GOLD FLAT ROAD CORRIDOR STUDY

Prepared for the

City of Nevada City

Prepared by

LSC Transportation Consultants, Inc.

TRANSPORTATION CONSULTANTS, INC.

Gold Flat Road Corridor Study

Prepared for the

City of Nevada City
317 Broad Street
Nevada City, California 95959
530 • 265 2496

Prepared by

LSC Transportation Consultants, Inc.
P.O. Box 5875
2690 Lake Forest Road, Suite C
Tahoe City, California 96145
530 • 583-4053

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LSC #087030

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Introduction

LSC Transportation Consultants, Inc. was retained by the City of Nevada City to conduct an evaluation of existing and future traffic conditions along Gold Flat Road in the western portion of Nevada City, and to evaluate potential improvements to ensure adequate traffic conditions in the future. As shown in Figure 1, this "Gold Flat Corridor" includes the following intersections:

- Gold Flat Road/Ridge Road/Nevada City Highway/Zion Street
- Gold Flat Road/Searls Way/Lower Grass Valley Road
- Gold Flat Road/Golden Center Freeway (SR20/SR49) westbound ramps
- Gold Flat Road/Golden Center Freeway eastbound ramps
- Gold Flat Road/Hollow Way/Caltrans Yard Access

Note that for purposes of this study, Ridge Road, Zion Street, and the Golden Center Freeway are assumed to lie in an east-west orientation, while Gold Flat Road and Ridge Road are assumed to lie in a north-south orientation. This 0.3-mile-long corridor serves as a key element of the roadway network in the Nevada City/Grass Valley area, carrying substantial volumes and serving a range of commercial, school, employment, and residential land uses. All roadways along the corridor consist of one travel lane in each direction, and traffic control is limited to Stop signs only.

The corridor can be considered in two key segments, each of which has geometric limitations that impact traffic operations:

- The Gold Flat/Ridge/Zion/Nevada City Highway junction is at an acute angle, with roughly a 35 degree angle between the Ridge/Gold Flat Road alignment and the Zion/Nevada City Highway alignment. This intersection was historically a 4-Way Stop, which operated poorly in part due to the large size of the intersection generated by the acute angle and multiple turn lanes. In 2007 it was converted to two closely-spaced "T" intersections, with Stop sign controls on all approaches. Each of these roadways consists of a single through travel lane in each direction, with additional turn lanes. Each turning movement of the approaching side streets has its own lane. The right-turn movements from Gold Flat Road to Zion Street and from Ridge Road to Nevada City Highway are controlled by Yield signs, while all other movements are controlled by Stop signs.

- The key issue associated with the other four study intersections is the very limited distance between the intersections. The distance along Gold Flat Road between the Searls/Lower Grass Valley intersection and the westbound ramp intersection is only roughly 100 feet, while there is only roughly 90 feet along Gold Flat Road between the eastbound ramp intersection and the Hollow Way/Caltrans Access Drive intersection. The distance between the two ramp intersections is on the order of 270 feet. As traffic volumes in the area grow, these short distances between intersections have the potential to cause interlocking traffic queues that can

FIGURE 1

Existing Study Area Roadways and Traffic Control

significantly degrade traffic conditions. Traffic control is currently provided by Stop signs on most but not all approaches: in order to minimize queues blocking adjacent intersections, there is no traffic control on the northbound Gold Flat Road movement at the eastbound ramps or Searls Road intersections, or on the southbound Gold Flat Road movement at the westbound ramps or Hollow Way.

The following chapter presents an evaluation of existing traffic conditions. Next, Chapter 3 presents forecasts of future traffic volumes, traffic conditions, and potential improvements to attain Level of Service standards and avoid traffic queue issues. Finally, Chapter 4 presents a summary of study findings and recommendations.

Chapter 2
Analysis of Existing Conditions

Existing Design Volumes

Existing volumes were developed based on counts conducted by LSC staff in May of 2007 and February of 2008. These counts were reviewed and found to reflect traffic activity over the course of a typical busy traffic period. These intersection volumes were then balanced between adjacent intersections. The resulting volumes are shown in Table 1. Note that these counts (and the remainder of the analysis) consider the AM peak hour, the PM peak hour of school traffic activity, as well as the PM peak hour of commute traffic activity, in order to ensure roadway elements operate acceptably under all peak conditions

Existing Level of Service

The City of Nevada City has not adopted a specific standard for Level of Service (LOS), and instead relies on the Nevada County standards. According to the *Nevada County General Plan* (Harland Bartholomew & Associates, Inc., 1995), the minimum acceptable LOS for the areas identified as Community Regions shall be LOS D, except where the existing LOS is less than D. In those situations, the LOS shall not be allowed to fall below the existing LOS. LOS D was applied in the Gold Flat Corridor.

Traffic analysis for intersections controlled by stop signs or traffic signals was conducted using the *Synchro/Simtraffic* analysis package (Version 6). This software has the advantage of reflecting the interaction between closely spaced intersections (like those found along Gold Flat Road near the interchange, or the two new intersections at Ridge/Zion). The design volumes were entered into the program, along with the existing roadway geometrics and traffic control. The only exception is that the improvements to the Gold Flat Road/Searls intersection (a second southbound lane for right-turn movements onto Lower Grass Valley Road and the freeway westbound on-ramps) is assumed to be completed, as this has already been approved for implementation in the summer of 2008.

A total of five simulations were run for each peak hour design period, and the results averaged. As shown in Table 2, overall LOS under these existing conditions is found to be good, for all three peak periods. Considering average delay through each intersection, LOS ranges from A to B for all peak periods. By individual turning movement, the results are as follows:

- At the two Ridge/Zion “T” intersections, all movements operate at LOS A or B in all design periods.

- At the Gold Flat Road/Hollow Way/Caltrans Driveway intersection, all movements operate at LOS A.

TABLE 1: 2008 Peak Hour Design Volumes

	NB			SB			EB			WB			North Leg		South Leg		East Leg		West Leg	
	Left	Thru	Right	Left	Thru	Right	Left	Thru	Right	Left	Thru	Right	In	Out	In	Out	In	Out	In	Out
AM Peak Hour																				
Hollow Way / Caltrans	0	179	9	84	145	6	16	1	4	5	0	68	235	263	188	154	73	94	21	6
GFR/ SR 20/49 EB Ramps	0	208	54	134	115	0	432	0	120	0	0	0	249	640	262	235	0	188	552	0
GFR/ SR 20/49 WB Ramps	105	534	0	0	205	250	0	0	0	43	0	185	455	719	639	248	228	0	0	355
Searls / GFR	48	412	258	34	321	9	5	8	28	105	5	23	364	440	718	454	133	300	41	62
Ridge and Zion East	166	0	273	0	0	0	0	277	178	185	239	0	0	0	439	363	424	550	455	405
Ridge and Zion West	0	0	0	249	0	29	36	206	2	0	217	188	278	224	0	2	405	455	244	246
School PM Peak Hour																				
Hollow Way / Caltrans	0	166	9	87	159	12	7	0	4	4	0	84	258	257	175	167	88	96	11	12
GFR/ SR 20/49 EB Ramps	0	204	53	194	137	0	376	0	121	0	0	0	331	580	257	258	0	247	497	0
GFR/ SR 20/49 WB Ramps	121	458	0	0	280	380	0	0	0	51	2	182	660	640	579	331	235	0	0	503
Searls / GFR	45	347	247	21	402	17	13	5	57	201	4	35	440	395	639	660	240	273	75	66
Ridge and Zion East	214	0	180	0	0	0	0	305	240	200	304	0	0	0	394	440	504	485	545	518
Ridge and Zion West	0	0	10	271	0	71	53	264	1	1	256	261	342	314	10	2	518	545	318	327
Commute PM Peak Hour																				
Hollow Way / Caltrans	0	214	10	68	193	3	7	0	0	3	0	94	264	315	224	196	97	78	7	3
GFR/ SR 20/49 EB Ramps	0	240	74	242	136	0	314	4	128	0	0	0	378	554	314	264	0	320	446	0
GFR/ SR 20/49 WB Ramps	185	368	0	0	337	327	0	0	0	41	2	183	664	551	553	378	226	0	0	514
Searls / GFR	49	297	204	10	420	6	13	3	59	185	3	21	436	331	550	664	209	217	75	58
Ridge and Zion East	215	0	115	0	0	0	0	294	232	203	248	0	0	0	330	435	451	409	526	463
Ridge and Zion West	0	0	2	239	0	36	48	285	4	0	192	271	275	319	2	4	463	526	337	228

Source: LSC Transportation Consultants, INC. *GFRCorridor.xls*

TABLE 2: 2008 Intersection Level of Service

No Improvements Other Than Separate SBR Lane on Gold Flat Road at Searls

	Total Intersection			Worst Movement			
Pk Hr / Intersection	Total Delay (hr)	Delay / Veh (sec)	LOS	Movement ID	Delay / Veh (sec)	LOS	95th % Queue (ft)
AM Peak Hour							
Hollow Way / Caltrans	0.9	3.8	A	EBT	8.6	A	18
GFR/ SR 20/49 EB Ramps	5.8	11.4	B	EBL	15.5	C	193
GFR/ SR 20/49 WB Ramps	4.1	6.4	A	WBL	22.2	C	97
Searls / GFR	3.8	6.2	A	SBL	19.0	C	83
Ridge and Zion East	4.4	6.9	A	WBL	11.4	B	66
Ridge and Zion West	3.6	8.0	A	SBL	10.5	B	97
School PM Peak Hour							
Hollow Way / Caltrans	0.9	3.4	A	NBT	7.6	A	64
GFR/ SR 20/49 EB Ramps	5.7	11.0	B	EBL	14.9	B	167
GFR/ SR 20/49 WB Ramps	5.0	7.0	A	WBL	34.3	D	85
Searls / GFR	6.5	9.6	A	W BT	26.7	D	164
Ridge and Zion East	5.4	7.7	A	WBL	11.9	B	64
Ridge and Zion West	4.9	8.6	A	EBT	12.1	B	102
Commute PM Peak Hour							
Hollow Way / Caltrans	1.2	4.4	A	NBT	8.6	A	83
GFR/ SR 20/49 EB Ramps	6.2	11.5	B	EBT	17.6	C	143
GFR/ SR 20/49 WB Ramps	5.5	7.9	A	WBL	52.6	F	106
Searls / GFR	5.2	8.5	A	EBT	17.1	C	29
Ridge and Zion East	4.8	7.5	A	WBL	11.9	B	68
Ridge and Zion West	4.3	8.1	A	EBT	11.9	B	100

Source: LSC Transportation Consultants, Inc. *GFRCorridor.xls*

- At the Gold Flat Road/Eastbound Ramps intersection, the worst movement LOS is B to C.

