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February 28, 2022

RE: Ramsey, Minnesota
CSAH 56 at Sunwood Drive Signal System
Flashing Yellow Arrow Considerations
SEH No. RAMSY 164323

Mr. Bruce Westby, PE
City Engineer
City of Ramsey
7550 Sunwood Drive Northwest
Ramsey, Minnesota 55303

Dear Bruce:

On November 5, 2021, we reviewed the intersection of CSAH 56 (Ramsey Boulevard) and Sunwood Drive in the City of Ramsey with regards to proposed modification of the existing intersection traffic signal left turn operations. Recently, the City has received requests from the public to have flashing yellow arrow operation installed and activated at intersections like this throughout the City. In response to these requests, the City had SEH perform an analysis of the intersection to determine if flashing yellow arrow operation can be utilized there. The analysis includes review of the feasibility, cost, and safety of the intersection for flashing yellow arrow operations. Following are the results of our analysis.

This 4-legged intersection was first signalized in 2004, with protected left turn phasing installed for the CSAH 56 approaches and protected/permissive left turn phasing for the Sunwood Drive approaches. The posted speed limit on CSAH 56 is 55 mph, while Sunwood Drive is posted at 30 mph to the north and 35 mph to the south. All intersection approaches have a single separate dedicated left turn lane.

The City provided SEH with AM and PM peak period turning movement traffic counts for this intersection (taken on January 26-27, 2022, between the hours of 6-9 am and 3-6 pm). SEH also obtained crash data for the intersection for the most recent 5 years of available crash data (January 2017 to December 31, 2021) through the MnCMAT site. SEH then completed a brief field review of the signal system to confirm that the existing traffic signal plans correspond to the current installation of the signal system and take into account the current intersection geometrics. As part of the field review, SEH also reviewed traffic signal cabinet components to determine if additional electrical equipment would be required to be provided in order to allow for flashing yellow arrow operation to be used.

As part of the signal system installation, the CSAH 56 intersection approaches were set up to operate with protected left turn phasing (3-section RLA-YLA-GLA signals). A separate left turn signal is centered on both the northbound and southbound left turn lanes. Far-left pole mounted left turn signals also exist facing each CSAH 56 intersection approach. Through signals (3-section RYG) are centered on each through lane. Both approaches have a single left turn lane, two through lanes, and a separate right turn lane.

The Sunwood Drive approaches currently operate with protected/permissive left turn phasing (5-section R-Y-G-YLA-GLA signals). A single overhead 5-section signal head exists facing the eastbound and westbound approaches, and this head is centered on the lane line between the left turn lane and through lane. No other overhead signal exists on either mast arm facing Sunwood Drive. Far left pole mounted 5-section signal heads also exist facing each approach.

The eastbound approach has a separate left turn lane, a single through lane, and a separate right turn lane. The westbound approach has a separate left turn lane and a shared through/right turn lane.

The intersection has an older controller cabinet WITHOUT sufficient load switch bays open and available to allow for flashing yellow arrow operations to be added for all four intersection approaches. It is recommended that this controller cabinet be replaced with a newer controller cabinet with capacity and capability to accommodate future flashing yellow arrow operations for all four intersection approaches. The controller unit is an older Econolite ASC 2S-2100 unit that is not capable of operating flashing yellow arrows and will be required to be replaced. The conflict monitor is an older EDI-SSM-12LE unit, also incapable of operating flashing yellow arrows. Thus, in order to be able to convert all intersection approaches to operate with a flashing yellow arrow, **we recommend that the controller cabinet, controller unit, and conflict monitor all be replaced**.

As part of our analysis of whether and when to operate the signal system with flashing yellow arrows, SEH utilized two sets of criteria as shown on the Minnesota Department of Transportation's (MnDOT) Office of Traffic Engineering (OTE) web site: flashing yellow arrow installation criteria from their "*Traffic Signal Timing and Coordination Manual*", and the *Flashing Yellow Arrow Tool for Time-of-Day Use* spreadsheet that incorporates various criteria to determine a relative risk factor for enacting flashing yellow arrows based on intersection geometrics and turning movement traffic count volumes.

With regards to utilizing Flashing Yellow Arrow operations for each left turn movement, please note the following:

- According to the current edition of the *AASHTO Geometric Design of Highways and Streets* manual, left-turning drivers "need sufficient sight distance to decide when it is safe to turn left across the lanes used by opposing traffic." This minimum required stopping sight distance along CSAH 56 for the design/posted speed of 55 mph is at least 495 feet of clear sight distance to the north and south. The stopping sight distance along Sunwood Drive for the design speed of 30 mph is at least 200 feet of clear sight distance to the east, and for 35 mph is at least 250 feet of clear sight distance to the west. Based on a field review of intersection geometrics, we estimated stopping sight distance on each CSAH 56 approach to be exceeding 1,000 feet. The stopping sight distances for both eastbound and westbound Sunwood Drive are also exceeding 1,000 feet.

