



MEMORANDUM

TO: Jon Holan, Community Development Director
City of Forest Grove

FROM: Anne Sylvester, PTE

DATE: November 2, 2015

PROJECT #: 0742.01 Forest Grove Westside Planning Project

SUBJECT: 2035 PM Peak Hour Traffic Operations Analysis of Revised Land Use
Alternative (10/26/15 Version)

Introduction and Background

The memorandum presents the results of traffic operations analysis for the revised land use alternative developed by the City of Forest Grove on October 26, 2015, for the Westside Planning Project. Included in this memo is a discussion of:

- Key elements in the land use alternative
- The methodology used to develop and analyze long-range traffic forecasts at key intersections impacted by Westside growth
- Review of the traffic forecasts and operating analysis results including a comparison with the adopted 2014 Transportation System Plan
- Identification of impacts associated with Westside development and potential roadway improvement needs

As illustrated in Figure 1, two areas within the City of Forest Grove are included in the Westside Planning Project:

- David Hill planning area
- Purdin Road planning area

David Hill - The David Hill planning area is located in the northwestern portion of the City of Forest Grove and has been included in the Urban Growth Boundary (UGB) for several years. David Hill is one of the city's prime growth areas and over 90 percent of this area is projected to develop by 2025. While urban land use designations currently exist, the need for street and infrastructure planning is urgent. However, due to the extent of unknown factors affecting the development of a transportation system for David Hill, the City's recently adopted Transportation System Plan (TSP) did not identify a potential future street system. The TSP called for further refinement planning to address the unique aspects of providing urban services in this topographically challenged area. This refinement planning has been incorporated into the Westside Project along with consideration of connectivity issues for the Gales Creek area located immediately south of David Hill.

Purdin Road - The Purdin Road planning area is located east of David Hill and directly north of the city. It is predominately used for agricultural purposes. This area was added to the UGB through legislative



action in 2014, but there has been no comprehensive planning to guide the designation of urban land uses or infrastructure. The Westside Planning Project is intended to meet these needs.

Figure 1. Westside Planning Project Study Areas



Revised Land Use Alternative (10/26/15)

Figure 2 was developed by City staff to illustrate the component elements of the Revised Westside Land Use Alternative dated October 26, 2015. This figure identifies a series of transportation zones by which different land uses are aggregated for analysis purposes. Table 1 includes detailed information concerning the specific land use types and quantities included in each zone. Figure 2 also shows existing riparian areas which must be avoided as the area is developed, along with the 440-foot contour interval on the west side of the David Hill area. This elevation represents the limit of existing city water service.

As indicated in Table 1, a net total of just over 374 acres have been identified for development as part of the Westside Planning Project. This excludes areas designated as vegetated corridors under Clean Water Services standards. Under the existing Comprehensive Plan (adopted in 2014) the two planning areas are entirely zoned for residential development yielding a total of 693 single family dwelling units. Under the Revised land use scenario, mixed use development is proposed consisting of single and multi-family dwellings, retail, a fire station and an elementary school. This development would include an estimated 2,132 dwelling units, an increase of 1,439 units over the existing plan with 247 more in the David Hill planning area and 1,192 more in the Purdin Road planning area. The development would also include 61,500 square feet of retail (yielding an estimated 78 employees), a 10.98-acre park, a 2-acre fire station with an estimated 3 employees, and a 65,000-square foot elementary school.

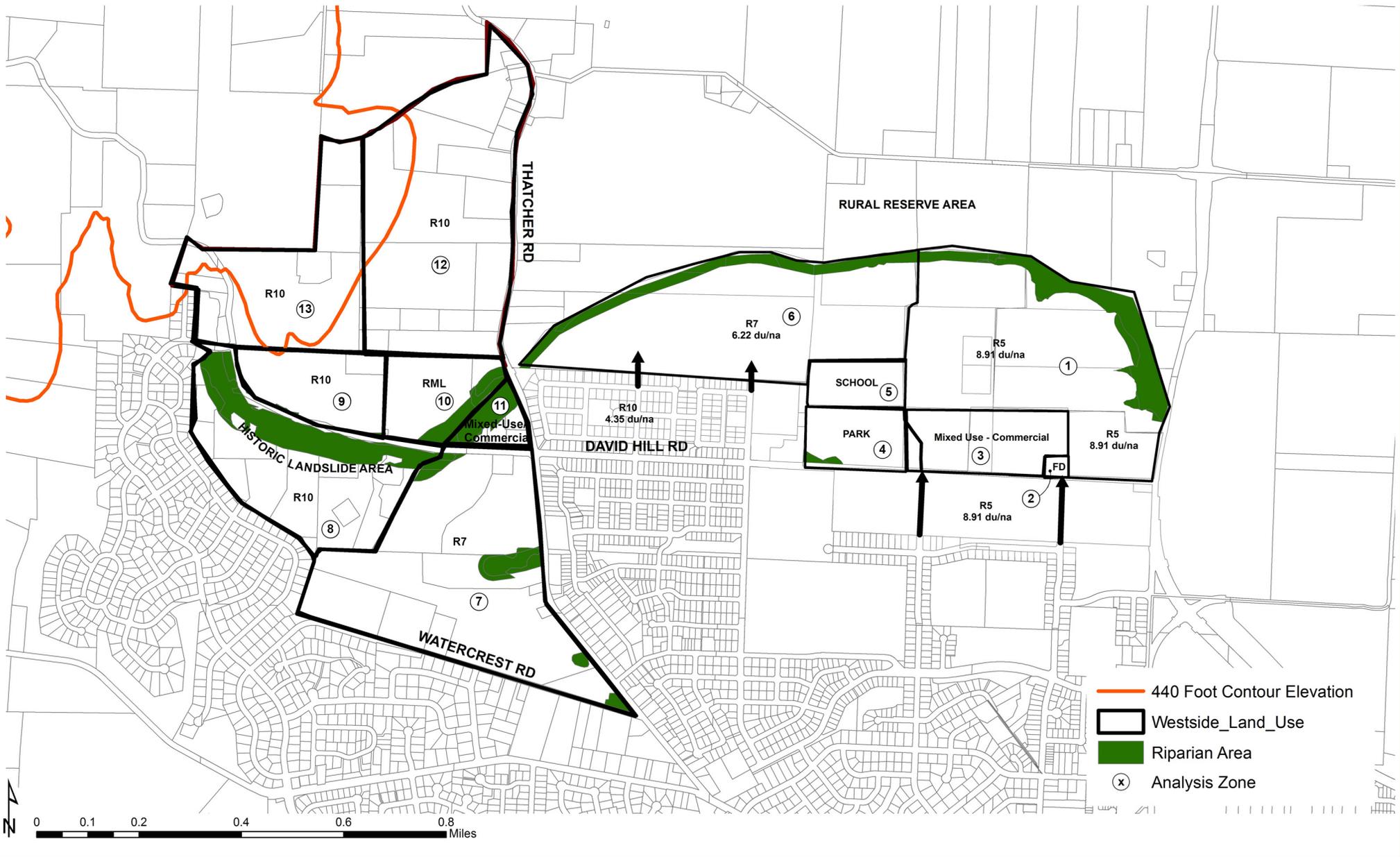


Figure 2
Revised Land Use Alternative (10/26/15)



