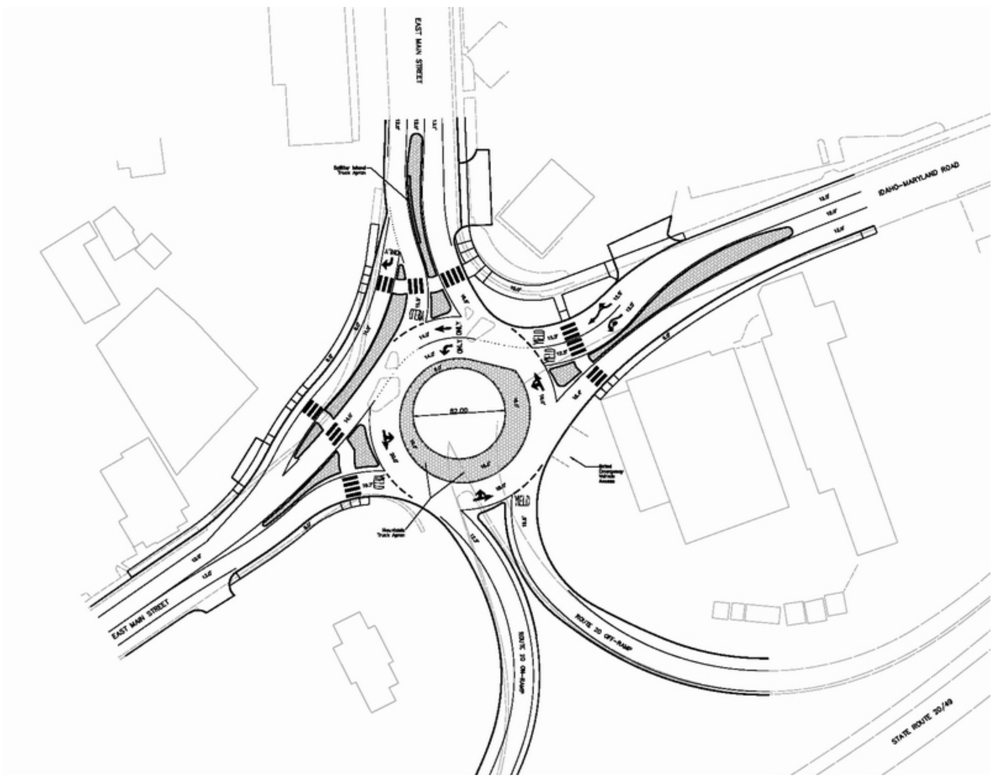
APPENDIX C

TRAFFIC ANALYSIS

Traffic Analysis

State Route 20 East Main Street/Idaho-Maryland Road Roundabout Project



East Main Street/Idaho-Maryland Road Roundabout Project

Located in Nevada County, Grass Valley, California

This Traffic Analysis has been prepared under the direction of the following registered traffic engineer. The engineer attests to the technical information contained herein and the engineering data upon which recommendations, conclusions, and decisions are based.

Engineer's Seal

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1. Project Description

The proposed project includes construction of a partial two-lane roundabout at the East Main Street/Idaho Maryland Road/Route 20 Westbound Ramps intersection (abbreviated herein as EMIM) in the City of Grass Valley. The roundabout would include a southbound-to-westbound bypass lane, and dual circulating lanes on the northern quadrant of the roundabout that allow for a dedicated left turn from westbound Idaho-Maryland Road onto the Route 20 on-ramp. The remaining three quadrants of the roundabout would include a single circulating lane. The proposed roundabout's layout is shown in the attached exhibit.

The intersection is currently controlled by all-way stop-controls. The westbound freeway ramps form the southern leg of the intersection. The eastbound freeway ramps are located on Idaho-Maryland Road approximately one-quarter mile to the east.

Over the past decade, both the City and Caltrans have considered numerous potential improvements to address the intersection's deficient operation. Signalization of the intersection has been deemed infeasible due to the potentially-adverse impacts to a short weave between freeway interchanges on westbound Route 20. Construction of a modern roundabout has been found to be the only acceptable improvement that meets the goals of providing acceptable operation of both the intersection and the freeway.

