MSA™

To: Chris Nosbich – City of Mount Vernon, IA

From: Ben Wilkinson, PE, and Nathan Cook

QA/QC: Mark Lenters

Subject: IA 1 at US 30
Roundabout In-Service Review

Date: June 13, 2018

## BACKGROUND

MSA was tasked by the City of Mount Vernon to provide an in-service review of the multi-lane roundabout at IA 1 and US 30 in Mount Vernon, IA. There is concern that the roundabout is experiencing higher than normal number of crashes, albeit, mainly property damage only (PDO) type crashes.

The intersection is currently exhibiting a total crash frequency of 16.8 crashes per year, well above a predicted average of approximately 6 to 8 crashes per year. A 60% reduction of crashes per year would need to be achieved for this roundabout to perform within the range of national expected average number of crashes for similar multi-lane roundabouts.

The results from this investigation should give informed recommendations to decision makers to combat the probable causes of overrepresented crash patterns with their corresponding countermeasures. Through the implementation of geometric, traffic control, and education countermeasures, it is anticipated that crashes will decrease based on success of similar treatment of other roundabouts. The goal of this effort is to reduce the number of crashes to those typical of other roundabouts with similar traffic flows.

## STUDY METHODOLOGY

Similar to traditional in-service reviews (FHWA methods), this study consisted of office and field reviews to document collision patterns and site deficiencies, which in-turn led to the development and evaluation of collision reduction countermeasures.

As part of this in-service review, the following tasks were completed:

1. Collision Analysis
2. Geometric Conformance Review

3. Operational Analysis
4. List of Identified Deficiencies (Office Review)
5. Site Visit – verification of deficiencies
6. Development of Countermeasures
7. Documentation/Reporting

First, a collision analysis was performed to identify target crash patterns. Then, the relative crash frequency in each quadrant of the intersection was compared to the potential conflicts present in each quadrant. Operational analysis was also performed to identify capacity deficiencies that may influence crash patterns.

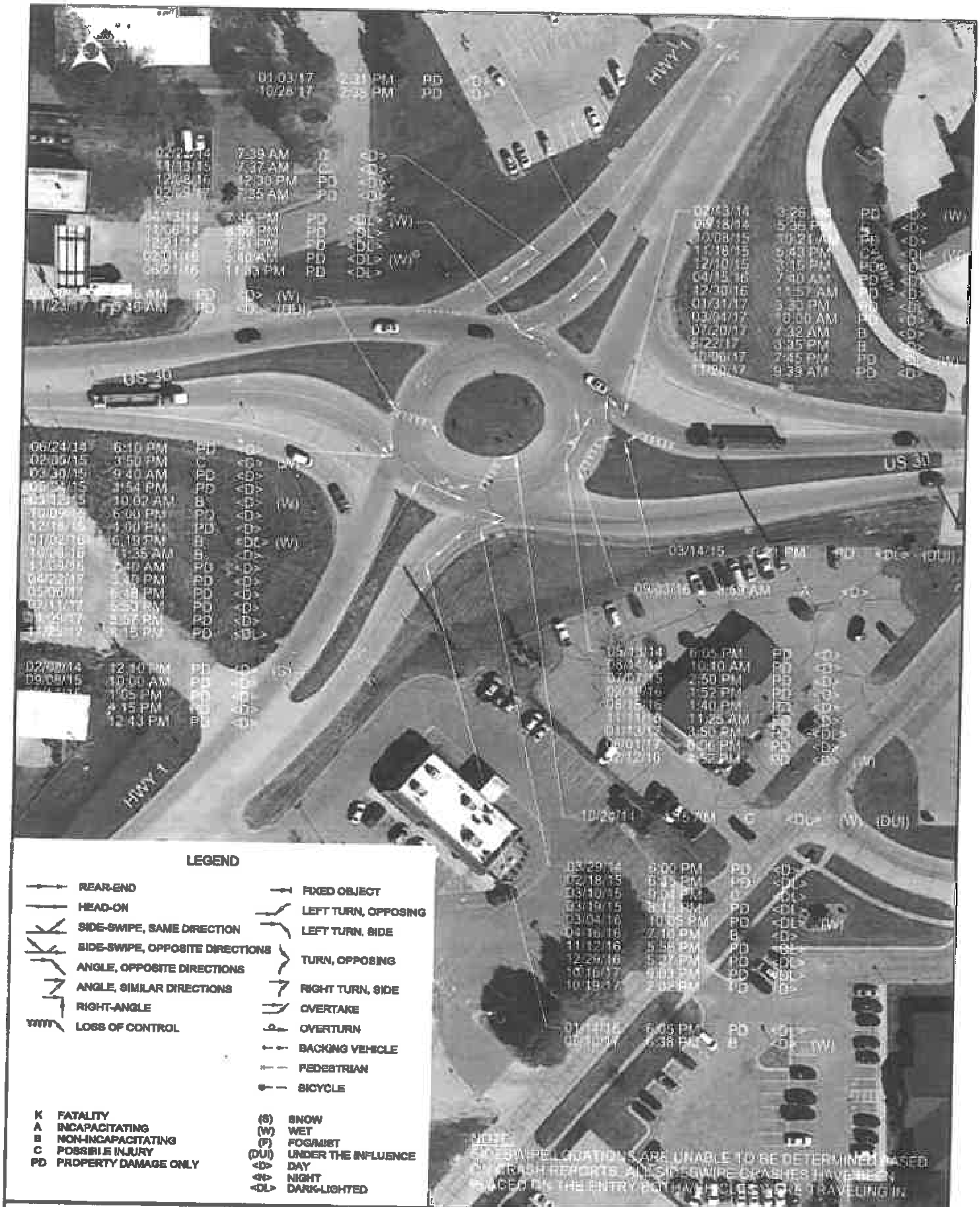
Field observations were undertaken to identify geometric anomalies, physical deficiencies and driver performance (human factors) issues at the roundabout. Subsequently, countermeasures are proposed based on findings from the previous tasks.

## CRASH ANALYSIS

Mount Vernon police retrieved crash data for this intersection from January 2014 through February 2018 (4.17 years). Within this period, 70 crashes were analyzed. Of the crashes on record, there were 43 angle collisions, 14 sideswipes, 5 fixed objects, and 8 rear-end collisions. Fifteen (15) crashes involved injuries, and no crashes involved a fatality. The total crash rate for the intersection is 2.2 crashes per million entering vehicles (MEV) and 0.5 crashes/MEV for injury type crashes. For comparison, a recent study of 32 similar multi-lane roundabouts in Wisconsin showed an average of 0.8 crashes/MEV and 0.14 injury crashes/MEV. Eleven (11) of the 70 crashes involved semi-trucks, which accounts for 16 percent of the total crashes. On average, there are 2.6 crashes per year involving semi-trucks; this is higher than expected since truck traffic only makes up 8 to 9 percent of the total traffic present at the intersection. See Table 1 for a summary of the manner of collisions occurring at the intersection. A complete collision diagram can be found in Exhibit 1.0.

**Table 1. Summary of Manner of Collision**

| Year | Crash Type | | | | Total |
|---|---|---|---|---|---|
| | Angle | Side Swipe | Rear End | Fixed Object | |
| 2014 | 7 | 3 | 1 | 1 | 12 |
| 2015 | 12 | 3 | 2 | 1 | 18 |
| 2016 | 11 | 3 | 1 | 1 | 16 |
| 2017 | 13 | 4 | 4 | 2 | 23 |
| 2018 | 0 | 1 | 0 | 0 | 1 |
| TOTAL | 43 | 14 | 8 | 5 | 70 |
| Percent of Total Crashes | 61% | 20% | 11% | 7% | |




CRASH DIAGRAM 01/2014 - 03/2018

US 30 INTERSECTION WITH HIGHWAY 1

MOUNT VERNON, IOWA

EXHIBIT 1.0

Crash Diagram 2014-present.dgn 5/21/2018 2:08:51 PM ncook

PLOT DATE: 5/21/2018 PLOT SCALE: 1:50

The roundabout experiences mainly property damage only (PDO) crashes; however, 3.6 injury type crashes are occurring on average per year. See Table 2 for a summary of crash severities occurring at the intersection.

**Table 2. Summary of Crash Severity**

| Year | Crash Severity (KABCO-scale) | | | | | Total |
|---|---|---|---|---|---|---|
| | Fatality | A | B | C | Property Damage Only | |
| 2014 | 0 | 0 | 0 | 3 | 9 | 12 |
| 2015 | 0 | 0 | 1 | 4 | 13 | 18 |
| 2016 | 0 | 1 | 3 | 0 | 12 | 16 |
| 2017 | 0 | 0 | 3 | 0 | 20 | 23 |
| 2018 | 0 | 0 | 0 | 0 | 1 | 1 |
| Total | 0 | 1 | 7 | 7 | 55 | 70 |
| Percent of Total Crashes | 0% | 1% | 10% | 10% | 79% | |

The roundabout experiences many of its crashes during the daytime. However, a good portion of crashes are occurring during the night time when traffic volumes are usually lower and even with the roundabout being lighted. See Table 3 for a summary of environmental conditions when crashes occur at the intersection.