Table 1. Comparison of Existing Comprehensive Plan and Revised Alternative

Zone	Area	Revised Land Use Alternative (10/26/2015)						2014 Comprehensive Plan				
		Density (units/ac)	Net Ac	Slope Deduction	Dwelling Units	KSF	Acres	Employees	Density (units/ac)	Net Ac	Slope Deduction	Dwelling Units
1	Purdin (R5)	8.71	67.76	0%	590					67.76	0%	2
2	Fire Station		2.00	0%				3		2.00	0%	
3	Purdin (Residential)	12.0	18.50	0%	221					18.50	0%	
3	Purdin (Retail Commercial) ¹					46.5		46				
4	Purdin (Park)		10.98	0%			10.98			10.98	0%	
5	Purdin (Elementary School) ²		11.96	0%		65.0				11.96	0%	
6	Purdin (R7)	6.22	62.08	0%	386				1/20 ac	62.08	0%	3
<i>Sub-Total Purdin</i>			<i>173.28</i>		<i>1,197</i>	<i>111.5</i>	<i>10.98</i>	<i>49</i>		<i>173.28</i>		<i>5</i>
7	Watercrest (R7) ³	6.22	56.50	10%	316				4.35	56.50	10%	220
8	South of David Hill Rd (R10) ⁴	4.35	10.39	20%	36				4.35	10.39	20%	36
9	North of David Hill Rd (R10)	4.35	14.18	15%	52				4.35	14.18	15%	52
10	David Hill Village (RML)	12.0	12.05	15%	122				4.35	12.05	15%	44
11	David Hill Village (Comm)		2.90	0%		15.0		32		2.90	0%	
11	David Hill Village (Res) ⁵	12.0	--	0%	4				4.35	--	0%	12
12	Thatcher (R10)	4.35	76.65	10%	300				4.35	76.65	10%	300
13	David Hill (R10)	4.35	28.50	15%	105				1.0	28.50	15%	24
<i>Sub-Total David Hill/Gales Creek</i>			<i>201.17</i>		<i>935</i>	<i>15.0</i>	<i>0</i>	<i>32</i>		<i>201.17</i>		<i>688</i>
Totals			374.45		2,132	126.5	10.98	81		374.45		693

¹ Retail employment based on FAR of 0.25 for retail uses and 11 employees per net acre of commercial land within mixed-use area (approximately 4.2 net acres).

² Assumes average school size of 65,000 sq. ft. consistent with newer elementary schools in Forest Grove.

³ Land area within Thatcher Park and Thatcher Woods has been deducted from total land area. This deduction is approximately 25.18 acres.

⁴ Area outside of riparian zone and landslide hazard area.

⁵ Assumes limited residential above retail or standalone-plex development



2035 Traffic Projections

To determine traffic impacts associated with the revised land use alternative and to identify any potential roadway improvement needs, the expected traffic volumes associated with this development must be forecast and analyzed. The process used to prepare Westside traffic projections is described in the following pages. For consistency with the City's recently adopted TSP, the 2035 PM peak hour was chosen as the basis for this analysis.

Traffic Forecasting Methodology

The development of 2035 PM peak hour projections for the Westside involved a multi-step process starting with review of the volumes and land development assumptions inherent in the TSP. These volumes were developed using Metro's regional travel demand model with a modified version of the Gamma population and employment projections that is based on the City's 2014 *Comprehensive Plan*. Seven intersections were identified for analysis as these were either critical locations in the Forest Grove transportation system or would likely experience the greatest degree of impact associated with proposed Westside land uses.

The process of moving from TSP forecasts to Westside forecasts based on the revised land use alternative includes the following steps:

1. **Comparison of Land Use Projections** – The household and employment forecasts that are consistent with the 2014 *Comprehensive Plan* and which undergird the TSP were compared with the estimate dwelling unit and employment forecasts for the Westside revised alternative for TAZ's 1392, 1393 and 1396 in the modified regional travel demand model.
2. **Calculation of Land Use Growth** – Estimates of new growth in household and employment forecasts (over the forecasts used in the TSP) were determined by location.
3. **Development of Trip Generation Estimates** – Trip end estimates consistent with the TSP were obtained from the regional model for TAZ's 1392 (Purdin Road area), 1393 (David Hill area) and 1396 (Gales Creek area). These estimates were factored up or down by location consistent with the new dwelling unit and/or employment growth in the revised alternative. For the Gales Creek and David Hill areas, total trip ends with the revised alternative are expected to very slightly decrease in comparison with the TSP. This is because, while the number of dwelling units increased with the revised alternative, the regional model originally included trips related to future employment in these areas. As the revised alternative includes only minor growth in employment in TAZ's 1393 and 1396, the net growth in trip-making in comparison to the TSP would likely decrease. Total trip ends for TAZ 1392 (the Purdin Road planning area) are expected to see a significant increase as this area was not included within the UGB at the time the TSP was developed. ITE trip generation rates were used to estimate likely daily and PM peak hourly traffic volumes for this area. These were added to the 2035 PM peak hour projections prepared for the TSP.
4. **Identification of Trip Distribution Patterns** – Trip distribution assumptions for the net increase in trips with the revised alternative were developed through review of traffic patterns from several different runs of the Metro regional model. The trip distribution analysis also incorporated a variety of roadway network additions that are included in the TSP, and thus in the regional travel forecasts. There is a strong attractiveness from the Purdin Road planning area to/from the north and east (linking Forest Grove with Hillsboro and Portland). Approximately 47 percent of net new trips are expected to travel in this direction. However, it is



anticipated that the majority of new trips to/from the Purdin planning area would be destined to the west and southwest (approximately 25 percent), south (about 5 percent) and southeast (about 23 percent). Highway 47 is a highly attractive route for these trips, as is David Hill and Thatcher Roads.

5. **Preparation of Trip Assignments** – Net new trips from each Westside analysis zone (see Figure 2 for the location of these zones) were assigned to the street system consistent with the assumed trip distribution pattern.