2. Study Parameters

Study Periods and Analysis Years

Conditions during the weekday a.m. and p.m. peak hours were analyzed to capture worst-case operation periods at the intersection. It should be noted that a midday school-related peak also occurs at the intersection, though typically lasts only 20 minutes and has slightly better operating conditions than the p.m. peak hour. Traffic conditions were projected for existing conditions (2006), a 2012 horizon year chosen by Caltrans and the City as an appropriate design year, and a 2026 horizon year chosen to assess potential long-term conditions. For the traffic analysis operating conditions at the EMIM intersection were examined with the existing all-way stop-controls, with a traffic signal, and with the proposed roundabout.

Level of Service (LOS) and Queuing Methodology

Operating conditions for the existing all-way stop controls were analyzed using the "All-Way Stop-Controlled Intersection" methodology contained in Chapter 10 of the *Highway Capacity Manual,* Transportation Research Board, 2000 (HCM). This methodology evaluates delay for each approach based on turning movements, opposing and conflicting traffic volumes, and the number of lanes. The delay which is calculated is then related to a Level of Service.

When evaluating operation of the EMIM intersection under control of a traffic signal, the Operations Method contained in the *Highway Capacity Manual* was used. This methodology is based on factors including traffic volumes, green time for each movement, phasing, and whether or not signals are coordinated. Average stopped delay per vehicle in seconds is used as the basis for evaluation in this LOS methodology.

Intersection operating conditions with a roundabout were determined using the SIDRA Intersection 3.1 roundabout analysis software. SIDRA uses the "gap acceptance" roundabout analysis method and utilizes various geometric data and traffic volumes to determine criteria such as vehicle delays and queue lengths. As with the all-way stop-controlled and signalized methods, LOS is determined using average vehicle delay. The ranges of average vehicle delay associated with each Level of Service are different for all-way stop-controls than for signals or roundabouts, as shown in Table 1.

Table 1
Intersection Level of Service Criteria

LOS	Unsignalized and All-way Stop-controlled Intersections	Signalized and Roundabout Intersections
A	Delay of 0 to 10 seconds	Delay of 0 to 10 seconds
B	Delay of 10 to 15 seconds	Delay of 10 to 20 seconds
C	Delay of 15 to 25 seconds	Delay of 20 to 35 seconds
D	Delay of 25 to 35 seconds	Delay of 35 to 55 seconds
E	Delay of 35 to 50 seconds	Delay of 55 to 80 seconds
F	Delay of more than 50 seconds	Delay of more than 80 seconds

References: *Highway Capacity Manual 2000,* Transportation Research Board, 2000, and SIDRA Intersection 3.1 User Guide, Akcelik & Associates, 2006

When considering any type of intersection control it is important to understand the potential effects of queuing, or stacking, created as drivers wait to proceed through. Peak queues should typically not extend into adjacent intersections, particularly adjacent intersections controlled by a traffic signal or roundabout. The 95th percentile queue length is generally used when evaluating queuing conditions and comparing various types of intersection control. The *Highway Capacity Manual* methodologies described above for all-way stop-controlled and signalized intersections produce queue estimates, as do the methodologies used by the SIDRA program for roundabouts.

Operations Standards

The City of Grass Valley has established LOS D as the minimum operating standard for intersections. Caltrans uses the threshold between LOS C and D as the minimum operating standard for ramp terminals.

SIDRA Environment Factor

The SIDRA Intersection software allows users to input an "Environment Factor" that adjusts the program's assumed follow-up headway and gap acceptance values to reflect local conditions and driver behavior. A factor of 1.0 represents typical capacity, whereas a 0.95 factor represents higher-than-average capacity and a factor of 1.05 represents lower-than-average capacity. Research conducted by the National Cooperative Highway Research Program (NCHRP) at roundabouts in the United States has revealed lower capacities than observed at roundabouts in Australia and the United Kingdom. This is presumably because roundabouts have been a prevailing form of intersection control in these countries for many years, in contrast to the United States where they are still relatively rare and many drivers are unfamiliar with their operation. The research suggests that the Environment Factor in SIDRA should be set to 1.20 for analysis of roundabouts in the United States.