**Table 3. Summary of Environmental Conditions**

| Year | Crash Conditions | | | | |
|---|---|---|---|---|---|
| | Snow | Wet | Day | Night-Lighted | DUI |
| 2014 | 1 | 3 | 8 | 4 | 1 |
| 2015 | 0 | 3 | 12 | 6 | 1 |
| 2016 | 0 | 3 | 10 | 6 | 0 |
| 2017 | 0 | 3 | 17 | 6 | 1 |
| 2018 | 0 | 1 | 1 | 0 | 0 |
| Total | 1 | 13 | 48 | 22 | 3 |
| Percent of Total Crashes | 1% | 19% | 69% | 31% | 4% |

Table 4 shows the distribution of crash severities at the intersection, along with a comparison of average injury and property damage only crashes at roundabouts across the US, and in WI and MN. As indicated in the table, the majority of crashes are property damage type crashes; however, injury crashes are higher than national averages.

**Table 4. Totals by Crash Severity**

| Crash Severity | Site # | % of Total | US %[1] | WI %[2] | MN %[3] | Avg. |
|---|---|---|---|---|---|---|
| Injury/fatality Crash | 15 | 21% | 8% | 17% | 11% | 12% |
| Property Damage Crash | 55 | 79% | 92% | 83% | 89% | 88% |

Based on crash prediction models, shown in Table 5, the roundabout is experiencing, more crashes, of all severities, than expected. This demonstrates the need for improvements at the intersection to reduce annual crashes to nationally predicted levels. A reduction of 10 crashes per year, a 60% reduction, would achieve safety operations comparable to model predictions.

**Table 5. Comparison of Actual Collision Frequency to Predicted Frequency (crashes per year)**

| Collision Class | Expected Annual Crashes (NCHRP Model)[1] | 95th Percentile Expected Crash Frequency (NCHRP Model) | Expected Annual Crashes (WI Calibrated NCHRP Model 2017)[2] | 95th Percentile Expected Crash Frequency (WI Calibrated NCHRP Model 2017) | Expected Annual Crashes (MDOT Safety Performance Functions 2011)[3] | 95th Percentile Expected Crash Frequency (MDOT Safety Performance Functions 2011) | Recorded Annual Freq. of Crashes (2012 to 2017) |
|---|---|---|---|---|---|---|---|
| Total Crashes | 6.6 | 17.6 | 7.8 | 21.8 | 1.9 | 5.3 | 16.8 |
| Injury Crashes | 0.5 | 1.2 | 1.1 | 2.9 | 0.2 | 0.5 | 3.6 |

Iowa 1 at US 30 is experiencing a crash rate of 2.2 crashes per million entering vehicles (MEV). This is well above the expected crash rate ranging from 1.0 to 0.2 MEV, shown in Table 6.

**Table 6. Comparison of Actual Crash Rate to Predicated Crash Rates**

| Collision Class | Site Crash Rate (2014 to 2018) | NCHRP Expected Crash Rate[1] | WI Expected Crash Rate[2] | MN Expected Crash Rate[3] |
|---|---|---|---|---|
| Total Crashes | 2.2 MEV | 0.9 MEV | 0.8 MEV | 0.2 MEV |
| Injury Crashes | 0.5 MEV | 0.07 MEV | 0.14 MEV | 0.03 MEV |

1 Using the crash Prediction Methodology in Chapter 5.4, NCHRP Report 672

2 Based on study of 32 multi-lane urban roundabouts in Wisconsin, June 2018

3 Evaluating the Performance and Safety Effectiveness of Roundabouts, The Michigan Department of Transportation, 2011

## OPERATIONAL ANALYSIS

The existing roundabout was analyzed in Junctions 9 (ARCADY) and HCS 7 roundabout design and capacity analysis software. ARCADY (Assessment of Roundabout Capacity and Delay) is a program based on U.K. empirical research into geometry-capacity relationships. Two features that ARCADY provides are its ability take into account horizontal geometric design sensitivity and its ability to be calibrated. These two features are critical to accurately modeling the in-service roundabout to determine expected operations for any proposed roundabout geometric modifications. It was determined that a 5% capacity reduction factor was required to calibrate the software to match field observations of queues for the AM and PM peak hours. Turning movement counts were provided by the Iowa Department of Transportation (IaDOT) are shown in Figure 1.

The results of the analysis represent capacity measures of level of service (LOS), delay and queuing, consistent with typical unsignalized capacity analysis methodologies (Highway Capacity Manual, 2010). The results of the ARCADY analyses are summarized in Table 7, detailed reports are in Appendix A. In general, the roundabout is exhibiting acceptable operations during the peak periods.

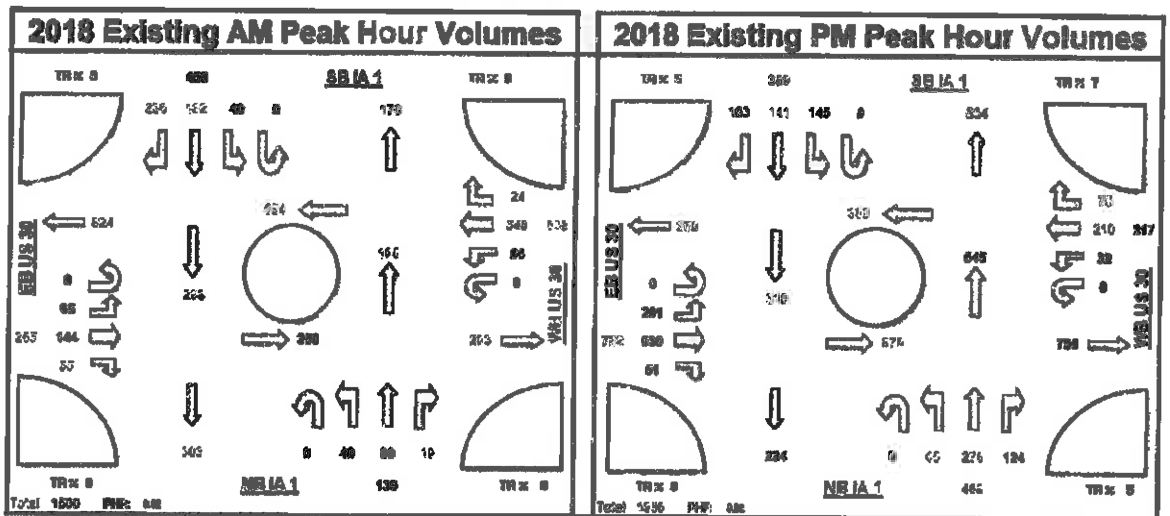



**Figure 1. 2018 Existing Peak Hour Turning Movement Volumes**

**Table 7. 2018 Existing Lane Configuration Roundabout Operational Analysis**

| Lane Group | | | SB IA 1 | | EB US 30 | | | NB IA 1 | | WB US 30 | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | LT | R | LT | T | R | LT | TR | LT | R |
| ARCADY | AM Peak | LOS | A | A | A | A | A | A | A | A | A |
| | | v/c | 0.32 | 0.34 | 0.14 | 0.14 | 0.06 | 0.09 | 0.09 | 0.62 | 0.02 |
| | | Queue (ft) | 50 | 75 | 25 | 25 | 25 | 25 | 25 | 50 | 25 |
| | | Delay (s) | 6.8 | 7.0 | 2.4 | 2.4 | 3.7 | 2.3 | 2.3 | 8.8 | 3.4 |
| | PM Peak | LOS | A | A | A | A | A | A | A | A | A |
| | | v/c | 0.30 | 0.11 | 0.47 | 0.47 | 0.06 | 0.40 | 0.40 | 0.30 | 0.09 |
| | | Queue (ft) | 50 | 25 | 25 | 25 | 25 | 50 | 50 | 50 | 25 |
| | | Delay (s) | 5.0 | 3.9 | 4.1 | 4.1 | 3.8 | 4.6 | 4.6 | 5.7 | 4.4 |
| HCM 7 | AM Peak | LOS | B | B | A | A | A | A | A | B | A |
| | | v/c | 0.42 | 0.41 | 0.11 | 0.12 | 0.06 | 0.07 | 0.08 | 0.62 | 0.02 |
| | | Queue (ft) | 50 | 50 | 25 | 25 | 25 | 25 | 25 | 125 | 25 |
| | | Delay (s) | 12.6 | 11.7 | 4.7 | 4.9 | 4.4 | 4.4 | 4.2 | 11.6 | 3.4 |
| | PM Peak | LOS | A | A | A | A | A | C | B | A | A |
| | | v/c | 0.34 | 0.12 | 0.40 | 0.45 | 0.05 | 0.48 | 0.48 | 0.34 | 0.10 |
| | | Queue (ft) | 50 | 25 | 50 | 75 | 25 | 75 | 75 | 50 | 25 |
| | | Delay (s) | 7.6 | 4.9 | 8.3 | 9.1 | 3.9 | 15.9 | 14.4 | 8.7 | 5.3 |

*LOS Source: 2010 Highway Capacity Manual - Unsignalized Intersections Delay in Seconds*
*Queue represents 95th percentile queue per lane, 25 feet per vehicle*

With the introduction of the US 30 bypass, currently under construction south of the intersection, much of the traffic on US 30 (eventually becoming Old US 30) will be reduced significantly. Because of this reduction in traffic, conversion to a single lane roundabout, including the existing yielding bypasses, were investigated as a possible countermeasure to reduce the number of crashes. The US 30 bypass is currently planned to be open in 2020-2021.