- At the Gold Flat Road/Westbound Ramps intersection, the worst movement (the westbound left-turn movement from the off-ramp to southbound Gold Flat Road) is C in the AM peak hour, D in the school PM peak hour, and F in the commute PM peak hour.

- At the Gold Flat Road/Searls intersection, worst movement LOS is C in the AM and commute PM peak hours, and D in the school PM peak hour.

As indicated, the only movement that provides an unacceptably poor LOS is the westbound left-turn movement from the off-ramp onto Gold Flat Road southbound. While the number of vehicles per hour making this movement is relatively low (41 vehicles, or roughly 1 vehicle every 1.5 minutes), there are relatively few acceptable gaps in the northbound and southbound traffic along Gold Flat Road. The traffic volumes are substantially below those needed to meet signal warrants, and the total vehicle-hours of delay on this movement is only 0.6 during the commute PM peak hour. Furthermore, the highest 95th percentile queue length (the queue length with a 5 percent chance of exceedance during the peak hour) is 106 feet, compared with an available ramp length of 940 feet between the Stop bar and the westbound ramp gore point. This condition therefore does not warrant substantial improvements at this time.

Chapter 3
Analysis of Future Conditions

This chapter first presents the methodology used to forecast future traffic volumes. Next, intersection operation assuming no change in traffic control is evaluated. Future conditions are then assessed assuming roundabouts or traffic signals, and the necessary configurations needed to provide adequate LOS under either control option are identified. Finally, the advantages/disadvantages of each are discussed.

Future Volumes

Future (2030) design were developed using the following steps:

1. PM peak hour roadway link traffic volumes estimated by the Western Nevada County TransCAD traffic model were obtained from Prism Engineering for 2006 and 2030 conditions. Screen shots depicting these model results are presented in Appendix A.

2. In addition, the land use files used as the basis for these models were obtained, as provided to Prism by the Nevada County Transportation and Sanitation Department. The model Traffic Analysis Zone (TAZ) network in the Gold Flat area is presented in Appendix A. This figure also indicates the structure of the traffic model (the "links and nodes") in the vicinity. Comparing the 2006 and 2030 land use files yields the growth in the study area assumed in the traffic model, as shown in Table 3.

3. The existing design volumes were factored by the modeled growth in volumes. Each 2008 turning movement was factored by the weighted average of the ratio of 2030 to 2006 model link volumes for both the inbound and outbound leg (weighted by the 2006 volume), adjusted to reflect 22 years of growth (2008 to 2030) rather than 24 years of growth (2006 to 2030). As the TransCAD model is only available for PM peak hour conditions, AM peak hour growth factors were identified by "flipping" the PM model growth factors. For instance, the AM eastbound inbound growth factor at a specific intersection was assumed to be equal to the PM westbound outbound growth factor.

4. Based upon a review of the model and a discussion with the study steering committee, the model results were adjusted as follows:

   - The traffic model does not include a link representing Lower Grass Valley Road. The existing design volumes were assumed to remain unchanged in the future, as no future growth in land use is assumed in the model for this TAZ (TAZ 103).

TABLE 3: Summary of 2006-2030 Land Use Growth Assumed in Nevada County Model for Gold Flat Road Area

Traffic Analysis Zone	Land Use Category	Commercial	High Intensity Commercial	Fire Station	Light Industrial	Professional Office	Public	Single Family Residential	Multifamily Residential	Rural Residential
	Units	Acres	Acres	Acres	Acres	Acres	Acres	DU	DU	DU
103		0.00	0.00	0.00	0.00	0.00	0.00	0	0	0
143		0.00	1.21	0.00	0.00	0.00	0.00	0	0	0
144		0.00	0.00	0.00	0.00	0.00	0.00	0	0	0
145		3.02	0.00	0.00	3.88	0.95	2.55	5	0	0
146		1.63	0.00	0.00	0.00	0.00	0.00	7	16	0
227		0.90	0.00	0.00	0.00	0.12	0.00	2	12	0
229		0.00	0.00	0.00	3.60	0.00	0.00	21	0	0
810		0.00	0.00	1.40	0.00	0.00	0.00	12	30	10
Total Gold Flat Area		5.55	1.21	1.40	7.48	1.07	2.55	47	58	10

Source: Nevada County Department of Transportation and Sanitation

- The traffic model also does not include a link reflecting either the Caltrans yard access driveway. Per Caltrans staff direction, the existing volumes on this driveway were increased by 49 percent to reflect future growth in staff levels and overall activity at this yard.

- A review of the land uses included in the 2030 model for the study area indicated that they generally reflect expected growth. The exception is a parcel on the southeast quadrant of the Gold Flat Road/Hollow Way intersection, where planning has been done (though not currently being actively pursued) for a hotel. The Nevada City Planning Director was contacted regarding this parcel, who indicted that a 78-room hotel is a reasonable planning assumption for purposes of this study. A simple trip generation, distribution, and assignment process was applied to this land use, using standard Institute of Transportation Engineers hotel rates, a distribution based on the site's location relative to regional access routes and important visitor destinations, and assuming that all access is provided via Hollow Way east of Gold Flat Road. As rates are not available for a "school PM peak hour" versus the typical PM peak hour, the school PM peak hour trip generation was assumed to be 30 percent lower than the commute PM peak hour trip generation, based on data regarding hotel parking demand by time of day. Trip generation of this land use is presented in Table 4. The resulting volumes were then added to the base values.

5. The resulting volumes were then balanced between intersections to yield the total future design volumes shown in Table 5.

TABLE 4: Hotel Trip Generation

				Weekday Trip Generation Rates							Weekday Vehicle Trips									
					AM Peak Hour			PM Peak Hour				AM Peak Hour			School Peak Hour			PM Peak Hour		
ITE Land Use	ITE Land Use Code	Quantity	Unit	Daily	In	Out	Total	In	Out	Total	Daily	In	Out	Total	In	Out	Total	In	Out	Total
Hotel	310	78	rooms	8.92	0.389	0.281	0.67	0.343	0.357	0.7	619	8	34	42	23	13	36	33	18	51

Note 1: Based on *ITE Trip Generation, 7th Edition* (ITE, 2003), average rates

Source: LSC Transportation Consultants, Inc. *GFRCorridor.xls*

Future Level of Service

Existing Roadway Configuration

Using the *Synchro/Simtraffic* program, the 2030 forecast traffic volumes were evaluated assuming no change from existing roadway geometrics and controls (other than the approved additional southbound through lane at Searls and right-turn lane onto the westbound on-ramp). As shown in Table 6, all intersections fail (LOS F for both worst movement and overall intersection) in at least one peak hour under these conditions. While the Ridge/Zion intersections would operate acceptably in the AM peak hour, both would fail in both the School PM peak hour and the Commute PM peak hour.

Table 5: 2030 Design Volumes

	NB			SB			EB			WB			North Leg		South Leg		East Leg		West Leg	
	Left	Thru	Right	Left	Thru	Right	Left	Thru	Right	Left	Thru	Right	In	Out	In	Out	In	Out	In	Out
AM																				
Hollow Way / Caltrans	0	378	14	95	217	7	31	1	6	11	0	153	319	562	392	234	164	110	38	7
GFR/ SR 20/49 EB Ramps	0	492	68	173	195	0	572	0	126	0	0	0	368	1064	560	321	0	241	698	0
GFR/ SR 20/49 WB Ramps	124	940	0	0	322	315	0	0	0	47	0	189	637	1129	1064	369	236	0	0	439
Searls / GFR	48	694	387	45	476	10	5	8	28	133	5	36	531	735	1129	637	174	440	41	63
Ridge and Zion East	275	0	460	0	0	0	0	377	269	262	357	0	0	0	735	531	619	837	646	632
Ridge and Zion West	0	0	0	359	0	44	53	287	2	0	358	274	403	327	0	2	632	646	342	402
PM School																				
Hollow Way / Caltrans	0	272	18	126	245	18	9	0	6	6	0	109	389	390	290	257	115	144	15	18
GFR/ SR 20/49 EB Ramps	0	288	103	363	228	0	449	0	160	0	0	0	591	737	391	388	0	466	609	0
GFR/ SR 20/49 WB Ramps	145	593	0	0	487	548	0	0	0	103	3	282	1035	875	738	590	388	0	0	696
Searls / GFR	45	516	314	34	678	17	15	5	57	300	4	47	729	578	875	1035	351	353	77	66
Ridge and Zion East	323	0	255	0	0	0	0	452	391	338	414	0	0	0	578	729	752	707	843	737
Ridge and Zion West	0	0	10	397	0	105	81	436	1	1	358	378	502	459	10	2	737	843	518	463
PM Commute																				
Hollow Way / Caltrans	0	342	21	106	285	4	9	0	0	5	0	120	395	471	363	290	125	127	9	4
GFR/ SR 20/49 EB Ramps	0	329	142	442	222	0	369	6	172	0	0	0	664	698	471	394	0	590	547	0
GFR/ SR 20/49 WB Ramps	221	477	0	0	577	461	0	0	0	86	3	278	1038	755	698	663	367	0	0	685
Searls / GFR	49	446	260	16	701	6	15	3	59	277	3	28	723	489	755	1037	308	279	77	58
Ridge and Zion East	325	0	164	0	0	0	0	439	380	342	336	0	0	0	489	722	678	603	819	661
Ridge and Zion West	0	0	2	349	0	53	73	468	4	0	269	392	402	465	2	4	661	819	545	322

Source: LSC Transportation Consultants, INC. *GFRCorridor.xls*

TABLE 6: 2030 Intersection Level of Service with Existing Roadway Configuration

Pk Hr / Intersection	Total Intersection: Total Delay (hr)	Total Intersection: Delay / Veh (sec)	Total Intersection: LOS	Worst Movement: Movement ID	Worst Movement: Delay / Veh (sec)	Worst Movement: LOS
AM Peak Hour						
Hollow Way / Caltrans	93.1	OVFL	F	NBT	OVFL	F
GFR/ SR 20/49 EB Ramps	OVFL	OVFL	F	EBL	OVFL	F
GFR/ SR 20/49 WB Ramps	17.3	20.7	C	WBL	123.4	F
Searls / GFR	14.9	18.2	C	SBL	58.7	F
Ridge and Zion East	9.4	10.3	B	WBL	18.1	C
Ridge and Zion West	7.0	11.0	B	SBL	16.6	C
School PM Peak Hour						
Hollow Way / Caltrans	16.7	47.5	E	NBT	100.28	F
GFR/ SR 20/49 EB Ramps	OVFL	OVFL	F	EBL	OVFL	F
GFR/ SR 20/49 WB Ramps	OVFL	OVFL	F	WBL	OVFL	F
Searls / GFR	62.5	88.5	F	WBL	OVFL	F
Ridge and Zion East	45.4	51.1	F	WBT	129.44	F
Ridge and Zion West	46.9	64.1	F	EBT	113.4	F
Commute PM Peak Hour						
Hollow Way / Caltrans	83.3	OVFL	F	NBT	OVFL	F
GFR/ SR 20/49 EB Ramps	130.9	OVFL	F	EBL	OVFL	F
GFR/ SR 20/49 WB Ramps	OVFL	OVFL	F	WBL	OVFL	F
Searls / GFR	51.6	74.7	F	SBT	116.1	F
Ridge and Zion East	OVFL	OVFL	F	WBT	OVFL	F
Ridge and Zion West	64.9	95.3	F	EBT	OVFL	F

Note: OVFL indicated delays greater than 200 secs, which cannot be accurately estimated

Source: LSC Transportation Consultants, Inc.