For evaluation of the EMIM intersection, the SIDRA Environment Factor has been set to 1.20 for the 2006 and 2012 analysis years. The factor is reduced to 1.05 for analysis of the 2026 horizon year, since it is reasonable to assume that drivers in the United States will become more familiar with roundabouts over the long-term, particularly when they have been in place at an intersection over a nearly 20-year period. Using a factor of 1.05 versus 1.0 still reflects the presence of some unfamiliar or less confident drivers, as well as the constrained nature of the site.

3. Applied Traffic Volumes

Existing Traffic Volumes

Peak hour traffic volume counts were obtained at the EMIM intersection, as well as adjacent intersections, in May of 2006 while local schools and Sierra Nevada College were still in session.

Future Traffic Volumes

Consistent with prior analyses conducted by PRISM Engineering for the Nevada County Transportation Commission (NCTC) in evaluating potential improvements to the EMIM intersection, as well as the potential impacts to mainline freeway operation, a growth rate of 2 percent per year was used. The 2 percent compounding rate was applied to 2006 volumes in establishing future horizon year traffic volumes for 2012 and 2026.

Traffic Volume Adjustments

Caltrans, the NCTC, and the City of Grass Valley have been considering several freeway interchange alternatives at the Dorsey Drive overcrossing of Route 20/49 for a number of years. Completion of new freeway ramps at Dorsey Drive would be expected to reduce traffic volumes at the EMIM intersection. While it is likely that a partial or full interchange at Dorsey Drive will be completed some time before the 2026 analysis year chosen for this analysis, it has not yet been determined how the improvements would be funded and how ramps at the new interchange would be configured. For these reasons no deductions to projected traffic volumes were taken to account for any improvements at Dorsey Drive.

Scandling Avenue is a City street that connects Idaho-Maryland Road to the northern leg of East Main Street, and in essence serves as a shortcut between the two streets. The street connects points approximately 650 feet to the east and 350 feet to the north of the EMIM intersection. About 165 vehicles were counted on Scandling Avenue using this westbound-to-northbound route during the p.m. peak hour in May 2006. Currently, the westbound Scandling Avenue approach to East Main Street is comprised of a single lane. When drivers attempt to make a left turn from Scandling Avenue onto East Main Street during peak hours, significant delays can occur for all drivers on the approach. The street itself is also fairly narrow and in poor condition.

The City expects to improve the condition of Scandling Avenue in the next several years, and reduce delays at the East Main Street intersection either by prohibiting left turns or providing separate left and right turn lanes. Once these improvements are made, use of the street is likely to increase significantly, reducing volumes on the westbound right turn movement at the EMIM intersection. For the 2012 and 2026 horizon years this movement was assumed to reduce by 25 percent. Actual reductions are likely to be higher given the potential driving time savings of using the Scandling Avenue route.

The applied peak hour traffic volumes at the EMIM intersection are shown in the attached exhibits.

4. Projected Traffic Conditions

Prior analyses conducted for the NCTC, City of Grass Valley, and Caltrans have led to the determination that a roundabout is the most appropriate form of traffic control for the EMIM intersection. To confirm this finding, however, a comparison of operating conditions and queuing under three different types of intersection control was conducted for this analysis. These include the current all-way stop controls, signalization, and the proposed roundabout.

The existing all-way stop-controls are operating unacceptably at LOS F during both the a.m. and p.m. peak hours, with queues extending nearly 2,000 feet on westbound Idaho-Maryland Road. Improvements on Scandling Avenue would lead to a reduction in these westbound queues, though operation would remain at LOS F and overall queues and delays would continue to increase.

Installation of a traffic signal at the intersection would improve intersection operation to an acceptable LOS D through the 2012 horizon year. Soon after 2012, however, conditions would deteriorate to LOS E, and the intersection would be failing at LOS F by the 2026 horizon year. Queues on the Route 20/49 offramp would also extend up to 675 feet by 2026 and again reach nearly 2,000 feet on westbound Idaho-Maryland Road.