The single lane roundabout was analyzed for design year 2040. Additionally, the roundabout was analyzed for existing year 2018 to determine if the countermeasure could be implemented immediately or have to wait for the US 30 bypass to be opened. Adjusted design year turning movement volumes were provided by the Iowa DOT and are shown in Figure 2.

The results of the ARCADY analyses are summarized in Table 8 and Table 9, detailed reports are in Appendix A. A single lane roundabout is expected to operate acceptably to design year 2040 with the introduction of the US 30 bypass. Unfortunately, a single lane roundabout is not expected to operate acceptably with the existing traffic volumes. The conversion to a single lane roundabout will need to wait until the US 30 bypass is opened. The single lane roundabout conversion will be further discussed in the countermeasure section.

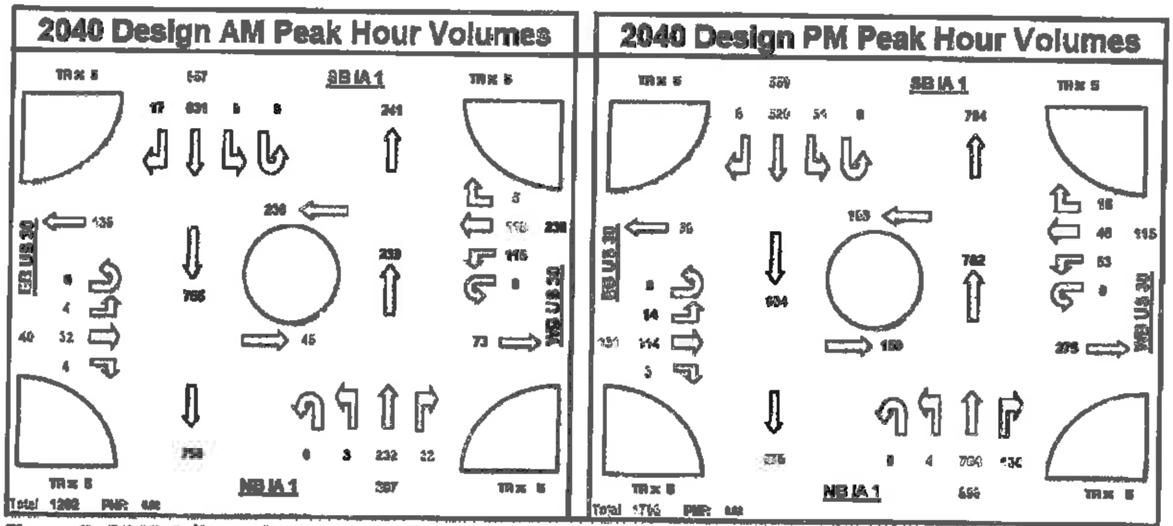



**Figure 2. 2040 Adjusted Design Year Peak Hour Turning Movement Volumes**

**Table 8. 2018 Single Lane Roundabout Operational Analysis**

| Lane Group | | | SB IA 1 | | EB US 30 | | NB IA 1 | WB US 30 | |
|---|---|---|---|---|---|---|---|---|---|
| | | | LT | R | LT | R | LTR | LT | R |
| ARCADY | AM Peak | LOS | A | A | A | A | A | A | A |
| | | v/c | 0.32 | 0.35 | 0.23 | 0.06 | 0.15 | 0.64 | 0.03 |
| | | Queue (ft) | 50 | 75 | 50 | 25 | 25 | 75 | 25 |
| | | Delay (s) | 7.1 | 7.3 | 4.7 | 3.8 | 4.2 | 9.7 | 3.5 |
| | PM Peak | LOS | A | A | C | A | D | A | A |
| | | v/c | 0.31 | 0.11 | 0.82 | 0.06 | 0.80 | 0.32 | 0.10 |
| | | Queue (ft) | 50 | 25 | 550 | 25 | 475 | 50 | 25 |
| | | Delay (s) | 5.2 | 4.0 | 19.6 | 3.9 | 27.7 | 6.2 | 4.7 |
| HCM 7 | AM Peak | LOS | B | B | A | A | A | B | A |
| | | v/c | 0.42 | 0.41 | 0.25 | 0.06 | 0.16 | 0.66 | 0.02 |
| | | Queue (ft) | 50 | 50 | 25 | 25 | 25 | 125 | 25 |
| | | Delay (s) | 12.6 | 11.7 | 6.6 | 4.4 | 5.3 | 13.4 | 3.6 |
| | PM Peak | LOS | A | A | D | A | [illegible] | B | A |
| | | v/c | 0.34 | 0.12 | 0.90 | 0.05 | [illegible] | 0.39 | 0.11 |
| | | Queue (ft) | 50 | 25 | 325 | 25 | [illegible] | 50 | 25 |
| | | Delay (s) | 7.6 | 4.9 | 32.6 | 3.9 | [illegible] | 10.5 | 6.1 |

*LOS Source: 2010 Highway Capacity Manual - Unsignalized Intersections Delay in Seconds*
*Queue represents 95th percentile queue per lane, 25 feet per vehicle*

**Table 9. 2040 Single Lane Roundabout Operational Analysis**

| Lane Group | | | SB IA 1 | | EB US 30 | | NB IA 1 | WB US 30 | |
|---|---|---|---|---|---|---|---|---|---|
| | | | LT | R | LT | R | LTR | LT | R |
| ARCADY | AM Peak | LOS | A | A | A | A | A | A | A |
| | | v/c | 0.65 | 0.02 | 0.05 | 0.00 | 0.25 | 0.24 | 0.01 |
| | | Queue (ft) | 75 | 25 | 25 | 25 | 50 | 50 | 25 |
| | | Delay (s) | 9.5 | 3.4 | 5.0 | 0.0 | 4.0 | 4.3 | 3.3 |
| | PM Peak | LOS | A | A | A | A | D | A | A |
| | | v/c | 0.52 | 0.01 | 0.17 | 0.00 | 0.88 | 0.15 | 0.02 |
| | | Queue (ft) | 50 | 25 | 25 | 25 | 900 | 25 | 25 |
| | | Delay (s) | 6.4 | 3.1 | 5.1 | 0.0 | 26.0 | 5.8 | 5.0 |
| HCM 7 | AM Peak | LOS | B | A | A | A | A | A | A |
| | | v/c | 0.70 | 0.02 | 0.07 | 0.01 | 0.23 | 0.25 | 0.01 |
| | | Queue (ft) | 150 | 25 | 25 | 25 | 25 | 25 | 25 |
| | | Delay (s) | 14.9 | 3.3 | 7.5 | 6.6 | 4.9 | 6.1 | 3.7 |
| | PM Peak | LOS | A | A | A | A | D | A | A |
| | | v/c | 0.51 | 0.01 | 0.21 | 0.00 | 0.89 | 0.20 | 0.03 |
| | | Queue (ft) | 75 | 25 | 25 | 25 | 325 | 25 | 25 |
| | | Delay (s) | 8.9 | 3.0 | 8.1 | 5.4 | 27.4 | 9.5 | 7.2 |

*LOS Source: 2010 Highway Capacity Manual - Unsignalized Intersections Delay in Seconds*
*Queue represents 95th percentile queue per lane, 25 feet per vehicle*

## Site Visit & Construction Conformance Review

**MSA conducted a site visit on Tuesday, April 24th, 2018. During the site visit, roundabout operations, driver behavior, geometric deficiencies, signing and marking were reviewed to supplement the office review and develop suitable countermeasures. The following section summarizes observations made during the site visit to help determine the roundabout's safety deficiencies.**

- **Plantings are absent from the splitters and central island giving drivers clear view of all approaches and on-coming vehicles, see Figure 3. This may be resulting in drivers making premature decisions about entering the roundabout, resulting in the high number of failure to yield crashes.**

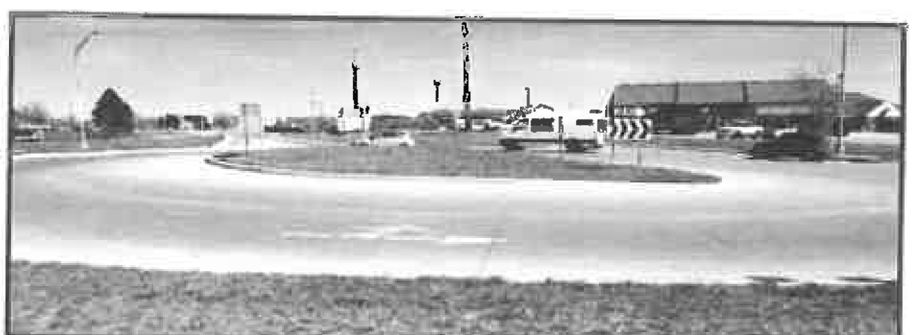


**Figure 3. Lack of Central Island Planting**

- **The roundabout also has a feeling of being "wide" and "open" due to no plantings, minimal signing, and near-by business parking lots, see Figure 4. Drivers may not realize they are approaching a roundabout resulting in last minute decisions.**

**Figure 4. Looking up the Eastbound Approach**

- Bypass splitter islands and truck apron curb heads are extremely low allowing vehicles to drive easily over them. Additionally, the bypass splitter islands have no concrete coloring and the truck apron is nearly faded way blending into the color of the roadway concrete. Numerous times, it was observed vehicles would drive onto the truck apron as if it was part of the circulating roadway, see Figure 5. This pattern is clearly seen by looking at the aerial image of the intersection and seeing where the driving paths (tire marks) are located.