In particular, the freeway ramp intersections would operate very poorly, generating traffic queues that would form back onto the freeway through travel lanes. The westbound off-ramp approach to Gold Flat Road will begin to fail quickly. In the short run, excessive delays can be avoided through extension of the separate westbound left and right-turn lanes on this approach.

It is also necessary to evaluate traffic conditions at the Ridge/Zion intersection assuming that the interchange intersections do not generate queues backing into the Ridge/Zion intersection. As shown in Table 7, on all intersections and design periods LOS C or better is provided for each intersection as a whole. However, at the western "T" intersection, LOS E is provided on the worst movement (eastbound through), with delays up to 49 seconds. Vehicle-hours of delay on this movement are as high as 11.1 vehicle-hours in the School PM peak hour. Comparing the delays and volumes with the criteria for Warrant 3 (Peak Hour) as presented in the *California Manual on Uniform Traffic Control Devices* (Caltrans, September 26, 2006), at least this warrant would be met in 2030 for all three peak hours.

TABLE 7: 2030 Ridge/Zion Intersection LOS -- Existing Configuration

Assuming no backup from Searls and Highway Ramps

	Total Intersection		Worst Movement			Queue on Middle Link (Ft)	
Pk Hr / Intersection	Delay / Veh (sec)	LOS	Movement ID	Delay / Veh (sec)	LOS	95%	Average
AM Peak Hour							
Ridge and Zion East	11.7	B	NBL	16.08	C	143	81
Ridge and Zion West	11.1	B	SBL	17.34	C	88	54
School Peak Hour							
Ridge and Zion East	16.6	C	NBL	23.94	C	201	123
Ridge and Zion West	24.7	C	EBT	48.44	E	102	61
PM Peak Hour							
Ridge and Zion East	14.1	B	WBL	20.5	C	184	106
Ridge and Zion West	18.7	C	EBT	36.5	E	71	44

Source: LSC Transportation Consultants, Inc.

Roundabout Scenario

In this scenario, the study intersections were assumed to be replaced with roundabouts. Preliminary designs were developed, as follows:

- At Ridge/Zion/Gold Flat Road/Nevada City Highway, two roundabouts (approximately 115 feet in outside diameter) would be provided, as shown in Figure 2. These roundabouts would be largely single lane, though a continuous second lane would be provided for the eastbound-to-southbound movement at the eastern roundabout, and for the westbound-to-northbound movement at the western roundabout. This would allow a two-lane approach to be provided for each of the movements between the two roundabouts, reducing queues as much as possible. A right-turn bypass lane would also be provided for the movement from southbound Ridge Road to westbound Nevada City Highway. A fourth leg of the western roundabout would provide direct access in both directions for the Imaginarium (on the west side of the building to allow better on-site circulation). Full-movement access to the Sierra Presbyterian Church parking lot on Gold Flat Road would be provided, though the existing driveway location would need to be moved roughly 40 feet to the south to avoid conflicts with the roundabout splitter island. Access to the California Department of Forestry (CDF) property would also be provided, though the use of the existing parking area between the building and Ridge Road would be limited. (As an aside, a single large roundabout at this intersection was considered but rejected due to the right-of-way impacts.)

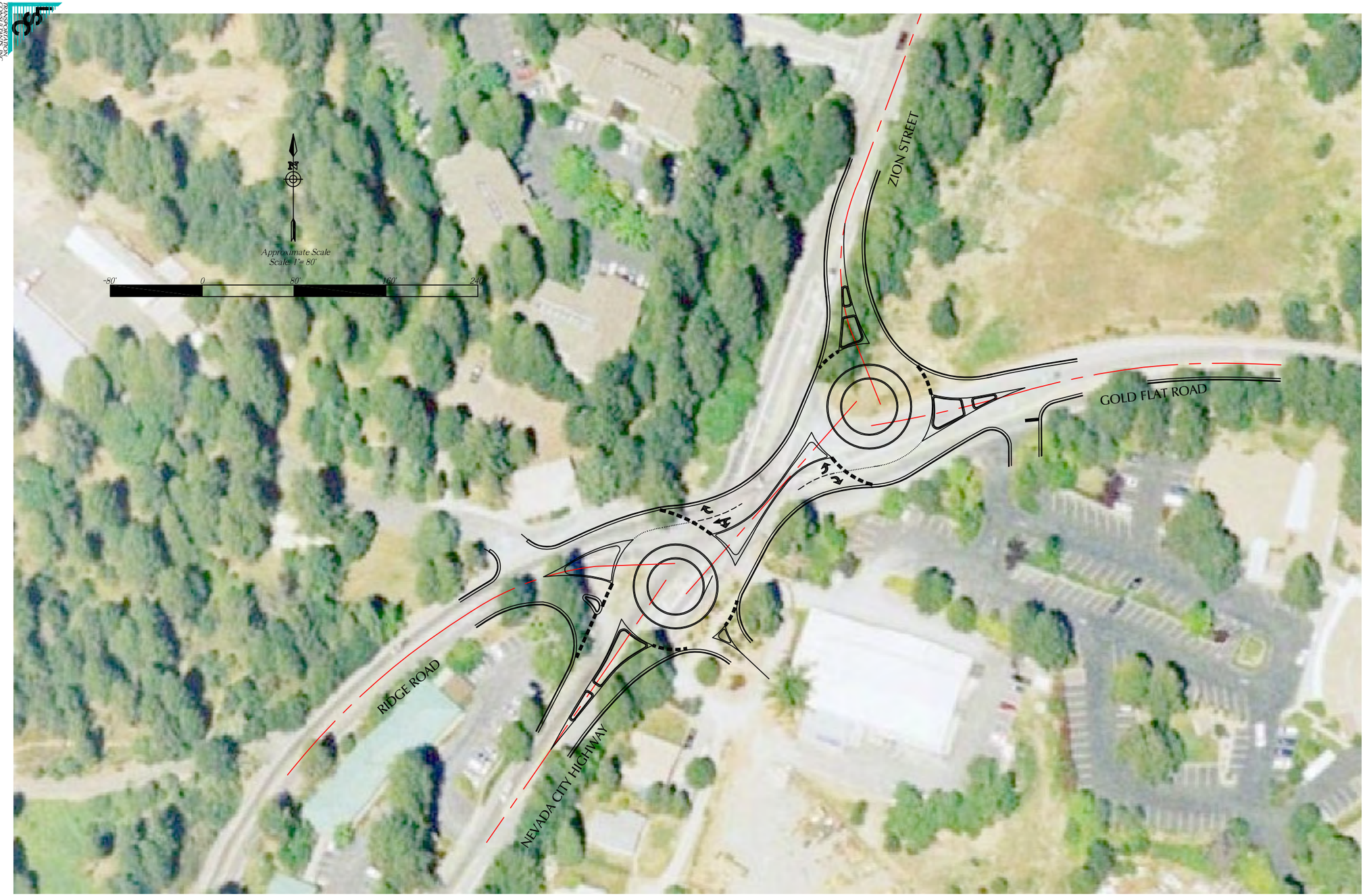


Figure 2

Potential Roundabout Layout

Ridge Rd. and Zion St. -Nevada City, California (LSC #087010)

- A large single lane roundabout with six approach and/or departure legs is provided to replace the Searls/Lower Grass Valley Road and the westbound freeway ramp intersections on Gold Flat Road. This is preliminarily planned at roughly a 145-foot outside diameter, as shown in Figure 3. Importantly, this design avoids the need for modifications on the existing overcrossing structure.

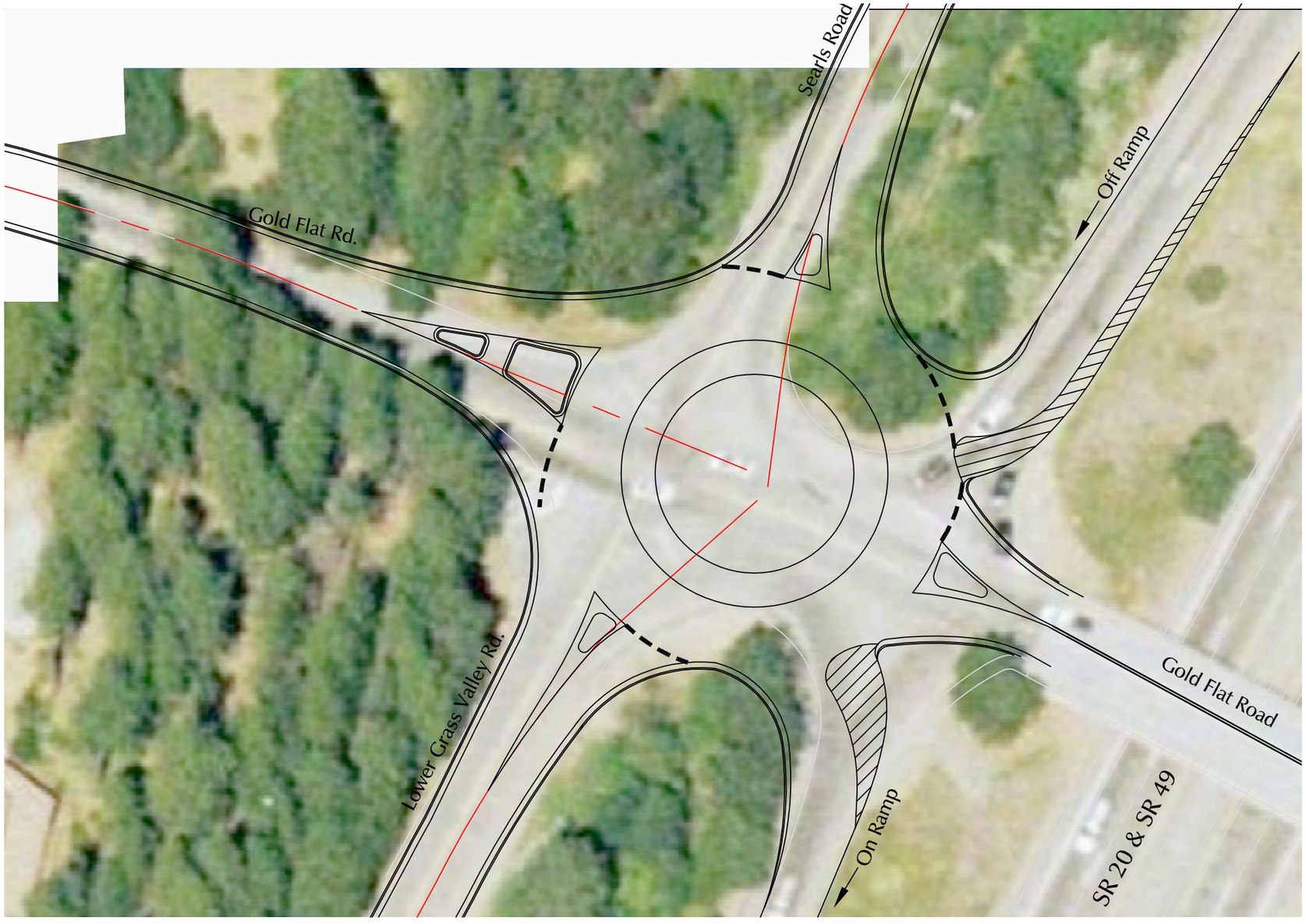
- A similar large single lane roundabout is provided to serve the eastbound freeway ramps, Hollow Way and Caltrans yard access drive along Gold Flat Road. As shown in Figure 4, this is also assumed to be roughly 145 feet in diameter. Again, this roundabout has been designed to avoid widening of the freeway overpass structure. Note that LSC's review of the original roundabout designed by Caltrans staff indicates that it would not provide sufficient travel path deflection, necessitating the larger design. In addition, the limited distance between some successive entrance and exit points would result in potential traffic safety concerns.