Of the three forms of intersection control, the proposed roundabout would provide the best operation and the shortest queues. Levels of Service are projected to be in the LOS B range through 2012, and at LOS D or better by 2026. The longest anticipated queues on the Route 20/49 offramp would be relatively short, at approximately 107 feet during the 2026 a.m. peak hour. Maintaining short queue lengths on the offramp is desirable given the low-speed hook ramp configuration and adjacent downgrade on westbound Route 20/49. The eastbound East Main Street approach to the EMIM roundabout is projected to experience the most lengthy delays and queues, particularly during the 2026 p.m. peak hour when queues could extend approximately 1,760 feet. The projected LOS D operation in 2026 is mostly attributable to conditions on this approach.

The projected operation with the various types of intersection control for each of the analysis periods is shown in Table 2.

Table 2
Intersection Average Delay, Levels of Service and Projected Queuing

	All-Way Stop Controls	**Signalized**	**Proposed Roundabout**
2006 AM Peak Hour	61.0 sec / LOS F	39.2 sec / LOS D	11.4 sec / LOS B
NB Offramp Approach	*67 ft*	*325 ft*	*46 ft*
SB E. Main St.	*136 ft*	*475 ft*	*48 ft*
EB E. Main St.	*200 ft*	*525 ft*	*197 ft*
WB Idaho-Maryland	*968 ft*	*775 ft*	*233 ft*
2006 PM Peak Hour	111.9 sec / LOS F	43.9 sec / LOS D	13.1 sec / LOS B
NB Offramp Approach	*76 ft*	*375 ft*	*44 ft*
SB E. Main St.	*267 ft*	*600 ft*	*121 ft*
EB E. Main St.	*176 ft*	*550 ft*	*237 ft*
WB Idaho-Maryland	*1,966 ft*	*950 ft*	*306 ft*
2012 AM Peak Hour	61.7 sec / LOS F	41.2 sec / LOS D	13.3 sec / LOS B
NB Offramp Approach	*79 ft*	*350 ft*	*62 ft*
SB E. Main St.	*185 ft*	*525 ft*	*62 ft*
EB E. Main St.	*315 ft*	*600 ft*	*315 ft*
WB Idaho-Maryland	*882 ft*	*775 ft*	*231 ft*
2012 PM Peak Hour	135.7 sec / LOS F	50.9 sec / LOS D	18.4 sec / LOS B
NB Offramp Approach	*92 ft*	*425 ft*	*56 ft*
SB E. Main St.	*447 ft*	*700 ft*	*181 ft*
EB E. Main St.	*263 ft*	*625 ft*	*467 ft*
WB Idaho-Maryland	*484 ft*	*1,025 ft*	*367 ft*
2026 AM Peak Hour	159.5 sec / LOS F	85.5 sec / LOS F	22.7 sec / LOS C
NB Offramp Approach	*121 ft*	*575 ft*	*107 ft*
SB E. Main St.	*452 ft*	*850 ft*	*83 ft*
EB E. Main St.	*996 ft*	*1,025 ft*	*794 ft*
WB Idaho-Maryland	*2,624 ft*	*1,375 ft*	*403 ft*
2026 PM Peak Hour	264.6 sec / LOS F	116.0 sec / LOS F	45.4 sec / LOS D
NB Offramp Approach	*608 ft*	*675 ft*	*65 ft*
SB E. Main St.	*1,058 ft*	*1,225 ft*	*297 ft*
EB E. Main St.	*924 ft*	*1,075 ft*	*1,759 ft*
WB Idaho-Maryland	*1,563 ft*	*1,950 ft*	*505 ft*

Notes: Conditions are expressed as average seconds of delay / Level of Service
NB = Northbound; SB = Southbound; EB = Eastbound; WB = Westbound

5. Roundabout Design Features

Design Components

Roundabouts have geometric elements that are unique among traffic control devices. The combination of various design elements must be customized to each roundabout intersection, and specifically configured to achieve the desired balance of safety, capacity, and speed regulation. Analysis of traffic volume projections indicated the need for a partial two-lane roundabout that provides a short westbound left turn lane onto the freeway on-ramp, as well as a southbound right turn bypass lane. In the initial design phase, various diameters and placements of the inscribed circle that could accommodate these elements were examined. The roundabout's ultimate positioning has been located to provide adequate deflection and speed control on all approaches, in addition to providing maneuverability for various types of design vehicles.