**Figure 5. Low Curb Height, Faded Coloring, and Vehicle Traversing Truck Apron**

- Concrete joints were not done per plan resulting in conflicting message to drivers when comparing the joints to direction of the pavement markings. As an example, right-turn bypass joints were pulled through the exit giving the driver the feeling it's free flow, see Figure 6. Additionally, at the entries, the pavement markings are up to two feet from the concrete joint when they should be right next to each other.

**Figure 6. Incorrect Joint Placement**

- Pavement markings again were not completed per plan, which maybe resulting in driver confusion and inevitably crashes. Examples of issues include:
    - Not pulling the pavement markings through the exit such as the north leg and east leg exits. This has had a negative result on the northbound through movement since the inside lane circulating has a curve to it which may give westbound drivers the sense that the inside lane can only turn left.
    - Pavement markings were pulled through the entry maybe resulting in drivers believing they have the right-of-way. Dot markings are fine in this area to give drivers direction on circulating lane choice and combating path overlap issues but dashed pavement markings may reverse driver priories, see Figure 7 blue arrow.
    - As mentioned previously, pavement markings are offset from joint lines giving drivers mixed signals, see Figure 7 orange arrow.
    - Pavement markings around the north, south and east leg are wrapped around the curb instead of coming to a point. Coming to a point helps to prevent vehicles from turning left at the entry.

**Figure 7. Incorrect Pavement Markings**

- Drivers were observed weaving in-between circulating lanes when other vehicles are not present, effectively driving the fast path.
- Many times drivers would stack up in the outside lane when the inside lane was available, particularly for the eastbound approach. This may be due to drivers being used to weaving in-between lanes when circulating.

- Large amounts of trucks were present traveling through the roundabout. Commonly trucks would stay in the outside lane at entry and then move to the inside lane circulating. This type of behavior can be contributing to the truck and car sideswipe crashes. Vehicles are able to drive on the left side of the truck at the entry and then become trapped in the circulating roadway.
- Overtracking of the outside curb was observed in every corner of the roundabout.
- Overtracking of the central island was also observed on the northeast side of the central island (occurring from northbound left turning trucks), resulting in damage to the curb head, see Figure 8.

**Figure 8. Evidence of Overtracking of the Central Island**

## Countermeasure Alternatives

Several countermeasures to improve the safety of the IA 1 at US 30 roundabout are presented in this section for consideration by the City of Mt. Vernon. Countermeasures are organized into low, medium, and high categories. Low countermeasures include improvements that range in cost up to $20,000 and can be implemented immediately. Medium countermeasures are expected to range in cost from $20,000 to $50,000. High countermeasures are expected to incur the most cost, $50,000 and greater, and usually require the most reconstruction of the intersection to implement.

### Low/Immediate Countermeasures

Installing planting or screenings in the medians on all approaches will help to promote yielding at entry. As described in the U.K. roundabout design guide, "in some circumstances excessive forward visibility at entry or visibility between adjacent entries can result in approach and entry speeds greater than desirable for the intersection geometry". Restricting sight to the left requires drivers to further reduce speed on approach before making a decision if there is an appropriate gap to enter or not. This restriction reduces driver's tendencies to "fly" into the roundabout when operating in off-peak periods. Screenings should be installed to allow for a minimum vision area of 50 feet back on the approach and upstream entry. Examples of plantings and screenings can be seen in Figure 9 and Figure 10. The version of screening applied in Oakland County in 2016 generated a 9 mph reduction in the 85$^{th}$ percentile speeds. It is too soon to conclude that their pilot study measure has been successful, but in the U.K., this measure has been applied to successfully reduce entry-circulating collisions.

**Figure 9. Example Median Planting**

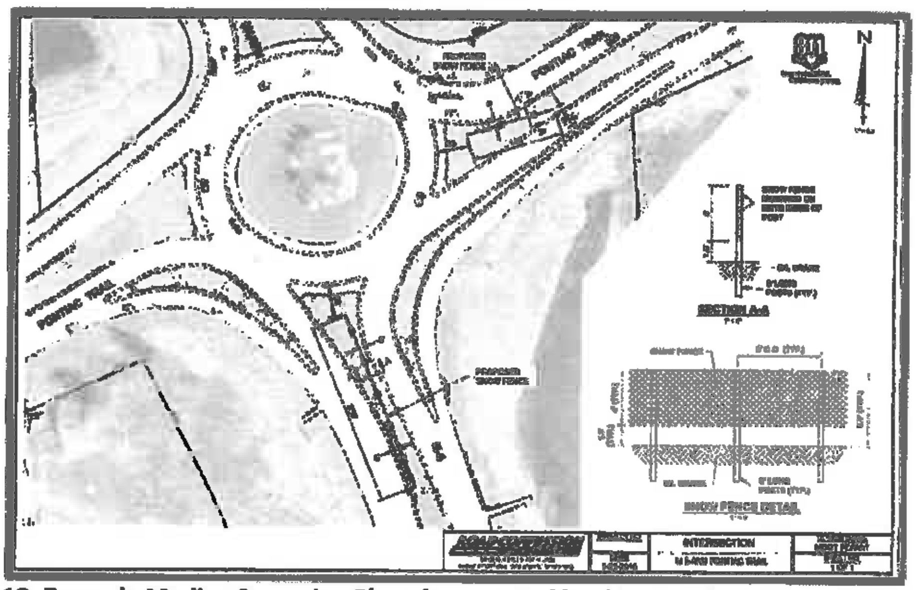


**Figure 10. Example Median Screening Plans (Source: Oakland County Road Commission, 2016)**

**Additionally, the central island should be mounded and include plantings that grow tall enough to restrict sight across the roundabout. This will help to alert drivers of the approaching roundabout further in advance and give the roundabout more definition and aesthetics. See Figure 11 of a typical cross section of the central island used by the Wisconsin DOT.**

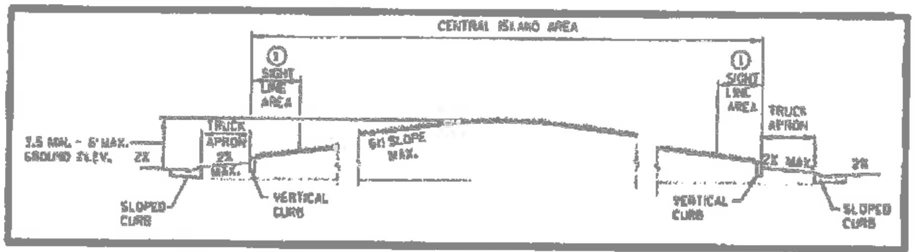



**Figure 11. WisDOT Central Island Typical Section**

Recommended plants should be salt tolerant and have a mature height of around 3 feet. Examples of these types of plants include, but are not limited to, Alpine Currant, Fragrant Sumac, Jackmanni, or Winged Euonymus.

The truck apron needs to be identified as not being a part of the circulatory roadway, and should not be traversed by vehicles. There are two options to signify this. The first option is paint chevron arrows on the truck apron in the direction travel, such as the example shown in Figure 12 from Coralville, IA. Alternatively, you can paint the whole truck apron a red color, such as it should have been done originally. Either option can be done with either paint or epoxy surface coloration. Two companies, Ennis and TransSafe, provide this color pavement marking treatment that uses a slurry type epoxy that is skid resistant, last for seven plus years, and allows for custom colors. This product is widely used for coloring bike paths across the country and is approved for use on roadways. Product sheets from both companies are attached in Appendix B. Both design and material options should be taken into consideration based on cost, the chasing arrows with paint would likely be the cheaper option but would require more maintenance and refreshing of the paint. On the other side, the full coloring of the truck apron with epoxy will likely last longer but have a higher initial cost. This countermeasure should also be considered for mountable splitter island areas if cost are not prohibitive.

**Figure 12. Truck Apron Chevron Example from Coralville, IA**

An alternative low-cost and immediate solution is to enhance approach signing. With approval of the Iowa DOT destination sign types (D1-5), as shown in Figure 13, should be installed on all approaches in place of the current route directional signs (M series). These signs help to give better advance warning of the approaching roundabout, as well as, destination and route guidance. With the large percentage of semi-truck related crashes involved at the roundabout a warning sign that identifies that trucks can use both lanes, such as the example in Figure 14, could be installed on the eastbound and northbound approaches where this is problematic. Yield signs could also be enhanced with LED indicators to enforce the need to yield on entry, see Figure 15.