It should be stressed that these layouts are preliminary and do not reflect detailed evaluation of factors such as utility locations, grades, and specific right-of-way requirements. These designs, however, have been developed to a sufficient detail to identify resulting level of service and queuing conditions, as well as to allow a review of the overall impacts of the improvements. These roundabouts were designed for the WB-50 trucks at all roundabouts. At the interchange roundabouts, a WB-67 can be accommodated, using the truck aprons for both the front and rear wheels.

As shown in Table 8, *SIDRA* analysis indicates that adequate LOS would be provided by these roundabouts through 2030. Averaging delays for all movements through each roundabout, LOS ranges from A to B. On an individual approach basis, the worst LOS in 2030 is found on the southbound Gold Flat Road approach to the roundabout on the north side of the freeway, where LOS is as low as D in the two PM peak hours (delay of up to 54 seconds). In addition, the northbound approach to this same roundabout on the north side of the freeway (Gold Flat Road) also has LOS of D in the PM peak hour, with an average delay of 35.5 seconds. Significantly, this analysis indicates that single lane roundabouts (with the existing overcrossing structure) can provide acceptable traffic conditions in the interchange area through 2030.

Another key traffic issue is the potential for traffic queues to cause operational problems. Table 9 presents forecast queue lengths in 2008 conditions, while Table 10 presents queue lengths in 2030 conditions. These values represent the 95th percentile queue length – that length which has only a 5 percent chance of being exceeded at any time over the course of a peak hour. As shown:

- In 2008, the traffic queues generated with roundabouts are modest (with a greatest value of 132 feet), and no critical queue lengths would be exceeded.



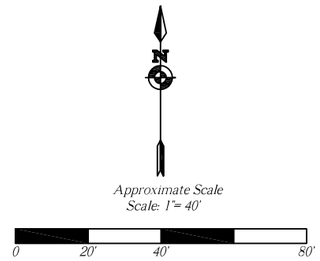


Figure 3

Potential Roundabout
Gold Flat Rd. West of Freeway

Gold Flat/Searls Intersection, Nevada City, California (LSC #077330)

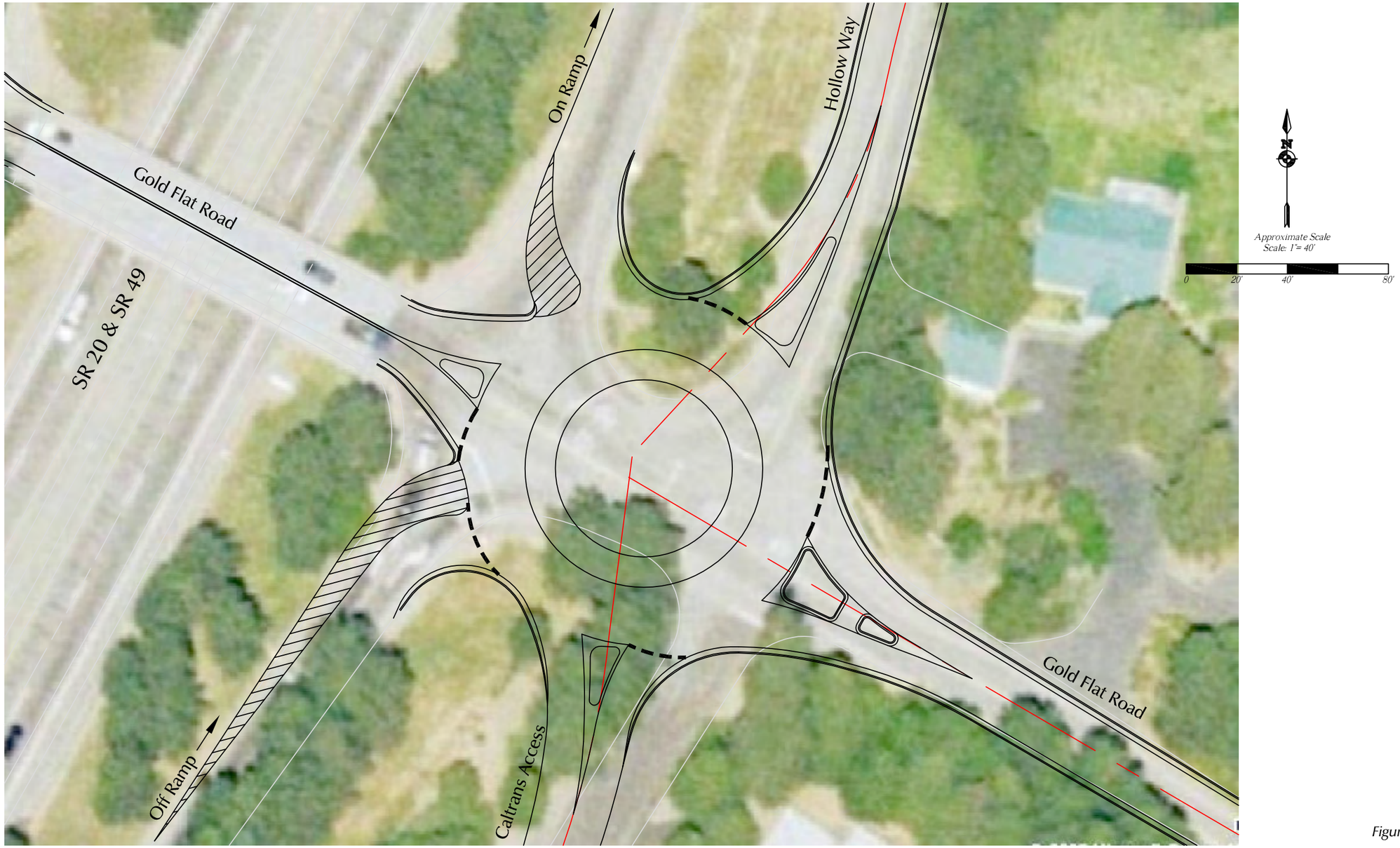


Figure 4

Potential Roundabout
Gold Flat Rd. East of Freeway

Gold Flat/Searls Intersection, Nevada City, California (LSC #087010)

TABLE 8: Intersection Level of Service with Roundabouts

Intersection	Total Intersection Delay / Veh (sec)	LOS	Worst Movement ID	Worst Movement Delay / Veh (sec)	LOS
2008					
AM Peak Hour					
Ridge and Zion West	9.1	A	Imaginarium	14.6	B
Ridge and Zion East	10.7	B	GFR NB	11.6	B
GFR/ SR 20/49 WB Ramps / Searls	8.1	A	Searls	13.6	B
GFR/ SR 20/49 EB Ramps / Hollow Wy	12.7	B	Hwy Off Ramp	15.8	B
School Peak Hour					
Ridge and Zion West	9.0	A	Imaginarium	14.6	B
Ridge and Zion East	11.0	B	GFR NB	12.3	B
GFR/ SR 20/49 WB Ramps / Searls	9.2	A	Searls	14.2	B
GFR/ SR 20/49 EB Ramps / Hollow Wy	12.8	A	Hwy Off Ramp	16.8	B
PM Peak Hour					
Ridge and Zion West	9.3	A	Ridge Rd	12.5	B
Ridge and Zion East	10.9	B	GFR NB	12.2	B
GFR/ SR 20/49 WB Ramps / Searls	9.6	A	Searls	14.1	B
GFR/ SR 20/49 EB Ramps / Hollow Wy	12.4	B	Hwy Off Ramp	16.7	B
2030					
AM Peak Hour					
Ridge and Zion West	10.2	B	Imaginarium	17.4	B
Ridge and Zion East	21.6	C	GFR NB	36.9	D
GFR/ SR 20/49 WB Ramps / Searls	11.3	B	Hwy Off	32.7	C
GFR/ SR 20/49 EB Ramps / Hollow Wy	26.9	C	GFR NB	51.5	D
School Peak Hour					
Ridge and Zion West	12.1	B	Imaginarium	17.1	B
Ridge and Zion East	23.1	C	Zion	33.2	C
GFR/ SR 20/49 WB Ramps / Searls	27	C	GFR SB	54.0	D
GFR/ SR 20/49 EB Ramps / Hollow Wy	21.6	C	Hwy Off	31.6	C
PM Peak Hour					
Ridge and Zion West	11.1	B	Imaginarium	19.8	B
Ridge and Zion East	16.9	B	Zion	21.9	C
GFR/ SR 20/49 WB Ramps / Searls	27.6	C	GFR SB	53.9	D
GFR/ SR 20/49 EB Ramps / Hollow Wy	23	C	GFR NB	36.1	D

Note: LOS based on signalized criteria. Deemed apporpriate since a roundabout is an alternative to signalizing an intersection.