  However, note that in the *Flashing Yellow Arrow Tool for Time-of-Day Use* spreadsheet, sight distance for left turning traffic at the stop bar in each left turn lane is calculated based on the distance between stop bars, left turn lane offsets (measured from the lane line of the near side left turn lane and the edge of median on the far side approaching left turn lane), and other standard lane and vehicular measurements.

  1. Based on plan measured distances and criteria proprietary to the spreadsheet, available sight distance for each CSAH 56 approach was calculated at around 270 feet in each direction (mostly due to potential blocking of approaching sight distance by opposing left turning traffic). If no opposing left turning traffic is present for a left turn movement, sight distance would be estimated to be exceeding 1,000 feet.

  2. For the Sunwood Drive approaches, based on plan measured distances and criteria proprietary to the spreadsheet, available sign distances for both approaches were calculated to be in excess of the 365 feet required for safely accommodating flashing yellow arrow operations (mostly due to potential blocking of approaching sight distance by opposing left turning traffic). If no opposing left turning traffic is present for a left turn movement, sight distance would be estimated to be exceeding 1,000 feet.

  Based on both criteria, there are sight distance concerns on each intersection approach when there is opposing left turning traffic but no concern if the opposing left turn lane is empty.

- Based on the recent crash history at this intersection, a total of 6 crashes were reported between January 2017 and December 31, 2021. 2 crashes were reported in 2018, 1 crash in 2019, 2 crashes in 2020, and 1 crash was reported in 2021.

Two (2) of the crashes were reported as either left turns into oncoming traffic or right angle crashes, with possible injuries noted for 1 of these crashes (listed as non-incapacitating). The right angle crashes were between southbound/eastbound through vehicles and between a southbound through vehicle and a northbound left turning vehicle.

One of the 6 crashes was reported during morning hours (10-11 am), with the other 5 crashes being between 1-8 pm (1 crash during PM peak traffic period of 3-6 pm).

Given the number and type of crashes recorded over the past 5 years of available crash data as well as analysis of the crash details, **there does not appear to be any safety concerns at this intersection with the presence of signalized operation as concerns about right angle crashes are minor.**

- One of the recommendations from the *MnDOT Traffic Signal Timing and Coordination Manual* is to utilize protected left turn phasing only either for situations where the posted speed limit exceeds 45 mph and the peak hour left turning volume is greater than 240 vehicles per hour, or for when the cross product between left turn traffic volumes and the opposing through/right turning traffic volumes exceed 80,000 for one opposing through lane or exceeding 100,000 for two or more opposing lanes. This would translate to a left turn volume of 150 vehicles per hour with opposing traffic volumes between 500-700 vehicles per hour. For this analysis, we used the more conservative cross product of 80,000 in determining our recommendations for time of day flashing yellow arrow operation.

  Turning movement traffic count data (taken at the intersection by the City between January 26-27, 2022) was used in the flashing yellow arrow analysis. With regards to the available information:

  a. For northbound CSAH 56, the cross product between northbound left turns and southbound opposing traffic peaks at around 35,000 in the AM peak period (7-8 am) and around 30,000 in the PM peak period (4-5 pm). The highest hour of northbound left turning traffic is between 4-5 pm (144 left turns) with at least 90 left turns recorded for all hours of the AM and PM peak traffic periods.

  b. For southbound CSAH 56, the cross product between southbound left turns and northbound opposing traffic peaks at around 9,800 in the AM peak period (6-7 am) and around 13,000 in the PM peak period (3-4 pm). The highest hour of southbound left turning traffic is between 7-8 am (64 left turns).

  c. For eastbound Sunwood Drive, the cross product between eastbound left turns and westbound opposing traffic peaks at around 3,500 in the AM peak period (7-8 am) and around 11,500 in the PM peak period (4-5 pm). The highest hour of eastbound left turning traffic is between 5-6 pm (56 left turns).

  d. For westbound Sunwood Drive, the cross product between westbound left turns and eastbound opposing traffic peaks at around 6,000 in the AM peak period (6-7 am) and at around 32,000 in the PM peak period (4-5 pm). The highest hour of westbound left turning traffic is between 4-5 pm (146 left turns).

Following up against the flashing yellow arrow criteria from the *MnDOT Traffic Signal Timing and Coordination Manual:*

1. There is sufficient turning room in the intersection so that left turn paths were not conflicting.

2. Only 1 left turn lane exists for each intersection approach, and there are less than 3 opposing through lanes of traffic facing each left turn lane.