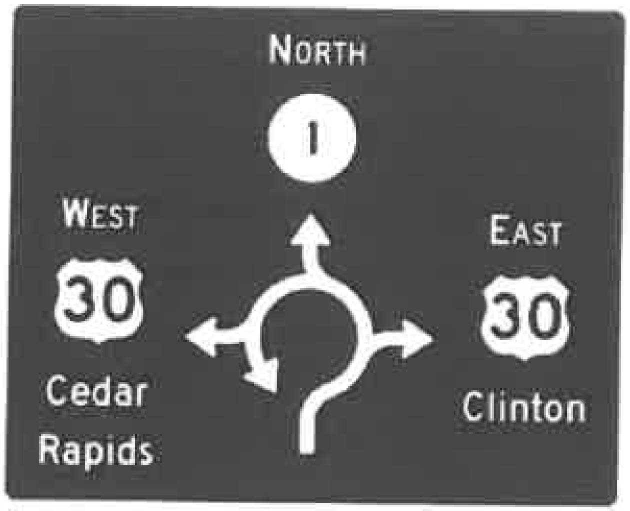



**Figure 13. Example of a Destination Sign Type**


**Figure 14. Truck Use Both Lanes Sign**


**Figure 15. LED-enhanced Yield sign (image courtesy of TAPCO)**

Campaigning for driver education about lane choices and yielding behavior is a low-cost measure that will also serve to relieve the failure to yield and improper lane change issue. Appendix C provides examples of handouts and flyers that could be used at the time the immediate countermeasures are installed. We also recommend selective enforcement whereby police officers will give warnings and hand out one of the education brochures.

## Medium Countermeasures

**Once the US 30 bypass is opened, conversion of the roundabout to single lane entries can be completed if approved by the Iowa DOT. Single lane roundabouts are safer than multi-lane roundabouts because they have less conflict points and proper lane choice is not a factor. The single lane roundabout would eliminate the present crash issue of sideswipe same direction since no side by side driving is allowed. Paint markings will be used to convert the roundabout versus reconstructing curb lines due to the increased cost. The yielding right-turn bypasses can remain as is since they do not pose a major crash contributor, even though operationally they are not needed. Additionally, pavement markings from the existing design should be corrected such as bringing edgelines to points at the splitter island. See Figure 16 and Exhibit 2.0 for the proposed improvements of the converted single lane roundabout.**


**Figure 16. Single Lane Roundabout Countermeasure**

With the reduction in traffic volumes and conversion to a single lane roundabout, an updated crash prediction model was completed to reevaluate the expected number of crashes following the completion of the US 30 bypass. As seen in Table 5, an updated average expected number of total crashes per year for the single lane roundabout is in the range of 3 to 9 and injury type crashes from 0.5 to 1.5 per year.

**Table 10. Comparison of Actual Collision Frequency to Predicted Frequency (crashes per year)**

| Collision Class | Expected Annual Crashes (NCHRP Model)[1] | 95th Percentile Expected Crash Frequency (NCHRP Model) | Expected Annual Crashes (WI Calibrated NCHRP Model 2017)[2] | 95th Percentile Expected Crash Frequency (WI Calibrated NCHRP Model 2017) | Expected Annual Crashes (MDOT Safety Performance Functions 2011)[3] | 95th Percentile Expected Crash Frequency (MDOT Safety Performance Functions 2011) |
|---|---|---|---|---|---|---|
| Total Crashes | 3.3 | 9.1 | 3.8 | 10.6 | 0.8 | 2.2 |
| Injury Crashes | 0.4 | 1.1 | 0.5 | 1.4 | 0.1 | 0.2 |

## HIGH COUNTERMEASURE

No high cost countermeasures are recommended. High countermeasures would likely be cost prohibitive to the community, requiring curb line changes or a full reconstruction of the roundabout. Implementation of the low and medium cost countermeasures are expected to improve the roundabout's safety and crash rate.

1 Using the crash Prediction Methodology in Chapter 5.4, NCHRP Report 672
2 Based on study of 32 multi-lane urban roundabouts in Wisconsin, June 2018
3 Evaluating the Performance and Safety Effectiveness of Roundabouts, The Michigan Department of Transportation, 2011

## Conclusion and Recommendations

Based on the crash analysis, there is an overrepresentation of angle and sideswipe crashes caused by failure to yield and improper lane changes at the intersection. The higher-than-expected frequency of crashes, of all severities and types, indicates a high potential for safety improvement. Findings from this report suggest that deficiencies in signing and marking, and geometry are contributors to driver error and the high percentages of crashes.

A 60% reduction of crashes per year would need to be achieved for this roundabout to perform within the range of national expected average number of crashes. Current research into the collision modification benefits of various roundabout safety countermeasures is not well established in the U.S. Generally, a geometry that conforms to the current guidelines is considered a safer design when accompanied by an aggressive public education/enforcement campaign. Case precedents of crash reduction have been observed for the kinds of improvements that are proposed in this report.

For a low-cost and immediate solution, coloring or painting the truck apron, installing median screening to restrict sight to the left, and mounding and landscaping the central island to restrict forward sight will serve to promote correct lane choices and driver compliance with yielding at entries. Additionally, installation of the destination type signs will give drivers further advance warning of the approaching roundabout. Installation of the warning signs informing drivers that trucks use both lanes should help reduce the sideswipe crashes.

Furthering driver education about lane choices and yielding behavior is another recommended low-cost measure that will also serve to relieve the failure to yield issue. Appendix C provides sample handouts and flyers that could be used at the time the immediate countermeasures are installed. We also recommend selective enforcement whereby police officers will give warnings and hand out one of the educational brochures.

Once the US 30 bypass is constructed the roundabout should be experiencing less traffic allowing for its conversion to a single lane roundabout. Single lane roundabouts are safer than multi-lane roundabouts because they have less conflict points and proper lane choice is not a factor. Conversion to the single lane roundabout can be done using pavement markings to keep cost low.

The implementation of the above-mentioned countermeasures should bring the roundabout within the range of expected crashes per year.

| MSA | US 10 at IA 1<br>Mount Vernon, Iowa | INTERSECTION OVERVIEW | SCALE 0 50 100 |
|---|---|---|---|
| | | | EXHIBIT: 2.0 |

# APPENDIX A – Operational Analysis

## *ARCADY Operational Analysis Documentation*

### *Standard Roundabout Capacity Model*

**Year 2018**
**AM Peak Hour**
**Existing Lane Configuration**

### *Volumes*

| From \ To | 1st exit | 2nd exit | 3rd exit | U-Turn | Total |
|---|---|---|---|---|---|
| SB IA 1 | [illegible] | 202 | [illegible] | 0 | 458 |
| EB US 30 | 55 | 144 | [illegible] | 0 | 265 |
| NB IA 1 | [illegible] | [illegible] | [illegible] | 0 | 139 |
| WB US 30 | 14 | [illegible] | 60 | 0 | 638 |
| Total | 334 | 954 | 212 | 0 | |

### *Truck Percentages*

| From \ To | 1st exit | 2nd exit | 3rd exit | U-Turn | Average |
|---|---|---|---|---|---|
| SB IA 1 | 8 | 8 | 8 | 8 | 8 |
| EB US 30 | 8 | 8 | 8 | 8 | 8 |
| NB IA 1 | 8 | 8 | 8 | 8 | 8 |
| WB US 30 | 8 | 8 | 8 | 8 | 8 |
| Average | 8 | 8 | 8 | 8 | |

### *Geometry and Analysis Results*

| Leg | SB IA 1 | EB US 30 | NB IA 1 | WB US 30 |
|---|---|---|---|---|
| V - Approach road half-width (ft) | 12.00 | 12.00 | 12.00 | 12.00 |
| E - Entry width (ft) | 24.00 | 25.00 | 26.00 | 24.00 |
| F - Effective flare length (ft) | 130.0 | 130.0 | 130.0 | 130.0 |
| R - Entry radius (ft) | 190.0 | 200.0 | 130.0 | 200.0 |
| D - Inscribed circle diameter (ft) | 150.0 | 150.0 | 120.0 | 150.0 |
| PHI - Conflict (entry) angle (deg) | 20.0 | 20.0 | 20.0 | 20.0 |
| Exit only | ☐ | ☐ | ☐ | ☐ |
| Leg has bypass | ☑ | ☑ | ☐ | ☑ |
| Percentage intercept adjustment (%) | 95.00 | 95.00 | 95.00 | 95.00 |
| Average Demand (Veh/hr) | 458 | 248 | 139 | 638 |
| Max delay (s) | 6.84 | 2.49 | 2.27 | 3.30 |
| Max LOS | A | A | A | A |
| Max 95th percentile Queue (Veh) | 1.7 | 0.5 | 0.5 | 1.5 |
| Max V/C Ratio | 0.32 | 0.34 | 0.15 | 0.42 |

**Year 2018**

**AM Peak Hour**

**Existing Lane Configuration**

***By-lane Results for Southbound Yielding Right-turn Bypass***

## *Volumes*

| From \ To | 1st exit | 2nd exit | 3rd exit | U-Turn | Total |
|---|---|---|---|---|---|
| SB IA 1 | [illegible] | 0 | 0 | 0 | 236 |
| EB US 30 | [illegible] | 144 | [illegible] | 0 | 265 |
| NB IA 1 | [illegible] | 80 | 40 | [illegible] | 139 |
| WB US 30 | 27 | 548 | [illegible] | 0 | 638 |
| Total | 354 | 772 | 172 | 0 | - |

## *Truck Percentages*

| From \ To | 1st exit | 2nd exit | 3rd exit | U-Turn | Average |
|---|---|---|---|---|---|
| SB IA 1 | 3 | 8 | 8 | 3 | 8 |
| EB US 30 | 8 | 8 | 8 | 8 | 8 |
| NB IA 1 | 3 | 8 | 3 | 8 | [illegible] |
| WB US 30 | 9 | 9 | 9 | 9 | 9 |
| Average | 8 | 8 | 8 | 8 | - |