Roadway Network Assumptions

Traffic forecasts for the revised alternative include the roadway system improvements and extensions in the Westside vicinity that were adopted as part of the City's TSP. These are described below:

- **David Hill Road** – The extension of David Hill Road is included from its current terminus eastward to intersect at Highway 47. A single lane roundabout was assumed for this intersection based on current project development activities.
- **Vista Drive/Talisman Lane** – The addition of the Vista Drive and Talisman Lane extensions between Gales Creek and Thatcher Roads are included. With these improvements a significant volume of existing and projected future traffic would be diverted away from the intersection of Gales Creek and Thatcher Roads. Without these improvements it will be necessary to signalize or otherwise improve traffic operations at the Gales Creek/Thatcher intersection.
- **Highway 47 at Verboort Road/Purdin Road** – Improvements to the intersection of Highway 47 and Verboort/Purdin Road are included to address existing safety issues and future capacity needs. A single lane roundabout was assumed based on current project development activities. Improvements to this location, increasing densification in the Westside and completion of the David Hill Road extension are all expected to draw traffic away from the Highway 47/Martin Road intersection, helping to address expected future congestion problems at this location.
- **Highway 47 at Martin Road** – As noted above, the addition of new local and arterial street connections in the northwestern portion of the City will help to reduce regional traffic entering the city via Martin Road. As noted in the TSP, the connection of Martin Road across Highway 47 ultimately connecting with 23rd Avenue. This connection is expected to reduce some traffic volumes along Highway 47, but would worsen traffic operations at the intersection with Martin Road, exacerbating the need for intersection improvements that could include signalization.
- **Main Street and B Street Extensions** – The proposed recommended street layout for the Purdin Road area includes connections into developed portions of the city via extensions of Main Street and B Streets. Extensions of these two streets are included in the adopted TSP between Hartford Drive and the David Hill Road extension.

2035 PM Peak Hour Turning Movement Projections

Figure 3 presents the 2035 PM peak hour turning movement projections resulting from the analysis process described above.

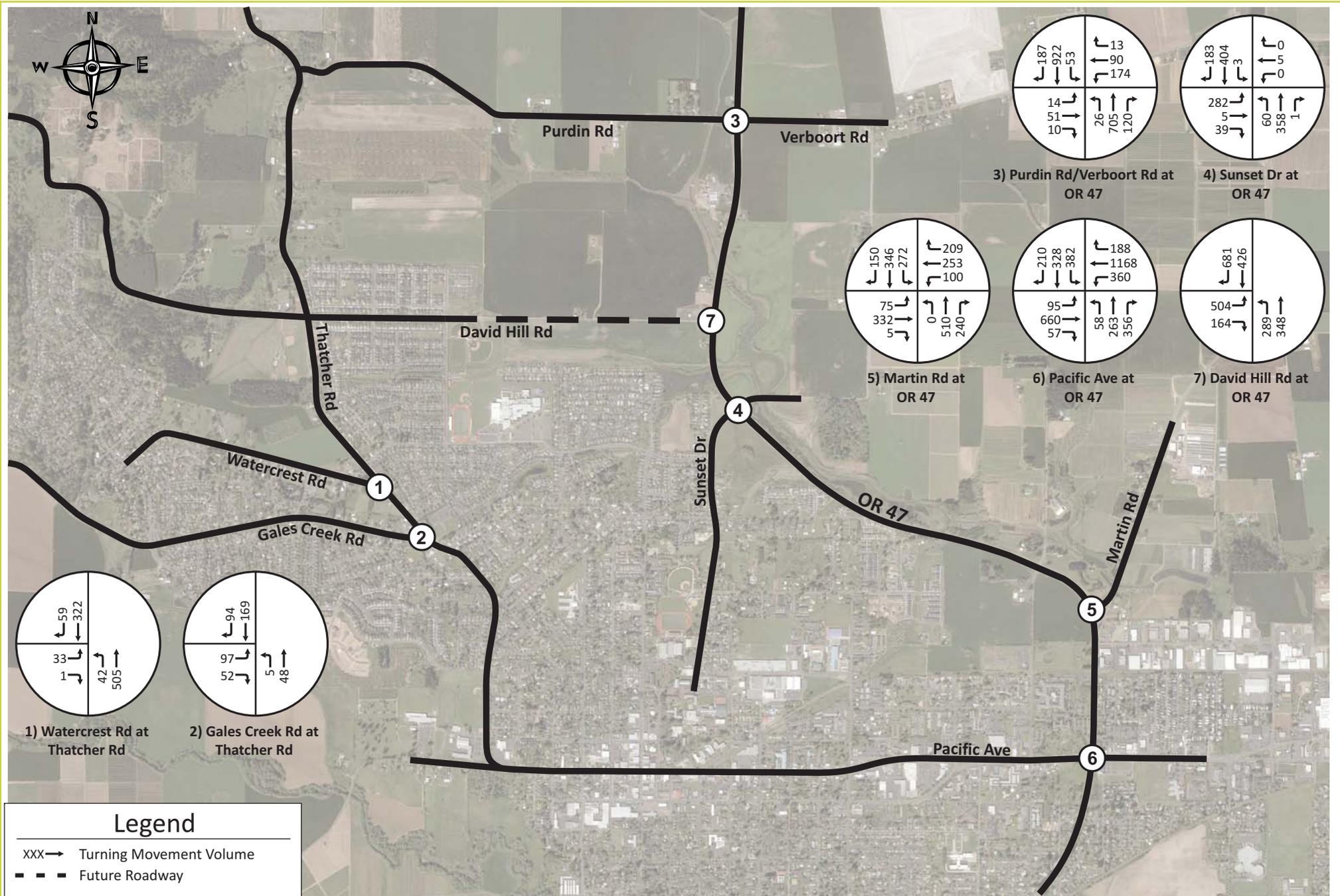


Figure 3
2035 PM Peak Hour Traffic Volumes
with Revised Land Use Alternative (10/26/15)



2035 Projected PM Peak Hour Traffic Operations

Mobility Standards

Level of Service, delay and volume-to-capacity ratios are used as measures of effectiveness for study intersection performance. As part of its adoption of the 2011 TSP, the City endorsed use of a minimum standard Level of Service (LOS) D to determine project improvement needs for streets under its jurisdiction. ODOT and Washington County standards apply to roadways under their jurisdiction. The applicable intersection operational standards for Washington County and ODOT are summarized below.

- ODOT defines a maximum volume-to-capacity ratio for Highway 47 of 0.99¹
- Washington County defines acceptable performance in urban areas as volume-to-capacity ratio of 0.99 with LOS E or better².

These two standards apply to the various intersections analyzed for Westside land uses.

2035 PM Peak Hour Operations Analysis Results

To identify the magnitude of traffic impacts associated with the revised alternative, a comparison was made with the 2035 PM peak hour traffic operations as incorporated into the recently adopted TSP. As noted above, traffic analysis in the TSP used future volume forecasts that were consistent with the adopted 2014 Comprehensive Plan. These forecasts also assumed the roadway connections and improvements discussed above. Operations analysis results based on adopted TSP traffic projections are presented in Table 2.