Source: LSC Transportation Consultants *GFRCorridor.xls*

TABLE 9: 2008 95th Percentile Queue Lengths

All Distances in Feet

	Critical Length		Roundabout			Signal			Critical Length Exceeded?	
			AM	School PM	Commute PM	AM	School PM	Commute PM	Roundabout	Signal
Gold Flat / Ridge / Zion / Nevada City Highway										
East (Zion)	NA		97	137	113	99	112	116	--	--
North (Ridge)	NA		56	52	66	130	146	121	--	--
North (Nevada City Highway)	NA		53	78	78	83	103	105	--	--
South (Gold Flat Road)	850	To Searls	121	109	81	73	100	116	NO	NO
Gold Flat / Searles / Lower Grass Valley Road / WB Ramps										
East (WB Off Ramp)	800	To Offramp Gore Point	55	51	45	164	124	136	NO	NO
East (Searls)	NA		27	51	43	103	139	133	--	--
North (Gold Flat Road)	850	To Zion St	62	109	114	128	118	131	NO	NO
West (Lower Grass Valley Rd)	NA		9	22	24	41	59	50	--	--
South (Gold Flat Road)	230	To EB Ramp Intx	94	78	72	246	207	145	NO	YES
Gold Flat / Hollow Wy / Caltrans Driveway / EB Ramps										
East (Hollow Way)	NA		24	27	31	71	92	105	--	--
North (Gold Flat Road)	230	To WB Ramp Intx	30	40	47	152	83	135	NO	NO
West (Eastbound Off Ramp)	940	To Offramp Gore Point	131	132	117	269	303	196	NO	NO
West (Caltrans Driveway)	NA		8	5	5	43	27	26	--	--
South (Gold Flat Road)	NA		57	53	65	75	95	107	--	--

TABLE 10: 2030 95th Percentile Queue Lengths

All Distances in Feet

	Critical Length		Roundabout 95%			Signal			Critical Length Exceeded?	
			AM	School PM	Commute PM	AM	School PM	Commute PM	Roundabout	Signal
Gold Flat / Ridge / Zion / Nevada City Highway										
East (Zion)	NA		298	746	468	173	369	556	--	--
North (Ridge)	NA		116	148	94	221	339	336	--	--
North (Nevada City Highway)	NA		104	270	254	98	216	239	--	--
South (Gold Flat Road)	850	To Searls	752	444	259	181	81	172	NO	NO
Gold Flat / Searles / Lower Grass Valley Road / WB Ramps										
East (WB Off Ramp)	800	To Offramp Gore Point	201	173	130	206	215	211	NO	NO
East (Searls)	NA		69	163	123	111	549	699	--	--
North (Gold Flat Road)	850	To Zion St	139	917	891	134	214	193	YES	NO
West (Lower Grass Valley Rd)	NA		14	61	66	42	104	65	--	--
South (Gold Flat Road)	230	To EB Ramp Intx	338	136	111	295	268	208	YES	YES
Gold Flat / Hollow Wy / Caltrans Driveway / EB Ramps										
East (Hollow Way)	NA		144	71	89	261	320	207	--	--
North (Gold Flat Road)	230	To WB Ramp Intx	52	94	112	166	195	172	NO	NO
West (Eastbound Off Ramp)	940	To Offramp Gore Point	335	422	354	440	499	768	NO	NO
West (Caltrans Driveway)	NA		25	14	11	111	35	43	--	--
South (Gold Flat Road)	NA		495	229	345	156	133	180	--	--

- In 2030, the Gold Flat/Ridge/Zion/Nevada City Highway roundabouts as well as the Gold Flat/Hollow Way/Caltrans/Eastbound Ramps roundabout would not create queuing issues. The Gold Flat/Searls/Lower Grass Valley Road/Westbound Ramp roundabout (at the 95th percentile level), however, would create two queue issues:

  - A southbound queue of 917 feet in the School PM peak hour and 891 feet in the Commute PM peak hour, both exceeding the available 850 feet to the closest of the Ridge/Zion roundabouts. A review of the 70th percentile queue lengths (463 and 451 feet), however, indicates that the proportion of the total hour when the southbound queue from the roundabout on the north side of the freeway would back into the eastern Ridge/Zion roundabout would be very limited. Given this limited potential for queue interference and the fact that reducing this queue would require a second circulating lane around at least a portion of the westbound ramp roundabout, this queue condition is not considered significant enough to warrant further improvements.

  - Similarly, the westbound ramp roundabout generates a northbound queue in the AM peak hour (at the 95th percentile level) of 338 feet, which exceeds the 230 feet available between the westbound and eastbound ramp roundabouts. At these very limited times, the northbound queue would form back to approximately the Hollow Way approach to the southern roundabout. The 70th percentile queue length (186 feet) is well within the available queue length. Providing a queue length of 230 feet or less at the 95th percentile level would require a second northbound approach lane to the westbound ramp roundabout, as well as widening of the overpass. Overall, it is concluded that adequate traffic operation conditions can be provided with the roundabout configurations shown in Figures 3 and 4.

The most important queue issue with regards to potential traffic safety problems is queuing on the freeway exit ramps. The longest ramp queue is forecast to occur on the eastbound off-ramp in the School PM peak hour, when a queue of 422 feet would occur on a ramp 940 feet in length. As this queue length still provides over 500 feet between the eastbound gore point and the back of queue, no traffic queue problems on the off-ramps would be associated with the roundabouts.

Signalized Intersection Scenario

Another potential option to improve traffic control would be to provide traffic signals along the study corridor. Given the close proximity of the four intersections at the interchange, realistically it is only feasible to consider signalization of these four intersections as a whole. Various intersection improvements were evaluated assuming signalization, using the *Synchro/Simtraffic* software package. A summary of LOS is presented in Table 11.

TABLE 11: Intersection Level of Service -- Signalized

Pk Hr / Intersection	Total Intersection: Total Delay (hr)	Total Intersection: Delay / Veh (sec)	Total Intersection: LOS	Worst Movement: Movement ID	Worst Movement: Delay / Veh (sec)	Worst Movement: LOS
2008						
AM Peak Hour						
Hollow Way / Caltrans	1.2	8.2	A	EBL	27.7	C
GFR/ Eastbound Ramps	7.8	26.2	C	SBL	49.8	D
GFR/ Westbound Ramps	5.9	16.0	B	NBL	28.5	C
Searls / GFR	5.2	14.2	B	NBL	48.2	D
Ridge/Zion	6.3	16.4	B	NBL	41.8	D
School PM Peak Hour						
Hollow Way / Caltrans	1.5	10.0	A	EBL	43.4	D
GFR/ Eastbound Ramps	6.7	21.9	C	EBL	30.1	C
GFR/ Westbound Ramps	4.8	11.6	B	NBL	36.5	D
Searls / GFR	5.7	14.5	B	NBL	39.5	D
Ridge/Zion	7.0	16.0	B	SBL	35.5	D
Commute PM Peak Hour						
Hollow Way / Caltrans	1.9	11.5	B	EBL	29.2	C
GFR/ Eastbound Ramps	6.3	20.0	B	EBL	33.7	C
GFR/ Westbound Ramps	5.3	13.1	B	NBL	40.5	D
Searls / GFR	5.6	15.7	B	NBL	44.7	D
Ridge/Zion	6.0	15.6	B	SBL	32.0	C
2030						
AM Peak Hour						
Hollow Way / Caltrans	8.0	31.1	C	EBL	86.2	F
GFR/ Eastbound Ramps	13.4	29.4	C	SBL	53.9	D
GFR/ Westbound Ramps	10.3	19.0	B	WBR	49.2	D
Searls / GFR	6.9	13.1	B	WBL	60.6	E
Ridge/Zion	10.8	19.0	B	SBL	39.1	D
School PM Peak Hour						
Hollow Way / Caltrans	6.9	29.6	C	WBR	123.3	F
GFR/ Eastbound Ramps	12.3	27.7	C	EBR	50.5	D
GFR/ Westbound Ramps	9.1	15.3	B	WBR	37.2	D
Searls / GFR	16.7	29.6	C	WBL	99.6	F
Ridge/Zion	15.6	23.7	C	SBL	55.2	E
Commute PM Peak Hour						
Hollow Way / Caltrans	6.2	24.8	C	EBL	108.2	F
GFR/ Eastbound Ramps	16.8	35.8	D	EBR	89.5	F
GFR/ Westbound Ramps	10.7	18.2	B	NBL	55.2	E
Searls / GFR	17.8	34.1	C	WBL	150.9	F
Ridge/Zion	17.7	29.9	C	SBL	61.0	E

Ridge/Zion/Gold Flat/Nevada City Highway

If signalized, this intersection would need to be reconfigured into the original skewed 4-legged configuration, in order to avoid the loss of overall efficiency associated with closely-spaced signals. To provide adequate LOS and queue conditions at the Ridge/Zion intersection in all three design periods in 2030, the configuration shown in Figure 5 would be required:

- Northbound (Gold Flat Road): Left-turn Lane, 2 Through Lanes, Free Right-turn Lane
- Eastbound (Nevada City Highway): Left-turn Lane, Through Lane, Right-turn Lane
- Southbound (Ridge Road): Left-turn Lane, Through Lane, Free Right-turn Lane
- Westbound (Zion Street): Left-turn Lane, Shared Through/Right-turn Lane

Note that this figure (and Figure 6) are schematic and do not reflect detailed design of items such as lane tapers. They are, however, sufficient to show the general extent of roadway widening.

This configuration would provide LOS B conditions in all three peak hour design periods in 2008. In 2030, LOS C would be provided in the School and Commute PM peak hours, and LOS B in the AM peak hour.

Freeway Interchange

Due to the close spacing between the intersections along Gold Flat Road at the SR20/49 on- and off-ramps, Searls Avenue, and Hollow Way, signalizing any one of these intersections would result in traffic queues that would block the other intersections, thereby necessitating signals at all four. The need to time signals to provide adequate progression for multiple travel paths also significantly reduces the overall efficiency of the roadway system, which in turn requires additional travel lanes to provide the needed capacity. In particular, the very short queue distances between the Searls Avenue and the westbound ramp intersections and between the eastbound ramp and Hollow Way intersections reduces overall capacity with signals.

In order to accommodate 2030 traffic volumes in all three design periods, extensive geometric improvements would be needed at the closely spaced intersections. As shown in Figure 6, this expansion would consist of the following:

- Gold Flat Road would need to be widened to include two through lanes in each direction from approximately five hundred feet southeast of its intersection with Hollow Way northwest until its intersection with Zion Street.