## *Geometry and Analysis Results*

| Leg | SB IA 1 | EB US 30 | NB IA 1 | WB US 30 |
|---|---|---|---|---|
| W - Approach road half-width (ft) | 12.00 | 12.00 | 12.00 | 12.00 |
| E - Entry width (ft) | 24.00 | 15.00 | 25.00 | 14.00 |
| l' - Effective flare length (ft) | 130.0 | 170.0 | 330.0 | 120.0 |
| R - Entry radius (ft) | 350.0 | 200.0 | 150.0 | 205.0 |
| D - Inscribed circle diameter (ft) | 130.0 | 130.0 | 130.0 | 130.0 |
| PHI - Conflict (entry) angle (deg) | 20.0 | 20.0 | 30.0 | 20.0 |
| Exit only | ☐ | ☐ | ☐ | ☐ |
| Leg has bypass | ☐ | ☑ | ☐ | ☑ |
| Percentage intercept adjustment (%) | 95.00 | 95.00 | 95.00 | 95.00 |
| Average Demand (Veh/hr) | 236 | 265 | 139 | 638 |
| Max delay (s) | 7.04 | 2.37 | 2.29 | 8.80 |
| Max LOS | A | [illegible] | [illegible] | A |
| Max 95th percentile Queue (Veh) | 2.3 | 0.5 | 0.5 | 1.3 |
| Max V/C Ratio | 0.34 | 0.12 | 0.09 | 0.52 |

# Year 2018
## AM Peak Hour
## Existing Lane Configuration
### *By-lane Results for Eastbound Yielding Right-turn Bypass*

### *Volumes*

| From \ To | 1st exit | 2nd exit | 3rd exit | U-Turn | Total |
|---|---|---|---|---|---|
| SB IA 1 | [illegible] | [illegible] | [illegible] | 0 | [illegible] |
| EB US 30 | [illegible] | [illegible] | [illegible] | 0 | [illegible] |
| NB IA 1 | [illegible] | [illegible] | [illegible] | 0 | [illegible] |
| WB US 30 | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |
| Total | 334 | 513 | 146 | 0 | |

### *Truck Percentages*

| From \ To | 1st exit | 2nd exit | 3rd exit | U-Turn | Average |
|---|---|---|---|---|---|
| SB IA 1 | 8 | 8 | 8 | 8 | 8 |
| EB US 30 | 8 | 8 | [illegible] | 8 | 8 |
| NB IA 1 | 8 | 8 | 8 | 8 | 8 |
| WB US 30 | 9 | 9 | 9 | 9 | 9 |
| Average | 8 | 8 | 8 | 8 | [illegible] |

### *Geometry and Analysis Results*

| Leg | SB IA 1 | EB US 30 | NB IA 1 | WB US 30 |
|---|---|---|---|---|
| V - Approach road half-width (ft) | [illegible] | [illegible] | [illegible] | [illegible] |
| E - Entry width (ft) | [illegible] | [illegible] | [illegible] | [illegible] |
| l' - Effective flare length (ft) | [illegible] | [illegible] | [illegible] | [illegible] |
| R - Entry radius (ft) | [illegible] | [illegible] | [illegible] | [illegible] |
| D - Inscribed circle diameter (ft) | [illegible] | [illegible] | [illegible] | [illegible] |
| PHI - Conflict (entry) angle (deg) | [illegible] | [illegible] | [illegible] | [illegible] |
| Exit only | ☐ | ☐ | ☐ | ☐ |
| Leg has bypass | ☑ | ☐ | ☐ | ☑ |
| Percentage intercept adjustment (%) | 35.00 | 35.00 | 35.00 | 35.00 |
| Average Demand (Veh/hr) | 455 | 55 | 139 | 536 |
| Max delay (s) | 5.34 | 2.73 | 2.48 | 5.04 |
| Max LOS | A | A | A | A |
| Max 95th percentile Queue (Veh) | 1.5 | 0.5 | 0.5 | 1.3 |
| Max V/C Ratio | 0.32 | 0.06 | 0.09 | 0.50 |

**Year 2018**

**AM Peak Hour**

**Existing Lane Configuration**

***By-lane Results for Westbound Yielding Right-turn Bypass***

***Volumes***

| From \ To | 1st exit | 2nd exit | 3rd exit | U-Turn | Total |
|---|---|---|---|---|---|
| SB IA 1 | 236 | [illegible] | [illegible] | 0 | 458 |
| EB US 30 | 56 | [illegible] | [illegible] | [illegible] | 265 |
| NB IA 1 | [illegible] | [illegible] | [illegible] | 0 | 139 |
| WB US 30 | [illegible] | [illegible] | [illegible] | 0 | 24 |
| Total | 334 | 406 | 146 | 0 | |

***Truck Percentages***

| From \ To | 1st exit | 2nd exit | 3rd exit | U-Turn | Average |
|---|---|---|---|---|---|
| SB IA 1 | 8 | [illegible] | 8 | 8 | 8 |
| EB US 30 | 8 | [illegible] | 8 | 8 | 8 |
| NB IA 1 | 8 | 8 | 8 | 8 | 8 |
| WB US 30 | 9 | 9 | 9 | 9 | 9 |
| Average | [illegible] | 8 | 8 | 8 | - |

*Geometry and Analysis Results*

| Leg | SB IA 1 | EB US 30 | NB IA 1 | WB US 30 |
|---|---|---|---|---|
| V - Approach road half-width (ft) | 12.00 | 12.00 | 12.00 | 12.00 |
| E - Entry width (ft) | 14.00 | [illegible] | [illegible] | 14.00 |
| l' - Effective flare length (ft) | 130.0 | 130.0 | 130.0 | [illegible] |
| R - Entry radius (ft) | [illegible] | 200.0 | [illegible] | 200.0 |
| D - Inscribed circle diameter (ft) | 130.0 | 160.0 | [illegible] | [illegible] |
| PHI - Conflict (entry) angle (deg) | 20.0 | 20.0 | 20.0 | 20.0 |
| Exit only | ☐ | ☐ | ☐ | ☐ |
| Leg has bypass | ☑ | ☑ | ☐ | ☐ |
| Percentage intercept adjustment (%) | 97.00 | 95.00 | 95.00 | [illegible] |
| Average Demand (Veh/hr) | 458 | 265 | 139 | 24 |
| Max delay (s) | 3.65 | 2.35 | 2.27 | 3.40 |
| Max LOS | A | A | A | A |
| Max 95th percentile Queue (Veh) | 1.1 | 0.5 | 0.5 | 0.5 |
| Max V/C Ratio | 0.22 | 0.13 | 0.05 | [illegible] |

**Year 2018**
**PM Peak Hour**
**Existing Lane Configuration**

### *Volumes*

| From \ To | 1st exit | 2nd exit | 3rd exit | U-Turn | Total |
|---|---|---|---|---|---|
| SB IA 1 | [illegible] | [illegible] | [illegible] | 0 | 389 |
| EB US 30 | [illegible] | [illegible] | 200 | 0 | 792 |
| NB IA 1 | [illegible] | 220 | [illegible] | 0 | 468 |
| WB US 30 | [illegible] | 270 | [illegible] | 0 | 317 |
| Total | [illegible] | [illegible] | [illegible] | 0 | |

### *Truck Percentages*

| From \ To | 1st exit | 2nd exit | 3rd exit | U-Turn | Average |
|---|---|---|---|---|---|
| SB IA 1 | 5 | 5 | 5 | 5 | 5 |
| EB US 30 | 8 | 8 | 8 | 8 | 8 |
| NB IA 1 | 5 | 5 | 5 | 5 | 5 |
| WB US 30 | 7 | 7 | 7 | 7 | 7 |
| Average | 6 | 6 | 6 | 6 | - |

### *Geometry and Analysis Results*

| Leg | SB IA 1 | EB US 30 | NB IA 1 | WB US 30 |
|---|---|---|---|---|
| V - Approach road half-width (ft) | 12.00 | 12.00 | 12.00 | 12.00 |
| E - Entry width (ft) | 14.00 | 15.00 | 26.00 | 14.00 |
| l' - Effective flare length (ft) | 130.0 | 130.0 | 130.0 | 130.0 |
| R - Entry radius (ft) | 150.0 | 200.0 | 130.0 | 200.0 |
| D - Inscribed circle diameter (ft) | 120.0 | 150.0 | 150.0 | 120.0 |
| PHI - Conflict (entry) angle (deg) | 20.0 | 20.0 | 20.0 | 20.0 |
| Exit only | ☐ | ☐ | ☐ | ☐ |
| Leg has bypass | ☑ | ☑ | ☐ | ☑ |
| Percentage intercept adjustment (%) | 95.00 | 95.00 | 95.00 | 95.00 |
| Average Demand (Veh/hr) | 389 | 792 | 468 | 317 |
| Max delay (s) | 5.01 | 4.05 | 4.58 | 5.74 |
| Max LOS | A | A | A | [illegible] |
| Max 95th percentile Queue (Veh) | 1.8 | 1.7 | 2.3 | 1.7 |
| Max V/C Ratio | 0.30 | 0.47 | [illegible] | 0.30 |

