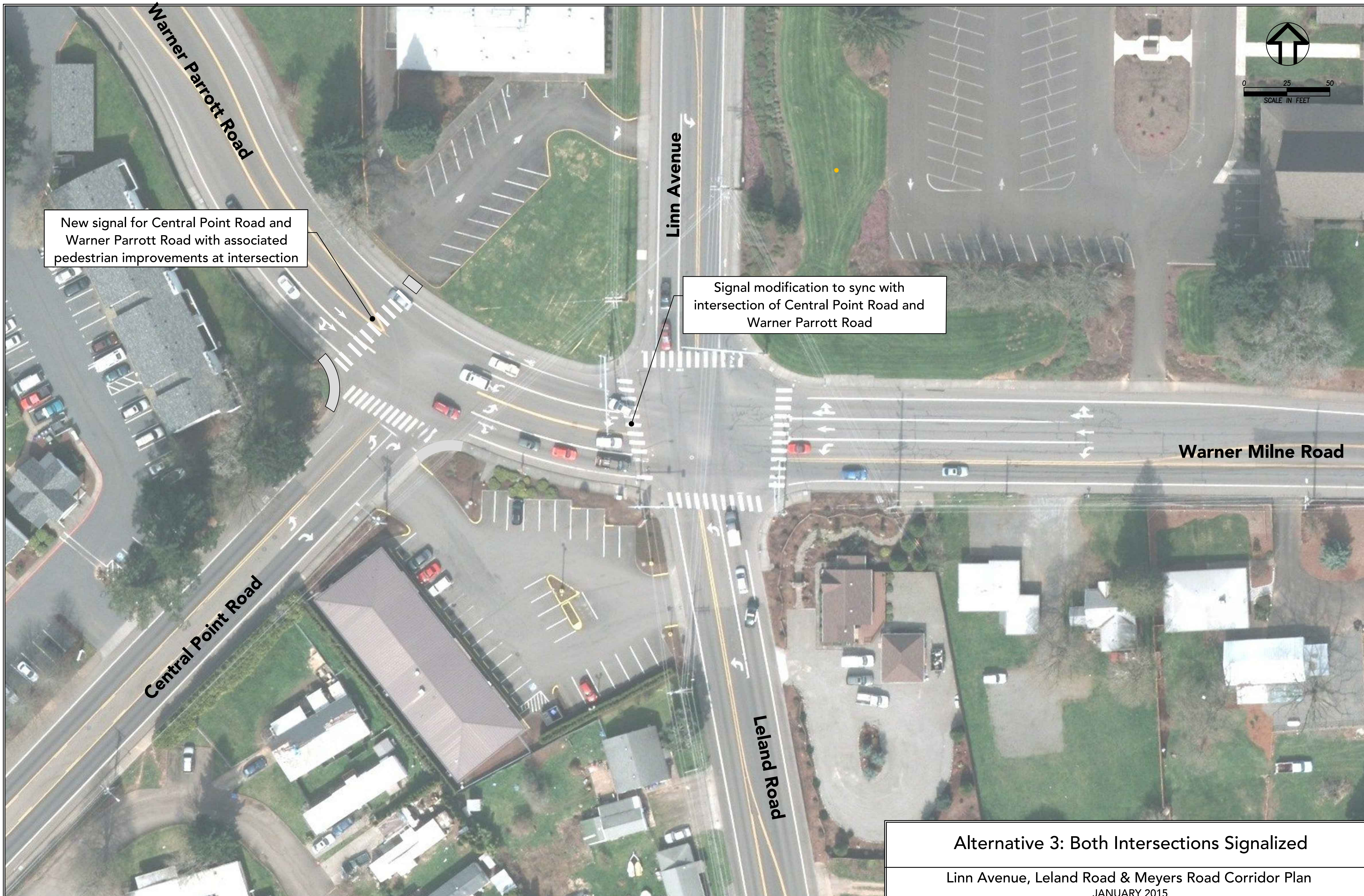
Linn Avenue, Leland Road & Meyers Road Corridor Plan
JANUARY 2015