- The bridge crossing the Golden Center Freeway (SR 20/49) would need to be widened to include six lanes: two through lanes plus a left-turn lane in each direction. Including, at a minimum, a 4-foot bicycle lane and 5-foot sidewalk on both

Figure 5

Schematic Signal Layout
Ridge Road and Zion Street

Figure 6
Schematic Signal Layout
Gold Flat Road Interchange

sides. Assuming standard 12-foot travel lanes – this bridge would need to be a minimum of 90 feet in width (excluding parapets). This structure is currently only 35 feet in width (including a 5-foot sidewalk on the west side).

- The off-ramp from eastbound SR20 would need to be reconfigured from its current right-turn lane and shared thru-left lane to provide an exclusive left-turn lane and a shared lane for all movements. There would need to be an exclusive free right-turn lane from southbound Gold Flat Road onto the westbound SR20 on-ramp.

- Southbound Gold Flat Road would also need to provide an exclusive left-turn lane onto Searls Avenue, and Searls Avenue would need to be widened to provide an additional westbound left-turn lane onto Gold Flat Road.

Careful signal timing and coordination would be necessary in order to effectively move traffic through this series of very closely spaced intersections. During the AM peak hour there is a high volume of traffic traveling northbound across the freeway overpass. This traffic consists of substantial volumes both from the SR 20 eastbound off-ramp and the northbound traffic on Gold Flat Road. The signals at both ramp intersections would need to be carefully timed to minimize blocking intersections due to spillback from closely spaced signalized intersections. During the PM peak hour, there is heavy southbound traffic crossing the overpass, including heavy left-turn movements from Searls Avenue to southbound Gold Flat Road and onto the SR20 eastbound ramp from Gold Flat Road. These intersections must be timed and coordinated properly to prevent traffic on the overpass from blocking the off-ramp intersections and causing ramp traffic queues to backup onto the freeway.

Signal timing was carefully adjusted to maximize overall LOS while avoiding excessive delays and queues on any one movement. As shown in Table 11, LOS in 2008 would range from A to C, with the best overall LOS provided at the Hollow Way/Caltrans intersection and the poorest LOS at the Westbound Ramp intersection.

By 2030, LOS would be reduced somewhat, but would still attain the standard of LOS D or better (considered as average for each intersection as a whole) at all intersections and over all design periods. The poorest LOS (LOS D) would be provided at the Westbound Ramp intersection in the Commute PM peak hour. Some individual movements would operate with relatively long average delays (which would be very much dependent upon specific signal timing). As the LOS standard is considered for the average overall movements at an intersection – these intersections would provide adequate LOS.

Traffic Queues

As shown in Table 9, in 2008 the only potential queue issue is that the northbound queue on Gold Flat Road at the westbound ramp interchange in the AM peak hour (246 feet) slightly exceeds the distance between the westbound and eastbound ramps (230 feet), indicating that drivers entering the Gold Flat Road/Eastbound Ramp intersections

from the south could potentially block the eastbound left-turn movement. As this condition is reflected in the *Simtraffic* analysis (which still provides adequate LOS and queues on the eastbound ramps), this is not considered to be a significant operational issue.

In 2030 as shown in Table 10, all traffic queues would be within critical lengths, with the exception of the northbound queue formed by the Westbound Ramp intersection. At the 95th percentile level, this queue is estimated to be 295 feet in the AM peak hour and 268 feet in the School PM peak hour, exceeding the 230 feet of available queue length between this intersection and the Eastbound Ramp intersection. A portion of the movements northbound from the Westbound Ramp intersection would need to wait for this queue to move before proceeding. As the simulation results reflect this condition and as adequate LOS and queue length conditions are identified on the inbound legs to the Westbound Ramp intersection, this is not considered to be a significant traffic operations problem that would require additional roadway widening (such as additional travel lanes).

As with the roundabout alternative, the queues on the freeway off-ramps would be within the available ramp length, indicating no significant safety concern regarding queuing back towards the freeway mainline lanes. The maximum queue length is forecast to be 768 feet on the eastbound off-ramp in the 2030 Commute PM peak hour, 172 feet shorter than the 940 feet available to the gore point.

Comparison of Scenarios

Level of Service

While both signals and roundabouts would attain the LOS D standard in both 2008 and 2030, as measured for the average of all movements through an intersection, overall LOS is better with roundabouts that with signals. In 2008, the worst-movement LOS with roundabouts is LOS B or better, while with signals worst-movement LOS is a low as LOS D. By 2030, the roundabouts provide a worst-movement LOS of D, but signals would provide several movements with LOS F conditions, particularly at the interchange.

Vehicle-Hours of Delay

Another key measure of the effectiveness of a roadway network is the vehicle-hours of delay. In addition to measuring inconvenience to motorists, this is a rough measure of the relative impacts on air pollutant emissions. Multiplying the total number of movements through each intersection by the average delay (and converting from seconds to hours) yields the vehicle-hours of delay generated by each of the scenarios

in each of the peak hours, as shown in Table 12 and depicted in Figure 7. A good overall measure of delay is the total vehicle-hours of delay over the three peak hours analyzed in this study. A review of this information reveals the following:

- At present, approximately 16.3 vehicle-hours of delay are generated in the School PM peak hour, 15.7 in the Commute PM peak hour, and 8.4 in the AM peak hour. Roughly twice as much delay is generated in the interchange area (as a whole) as at the Ridge/Zion "T" intersections.

- Converting the corridor to roundabouts at present would increase delays at Ridge/Zion but decrease delays at the freeway interchange, yielding roughly comparable overall delays.

- Converting the corridors to traffic signals at present would substantially increase overall delays, with delays at the interchange roughly doubling.

- In 2030, roundabouts throughout the study corridor would generate 123.3 vehicle-hours of delay over the three peak hours, which is 31 percent less than the 178.3 vehicle-hours of delay with traffic signals.

TABLE 12: Summary of Peak Hour Delay by Scenario

	Vehicle-Hours of Delay				
	2008			2030	
	Unsignalized	Roundabout	Signalized	Roundabout	Signalized
Ridge / Zion / Gold Flat / Nevada City Highway					
AM Peak Hour	4.6	6.3	6.3	15.9	11.1
School PM Peak Hour	5.9	7.4	6.9	19.9	15.5
Commute PM Peak Hour	5.2	6.7	6.0	14.3	17.6
Sum: 3 Peak-Hours	15.6	20.4	19.3	50.1	44.1
Freeway Interchange					
AM Peak Hour	8.4	7.0	19.7	18.8	38.2
School PM Peak Hour	10.4	7.9	18.4	26.8	44.8
Commute PM Peak Hour	10.5	8.0	19.0	27.6	51.2
Sum: 3 Peak Hours	29.4	22.9	57.2	73.2	134.1
Total Corridor					
AM Peak Hour	13.0	13.2	26.1	34.7	49.3
School PM Peak Hour	16.3	15.3	25.4	46.7	60.3
Commute PM Peak Hour	15.7	14.7	25.0	41.9	68.7
Sum: 3 Peak Hours	45.0	43.3	76.5	123.3	178.3

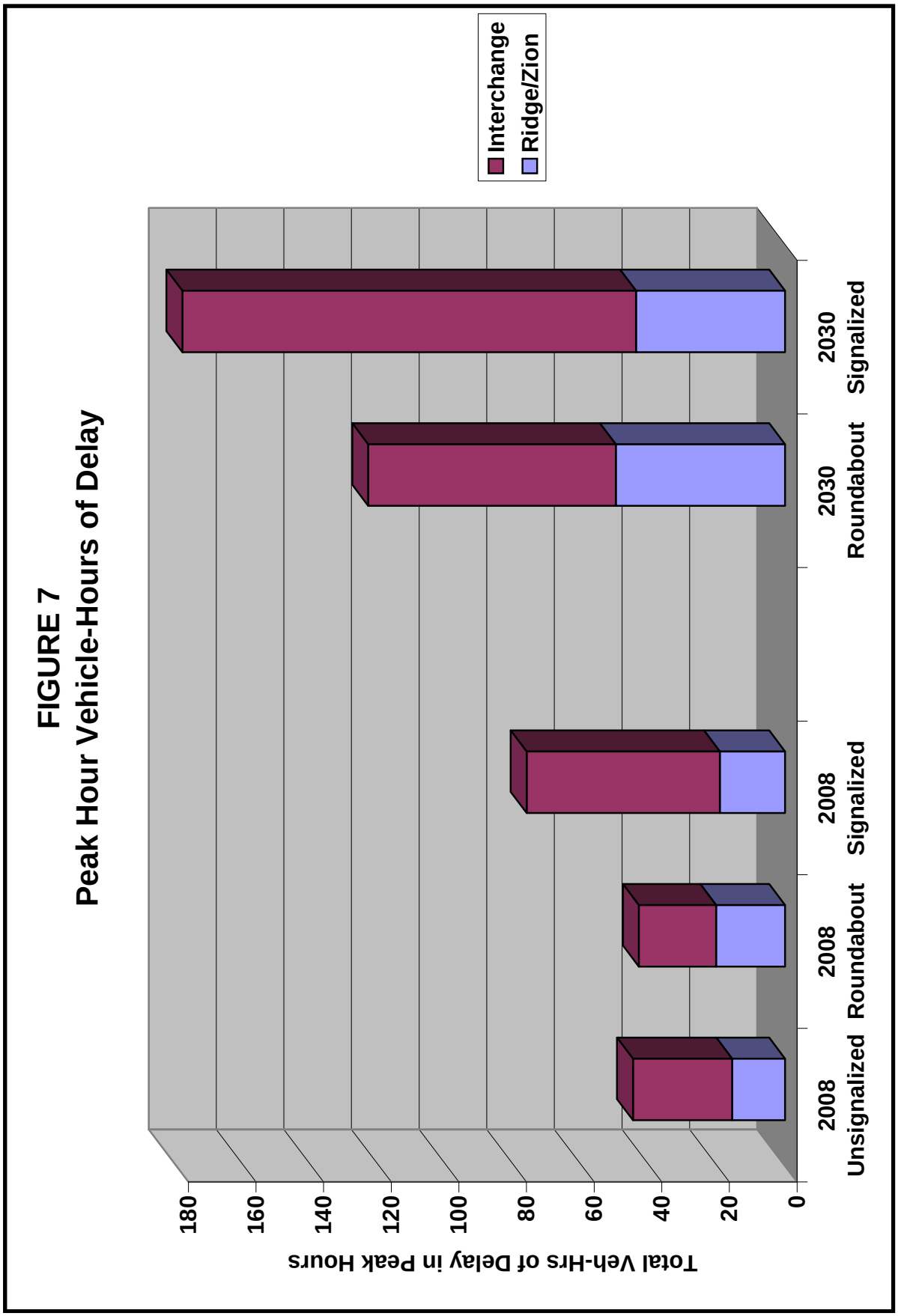


FIGURE 7
Peak Hour Vehicle-Hours of Delay
Interchange
Ridge/Zion
Total Veh-Hrs of Delay in Peak Hours
0
20
40
60
80
100
120
140
160
180
2008 Unsignalized
2008 Roundabout
2008 Signalized
2030 Roundabout
2030 Signalized

- At Ridge/Zion in 2030, a single traffic signal would generate approximately 13 percent less delay than the two roundabouts over the course of the three peak hours. A signal would generate lower overall delays in the School AM and PM peak hour, but more delays in the Commute PM peak hour. While not specifically studied, traffic delays at roundabouts at non-peak times are typically less than at traffic signals.