Table 2. 2035 PM Peak Hour Intersection Level of Service with TSP Land Uses and Streets

No.	Intersection	Operational Standard	Level of Service (LOS) ¹	Average Delay* (Seconds)	Volume / Capacity (V/C)
<i>Unsignalized Intersections</i>					
1	Thatcher Road/Watercrest Road	LOS E/0.99	A/C	17.2 ²	0.09 ²
2	Gales Creek Road/Thatcher Road	LOS E/0.99	A/B	11.6 ²	0.24 ²
3	Highway 47/Verboort & Purdin	V/C=0.99	A/F	>200 ²	>2.00 ^{2,3}
5	Highway 47/Martin Road	V/C=0.99	A/F	>200 ²	>2.00 ²
7	Highway 47/David Hill Road	V/C=0.99	-/F	>200 ²	1.54 ^{2,4}
<i>Signalized Intersections</i>					
4	Highway 47/Sunset Drive	V/C=0.99	B	16.1	0.50
6	Pacific Avenue/Quince Street	V/C=0.99	D	53.4	0.97

* Minor street average delay reported for unsignalized intersections

1 For unsignalized intersections the first value is the free movement; second value is the worst stopped movement. At signalized locations the value is for the entire intersection.

2 Worst stopped movement.

3 Development of local street connections in Forest Grove may divert added WB traffic to this location requiring improvements. This analysis assumes existing lane configuration and traffic control. Subsequent to TSP preparation, improvement of the intersection as a single lane roundabout was undertaken.

4 Assumes stop control for side street traffic. Subsequent to TSP preparation, improvement of the intersection as a single lane roundabout was undertaken.

¹ Oregon Highway Plan, Policy Element, Table 7, Oregon Department of Transportation, 1999.

² Washington County 2020 Transportation System Plan, Washington County, 2002.



Table 2 includes information for each intersection including the relevant operational standard based on roadway jurisdiction (e.g., ODOT, or Washington County), Level of Service for the through unstopped movement and the worst stopped movement, average delay for the worst stopped movement, and volume-to-capacity ratio for the worst stopped movement.

As indicated in this table, two intersections along Highway 47 are expected to fail by 2035 during the PM peak hour – Highway 47 at Verboort Road/Purdin Road and Highway 27 at Martin Road. The TSP assumes that both of these intersections would retain their existing configurations.

Table 3 presents a summary of intersection operations analysis results for conditions with the revised land use alternative. As indicated in the table, the intersection of Highway 47 with Martin Road would still show significant failure and will need further study to identify an appropriate solution. The intersection of Highway 47 with Verboort/Purdin Road was assumed to be improved to a single lane roundabout which provides substantially more capacity than the existing stop-controlled single lane configuration. However, by 2035 with the addition of Purdin Road planning area traffic, this location could begin to see significant delays with a volume/capacity ratio exceed the adopted mobility standard. The new intersection of Highway 47 with David Hill Road is currently being developed as a single lane roundabout, but this location is also expected to see failure by 2035 with the addition of Purdin Road traffic.

All other intersections within the study area are expected to operate within their adopted mobility standards during the 2035 PM peak hour.

Table 3. 2035 PM Peak Hour Intersection Level of Service with Westside Revised Land Use Scenario

No.	Intersection	Operational Standard	Level of Service (LOS) ¹	Average Delay* (Seconds)	Volume / Capacity (V/C)
<i>Unsignalized Intersections</i>					
1	Thatcher Road/Watercrest Road	LOS E/0.99	A/C	21.8 ²	0.15 ²
2	Gales Creek Road/Thatcher Road	LOS E/0.99	A/B	10.8 ²	0.21 ²
5	Highway 47/Martin Road	V/C=0.99	-/F	158.8²	1.21²
<i>Roundabouts</i>					
3	Highway 47/Verboort & Purdin	V/C=0.99	F	87.4^{2,3}	1.34^{2,3}
7	Highway 47/David Hill Road	V/C=0.99	F	91.4^{2,3}	1.33^{2,3}
<i>Signalized Intersections</i>					
4	Highway 47/Sunset Drive	V/C=0.99	C	33.4	0.60
6	Pacific Avenue/Quince Street	V/C=0.99	E	65.5	0.99

* Minor street average delay reported for unsignalized intersections

1 For unsignalized intersections the first value is the free movement; second value is the worst stopped movement. At signalized locations the value is for the entire intersection.

2 Worst stopped movement.

3 Pending single lane roundabout intersection improvements are assumed here.



Improvements

In order to address the expected deficiencies the following intersection improvements could be considered.

Highway 47 at Martin Road

This intersection is currently unsignalized with stop-control on Martin Road. It operates within ODOT's mobility targets based on the TSP's existing conditions analysis. As noted in the TSP, as the community grows, this intersection (and the immediately adjacent intersection of 24th Avenue) will become increasingly congested. Both signalization and installation of a roundabout were considered for this location during the TSP planning process (the intersection is expected to meet signal warrants based on the 2035 traffic projections in the TSP). However, no resolution of differences among affected agencies on the appropriate improvement could be achieved. Accordingly, this area is shown in the Roadway Network Plan as a "TPR Refinement Area" for which further study and deliberation needs to be conducted leading to a recommended course of action.

Highway 47 at Verboort Road/Purdin Road

This intersection is currently located outside of the Forest Grove UGB in rural Washington County. Working together, Washington County and ODOT have partnered to develop an improvement concept to address existing safety deficiencies and future congestion needs at this location. Dependent on the final land use plan for the Purdin Road planning area, some improvement to this intersection may be needed by 2035. This improvement could include added channelization at the roundabout.

Highway 24 at David Hill Road

Washington County and ODOT have also partnered to extend David Hill Road from its existing easterly terminus to connect with Highway 47, including development of a single lane roundabout at the new intersection. As with the Verboort Road/Purdin Road intersection and dependent on the final land use plan for the Purdin Road planning area, some improvement to this intersection may be needed by 2035. This improvement could include added channelization at the roundabout.

APPENDIX A
TRAFFIC OPERATIONS ANALYSIS WORKSHEETS

Westside Planning Project
16: Thatcher Rd & Watercrest Rd

2035 PM Peak with Development

Intersection

Int Delay, s/veh 1.1

Movement	EBL	EBR	SET	SER	NWL	NWT
Vol, veh/h	33	1	322	59	42	505
Conflicting Peds, #/hr	0	0	0	0	0	0
Sign Control	Stop	Stop	Free	Free	Free	Free
RT Channelized	-	None	-	None	-	None
Storage Length	0	-	-	-	-	-
Veh in Median Storage, #	0	-	0	-	-	0
Grade, %	0	-	0	-	-	0
Peak Hour Factor	92	92	92	92	92	92
Heavy Vehicles, %	2	2	2	2	2	2
Mvmt Flow	36	1	350	64	46	549