3. The intersection is not anticipated to have an excessively high crash rate with respect to left turning movements.

Based on criteria from the *MnDOT Traffic Signal Timing and Coordination Manual,* as there is no significant anticipated crash history for left turning traffic at the intersection and sight distance is reasonable, the City should be able to consider using Flashing Yellow Arrow operations at this intersection during several hours of a typical day. **However, due to higher posted speeds and higher peak hour traffic volumes on CSAH 56, along with higher peak left turning traffic volumes on Sunwood Drive, we have concerns about operating with flashing yellow arrow operations on each roadway during these peak traffic periods.**

Following up further with the *Flashing Yellow Arrow Tool for Time-of-Day Use* spreadsheet, we inputted left turning traffic volumes and opposing traffic volumes (combined through and right turning traffic) into the spreadsheet for each intersection approach (with an overall cross product at 80,000 using base conditions of 150 left turns per hour and 533 approaching vehicles per hour). Using this information, the spreadsheet calculates a relative risk factor for having flashing yellow arrow operations during each hour of available traffic volumes. A risk factor of greater than 1.0 indicates that there is a higher risk of a left turn crash based on comparison against base conditions, and the signal is recommended to be operated with protected left turn phasing during those periods.

- For northbound CSAH 56, the highest AM peak period risk factor is 0.66, while in the PM peak period the highest risk factor is 0.60. Risk factors exceed 0.6 between 6-8 am and are at 0.6 between 4-5 pm.

- For southbound CSAH 56, the highest AM peak period risk factor is 0.35, while in the PM peak period the highest risk factor is 0.42.

- For eastbound Sunwood Drive, the highest AM peak period risk factor is 0.31, while in the PM peak period the highest risk factor is 0.48.

- For westbound Sunwood Drive, the highest AM peak period risk factor is 0.37, while in the PM peak period the highest risk factor is 0.71. Risk factors exceed 0.6 between 4-5 pm.

Since traffic volumes can fluctuate daily based on several factors, we recommend that the City consider using a risk factor of 0.60 to 0.80 with the currently available traffic counts. This will account for those periods where traffic volumes are fluctuating due to area factors (crashes, bypass traffic, weather, etc.). For our analysis, due to higher posted speeds on CSAH 56, we considered the thresholds for recommending flashing yellow arrow operations as having an approach either exceed/be close to a risk factor of 0.6 or having opposing traffic volumes that exceed 700 vehicles in an hour

Utilizing information from both sets of analysis, **for both approaches of Sunwood Drive**, due to potential concerns about left turning traffic volumes approaching 150 vehicles per hour during the peak PM traffic period, we recommend considering **protected only left turn phasing being used both weekdays and weekends between the hours of 3:30-5:30 pm**. For all other hours of the day and all hours on weekends, protected/permissive flashing yellow arrow operations should be able to be utilized.

For the CSAH 56 approaches, concerns about higher opposing traffic volumes along with higher posted speed limits, we recommend considering **protected only left turn phasing being used on both weekdays and weekends between the hours of 6:30 am-8:30 am and also between 3:30-5:30 pm**. For all other hours of a typical weekday and weekend, flashing yellow arrow operations should be able to be utilized on CSAH 56.

Note that any changes in the operation of this signal system should be monitored by the City and Anoka County, including annual review of crash data to ensure that crash frequency does not increase due to the proposed left turn signal operations.

Upon further observation and review of the operation of this signal system in the future, there may be the opportunity to extend these hours of flashing yellow arrow operation should the intersection operate safely and efficiently with these proposed modifications. For the time being, we recommend that the City and Anoka County operate the signal system in flashing yellow arrow mode only as noted above.

Any changes to the operation of the left turn signal phases are not anticipated to impact overall operations of the intersection in a negative way (and delays for left turning traffic will decrease with flashing yellow arrow operations which will improve the overall operation of the intersection).

The following modifications to the existing signal system installation will be required to revise the operation of this signal system and add flashing yellow arrows for all intersection approaches:

- For northbound and southbound CSAH 56, the overhead end mounted and far left pole mounted left turn signals for these intersection approaches will require having 3-section RLA-YLA-GLA signal heads replaced with 4-section RLA-YLA-FYLA-GLA signal heads. No additional cabling will be required to be installed to operate these signal heads based on a review of the field wiring diagram, as there are sufficient spare conductors available to allow for the new 4-section signal heads to be installed. No additional through traffic signal heads will be required to be installed for these approaches, as each approaching through lane has its own separate signal centered on the lane.