Alternative 2: Unsignalized Left-Turn Restriction with Unsignalized U-Turn

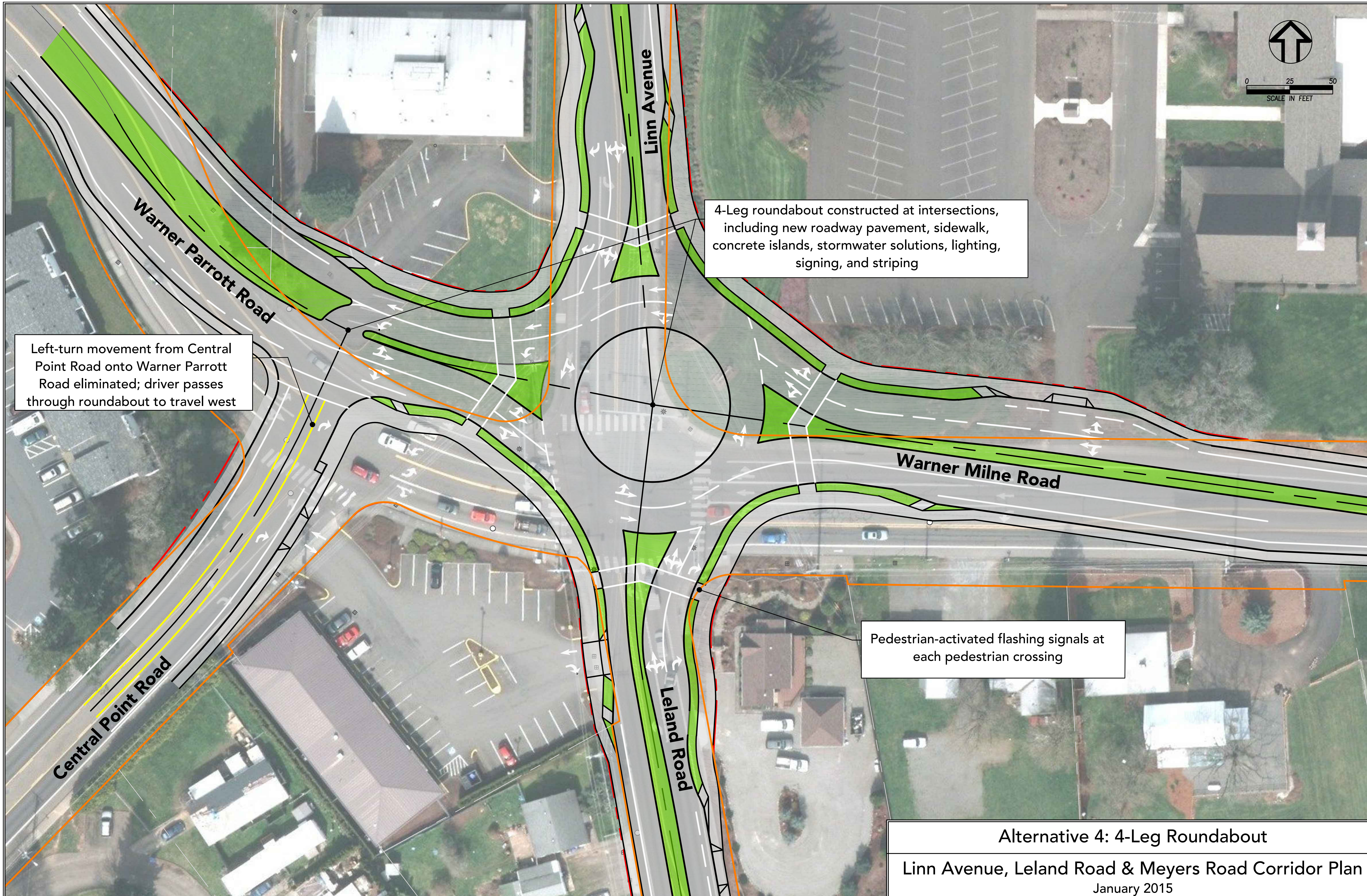
Linn Avenue, Leland Road & Meyers Road Corridor Plan