Major/Minor	Minor1	Minor2	Major1	Major2	Major2	Major2
Conflicting Flow All	1022	382	0	0	414	0
Stage 1	382	-	-	-	-	-
Stage 2	640	-	-	-	-	-
Critical Hdwy	6.42	6.22	-	-	4.12	-
Critical Hdwy Stg 1	5.42	-	-	-	-	-
Critical Hdwy Stg 2	5.42	-	-	-	-	-
Follow-up Hdwy	3.518	3.318	-	-	2.218	-
Pot Cap-1 Maneuver	261	665	-	-	1145	-
Stage 1	690	-	-	-	-	-
Stage 2	525	-	-	-	-	-
Platoon blocked, %			-	-	-	-
Mov Cap-1 Maneuver	246	665	-	-	1145	-
Mov Cap-2 Maneuver	246	-	-	-	-	-
Stage 1	690	-	-	-	-	-
Stage 2	495	-	-	-	-	-

Approach	EB	SE	NW
HCM Control Delay, s	21.8	0	0.6
HCM LOS	C		

Minor Lane/Major Mvmt	NWL	NWT	EBLn1	SET	SER
Capacity (veh/h)	1145	-	251	-	-
HCM Lane V/C Ratio	0.04	-	0.147	-	-
HCM Control Delay (s)	8.3	0	21.8	-	-
HCM Lane LOS	A	A	C	-	-
HCM 95th %tile Q(veh)	0.1	-	0.5	-	-

Westside Planning Project
5: Gales Creek Rd & Thatcher Rd

2035 PM Peak with Development

Intersection

Int Delay, s/veh 3.5

Movement	EBL	EBT	WBT	WBR	SBL	SBR
Vol, veh/h	5	48	169	94	97	52
Conflicting Peds, #/hr	0	0	0	0	0	0
Sign Control	Free	Free	Free	Free	Stop	Stop
RT Channelized	-	None	-	Yield	-	None
Storage Length	150	-	-	-	0	-
Veh in Median Storage, #	-	0	0	-	0	-
Grade, %	-	0	0	-	0	-
Peak Hour Factor	93	93	93	93	93	93
Heavy Vehicles, %	2	2	2	2	2	2
Mvmt Flow	5	52	182	101	104	56

Major/Minor	Major1	Major2	Minor2
Conflicting Flow All	182	0	244
Stage 1	-	-	182
Stage 2	-	-	62
Critical Hdwy	4.12	-	6.42
Critical Hdwy Stg 1	-	-	5.42
Critical Hdwy Stg 2	-	-	5.42
Follow-up Hdwy	2.218	-	3.518
Pot Cap-1 Maneuver	1393	-	744
Stage 1	-	-	849
Stage 2	-	-	961
Platoon blocked, %	-	-	-
Mov Cap-1 Maneuver	1393	-	741
Mov Cap-2 Maneuver	-	-	741
Stage 1	-	-	849
Stage 2	-	-	958

Approach	EB	WB	SB
HCM Control Delay, s	0.7	0	10.8
HCM LOS			B

Minor Lane/Major Mvmt	EBL	EBT	WBT	WBR	SBLn1
Capacity (veh/h)	1393	-	-	-	779
HCM Lane V/C Ratio	0.004	-	-	-	0.206
HCM Control Delay (s)	7.6	-	-	-	10.8
HCM Lane LOS	A	-	-	-	B
HCM 95th %tile Q(veh)	0	-	-	-	0.8

Westside Planning Project
11: Hwy 47 & Martin Rd

2035 PM Peak with Development

Intersection

Int Delay, s/veh 0

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBR	SEL	SER
Vol, veh/h	75	332	5	100	253	209	510	240	272	346
Conflicting Peds, #/hr	0	0	0	0	0	0	0	0	0	0
Sign Control	Stop	Stop	Stop	Stop	Stop	Stop	Free	Free	Free	Free
RT Channelized	-	-	None	-	-	None	-	None	-	-
Storage Length	0	-	-	0	-	-	0	220	200	0
Veh in Median Storage, #	-	1	-	-	1	-	0	-	0	-
Grade, %	-	0	-	-	0	-	0	-	0	-
Peak Hour Factor	92	92	92	96	92	96	96	96	96	96
Heavy Vehicles, %	2	2	2	4	2	2	3	3	0	5
Mvmt Flow	82	361	5	104	275	218	531	250	283	360

Major/Minor	Minor2		Minor1			Major2	
Conflicting Flow All	1255	1009	442	1192	1090	0	0
Stage 1	1009	1009	-	0	0	-	-
Stage 2	246	0	-	1192	1090	-	-
Critical Hdwy	7.12	6.52	6.22	7.14	6.52	-	-
Critical Hdwy Stg 1	6.12	5.52	-	-	-	-	-
Critical Hdwy Stg 2	-	-	-	6.14	5.52	-	-
Follow-up Hdwy	3.518	4.018	3.318	3.536	4.018	-	-
Pot Cap-1 Maneuver	148	~ 240	615	162	~ 215	-	-
Stage 1	290	~ 318	-	-	-	-	-
Stage 2	-	-	-	226	291	-	-
Platoon blocked, %	-	-	-	-	-	-	-
Mov Cap-1 Maneuver	-	~ 240	615	-	~ 215	-	-
Mov Cap-2 Maneuver	~ -9397	~ 303	-	-	303	-	-
Stage 1	290	~ 318	-	-	-	-	-
Stage 2	-	-	-	-	291	-	-

Approach EB WB SE

HCM Control Delay, s

HCM LOS - -

Minor Lane/Major Mvmt	EBLn1	EBLn2	WBLn1	WBLn2	SEL	SER	SER2
Capacity (veh/h)	-	305	-	-	-	-	-
HCM Lane V/C Ratio	-	1.201	-	-	-	-	-
HCM Control Delay (s)	-	153.8	-	-	-	-	-
HCM Lane LOS	-	F	-	-	-	-	-
HCM 95th %tile Q(veh)	-	16.2	-	-	-	-	-