The westbound Idaho-Maryland Road approach would flare to two lanes entering the roundabout, creating an approximately 60-foot long left turn lane for traffic destined for the Route 20/49 on-ramp. The length of this lane was kept short in order to minimize the potential for a dominating stream of traffic destined for the on-ramp. This maintains one of the benefits of a roundabout at the EMIM intersection: the ability to "meter" traffic onto the freeway ramp and have the least potential impact to the short ramp weave on the mainline freeway.

The central island of a roundabout is the innermost area that is raised and landscaped. A "truck apron" is provided between the central island and circulating lanes to provide additional traversable area around the raised central island for the trailers of large trucks to mount as necessary. The dimensions of the roundabout's central island and mountable truck apron were determined by a combination of large vehicle maneuverability testing and the need to regulate vehicle speeds.

Splitter islands are provided on all four roundabout approaches. Their purpose is to provide shelter for pedestrians, assist in controlling speeds, guide traffic into the roundabout, physically separate entering and exiting traffic streams, and deter wrong-way movements. Additionally, splitter islands can be used as a place for mounting signs and occasionally planting low-profile landscaping. On approaches with pedestrian crossings, the splitter islands include a 10-foot wide break through which the crosswalk passes; it is set back approximately 20 feet (one vehicle length) from the circulatory roadway.

Landscaping plays an important role in roundabout design. Trees and other vertical elements in the central island serve not only aesthetic purposes, but alert drivers to the presence of a roundabout from a distance. Vertical elements in the center island also focus drivers' attention only on circulating traffic, rather than activity on adjacent approaches. The EMIM intersection will include carefully-considered landscaping plans that achieve these goals while providing an attractive gateway to the community.

Vehicle Maneuverability

Because the EMIM intersection is a freeway ramp terminal, Caltrans requires that full maneuverability for "California Legal" semi truck design vehicles be provided. The California Legal truck is a large 65-foot long vehicle, typically used for long-haul trucking operations. Based on observations, the majority of trucks passing through the EMIM intersection are much smaller single-unit trucks, with the observed semi truck-trailers WB-40 sized (45 feet long) or less. Caltrans has also indicated that permit loads occasionally travel down southbound East Main Street and onto the westbound Route 20/49 freeway on-ramp, with oversized-vehicles hauling mobile homes being the largest of permit loads.

The AutoTurn software analysis tool was used to test the maneuverability of these large design vehicles through the roundabout, with iterative adjustments to the design made as necessary. In the resulting design, California Legal trucks are able to negotiate all movements except the westbound right turn, though this movement can be easily made by passing the intersection on Scandling Avenue. A WB-50 truck can make the right turn movement at the roundabout. The mobile home permit load design vehicle can successfully negotiate the southbound through movement onto the freeway, though sign posts will need to be removable to accommodate the exceptional width of the loads. Note that emergency response vehicles such as fire trucks are significantly smaller than the chosen design vehicles, and will easily be able to negotiate all movements at the roundabout.

Speed Moderation

The roundabout layout was tested to ensure that appropriate vehicle speeds were maintained for passenger vehicles at the entry, within the roundabout and upon exiting. Drivers would be able to maneuver through the roundabout most quickly during times where there is little traffic. The driving path that results in the greatest speeds is called the "fastest path," and is calculated for various maneuvers associated with a roundabout.

The fastest paths for vehicles entering from the single-lane roundabout approaches would be approximately 20 mph, while the fastest path on the dual-lane Idaho-Maryland Road entry is 23 mph. The fastest circulating speeds within the roundabout would be in the 14-18 mph range. The fastest exiting speeds, measured at the exiting approach's crosswalk, would be approximately 20-22 mph. Fastest speeds in the southbound right turn bypass lane would be approximately 25 mph. All of the projected speeds fall within acceptable parameters for urban roundabouts, including the differentials among various circulating and entering speeds.

A summary of the projected fastest-path speeds is provided in Table 3.