JANUARY 2015



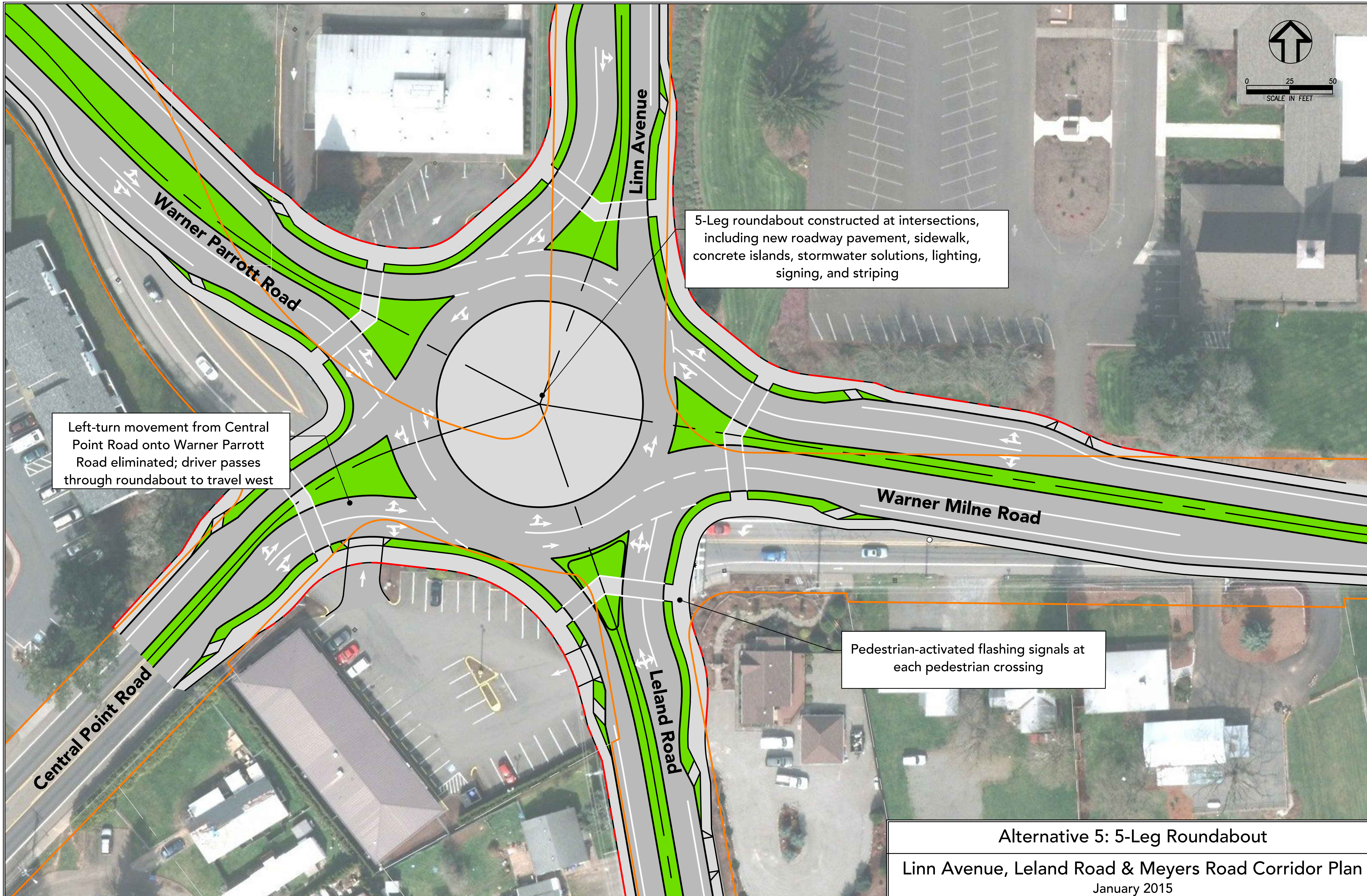
Alternative 3: Both Intersections Signalized

Linn Avenue, Leland Road & Meyers Road Corridor Plan
JANUARY 2015



Alternative 4: 4-Leg Roundabout

Linn Avenue, Leland Road & Meyers Road Corridor Plan
January 2015



Alternative 5: 5-Leg Roundabout

Linn Avenue, Leland Road & Meyers Road Corridor Plan

January 2015

Cost Estimates

Alternative 1: Unsignalized Left-Turn Restriction with Signalized U-Turn
Planning Level Opinion of Cost

Linn Avenue, Leland Road and Meyers Road Corridor Plan
City of Oregon City, OR

Prepared by: Wallis Engineering — Date: 1/13/2015
WE Job No. 1366A

Construction			
Description	Quantity	Units	Cost
Mobilization	1	L.S.	$3,600
Traffic Control	1	L.S.	$3,200
Erosion Control	1	L.S.	$700
Channelizing Island & Median	1	L.S.	$9,000
Signing and Striping	1	L.S.	$2,300
Signal Improvements	1	L.S.	$40,000
Construction Subtotal			*$58,800*
Construction and Project Contingency at 30%			*$17,640*
Construction Total			***$76,440***
Right of Way			
Right of Way			$0
Right of Way Contingency at 50%			$0
Right of Way Total			***$0***
Engineering and Permitting			
Design Engineering and Administration			$20,000
Construction Engineering Services			$10,000
Environmental Permitting			$5,000
Engineering and Permitting Total			***$35,000***
PROJECT GRAND TOTAL			**$111,440**

ASSUMPTIONS

1. For reference: ENR Construction Cost Index for Seattle for July 2014; 10161.68.
2. Mobilization at 7% of construction subtotal.
3. Temporary traffic control at 7% of construction subtotal.
4. Erosion control at 1.5% of construction subtotal.
5. New signal pole on SE corner of Linn/Leland/Warner Milne/Warner Parrott (cost would be significantly less if existing pole is structurally adequate for new equipment)
6. Environmental Permitting is lump sum.