Notes

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

MOVEMENT SUMMARY

 **Site: Purdin Rd/Verboort Rd at Hwy 47**

Projected 2035 Total Westside Volumes
PM Peak Hour
Roundabout

Movement Performance - Vehicles											
Mov ID	OD Mov	Demand Total veh/h	Flows HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	Queue Distance ft	Prop. Queued	Effective Stop Rate per veh	Average Speed mph
South: NB Hwy 47											
3	L2	27	7.0	0.791	11.9	LOS B	11.2	287.8	0.79	0.57	35.2
8	T1	734	3.0	0.791	5.9	LOS A	11.2	287.8	0.79	0.57	35.3
18	R2	125	6.0	0.791	5.9	LOS A	11.2	287.8	0.79	0.57	34.2
Approach		886	3.5	0.791	6.1	LOS A	11.2	287.8	0.79	0.57	35.1
East: WB Verboort Rd											
1	L2	181	1.0	0.528	19.2	LOS B	4.6	115.6	0.96	1.05	31.5
6	T1	94	0.0	0.528	13.3	LOS B	4.6	115.6	0.96	1.05	31.4
16	R2	14	0.0	0.528	13.3	LOS B	4.6	115.6	0.96	1.05	30.6
Approach		289	0.6	0.528	17.0	LOS B	4.6	115.6	0.96	1.05	31.4
North: SB Hwy 47											
7	L2	55	14.0	1.342	174.2	LOS F	122.6	3177.3	1.00	3.41	10.1
4	T1	960	5.0	1.342	168.2	LOS F	122.6	3177.3	1.00	3.41	10.1
14	R2	195	0.0	1.342	168.1	LOS F	122.6	3177.3	1.00	3.41	10.0
Approach		1210	4.6	1.342	168.4	LOS F	122.6	3177.3	1.00	3.41	10.1
West: EB Purdin Rd											
5	L2	15	14.0	0.199	18.5	LOS B	1.4	35.0	0.93	0.91	32.7
2	T1	53	2.0	0.199	12.4	LOS B	1.4	35.0	0.93	0.91	32.9
12	R2	10	0.0	0.199	12.4	LOS B	1.4	35.0	0.93	0.91	32.1
Approach		78	4.0	0.199	13.5	LOS B	1.4	35.0	0.93	0.91	32.8
All Vehicles		2464	3.7	1.342	87.4	LOS F	122.6	3177.3	0.92	2.03	15.8

Level of Service (LOS) Method: Delay & v/c (HCM 2010).

Roundabout LOS Method: Same as Signalised Intersections.

Vehicle movement LOS values are based on average delay and v/c ratio (degree of saturation) per movement

LOS F will result if v/c > 1 irrespective of movement delay value (does not apply for approaches and intersection).

Intersection and Approach LOS values are based on average delay for all movements (v/c not used as specified in HCM 2010).

Roundabout Capacity Model: SIDRA Standard.

SIDRA Standard Delay Model is used. Control Delay includes Geometric Delay.

Gap-Acceptance Capacity: SIDRA Standard (Akçelik M3D).

HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.

MOVEMENT SUMMARY

 **Site: David Hill Rd at Hwy 47**

Projected 2035 Total Westside Volumes
PM Peak Hour
Roundabout

Movement Performance - Vehicles											
Mov ID	OD Mov	Demand Total veh/h	Flows HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	of Queue Distance ft	Prop. Queued	Effective Stop Rate per veh	Average Speed mph
South: NB Hwy 47											
3	L2	314	2.0	0.995	47.3	LOS D	27.8	705.2	1.00	1.68	23.0
8	T1	378	2.0	0.995	41.4	LOS D	27.8	705.2	1.00	1.68	22.9
Approach		692	2.0	0.995	44.1	LOS D	27.8	705.2	1.00	1.68	22.9
North: SB Hwy 47											
4	T1	463	2.0	1.329	162.5	LOS F	119.3	3030.8	1.00	3.36	10.3
14	R2	743	2.0	1.329	162.5	LOS F	119.3	3030.8	1.00	3.36	10.2
Approach		1207	2.0	1.329	162.5	LOS F	119.3	3030.8	1.00	3.36	10.3
West: EB David Hill Rd											
5	L2	548	2.0	0.830	19.8	LOS B	14.0	356.1	1.00	1.05	30.9
12	R2	178	2.0	0.830	13.9	LOS B	14.0	356.1	1.00	1.05	30.0
Approach		726	2.0	0.830	18.4	LOS B	14.0	356.1	1.00	1.05	30.7
All Vehicles		2625	2.0	1.329	91.4	LOS F	119.3	3030.8	1.00	2.28	15.4

Level of Service (LOS) Method: Delay & v/c (HCM 2010).

Roundabout LOS Method: Same as Signalised Intersections.

Vehicle movement LOS values are based on average delay and v/c ratio (degree of saturation) per movement

LOS F will result if v/c > 1 irrespective of movement delay value (does not apply for approaches and intersection).

Intersection and Approach LOS values are based on average delay for all movements (v/c not used as specified in HCM 2010).

Roundabout Capacity Model: SIDRA Standard.

SIDRA Standard Delay Model is used. Control Delay includes Geometric Delay.

Gap-Acceptance Capacity: SIDRA Standard (Akçelik M3D).

HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.

Westside Planning Project
 89: Sunset Dr/ Bend Rd & Hwy 47

2035 PM Peak with Development

												
Movement	SEL	SET	SER	NWL	NWT	NWR	NEL	NET	NER	SWL	SWT	SWR
Lane Configurations												
Volume (veh/h)	3	404	183	60	358	1	282	5	39	1	5	1
Number	5	2	12	1	6	16	7	4	14	3	8	18
Initial Q (Qb), veh	0	0	0	0	0	0	0	0	0	0	0	0
Ped-Bike Adj(A_pbT)	1.00		1.00	1.00		1.00	1.00		1.00	1.00		1.00
Parking Bus, Adj	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Adj Sat Flow, veh/h/ln	1800	1714	1782	1800	1731	1800	1748	1800	1800	1800	1800	1800
Adj Flow Rate, veh/h	3	434	0	65	385	1	303	5	42	1	5	1
Adj No. of Lanes	1	1	1	1	1	0	1	1	0	1	1	0
Peak Hour Factor	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93
Percent Heavy Veh, %	0	5	1	0	4	4	3	0	0	0	0	0
Cap, veh/h	317	757	669	317	777	2	396	40	340	365	356	71
Arrive On Green	0.18	0.44	0.00	0.18	0.45	0.43	0.24	0.24	0.24	0.24	0.24	0.24
Sat Flow, veh/h	1714	1714	1515	1714	1726	4	1391	165	1389	1380	1457	291
Grp Volume(v), veh/h	3	434	0	65	0	386	303	0	47	1	0	6
Grp Sat Flow(s),veh/h/ln	1714	1714	1515	1714	0	1730	1391	0	1555	1380	0	1749
Q Serve(g_s), s	0.2	22.7	0.0	3.9	0.0	19.0	25.3	0.0	2.8	0.1	0.0	0.3
Cycle Q Clear(g_c), s	0.2	22.7	0.0	3.9	0.0	19.0	25.7	0.0	2.8	2.9	0.0	0.3
Prop In Lane	1.00		1.00	1.00		0.00	1.00		0.89	1.00		0.17
Lane Grp Cap(c), veh/h	317	757	669	317	0	779	396	0	380	365	0	428
V/C Ratio(X)	0.01	0.57	0.00	0.21	0.00	0.50	0.76	0.00	0.12	0.00	0.00	0.01
Avail Cap(c_a), veh/h	317	757	669	317	0	779	537	0	538	505	0	605
HCM Platoon Ratio	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Upstream Filter(I)	1.00	1.00	0.00	1.00	0.00	1.00	1.00	0.00	1.00	1.00	0.00	1.00
Uniform Delay (d), s/veh	40.0	25.0	0.0	41.5	0.0	23.4	44.1	0.0	35.5	36.5	0.0	34.4
Incr Delay (d2), s/veh	0.0	3.1	0.0	0.3	0.0	2.3	4.5	0.0	0.1	0.0	0.0	0.0
Initial Q Delay(d3),s/veh	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
%ile BackOfQ(50%),veh/ln	0.1	11.4	0.0	1.9	0.0	9.5	10.3	0.0	1.2	0.0	0.0	0.2
LnGrp Delay(d),s/veh	40.0	28.2	0.0	41.8	0.0	25.6	48.6	0.0	35.6	36.5	0.0	34.4
LnGrp LOS	D	C		D		C	D		D	D		C
Approach Vol, veh/h		437			451			350				7
Approach Delay, s/veh		28.3			27.9			46.8				34.7
Approach LOS		C			C			D				C
Timer	1	2	3	4	5	6	7	8				
Assigned Phs	1	2		4	5	6		8				
Phs Duration (G+Y+Rc), s	28.2	57.0		34.8	27.2	58.0		34.8				
Change Period (Y+Rc), s	6.0	6.0		6.0	6.0	6.0		6.0				
Max Green Setting (Gmax), s	10.0	51.0		41.0	9.0	52.0		41.0				
Max Q Clear Time (g_c+I1), s	5.9	24.7		27.7	2.2	21.0		4.9				
Green Ext Time (p_c), s	0.0	1.6		1.2	0.1	1.4		1.5				
Intersection Summary												
HCM 2010 Ctrl Delay			33.4									
HCM 2010 LOS			C									