Table 3
Projected Fastest-Path Vehicle Speeds

Movement	Northbound SR 20 Offramp	Southbound E. Main St	Eastbound E. Main St	Westbound Idaho-Maryland Rd
Entering	20	20	20	23
Circulating	16	16	16	18
Exiting	20	20	20	22
Left Turn	15	14	15	14
Right Turn	20	25	19	18

Note: All values are in miles per hour

Design for Pedestrians and Bicyclists

Pedestrian facilities currently do not exist on the south side of East Main Street and Idaho-Maryland Road. There is very little potential for sidewalks to ever be constructed on the south side of East

Main Street leading into downtown Grass Valley given the extremely limited right-of-way and presence of historical buildings. A continuous sidewalk does exist on the north side of the street.

The proposed roundabout layout would improve existing sidewalks on the northwest and northeast corners of the intersection, maintaining full connectivity to the north, east, and west. A new section of sidewalk would be provided along the south side of East Main Street to the west of the intersection, directing any pedestrian traffic in this area to crosswalks leading to the north side of the intersection. Another new sidewalk would be constructed on the south side of Idaho-Maryland Road within the roundabout area (along the frontage of the existing Hills Flat Lumber Company buildings), also directing pedestrians to a crosswalk leading to the north side of the intersection.

The roundabout would provide no pedestrian crossing of the Route 20/49 ramps, since there is no existing or anticipated pedestrian crossing demand on this leg, and only limited potential for continuous pedestrian facilities to ever exist on the west side of the intersection. As a secondary note, while sufficient sight distance to pedestrian crossing areas could be achieved on the offramp, the hook ramp design does limit the long-range distance at which drivers could see a crossing pedestrian. Given these conditions it was deemed appropriate to direct pedestrian traffic (should any occur) to the north side of the intersection.

At single-lane roundabouts, most bicyclists are comfortable "claiming the lane" and proceeding through the roundabout with vehicles, which are traveling at low speeds in the 15-20 mph range. Providing 10-foot wide multi-use paths on the periphery of roundabouts for less-confident bicyclists to use is desirable, particularly at multi-lane roundabouts. The EMIM intersection includes a new 10-foot wide path on the northeast corner of the intersection, adjacent to the multi-lane westbound approach. Westbound cyclists can avoid the multi-lane portion of the roundabout by using the path, crossing the north leg of the intersection, and using a 5-foot wide striped shoulder area that is provided along the southbound right turn bypass lane.

6. Safety

The EMIM intersection has been designed with state-of-the-practice safety considerations including speed moderation, speed consistency, and reduction in potential for vehicle path overlap. The intersection is expected to have an excellent long-term safety performance. Research conducted by both the Insurance Institute for Highway Safety (IIHS) and the NCHRP indicate that installation of modern roundabouts typically results in decreases in total intersection crashes, and significant decreases in injury and fatal crashes. There are multiple characteristics of roundabouts that lead to their notable safety performance, the most influential of which are related to speed moderation and reduction in conflict points. Properly-designed urban roundabouts are configured to regulate all vehicle speeds to the 15-25 mph range. Collisions in roundabouts, when they do occur, are low-speed incidents that often result only in property damage. Compared to conventional intersections, roundabouts also have fewer conflict points, or locations where a collision can occur.

7. Transportation/Traffic Components of CEQA Checklist

The proposed roundabout project is expected to create no adverse transportation or traffic impacts. The following table includes a suggested format for completion of the CEQA Transportation/Traffic checklist.

TRANSPORTATION/TRAFFIC Would the project:	**Potentially Significant Impact**	**Less Than Significant with Mitigation**	**Less Than Significant Impact**	**No Impact**
a) Cause an increase in traffic which is substantial in relation to the existing traffic load and capacity of the street system?				**X** Project would reduce congestion, or improve operation
b) Exceed, either individually or cumulatively, a level of service standard established by the county congestion management agency for designated roads or highways?				**X** Project would result in improved compliance
c) Result in a change in air traffic patterns, including either an increase in traffic levels or a change in location that results in substantial safety risks?				**X**
d) Substantially increase hazards due to a design feature or incompatible uses?			**X** Project incorporates state-of-the-practice safety design	
e) Result in inadequate emergency access?			**X** Geometry accommodates emergency vehicles	
f) Result in inadequate parking capacity?				**X**
g) Conflict with adopted policies, plans, or programs supporting alternative transportation?			**X** Design accommodates pedestrians and bicyclists	

8. Project Personnel

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