## Year 2018
## PM Peak Hour
## Existing Lane Configuration
## *By-lane Results for Southbound Yielding Right-turn Bypass*

### *Volumes*

| From \ To | 1st exit | 2nd exit | 3rd exit | U-Turn | Total |
|---|---|---|---|---|---|
| SB IA 1 | [illegible] | 0 | 0 | 0 | [illegible] |
| EB US 30 | [illegible] | [illegible] | 203 | 0 | 782 |
| NB IA 1 | [illegible] | [illegible] | [illegible] | [illegible] | 465 |
| WB US 30 | [illegible] | [illegible] | [illegible] | 0 | 317 |
| Total | 353 | 1018 | 299 | 0 | - |

### *Truck Percentages*

| From \ To | 1st exit | 2nd exit | 3rd exit | U-Turn | Average |
|---|---|---|---|---|---|
| SB IA 1 | 5 | 5 | 5 | 5 | 5 |
| EB US 30 | 8 | 8 | 8 | 8 | 8 |
| NB IA 1 | 5 | 5 | 5 | 5 | 5 |
| WB US 30 | 7 | 7 | 7 | 7 | 7 |
| Average | 6 | 6 | 6 | 6 | - |

### *Geometry and Analysis Results*

| Leg | SB IA 1 | EB US 30 | NB IA 1 | WB US 30 |
|---|---|---|---|---|
| V - Approach road half-width (ft) | 12.00 | 12.00 | 12.00 | 12.00 |
| E - Entry width (ft) | [illegible] | [illegible] | [illegible] | [illegible] |
| l' - Effective flare length (ft) | [illegible] | [illegible] | [illegible] | [illegible] |
| R - Entry radius (ft) | [illegible] | 200.0 | [illegible] | 200.0 |
| D - Inscribed circle diameter (ft) | [illegible] | [illegible] | [illegible] | [illegible] |
| PHI - Conflict (entry) angle (deg) | 30.0 | 30.0 | 30.0 | 30.0 |
| Exit only | ☐ | ☐ | ☐ | ☐ |
| Leg has bypass | ☐ | ☑ | ☐ | ☑ |
| Percentage intercept adjustment (%) | 95.00 | 95.00 | 95.00 | 95.00 |
| Average Demand (Veh/hr) | 103 | 782 | 465 | 317 |
| Max delay (s) | 3.91 | 3.23 | 4.02 | 5.74 |
| Max LOS | | A | A | A |
| Max 95th percentile Queue (Veh) | 0.5 | 2.4 | 2.7 | 2.7 |
| Max V/C Ratio | 0.11 | 0.42 | 0.37 | 0.30 |

## Year 2018
## PM Peak Hour
## Existing Lane Configuration
### *By-lane Results for Eastbound Yielding Right-turn Bypass*

*Volumes*

| From \ To | 1st exit | 2nd exit | 3rd exit | U-Turn | Total |
|---|---|---|---|---|---|
| SB IA 1 | [illegible] | [illegible] | [illegible] | 0 | 389 |
| EB US 30 | [illegible] | [illegible] | [illegible] | 0 | 51 |
| NB IA 1 | [illegible] | [illegible] | [illegible] | 0 | 468 |
| WB US 30 | [illegible] | [illegible] | [illegible] | 0 | 317 |
| Total | 353 | 629 | 243 | 0 | - |

*Truck Percentages*

| From \ To | 1st exit | 2nd exit | 3rd exit | U-Turn | Average |
|---|---|---|---|---|---|
| SB IA 1 | 5 | 5 | 5 | 5 | 5 |
| EB US 30 | 8 | 8 | 8 | 8 | 8 |
| NB IA 1 | 5 | 5 | 5 | 5 | 5 |
| WB US 30 | 7 | 7 | 7 | 7 | 7 |
| Average | 6 | 6 | 6 | 6 | - |

*Geometry and Analysis Results*

| Leg | SB IA 1 | EB US 30 | NB IA 1 | WB US 30 |
|---|---|---|---|---|
| V - Approach road half-width (ft) | 12.00 | 12.00 | 12.00 | 12.00 |
| E - Entry width (ft) | 14.00 | 14.00 | 14.00 | 14.00 |
| l' - Effective flare length (ft) | 330.0 | 330.0 | 330.0 | 330.0 |
| R - Entry radius (ft) | 150.0 | 200.0 | 200.0 | 200.0 |
| D - Inscribed circle diameter (ft) | 150.0 | 150.0 | 150.0 | 150.0 |
| PHI - Conflict (entry) angle (deg) | 30.0 | 30.0 | 30.0 | 30.0 |
| Exit only | ☐ | ☐ | ☐ | ☐ |
| Leg has bypass | ☑ | ☐ | ☐ | ☑ |
| Percentage intercept adjustment (%) | 95.00 | 95.00 | 95.00 | 95.00 |
| Average Demand (Veh/hr) | 389 | 51 | 468 | 317 |
| Max delay (s) | 5.46 | 3.77 | 2.95 | 4.21 |
| Max LOS | A | A | [illegible] | A |
| Max 95th percentile Queue (Veh) | 1.3 | 0.1 | 1.1 | 1.5 |
| Max V/C Ratio | 0.30 | 0.0[illegible] | 0.28 | 0.26 |

**Year 2018**

**PM Peak Hour**

**Existing Lane Configuration**

***By-lane Results for Westbound Yielding Right-turn Bypass***

### *Volumes*

| From \ To | 1st exit | 2nd exit | 3rd exit | U-Turn | Total |
|---|---|---|---|---|---|
| SB IA 1 | [illegible] | [illegible] | [illegible] | 0 | 388 |
| EB US 30 | 3 | [illegible] | 200 | 0 | 762 |
| NB IA 1 | 124 | [illegible] | 66 | 0 | 468 |
| WB US 30 | 75 | 0 | 0 | 0 | 75 |
| Total | 353 | 949 | 412 | 0 | - |

### *Truck Percentages*

| From \ To | 1st exit | 2nd exit | 3rd exit | U-Turn | Average |
|---|---|---|---|---|---|
| SB IA 1 | 5 | 5 | 5 | 5 | 5 |
| EB US 30 | 8 | 8 | 8 | 8 | 8 |
| NB IA 1 | 5 | 5 | 5 | 5 | 5 |
| WB US 30 | 7 | 7 | 7 | 7 | 7 |
| Average | 6 | 6 | 6 | 6 | - |

### *Geometry and Analysis Results*

| Leg | SB IA 1 | EB US 30 | NB IA 1 | WB US 30 |
|---|---|---|---|---|
| V - Approach road half-width (ft) | [illegible] | [illegible] | [illegible] | [illegible] |
| E - Entry width (ft) | 14.00 | 25.00 | 25.00 | 14.00 |
| l' - Effective flare length (ft) | [illegible] | [illegible] | [illegible] | [illegible] |
| R - Entry radius (ft) | [illegible] | [illegible] | [illegible] | [illegible] |
| D - Inscribed circle diameter (ft) | [illegible] | [illegible] | [illegible] | [illegible] |
| PHI - Conflict (entry) angle (deg) | [illegible] | [illegible] | [illegible] | [illegible] |
| Exit only | ☐ | ☐ | ☐ | ☐ |
| Leg has bypass | ☑ | ☑ | ☐ | ☐ |
| Percentage intercept adjustment (%) | 95.00 | 95.00 | 95.00 | 95.00 |
| Average Demand (Veh/hr) | 389 | 762 | 468 | 75 |
| Max delay (s) | 4.88 | 3.30 | 4.53 | 4.49 |
| Max LOS | A | [illegible] | A | A |
| Max 95th percentile Queue (Veh) | 1.0 | 1.3 | 2.3 | 0.5 |
| Max V/C Ratio | [illegible] | [illegible] | [illegible] | [illegible] |

**Year 2018**
**AM Peak Hour**
**Single Lane**

### *Volumes*

| From \ To | 1st exit | 2nd exit | 3rd exit | U-Turn | Total |
|---|---|---|---|---|---|
| SB IA 1 | [illegible] | [illegible] | 48 | 0 | 458 |
| EB US 30 | [illegible] | 144 | 66 | [illegible] | 265 |
| NB IA 1 | [illegible] | 80 | [illegible] | 0 | 139 |
| WB US 30 | 34 | 558 | [illegible] | 0 | 638 |
| Total | 334 | 954 | 212 | 0 | [illegible] |

### *Truck Percentages*

| From \ To | 1st exit | 2nd exit | 3rd exit | U-Turn | Average |
|---|---|---|---|---|---|
| SB IA 1 | 8 | 8 | 8 | 6 | 8 |
| EB US 30 | 8 | 8 | 8 | [illegible] | 8 |
| NB IA 1 | 8 | 8 | 8 | 8 | 8 |
| WB US 30 | 9 | 9 | 9 | 9 | 9 |
| Average | 8 | 8 | 8 | 8 | [illegible] |