- For eastbound Sunwood Drive, either a 5-foot extension or installation of a 5 foot longer mast arm to replace the existing 35 foot long mast arm will be required to be installed in order to be able to center a new left turn signal head over the approaching left turn lane. **For the purposes of the estimated construction costs included in this analysis, replacement of this mast arm was included in the Engineers estimate of construction costs, as is typical policy for signal systems on Anoka County roadways and operated by the County**. The overhead and far left pole mounted 5-section signal heads would then be replaced with new 4-section RLA-YLA-FYLA-GLA signal heads. A new 3-section RYG signal head with either a strap-on mid mast arm mount (on the existing mast arm) or a new mid-mount (on a new mast arm) will be required to be furnished and installed so that a RYG signal head is able to be centered on the approaching through lane. No additional cabling will be required to be installed to operate these signal heads based on a review of the field wiring diagram, as there are sufficient spare conductors available to allow for the new 3-section and 4-section signal heads to be installed.

- For westbound Sunwood Drive, either a 5-foot extension or installation of a 5 foot longer mast arm to replace the existing 35 foot long mast arm will be required to be installed in order to be able to center a new left turn signal head over the approaching left turn lane. **For the purposes of the estimated construction costs included in this analysis, replacement of this mast arm was included in the Engineers estimate of construction costs, as is typical policy for signal systems on Anoka County roadways and operated by the County**. The overhead and far left pole mounted 5-section signal heads would then be replaced with new 4-section RLA-YLA-FYLA-GLA signal heads. A new 3-section RYG signal head with either a strap-on mid mast arm mount (on the existing mast arm) or a new mid-mount (on a new mast arm) will be required to be furnished and installed so that a RYG signal head is able to be centered on the approaching through lane. No additional cabling will be required to be installed to operate these signal heads based on a review of the field wiring diagram, as there are sufficient spare conductors available to allow for the new 3-section and 4-section signal heads to be installed

- With regards to left turn lane detection, the *MnDOT Traffic Control Signal Design Manual* recommends that either four loop detectors be installed for proper detection (at 5', 20', 35' and 50' from the stop bar or crosswalk) or that two separately wired loop detectors be installed for existing signal system retrofits at 10' and 40' from the stop bar or crosswalk. Recent County practice has been to have the four separate loop detectors installed in each left turn lane in order to be able to operate the left turn lanes on non-lock operation.

  For this signal system, four (4) left turn lane detectors were previously installed at 15 foot spacing and in close proximity to the stop bar on both Sunwood Drive intersection approaches (with separate lead-in cables for 2 of the 4 loop detectors in each left turn lane). Thus, no loop detector work is required to be completed for the Sunwood Drive approaches.

  For the CSAH 56 approaches, left turn lane detection was installed at 10' and 40' from the stop bar for these intersection approaches (each wired separately). To meet current County practice, additional loop detectors will be required to be furnished and installed -5 feet and 25 feet from the stop bar in both left turn lanes.

Thus, a total of 4 new loop detectors are recommended to be installed with any flashing yellow arrow modifications. No additional 2/c#14 cables or controller cabinet loop detector cards will be required to operate these new loop detectors since existing loop detectors are already wired separately in each left turn lane.

- The height of all overhead signals was also checked during the field review of the intersection to confirm that the distance between each overhead signal (from the bottom of the background shield) to the roadway surface was at least 17 feet. Note that all overhead signal heads are installed such that 2 of the signal indications are mounted below the mast arm mount and 1-3 signal indications are mounted above the mount. From this review, all overhead signals are currently at least 17 feet above the ground line.

  What this means is that modifying any of the end mounted signals to have 4-section signal heads will not pose a height issue for any of the 4 approaches.

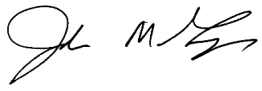
- Other minor modifications to the signal system include relocation of EVP detectors and Type D street name signs on the eastbound and westbound facing mast arms to accommodate signal head placements.

To allow for flashing yellow arrow operation on each intersection approach, we estimate that these modifications (completed by an electrical signal contractor) will cost approximately **$94,000**. A detailed preliminary engineer's estimate of costs is attached to this letter for your information.