Westside Planning Project
89: Sunset Dr/ Bend Rd & Hwy 47

2035 PM Peak with Development



Movement	SEL	SET	SER	NWL	NWT	NWR	NEL	NET	NER	SWL	SWT	SWR
Lane Configurations												
Volume (vph)	3	404	183	60	358	1	282	5	39	1	5	1
Ideal Flow (vphpl)	1800	1800	1800	1800	1800	1800	1800	1800	1800	1800	1800	1800
Total Lost time (s)	5.0	4.0	4.0	6.0	4.0		5.5	5.5		5.5	5.5	
Lane Util. Factor	1.00	1.00	1.00	1.00	1.00		1.00	1.00		1.00	1.00	
Frpb, ped/bikes	1.00	1.00	0.98	1.00	1.00		1.00	1.00		1.00	1.00	
Flpb, ped/bikes	1.00	1.00	1.00	1.00	1.00		1.00	1.00		1.00	1.00	
Frt	1.00	1.00	0.85	1.00	1.00		1.00	0.87		1.00	0.97	
Flt Protected	0.95	1.00	1.00	0.95	1.00		0.95	1.00		0.95	1.00	
Satd. Flow (prot)	1710	1714	1480	1710	1730		1660	1559		1710	1755	
Flt Permitted	0.95	1.00	1.00	0.95	1.00		0.75	1.00		0.73	1.00	
Satd. Flow (perm)	1710	1714	1480	1710	1730		1317	1559		1307	1755	
Peak-hour factor, PHF	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93
Adj. Flow (vph)	3	434	197	65	385	1	303	5	42	1	5	1
RTOR Reduction (vph)	0	0	98	0	0	0	0	30	0	0	1	0
Lane Group Flow (vph)	3	434	99	65	386	0	303	17	0	1	5	0
Confl. Peds. (#/hr)			1	1								
Heavy Vehicles (%)	0%	5%	1%	0%	4%	0%	3%	0%	0%	0%	0%	0%
Turn Type	Prot	NA	Perm	Prot	NA		Perm	NA		Perm	NA	
Protected Phases	5	2		1	6			4				8
Permitted Phases			2				4	4		8		
Actuated Green, G (s)	1.8	58.3	58.3	11.3	67.8		32.4	32.4		32.4	32.4	
Effective Green, g (s)	2.8	60.3	60.3	11.3	69.8		32.9	32.9		32.9	32.9	
Actuated g/C Ratio	0.02	0.50	0.50	0.09	0.58		0.27	0.27		0.27	0.27	
Clearance Time (s)	6.0	6.0	6.0	6.0	6.0		6.0	6.0		6.0	6.0	
Vehicle Extension (s)	3.0	3.0	3.0	3.0	3.0		3.0	3.0		3.0	3.0	
Lane Grp Cap (vph)	39	861	743	161	1006		361	427		358	481	
v/s Ratio Prot	0.00	c0.25		c0.04	c0.22			0.01				0.00
v/s Ratio Perm			0.07				c0.23			0.00		
v/c Ratio	0.08	0.50	0.13	0.40	0.38		0.84	0.04		0.00	0.01	
Uniform Delay, d1	57.3	19.9	15.9	51.2	13.5		41.1	31.9		31.6	31.7	
Progression Factor	0.84	0.51	0.01	1.01	1.09		1.00	1.00		1.00	1.00	
Incremental Delay, d2	0.6	1.6	0.3	1.6	1.1		15.6	0.0		0.0	0.0	
Delay (s)	49.0	11.7	0.4	53.3	15.9		56.7	32.0		31.6	31.7	
Level of Service	D	B	A	D	B		E	C		C	C	
Approach Delay (s)		8.3			21.3			53.3			31.7	
Approach LOS		A			C			D			C	

Intersection Summary

HCM 2000 Control Delay	23.4	HCM 2000 Level of Service	C
HCM 2000 Volume to Capacity ratio	0.60		
Actuated Cycle Length (s)	120.0	Sum of lost time (s)	15.5
Intersection Capacity Utilization	62.0%	ICU Level of Service	B
Analysis Period (min)	15		
c Critical Lane Group			