Alternative 2: Unsignalized Left-Turn Restriction without Signalized U-Turn
Planning Level Opinion of Cost

Linn Avenue, Leland Road and Meyers Road Corridor Plan
City of Oregon City, OR

Prepared by: Wallis Engineering | Date: 1/13/2015
WE Job No. 1366A

Construction			
Description	Quantity	Units	Cost
Mobilization	1	L.S.	$800
Traffic Control	1	L.S.	$700
Erosion Control	1	L.S.	$170
Channelizing Island & Median	1	L.S.	$9,000
Signing and Striping	1	L.S.	$2,300
Construction Subtotal			*$12,970*
Construction and Project Contingency at 30%			*$3,891*
Construction Total			***$16,861***
Right of Way			
Right of Way			$0
Right of Way Contingency at 50%			$0
Right of Way Total			***$0***
Engineering and Permitting			
Design Engineering and Administration			$15,000
Construction Engineering Services			$5,000
Environmental Permitting			$5,000
Engineering and Permitting Total			***$25,000***
PROJECT GRAND TOTAL			**$41,861**

ASSUMPTIONS

1. For reference: ENR Construction Cost Index for Seattle for July 2014; 10161.68.
2. Mobilization at 7% of construction subtotal.
3. Temporary traffic control at 7% of construction subtotal.
4. Erosion control at 1.5% of construction subtotal.
5. Environmental Permitting is lump sum.

Alternative 3: Signalized Intersections
Planning Level Opinion of Cost

Linn Avenue, Leland Road and Meyers Road Corridor Plan
City of Oregon City, OR

Prepared by: Wallis Engineering Date: 1/10/15
WE Job No. 1366A

Construction			
Description	Quantity	Units	Cost
Mobilization	1	L.S.	$ 24,500
Traffic Control	1	L.S.	$ 21,000
Erosion Control	1	L.S.	$ 5,200
Channelizing Island & Median	1	L.S.	$ 5,700
Sidewalk and Curb Ramps	1	L.S.	$ 10,100
Signing and Striping	1	L.S.	$ 3,980
Signal Improvements	1	L.S.	$ 275,000
Lighting	1	L.S.	$ 50,000
Construction Subtotal			*$ 395,480*
Construction and Project Contingency at 30%			*$ 118,644*
Construction Total			***$ 514,124***
Right of Way			
Right of Way			$ 0
Right of Way Contingency at 50%			$ 0
Right of Way Total			***$ 0***
Engineering and Permitting			
Design Engineering and Administration at 13%			$ 66,836
Construction Engineering Services at 12%			$ 61,695
Environmental Permitting			$ 50,000
Engineering and Permitting Total			***$ 178,531***
PROJECT GRAND TOTAL			**$ 692,655**

ASSUMPTIONS

1. For reference: ENR Construction Cost Index for Seattle for July 2014; 10161.68.
2. Mobilization at 7% of construction subtotal.
3. Temporary traffic control at 6% of construction subtotal.
4. Erosion control at 1.5% of construction subtotal.
5. New signal at Central Point Rd/Warner Parrott Rd.
6. Signal at Linn Ave/Leland Rd/Warner Parrott Rd/Warner Milne Rd is modified to work as one signalized intersection with new signal at Central Point Rd/Warner Parrott Rd.
7. Environmental Permitting is lump sum.