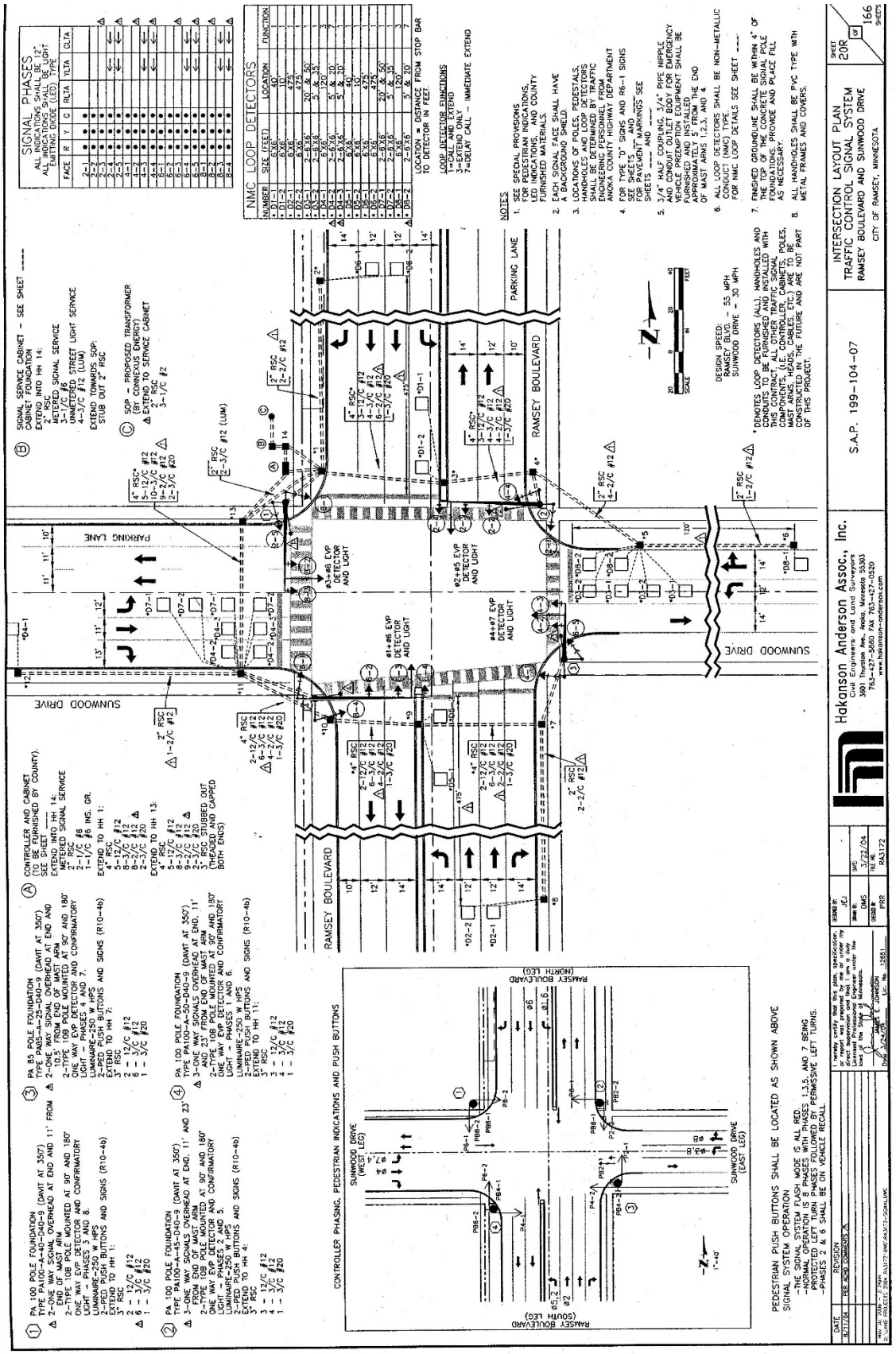
Please review our analysis and feel free to contact me at 651.402.4383 with any questions or concerns that you may have related to our analysis. If you wish to meet to go over these issues, I am available to meet at your convenience.

We hope that this information provides you with insight needed to help evaluate and recommend the appropriate signal phasing for this intersection.

Sincerely,
Short Elliott Hendrickson, Inc.