Westside Planning Project
27: Hwy 47 & Pacific Ave

2035 PM Peak with Development

												
Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Volume (veh/h)	95	660	57	360	1168	188	58	263	359	382	328	210
Number	5	2	12	1	6	16	3	8	18	7	4	14
Initial Q (Qb), veh	0	0	0	0	0	0	0	0	0	0	0	0
Ped-Bike Adj(A_pbT)	1.00		1.00	1.00		0.99	1.00		1.00	1.00		1.00
Parking Bus, Adj	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Adj Sat Flow, veh/h/ln	1636	1731	1565	1636	1748	1714	1667	1667	1698	1714	1617	1800
Adj Flow Rate, veh/h	96	667	0	364	1180	85	59	266	0	386	331	192
Adj No. of Lanes	1	2	1	1	2	1	1	1	1	1	1	0
Peak Hour Factor	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99
Percent Heavy Veh, %	10	4	15	10	3	5	8	8	6	5	16	16
Cap, veh/h	104	712	288	377	1300	568	66	278	241	395	352	204
Arrive On Green	0.13	0.43	0.00	0.08	0.13	0.13	0.04	0.17	0.00	0.24	0.37	0.37
Sat Flow, veh/h	1558	3288	1330	1558	3320	1450	1587	1667	1443	1633	961	558
Grp Volume(v), veh/h	96	667	0	364	1180	85	59	266	0	386	0	523
Grp Sat Flow(s),veh/h/ln	1558	1644	1330	1558	1660	1450	1587	1667	1443	1633	0	1519
Q Serve(g_s), s	7.3	23.2	0.0	27.9	42.1	2.9	4.4	19.0	0.0	28.2	0.0	39.9
Cycle Q Clear(g_c), s	7.3	23.2	0.0	27.9	42.1	2.9	4.4	19.0	0.0	28.2	0.0	39.9
Prop In Lane	1.00		1.00	1.00		1.00	1.00		1.00	1.00		0.37
Lane Grp Cap(c), veh/h	104	713	288	377	1300	568	66	278	241	395	0	557
V/C Ratio(X)	0.92	0.94	0.00	0.97	0.91	0.15	0.89	0.96	0.00	0.98	0.00	0.94
Avail Cap(c_a), veh/h	104	713	288	377	1300	568	66	278	241	395	0	557
HCM Platoon Ratio	2.00	2.00	2.00	0.33	0.33	0.33	1.00	1.00	1.00	1.00	1.00	1.00
Upstream Filter(I)	0.60	0.60	0.00	0.66	0.66	0.66	1.00	1.00	0.00	1.00	0.00	1.00
Uniform Delay (d), s/veh	51.7	33.2	0.0	54.7	50.1	7.5	57.2	49.6	0.0	45.2	0.0	36.7
Incr Delay (d2), s/veh	47.1	14.8	0.0	29.2	7.5	0.4	74.0	42.4	0.0	39.4	0.0	24.1
Initial Q Delay(d3),s/veh	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
%ile BackOfQ(50%),veh/ln	4.5	11.8	0.0	15.1	20.7	1.2	3.3	12.0	0.0	17.0	0.0	20.4
LnGrp Delay(d),s/veh	98.8	48.0	0.0	83.9	57.6	7.9	131.3	92.0	0.0	84.6	0.0	60.8
LnGrp LOS	F	D		F	E	A	F	F		F		E
Approach Vol, veh/h		763			1629			325			909	
Approach Delay, s/veh		54.4			60.9			99.1			70.9	
Approach LOS		D			E			F			E	
Timer	1	2	3	4	5	6	7	8				
Assigned Phs	1	2	3	4	5	6	7	8				
Phs Duration (G+Y+Rc), s	33.0	30.0	9.0	48.0	12.0	51.0	33.0	24.0				
Change Period (Y+Rc), s	4.0	5.0	4.0	4.0	4.0	5.0	4.0	4.0				
Max Green Setting (Gmax), s	29.0	25.0	5.0	44.0	8.0	46.0	29.0	20.0				
Max Q Clear Time (g_c+I1), s	29.9	25.2	6.4	41.9	9.3	44.1	30.2	21.0				
Green Ext Time (p_c), s	0.0	0.0	0.0	1.0	0.0	1.6	0.0	0.0				
Intersection Summary												
HCM 2010 Ctrl Delay			65.5									
HCM 2010 LOS			E									

Westside Planning Project
27: Hwy 47 & Pacific Ave

2035 PM Peak with Development

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR	
Lane Configurations													
Volume (vph)	95	660	57	360	1168	188	58	263	359	382	328	210	
Ideal Flow (vphpl)	1800	1800	1800	1800	1800	1800	1800	1800	1800	1800	1800	1800	
Total Lost time (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	
Lane Util. Factor	1.00	0.95	1.00	1.00	0.95	1.00	1.00	1.00	1.00	1.00	1.00	1.00	
Frpb, ped/bikes	1.00	1.00	0.98	1.00	1.00	0.97	1.00	1.00	1.00	1.00	1.00	1.00	
Flpb, ped/bikes	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	
Frt	1.00	1.00	0.85	1.00	1.00	0.85	1.00	1.00	0.85	1.00	0.94		
Flt Protected	0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00		
Satd. Flow (prot)	1555	3288	1300	1555	3320	1412	1583	1667	1443	1629	1522		
Flt Permitted	0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00	1.00	0.95	1.00		
Satd. Flow (perm)	1555	3288	1300	1555	3320	1412	1583	1667	1443	1629	1522		
Peak-hour factor, PHF	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	
Adj. Flow (vph)	96	667	58	364	1180	190	59	266	363	386	331	212	
RTOR Reduction (vph)	0	0	45	0	0	106	0	0	303	0	19	0	
Lane Group Flow (vph)	96	667	13	364	1180	84	59	266	61	386	524	0	
Confl. Peds. (#/hr)	4		1	1		4							
Heavy Vehicles (%)	10%	4%	15%	10%	3%	5%	8%	8%	6%	5%	16%	4%	
Turn Type	Prot	NA	Perm	Prot	NA	Perm	Prot	NA	Perm	Prot	NA		
Protected Phases	5	2		1	6		3	8		7	4		
Permitted Phases			2			6			8				
Actuated Green, G (s)	8.0	25.0	25.0	29.0	46.0	46.0	5.0	20.0	20.0	29.0	44.0		
Effective Green, g (s)	8.0	26.0	26.0	29.0	47.0	47.0	5.0	20.0	20.0	29.0	44.0		
Actuated g/C Ratio	0.07	0.22	0.22	0.24	0.39	0.39	0.04	0.17	0.17	0.24	0.37		
Clearance Time (s)	4.0	5.0	5.0	4.0	5.0	5.0	4.0	4.0	4.0	4.0	4.0		
Vehicle Extension (s)	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0		
Lane Grp Cap (vph)	103	712	281	375	1300	553	65	277	240	393	558		
v/s Ratio Prot	0.06	0.20		c0.23	c0.36		0.04	c0.16		0.24	c0.34		
v/s Ratio Perm			0.01			0.06			0.04				
v/c Ratio	0.93	0.94	0.04	0.97	0.91	0.15	0.91	0.96	0.25	0.98	0.94		
Uniform Delay, d1	55.7	46.2	37.2	45.1	34.5	23.6	57.3	49.6	43.5	45.2	36.7		
Progression Factor	0.98	0.86	1.00	0.90	0.94	0.85	1.00	1.00	1.00	0.93	0.90		
Incremental Delay, d2	52.3	16.0	0.2	31.5	8.1	0.4	78.9	43.1	0.6	40.4	23.7		
Delay (s)	106.7	55.9	37.4	72.0	40.3	20.4	136.2	92.7	44.0	82.3	56.8		
Level of Service	F	E	D	E	D	C	F	F	D	F	E		
Approach Delay (s)		60.6			44.8			70.8			67.4		
Approach LOS		E			D			E			E		
Intersection Summary													
HCM 2000 Control Delay			57.2		HCM 2000 Level of Service					E			
HCM 2000 Volume to Capacity ratio			0.99										
Actuated Cycle Length (s)			120.0		Sum of lost time (s)					16.0			
Intersection Capacity Utilization			90.6%		ICU Level of Service					E			
Analysis Period (min)			15										
c Critical Lane Group													