- At the interchange, traffic signals would generate 134.1 vehicle-hours of delay, compared with 73.2 vehicle-hours with roundabouts. Higher delays would be generated by signals in each of the three peak hours studied.

Queue Issues

As discussed above, neither scenario is expected to generate traffic queues that cause significant operational issues. The one queue consideration associated with roundabouts not also associated with signals is southbound queues generated by the Westbound Ramp roundabout that would form back into the Ridge/Zion intersection. Both scenarios would generate northbound queues across the freeway overpass that would form back into the eastbound ramp intersection, though the roundabout scenario generates these queues in only the AM peak hour – the signal scenario generates these queues in both the AM and School PM peak hours. Along Zion Street, the westbound queue generated at Ridge/Zion would have the same impacts under either scenario: not extending to Providence Mine Road in 2008 under any of the peak hours, but extending beyond Providence Mine Road (but not as far as Doane Road) in 2030 in the two PM peak hours.

Right-of-Way Requirements and Access Impacts

The roundabout scenario would have the following impacts on adjacent properties:

- The northwest corner of the parcel on the southeast quadrant of the Gold Flat Road/Zion Street intersection would be required for the eastern roundabout.

- While right-of-way would probably not be required, the parking access to the Sierra Presbyterian Church from Gold Flat Road would need to be relocated roughly 30 feet to the south. No significant change in the number of parking spaces is expected.

- Right of way would be required from the School District's Imaginarium parcel. Direct access to the site would be maintained. While no significant impact on parking would result, several mature trees along the south side of Nevada City Highway would need to be removed.

- Right of way would also be required in the easternmost portion of the School District administrative office parcel in the northwest quadrant of Ridge Road and Nevada City Highway. Several existing mature trees would also need to be removed, though the existing parking count can be maintained.

- The parking immediately in front of the CDF building (which appears to be partially in the right-of-way) would be effectively eliminated, as the remaining distance between the roundabout exit lane curb and the building would be insufficient for circulation. It may be possible to provide replacement parking (though not as convenient) in the westernmost portion of existing Zion Street that would be realigned for the eastern Gold Flat Road/Zion roundabout.

- Existing public right-of-way in the vicinity of the interchange is relatively generous, including a right-of-way width of 100 feet along Gold Flat Road as well as the freeway right-of-way. As a result, at this planning level it appears that the roundabouts could be constructed without the need for existing private lands. All existing access would be maintained.

The signal scenario would have the following right-of-way and access impacts:

- The signalized layout of the travel lanes at Ridge/Zion would fit within existing right-of-way.

- The existing northeastern access from the Imaginarium onto Nevada City Highway (currently between the two “T” intersections) would be eliminated. While the southwestern access would be maintained, left-turns into and out of this driveway would frequently be blocked by traffic queues.

- Access to CDF and to the Sierra Presbyterian Church would be maintained.

- No additional right-of-way would be required in the interchange area (assuming that the overpass structure can be replaced without significantly shifting the existing centerline of Gold Flat Road).

- All existing access would be maintained, though traffic queues from the Hollow Way signal would often block left-turn movements into and out of the residence on the southeast quadrant of Hollow Way and Gold Flat Road.

Overall, these impacts in the interchange area are comparable (both minimal). However, the roundabouts would have a greater impact on properties around the Ridge/Zion intersection. While all uses can be maintained, redesign of access and parking would be required on the existing uses in the vicinity.

Construction Impacts

Maintaining traffic flow through the Gold Flat corridor during construction of improvements is important, given that it is a key link in the regional roadway network. The most crucial construction challenge associated with the signal scenario would be construction of a new, much wider freeway overpass. While it may be possible (and cost effective) to widen the existing structure, depending on the condition of this structure and final design, it may otherwise be necessary to fully replace the overpass. This would entail constructing at least the width necessary for two travel lanes adjacent to the existing structure, after which traffic would be shifted to the new partial structure and the existing structure removed and replaced. This ultimately could result in a centerline location different from the existing location, with possible right-of-way impacts. In either case, construction delays in the interchange area would be significant.

In comparison, the roundabout scenario does not require replacement of the overpass structure. In addition, the initial phases of roundabout construction can take place off of existing roadways. Traffic can then be rerouted onto the new roundabout portions while the work in the existing roadways is completed. While significant delays would still result, overall the roundabout scenario would result in less construction delays than the signal scenario.

Impacts on Transit Operations

Gold Country Stage Route 1 currently travels along Nevada City Highway and Zion Street 26 times eastbound and 9 times westbound each weekday. Gold Country Stage Route 2 currently travels through the corridor 11 times per weekday and 9 times on Saturdays in each direction. Traveling from Grass Valley to Nevada City, the route enters the study area along Ridge Road, turns left on Zion Street (to Seven Hills Center), returns to Gold Flat Road at Searls Avenue, makes a left-turn onto Gold Flat Road, and then onto Hollow Way. The return trip follows these turns in the opposite direction. Reviewing the delays on the individual movements used by the transit buses, there is not a significant difference in delays between the roundabout and signal scenarios. Under either scenario, existing bus stops near Ridge/Zion would need to be relocated.

Impacts on Traffic Safety

Generally, the frequency and severity of accidents is less for a roundabout than a traffic signal. *Roundabouts: An Informational Guide* (US Department of Transportation, Federal Highway Administration, 2000) states the following reasons for increased safety at roundabouts:

- Roundabouts have fewer conflict points in comparison to conventional intersections. The potential for hazardous conflicts, such as right angle and left-turn head-on crashes is eliminated with roundabout use.

- Low absolute speeds associated with roundabouts allow drivers more time to react to potential conflicts.

- Since most road users travel at similar speeds through roundabouts, i.e., have low relative speeds, crash severity is generally reduced compared to most traditionally controlled intersections.

- Pedestrians need only cross one direction of traffic at a time at each approach as they traverse roundabouts. Furthermore, conflicting vehicles come from a more defined path at roundabouts and thus pedestrians have fewer places to check for conflicting vehicles. In addition, the speeds of motorists entering and exiting a roundabout are reduced with good design.

According to *Roundabouts: An Informational Guide*, "experiences in the United States show a reduction in crashes after building a roundabout of about 37 percent for all crashes and 51 percent for injury crashes."

Perhaps the most detailed review of traffic safety at roundabouts in the US is presented in *Crash Reductions Following Installation of Roundabouts in the United States*, prepared by the Insurance Institute for Highway Safety in 2000. This study indicated that roundabouts yielded a 39 percent reduction in all accidents, a 76 percent reduction in accidents resulting in injuries, and fully a 90 percent reduction in the most severe accidents resulting in fatalities and incapacitating injuries. This study concludes that *"roundabout installation should be strongly promoted as an effective safety treatment for intersections."*

The most recent research project regarding roundabout safety in the U.S. is Report 572: *Roundabouts in the United States* published by the National Cooperative Highway Research Program of the Transportation Research Board in 2007. The key conclusion of this extensive study is "*With the exception of conversions from all-way stop-controlled intersections, where crash experience remains statistically unchanged, roundabouts have improved both overall crash rates and, particularly, injury crash rates in a wide range of settings (urban, suburban and rural) and previous forms of traffic control (two-way stop and signal).*"

The closely-spaced traffic signals in the interchange area would also create a potential traffic safety issue. Both north and south of the freeway, traffic signals facing in the same direction along Gold Flat Road would be required in short succession. There is the potential that drivers seeing a green indication at the second signal may overlook a red indication at the first signal, resulting in an accident.

Impacts on Bicycle and Pedestrian Travel

Existing bicycle and pedestrian use levels in the corridor are relatively low. Both alternatives would provide additional protected locations for crossing Gold Flat Road. While defining specific bicycle and pedestrian facilities has not been part of this study scope, an equivalent level of such facilities could be provided with either signals or roundabouts.

The additional roadway widening required to accommodate signals would tend to degrade the attractiveness of the corridor for non-motorized travel in comparison with the roundabout alternative. This greater roadway width also tends to increase average vehicle speeds, which can increase the severity of accidents with bicyclists or pedestrians. In addition, roundabouts generally are found to have a greater safety record with regards to pedestrians. Studies conducted in England indicate that the number of pedestrian crashes occurring at roundabout intersections is generally lower (by 33 to 54 percent). In addition, Dutch studies indicate a 73 percent reduction in pedestrian crashes at intersections converted to roundabouts. The data regarding bicycle crashes at roundabouts are not conclusive. Studies conducted in both England and France indicated that the occurrence of bicycle crashes increased after the installation of modern roundabouts at the study intersections (many of these intersections were low-volume locations). However, a study of Dutch roundabouts indicated that roundabouts that provide a separate bicycle path resulted in a 90 percent reduction of bicycle crashes. NCHRP Report 572: *Roundabouts in the United States* did not develop a sufficient database on pedestrian and bicycle accidents to make definitive conclusions regarding pedestrian accidents, but does conclude that *"From a safety perspective, where safety is measured in terms of crashes or in terms of a surrogate such as conflicts, the roundabouts observed performed very well. Bicyclists appear to have very few problems interacting with motorists and maneuvering through a roundabout. In summary, the findings of this research did not find any substantial safety problems for non-motorists at roundabouts, as indicated by there being few reported crashes and a very small number of observed conflicts." (p 110).*

Urban Design Considerations

From an urban design perspective, the greatest impact of the signal scenario would be the widening of Gold Flat Road to effectively four lanes from Zion Road to Searls Road, and the six lane overpass structure. In comparison, a roundabout is generally considered to provide a higher quality of urban design than does a large signalized intersection, particularly in that a roundabout interrupts a motorist's view of a large expanse of unbroken pavement. The urban design benefit of a roundabout is also increased by the ability to place large vertical elements (such as sculpture or trees) in the center island. In the outermost portion of the center island driver sight distance requirements preclude any vertical design elements. In the center area of the island (particularly for the relatively large roundabouts at the interchange), driver sight distance issues do not limit the height of a design element.