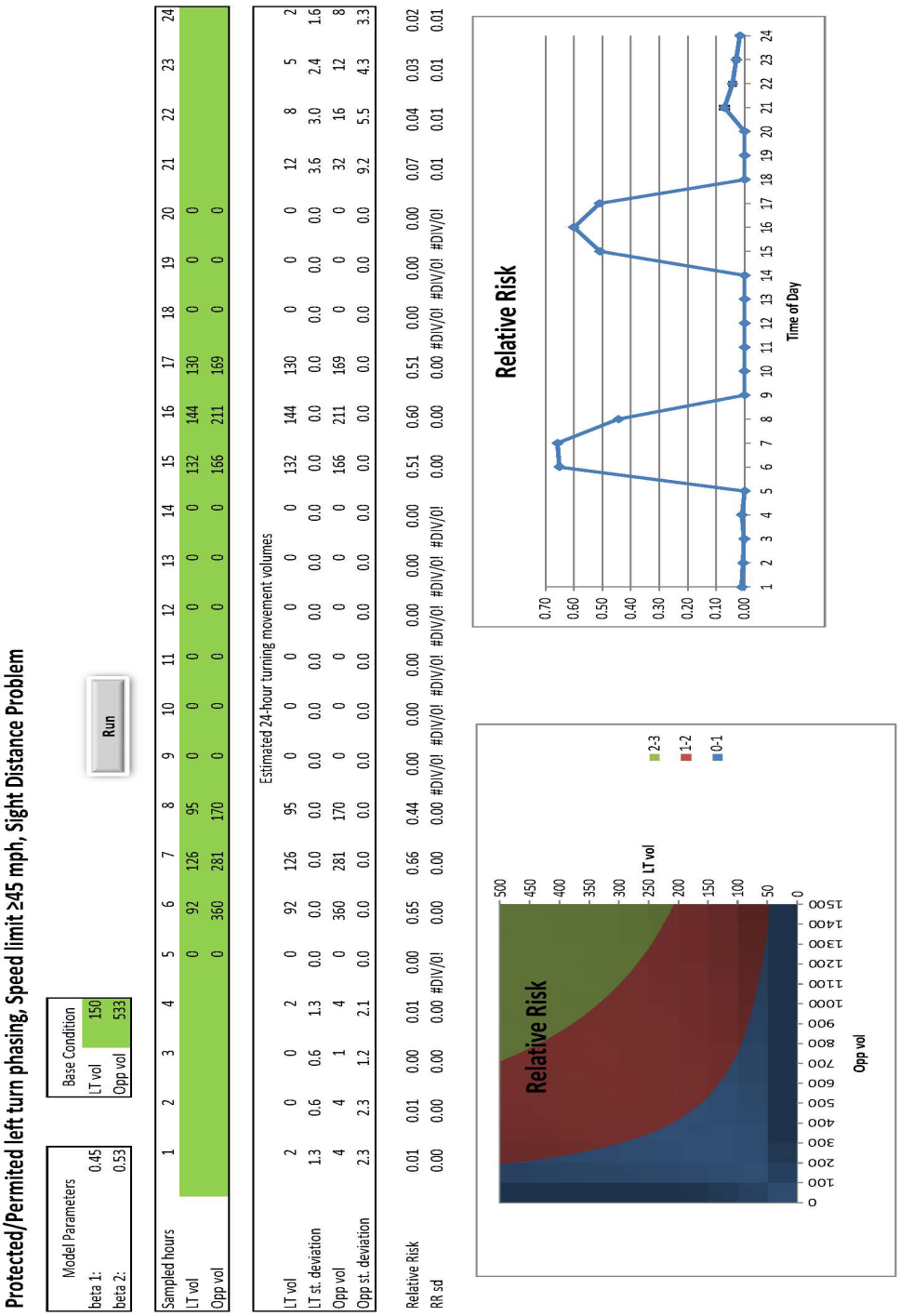
John M. Gray, PE
Senior Professional Traffic Engineer


SIGNAL PHASES
NMC LOOP DETECTORS
NOTES
1. SEE SPECIAL PROVISIONS FOR PEDESTRIAN INDICATIONS, LED INDICATIONS, AND COUNTY FURNISHED MATERIALS.
2. EACH SIGNAL FACE SHALL HAVE A BACKGROUND SHIELD.
3. LOCATIONS OF POLES, PEDESTALS, HANDHOLES AND LOOP DETECTORS SHALL BE DETERMINED BY TRAFFIC ENGINEERING PERSONNEL FROM ANOKA COUNTY HIGHWAY DEPARTMENT
4. FOR TYPE "D" SIGNS AND R6-1 SIGNS SEE SHEETS ____ AND FOR PAVEMENT MARKINGS SEE SHEETS ____ AND ____
5. 3/4" HALF COUPLING, 3/4" PIPE NIPPLE AND CONDUIT OUTLET BODY FOR EMERGENCY VEHICLE PREEMPTION EQUIPMENT SHALL BE FURNISHED AND INSTALLED FOR PHASES 1, 2, 3, AND 4.
6. ALL LOOP DETECTORS SHALL BE NON-METALLIC CONDUIT (NMC) TYPE. FOR NMC LOOP DETAILS SEE SHEET ____
7. FINISHED GROUNDLINE SHALL BE WITHIN 4" OF THE TOP OF THE CONCRETE SIGNAL POLE FOUNDATION. PROVIDE AND PLACE FILL AS NECESSARY.
8. ALL HANDHOLES SHALL BE PVC TYPE WITH METAL FRAMES AND COVERS.
RAMSEY BOULEVARD
SUNWOOD DRIVE
PARKING LANE
CONTROLLER PHASING, PEDESTRIAN INDICATIONS AND PUSH BUTTONS
PEDESTRIAN PUSH BUTTONS SHALL BE LOCATED AS SHOWN ABOVE
SIGNAL SYSTEM OPERATION
Hakanson Anderson Assoc., Inc.
S.A.P. 199-104-07
INTERSECTION LAYOUT PLAN
TRAFFIC CONTROL SIGNAL SYSTEM
RAMSEY BOULEVARD AND SUNWOOD DRIVE
CITY OF RAMSEY, MINNESOTA
SHEET 20R OF 166 SHEETS