Alternative 4: Four-Leg Roundabout
Planning Level Opinion of Cost

Linn Avenue, Leland Road and Meyers Road Corridor Plan
City of Oregon City, OR

Prepared by: Wallis Engineering — Date: 1/13/2015
WE Job No. 1366A

Construction			
Description	Quantity	Units	Cost
Mobilization	1	L.S.	$111,700
Traffic Control	1	L.S.	$111,700
Erosion Control	1	L.S.	$24,000
Roundabout	1	L.S.	$1,024,600
Signing and Striping	1	L.S.	$60,000
Stormwater	1	L.S.	$74,700
Landscaping	1	L.S.	$41,740
Pedestrian-Activated Signals	1	L.S.	$120,000
Lighting	1	L.S.	$250,000
Construction Subtotal			*$1,818,440*
Construction and Project Contingency at 30%			*$545,532*
Construction Total			***$2,363,972***
Right of Way			
Right of Way			$143,820
Right of Way Contingency at 50%			$71,910
Right of Way Total			***$215,730***
Engineering and Permitting			
Design Engineering and Administration at 13%			$307,316
Construction Engineering Services at 12%			$283,677
Environmental Permitting			$50,000
Engineering and Permitting Total			***$640,993***
PROJECT GRAND TOTAL			**$3,220,695**

ASSUMPTIONS

1. For reference: ENR Construction Cost Index for Seattle for July 2014; 10161.68.
2. Mobilization at 7% of construction subtotal.
3. Temporary traffic control at 7% of construction subtotal.
4. Erosion control at 1.5% of construction subtotal.
5. Landscaping includes excavation, soil, and light landscaping.
6. Stormwater improvements include collection and conveyance improvements, and quality and treatment (assumed necessary for new impervious surfaces).
7. Signing and striping assumed to include all striping within roundabout limits, all signing within roundabout limits and directional signing leading up to roundabout.
8. ROW needs determined through Oregon City GIS maps.
9. All ROW is assumed to be partial strip takes. No relocations are assumed.
10. Environmental Permitting is lump sum.

Alternative 5: 5-leg Roundabout
Planning Level Opinion of Cost

Linn Avenue, Leland Road and Meyers Road Corridor Plan
City of Oregon City, OR

Prepared by: Wallis Engineering — Date: 1/13/2015
WE Job No. 1366A

Construction			
Description	Quantity	Units	Cost
Mobilization	1	L.S.	$114,600
Traffic Control	1	L.S.	$114,600
Erosion Control	1	L.S.	$24,200
Roundabout	1	L.S.	$1,023,000
Signing and Striping	1	L.S.	$60,000
Stormwater	1	L.S.	$74,700
Landscaping	1	L.S.	$54,000
Pedestrian-Activated Signals	1	L.S.	$150,000
Lighting	1	L.S.	$250,000
Construction Subtotal			*$1,865,100*
Construction and Project Contingency at 30%			*$559,530*
Construction Total			***$2,424,630***
Right of Way			
Right of Way			$179,750
Right of Way Contingency at 50%			$89,875
Right of Way Total			***$269,625***
Engineering and Permitting			
Design Engineering and Administration at 13%			$315,202
Construction Engineering Services at 12%			$290,956
Environmental Permitting			$50,000
Engineering and Permitting Total			***$656,158***
PROJECT GRAND TOTAL			**$3,350,413**

ASSUMPTIONS

1. For reference: ENR Construction Cost Index for Seattle for July 2014; 10161.68.
2. Mobilization at 7% of construction subtotal.
3. Temporary traffic control at 7% of construction subtotal.
4. Erosion control at 1.5% of construction subtotal.
5. Landscaping includes excavation, soil, and light landscaping.
6. Stormwater improvements include collection and conveyance improvements, and quality and treatment (assumed necessary for new impervious surfaces).
7. Signing and striping assumed to include all striping within roundabout limits, all signing within roundabout limits and directional signing leading up to roundabout.
8. ROW needs determined through Oregon City GIS maps.
9. All ROW is assumed to be partial strip takes. No relocations are assumed.
10. Environmental Permitting is lump sum.

Present Worth Analysis

Present Worth Analysis

Option #	Annual Weekday PM Peak Hour Delay Cost	Construction Cost	Annual Crash Savings	Annual Maintenance Cost	Present Worth	Is option viable from an operations perspective?
no-build	$316,593	$0	$0	$2,000	($4,329,783)	no
1	$279,270	$115,000	$18,760	$2,000	($3,678,173)	yes
2	$254,475	$45,000	$18,760	$2,000	($3,273,894)	yes
3	$751,158	$700,000	$0	$3,000	($10,922,330)	no
4	$98,658	$3,220,000	$90,360	$1,500	($3,229,312)	yes
5	$91,872	$3,350,000	$149,120	$1,500	($2,463,520)	yes

Notes

1. Assumed interest rate is 4%.
2. Assumed 20-year design life for improvements.
3. Maintenance costs do not include maintenance of pavement or utilities within the intersection.
4. Maintenance costs for the intersection signal are recent costs for the existing signal.
5. Maintenance costs for the roundabout are assumed to be equal to the landscaping costs for a similar roundabout at Washington/Clackamas River Drive.