There are, however, elements of a roundabout that have visual impacts. For instance, a substantial amount of directional signage is required at a roundabout. In addition, roundabouts require a relatively high level of lighting, so drivers can clearly see the various merge/diverge points at night, though “cut-off shields” can minimize the impacts of glare on adjacent properties and the night sky. However, overall a roundabout provides a significant improvement in urban design over the signal improvement option.

Impact on Emergency Vehicle Response

Input received from fire department representatives indicates that existing roundabouts have not resulted in delays in emergency response times that are seen as a problem. It is reported that emergency response times through the roundabouts in the Vail, Colorado area were actually reduced, as overall traffic queuing and delay was reduced from the prior conditions. In general, it is reported that vehicles simply move to the curb within the roundabout under typical or low traffic conditions when emergency equipment approaches in “sirens on” mode; under peak conditions with multilane roundabouts, Vail officials reported that drivers infrequently pull over in a manner that does not allow emergency equipment to proceed, but in these instances the emergency vehicle driver can “coax” the driver to pull forward into available space with only minimal delay.

Timing of Necessary Improvements

Interchange Area

Using straight-line interpolation between the 2008 and 2030 design volumes, LOS and queue lengths on the off-ramps were evaluated for the four intersections around the Gold Flat Road interchange area for 2013 and 2018. As shown in Table 13, in 2013 adequate queuing conditions would be provided at all times, but individual turning movements would not attain standards at the Westbound Ramp intersection (in all three design periods) as well as at the Searls/Lower Grass Valley Road intersection (in the AM and School PM peak hours). By 2018, all four intersections would not attain LOS standards in one or more of the design periods (particularly at the Westbound Ramp intersection), and the maximum queue formed by the Westbound Ramp intersection on the westbound off-ramp would extend back east beyond the off-ramp gore point (even with a full right-turn lane along this ramp). It can be concluded that improvements to the Westbound Ramp and the Searls/Lower Grass Valley road intersections will be necessary within the next five years, while improvements to the intersections south of the freeway will be required by 2018.

Our preliminary findings are that the roundabouts or signals on Gold Flat Road at the westbound off-ramps/Searls/Lower Grass Valley Highway intersections and at the eastbound off-ramps/Hollow Way/Caltrans access intersections will be needed as early as 5 years from now, and no later than 10 years from now. A few years of traffic growth could be accommodated by providing longer separate left-turn and through/right lanes

TABLE 13: Evaluation of Timing of Interchange Improvements

Year/Pk Hr / Intersection	Total Intersection Delay / Veh (sec)	Total Intersection LOS	Worst Movement ID	Worst Movement Delay / Veh (sec)	Worst Movement LOS	Highway Ramp Queues 95%	Highway Ramp Queues Max	Attain Standards? LOS	Attain Standards? Queue
2013									
AM Peak Hour									
Hollow Way / Caltrans	5.0	A	NBT	9.5	A			Yes	--
GFR/ HWY 20 N/E Bound	15.5	C	EBL	24.6	C	174	298	Yes	Yes
GFR/ Hwy 20 S/W Bound	9.6	A	WBR	40.3	E	294	429	No	Yes
Searls / GFR	11.4	B	SBL	45.0	E			No	--
School Peak Hour									
Hollow Way / Caltrans	4.1	A	NBT	9.0	A			Yes	--
GFR/ HWY 20 N/E Bound	15.5	C	EBL	25.4	D	130	196	Yes	Yes
GFR/ Hwy 20 S/W Bound	9.8	A	WBL	72.2	F	290	464	No	Yes
Searls / GFR	18.1	C	WBL	55.7	F			No	--
Commute PM Peak Hour									
Hollow Way / Caltrans	5.1	A	NBT	9.9	A			Yes	--
GFR/ HWY 20 N/E Bound	13.4	B	EBL	17.7	C	102	136	Yes	Yes
GFR/ Hwy 20 S/W Bound	9.4	A	WBT	71.0	F	161	203	No	Yes
Searls / GFR	12.0	B	WBL	26.7	D			Yes	--
2018									
AM Peak Hour									
Hollow Way / Caltrans	7.3	A	NBT	13.7	B			Yes	--
GFR/ HWY 20 N/E Bound	39.8	E	EBL	82.3	F	387	379	No	Yes
GFR/ Hwy 20 S/W Bound	15.3	C	WBR	82.2	F	779	864	No	Yes
Searls / GFR	25.6	D	SBL	97.5	F			No	--
School Peak Hour									
Hollow Way / Caltrans	8.5	A	NBT	18.3	C			Yes	--
GFR/ HWY 20 N/E Bound	48.4	E	EBL	111.2	F	495	571	No	Yes
GFR/ Hwy 20 S/W Bound	29.6	D	WBL	410.6	F	882	969	No	No
Searls / GFR	76.7	F	WBL	367.7	F			No	--
PM Peak Hour									
Hollow Way / Caltrans	20.7	C	NBT	44.3	E			No	--
GFR/ HWY 20 N/E Bound	43.7	E	EBT	105.7	F	460	501	No	Yes
GFR/ Hwy 20 S/W Bound	30.9	D	WBL	671.1	F	628	754	No	Yes
Searls / GFR	53.5	F	WBT	139.7	F			No	--

Note: Assumes offramp turn pockets would be extended.

Source: LSC Transportation Consultants, Inc.

on the two off-ramps (to reduce queue blocking and reduce queue lengths forming back onto the freeway), but this work would be largely wasted once the roundabouts are constructed.

An evaluation of LOS at the existing Ridge/Zion “T” intersections was also conducted in five-year volume increments. Worst movement LOS was found to remain at acceptable levels (specifically, LOS C) through 2023, only degrading to LOS E in 2028. The need to provide signals or roundabouts at the Ridge/Zion intersection(s) will be required within 10 to 15 years.

Ridge/Zion/Nevada City Highway/Gold Flat Road

A similar evaluation of timing for improvements to the existing two “T” intersections in the Ridge/Zion area is presented as Table 14. As shown, in 2023 all movements are forecast to achieve LOS standards. In 2028, the eastbound through movement would fall to LOS E. This analysis indicates that the existing unsignalized “T” intersections would not require replacement with roundabouts or a signal for at least 15 years.

TABLE 14: Evaluation of Timing of Ridge/Zion Improvements

Worst Case: School PM Peak Hour

	Total Intersection		Worst Movement		
Year/Intersection	Delay / Veh (sec)	LOS	Movement ID	Delay / Veh (sec)	LOS
2023					
Ridge and Zion East	11.3	B	WBL	16.42	C
Ridge and Zion West	12.2	B	SBL	18.52	C
2028					
Ridge and Zion East	15.2	C	WBL	22.44	C
Ridge and Zion West	20.8	C	EBT	40.76	E

Chapter 4
Conclusions and Recommendations

The conclusions and recommendations of this study are summarized as follows:

- Overall, existing traffic conditions in the study corridor are at acceptable levels in all three study design periods (AM peak hour, School PM peak hour, and Commute PM peak hour). The sole exception is the westbound left-turn movement from the westbound Golden Center Freeway off-ramp to southbound Gold Flat Road, which currently operates at LOS F in the Commute PM peak hour. However, as volumes making this movement are relatively low, delays are not excessive, and no queue problems result, this is not considered to be a significant traffic problem warranting immediate remedy.

- Based upon the Western Nevada County TransCAD model as well as estimates of the traffic impact associated with nearby development (not reflected in the model land uses), traffic volumes in the area are forecast to increase by 49 percent by 2030 over 2008 volumes. This growth will be relatively consistent over the various roadway segments in the study area.

- Without modification, the four intersections in the interchange area would fail very significantly in 2030, with delays too high to accurately estimate.

- If the queuing back from the interchange were eliminated, the existing Ridge/Zion unsignalized “T” intersections would also fail in 2030, but just barely (LOS E on the worst movement). Given the right-of-way and other impacts associated with fixing this deficiency versus the relatively minor benefit, it appears that major modification of these T intersections will not be warranted. However, more minor improvements to the intersections (such as shoulders and extending the queue distance between the two intersections) should be considered.

- A “roundabout scenario” for the corridor would consist of two smaller roundabouts (largely single lane) to replace the two existing “T” intersections at Ridge/Zion, a larger single lane roundabout with a total of six legs to replace the Searls/Lower Grass Valley Road and the Westbound Ramps intersections, and a similar larger six-leg single lane roundabout to replace the Eastbound Ramps and Hollow Way/Caltrans intersections.

- A “signal scenario” would consist of a single 4-legged signal at Ridge/Zion and four signals at each of the four existing intersections in the interchange area. Due to the close spacing of these signals, overall efficiency would be reduced. This scenario would require widening of the existing freeway overpass structure to a total of six travel lanes (four through lanes plus two left-turn lanes), as well as widening of Gold Flat Road between Searls Road and Zion Street to two through travel lanes in each direction.

- Both scenarios would provide overall adequate LOS, though the roundabouts would result in overall better LOS than the signals.

- Implementing the roundabout scenario would not significantly change overall traffic delays from current conditions, but implementing the signal scenario would roughly double delays.

- At Ridge/Zion in 2030, a traffic signal would generate slightly (13 percent) less overall peak hour delay than the two roundabouts. However, delays during off-peak periods (not analyzed) would be less with roundabouts.

- In 2030, the two large roundabouts at the interchange would generate 45 percent less overall peak hour delays than the four traffic signals.

- The signal scenario could be constructed within existing public rights-of-way. The eastern driveway to the Imaginarium on Nevada City Highway would need to be eliminated but the western driveway would remain. In comparison, the roundabout scenario would not require additional right-of-way in the interchange area, but would require additional right-of-way in all four quadrants of the Ridge/Zion intersection, as well as changes to access to both the Imaginarium as well as the Sierra Presbyterian Church.

- In addition to the factors discussed above, the overall roundabout scenario is found to be preferable to the signal scenario with respect to construction traffic impacts, traffic safety, pedestrian and bicycle travel, and urban design considerations. No significant difference between the two alternatives was found with regards to traffic queues, impact on transit operations, or emergency vehicle response.

- Roundabouts are clearly the preferred solution to future traffic problems along Gold Flat Road in the interchange area. In particular, the provision of four very closely spaced signals would create excessive delays as well as potential safety concerns.

- Planning for the improvements at the interchange area should proceed as fast as possible. Assuming “straight line” traffic growth in this area (with respect to the 2030 traffic model forecasts), traffic conditions in this area will worsen – falling substantially below standards by even 2013.

- While provision of roundabouts or signals at the Ridge/Zion/Gold Flat Road/Nevada City Highway intersection are not included as part of this plan, if future traffic volumes grow beyond the levels forecast in this study two roundabouts are the recommended solution, so long as detailed designs can be accommodated without significant right-of-way impacts on adjacent properties. If not, a 4-leg signalized intersection would be an acceptable long-term solution.