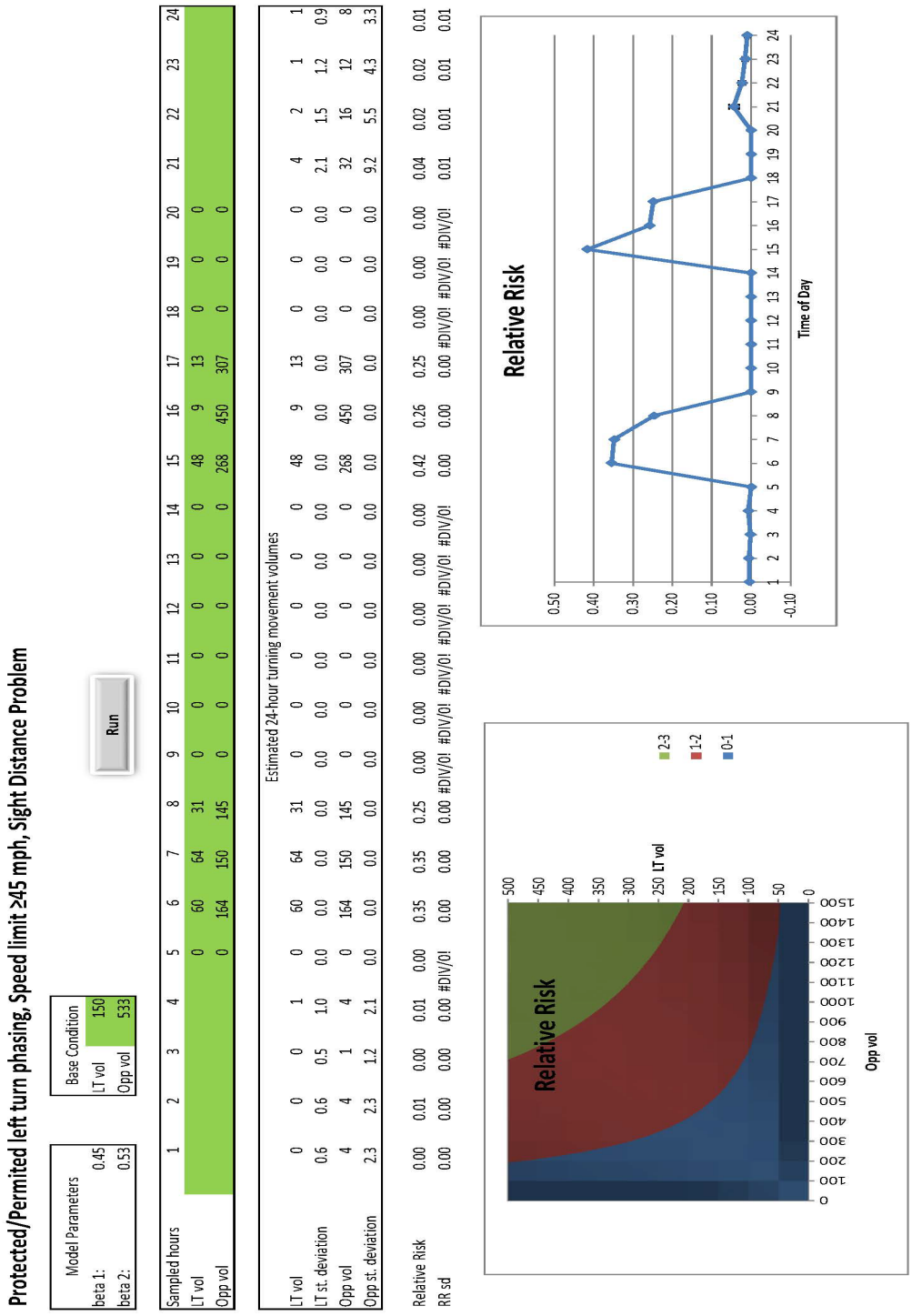
Preliminary Estimated Costs and Quantities
Revise Signal System (Flashing Yellow Arrow Modifications)
CSAH 56 (Ramsey Boulevard) at Sunwood Drive
City of Ramsey, Minnesota (Anoka County)
Prepared by JMG (SEH) on February 22, 2022

Item	Estimated Quantity	Estimated Unit Cost	Estimated Total Cost
Remove 3 and 5 Section Signals	8	$400	$3,200
4-Section Signals (with LED)	8	$1,200	$9,600
Remove Mast Arm	2	$2,500	$5,000
40 Foot Mast Arm	2	$8,500	$17,000
Overhead Mast Arm Mounts	6	$300	$1,800
Salvage and Install Type D Signs	2	$500	$1,000
3-Section Signals (with LED)	2	$1,000	$2,000
6 x 6 NMC Loop Detectors	4	$2,000	$8,000
Remove R10-12 Sign Panels	2	$200	$400
Salvage and Install EVP Detectors	2	$300	$600
R10-X12 Sign Panels	4	$700	$2,800
Replace Controller and Cabinet	1	$28,000	$28,000
Traffic Control	1	$2,500	$2,500
Sub Total			$81,900
Miscellaneous	15%		$12,100
Total Estimated Revise Signal System Contractor Costs			$94,000

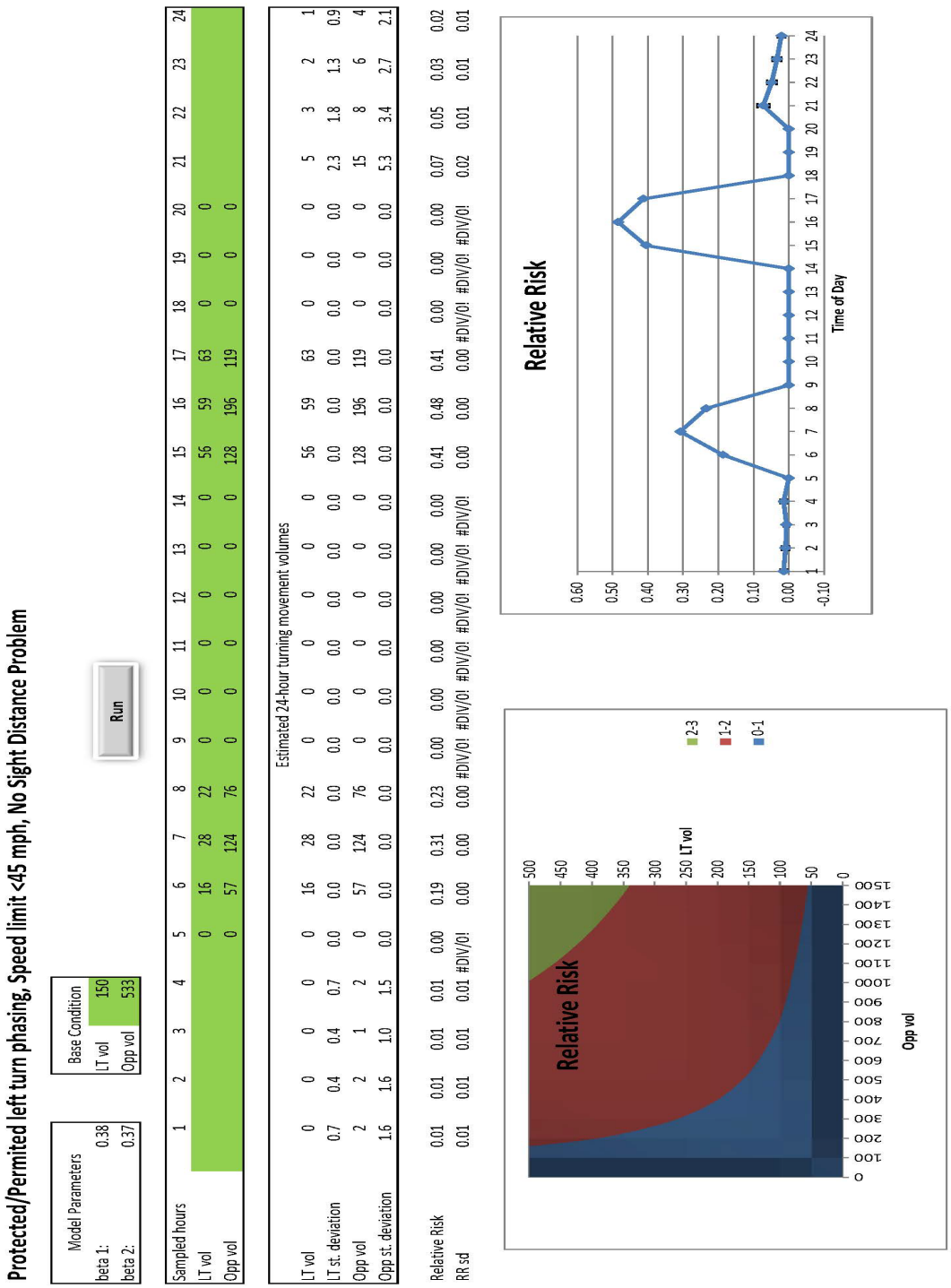
NORTHBOUND LEFT TURN FLASHING YELLOW ARROW CRITERIA ANALYSIS



SOUTHBOUND LEFT TURN FLASHING YELLOW ARROW CRITERIA ANALYSIS



EASTBOUND LEFT TURN FLASHING YELLOW ARROW CRITERIA ANALYSIS



WESTBOUND LEFT TURN FLASHING YELLOW ARROW CRITERIA ANALYSIS