### *Geometry and Analysis Results*

| Leg | SB IA 1 | EB US 30 | NB IA 1 | WB US 30 |
|---|---|---|---|---|
| V - Approach road half-width (ft) | 12.00 | 12.00 | 12.00 | 12.00 |
| E - Entry width (ft) | 14.00 | 14.00 | 14.00 | 14.00 |
| l' - Effective flare length (ft) | 130.0 | 130.0 | 130.0 | 130.0 |
| R - Entry radius (ft) | 75.0 | 75.0 | 75.0 | 75.0 |
| D - Inscribed circle diameter (ft) | 130.0 | 150.0 | 140.0 | 140.0 |
| PHI - Conflict (entry) angle (deg) | 20.0 | 20.0 | 20.0 | 20.0 |
| Exit only | ☐ | ☐ | ☐ | ☐ |
| Leg has bypass | ☑ | ☑ | ☐ | ☑ |
| Percentage intercept adjustment (%) | 85.00 | 85.00 | 85.00 | 85.00 |
| Average Demand (Veh/hr) | 458 | 265 | 139 | 638 |
| Max delay (s) | 7.08 | 4.58 | 4.15 | 2.95 |
| Max LOS | A | A | A | A |
| Max 95th percentile Queue (Veh) | 2.0 | 3.3 | 0.5 | 3.1 |
| Max V/C Ratio | 0.36 | 0.22 | 0.15 | 0.54 |

## Year 2018
## AM Peak Hour
## Single Lane
### *By-lane Results for Southbound Yielding Right-turn Bypass*

### *Volumes*

| From \ To | 1st exit | 2nd exit | 3rd exit | U-Turn | Total |
|---|---|---|---|---|---|
| SB IA 1 | [illegible] | 0 | 0 | 0 | 236 |
| EB US 30 | 56 | 141 | 68 | 0 | 265 |
| NB IA 1 | 10 | 86 | 43 | 0 | 139 |
| WB US 30 | 34 | 5[illegible] | 14 | 0 | 630 |
| Total | 334 | 772 | 122 | 0 | - |

### *Truck Percentages*

| From \ To | 1st exit | 2nd exit | 3rd exit | U-Turn | Average |
|---|---|---|---|---|---|
| SB IA 1 | 8 | 8 | 8 | 8 | 8 |
| EB US 30 | 8 | 8 | 8 | 8 | 8 |
| NB IA 1 | 8 | 8 | 8 | 8 | 8 |
| WB US 30 | 9 | 8 | 8 | 9 | 9 |
| Average | 8 | 8 | 8 | 8 | - |

### *Geometry and Analysis Results*

| Leg | SB IA 1 | EB US 30 | NB IA 1 | WB US 30 |
|---|---|---|---|---|
| V - Approach road half-width (ft) | 22.00 | 22.00 | 22.00 | 22.00 |
| E - Entry width (ft) | 24.00 | 24.00 | 24.00 | 24.00 |
| l' - Effective flare length (ft) | 130.0 | 130.0 | 130.0 | 130.0 |
| R - Entry radius (ft) | 75.0 | 75.0 | 75.0 | 75.0 |
| D - Inscribed circle diameter (ft) | [illegible] | 160.0 | 140.0 | 140.0 |
| PHI - Conflict (entry) angle (deg) | 20.0 | 20.0 | 20.0 | 20.0 |
| Exit only | ☐ | ☐ | ☐ | ☐ |
| Leg has bypass | ☐ | ☑ | ☐ | ☑ |
| Percentage intercept adjustment (%) | [illegible] | 25.00 | 35.00 | 25.00 |
| Average Demand (Veh/hr) | 236 | 247 | 139 | 539 |
| Max delay (s) | 7.30 | 3.88 | 4.06 | 9.66 |
| Max LOS | [illegible] | A | A | A |
| Max 95th percentile Queue (Veh) | 2.4 | 1.1 | 0.5 | 3.3 |
| Max V/C Ratio | [illegible] | 0.20 | 0.15 | 0.54 |

**Year 2018**

**AM Peak Hour**

**Single Lane**

***By-lane Results for Eastbound Yielding Right-turn Bypass***

### *Volumes*

| From \ To | [illegible] | [illegible] | [illegible] | [illegible] | Total |
|---|---|---|---|---|---|
| SB IA 1 | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |
| [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | 55 |
| [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |
| [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |
| Total | 334 | 810 | [illegible] | 0 | - |

### *Truck Percentages*

| From \ To | 1st exit | 2nd exit | 3rd exit | U-Turn | Average |
|---|---|---|---|---|---|
| SB IA 1 | [illegible] | 3 | [illegible] | [illegible] | [illegible] |
| EB US 30 | 3 | 3 | [illegible] | 3 | [illegible] |
| NB IA 1 | [illegible] | 3 | 3 | [illegible] | [illegible] |
| WB US 30 | [illegible] | [illegible] | [illegible] | [illegible] | 9 |
| Average | 8 | 8 | [illegible] | 8 | - |

### *Geometry and Analysis Results*

| Leg | SB IA 1 | EB US 30 | NB IA 1 | WB US 30 |
|---|---|---|---|---|
| V - Approach road half-width (ft) | [illegible] | [illegible] | [illegible] | [illegible] |
| E - Entry width (ft) | [illegible] | [illegible] | [illegible] | [illegible] |
| ℓ' - Effective flare length (ft) | [illegible] | [illegible] | [illegible] | [illegible] |
| R - Entry radius (ft) | [illegible] | [illegible] | [illegible] | [illegible] |
| D - Inscribed circle diameter (ft) | [illegible] | [illegible] | [illegible] | [illegible] |
| PHI - Conflict (entry) angle (deg) | [illegible] | [illegible] | [illegible] | [illegible] |
| Exit only | ☐ | ☐ | ☐ | ☐ |
| Leg has bypass | ☑ | ☐ | ☐ | ☑ |
| Percentage intercept adjustment (%) | 95.00 | 95.00 | 25.00 | 95.00 |
| Average Demand (Veh/hr) | 458 | 55 | 139 | 638 |
| Max delay (s) | 7.09 | 3.53 | 3.61 | 5.70 |
| Max LOS | [illegible] | A | A | A |
| Max 95th percentile Queue (Veh) | 2.0 | 0.5 | 0.5 | 3.5 |
| Max V/C Ratio | 0.32 | 0.06 | 0.12 | 0.62 |

**Year 2018**

**AM Peak Hour**

**Single Lane**

***By-lane Results for Westbound Yielding Right-turn Bypass***

### *Volumes*

| From \ To | [illegible] | [illegible] | [illegible] | [illegible] | Total |
|---|---|---|---|---|---|
| **SB IA 1** | [illegible] | [illegible] | [illegible] | [illegible] | 458 |
| [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | 265 |
| NB IA 1 | [illegible] | [illegible] | [illegible] | [illegible] | 139 |
| WB US 30 | [illegible] | [illegible] | [illegible] | [illegible] | 24 |
| Total | [illegible] | [illegible] | [illegible] | [illegible] | - |

### *Truck Percentages*

| From \ To | 1st exit | 2nd exit | 3rd exit | U-Turn | Average |
|---|---|---|---|---|---|
| **SB IA 1** | 8 | 8 | 8 | 8 | 8 |
| **EB US 30** | 8 | 8 | 8 | 8 | 8 |
| **NB IA 1** | 8 | 8 | 8 | 8 | 8 |
| **WB US 30** | 9 | 9 | 9 | 9 | 9 |
| Average | 8 | 8 | 8 | 8 | - |

### *Geometry and Analysis Results*

| Leg | SB IA 1 | EB US 30 | NB IA 1 | WB US 30 |
|---|---|---|---|---|
| V - Approach road half-width (ft) | 12.00 | 12.00 | 12.00 | [illegible] |
| E - Entry width (ft) | 14.00 | 14.00 | 14.00 | 14.00 |
| l' - Effective flare length (ft) | 330.0 | 330.0 | 330.0 | 330.0 |
| R - Entry radius (ft) | 75.0 | 75.0 | 75.0 | 75.0 |
| D - Inscribed circle diameter (ft) | 130.0 | 130.0 | 130.0 | 130.0 |
| PHI - Conflict (entry) angle (deg) | 20.0 | 20.0 | 20.0 | 20.0 |
| Exit only | ☐ | ☐ | ☐ | ☐ |
| Leg has bypass | ☑ | ☑ | ☐ | ☐ |
| Percentage intercept adjustment (%) | 95.00 | 95.00 | 47.00 | 95.00 |
| Average Demand (Veh/hr) | 458 | 265 | 139 | 24 |
| Max delay (s) | 3.57 | 3.45 | 4.16 | 3.52 |
| Max LOS | A | A | A | A |
| Max 95th percentile Queue (Veh) | 0.2 | 1.3 | 0.3 | 0.5 |
| Max V/C Ratio | 0.12 | 0.22 | 0.15 | [illegible] |

## Year 2018
## PM Peak Hour
## Single Lane

### Volumes

| From \ To | 1st exit | 2nd exit | 3rd exit | U-Turn | Total |
|---|---|---|---|---|---|
| SB IA 1 | [illegible] | [illegible] | [illegible] | 0 | 389 |
| EB US 30 | 53 | 520 | 209 | 0 | 782 |
| NB IA 1 | 124 | 279 | 65 | 0 | 468 |
| WB US 30 | 75 | 200 | 32 | 0 | 312 |
| Total | 353 | 1159 | 444 | 0 | - |

### Truck Percentages

| From \ To | 1st exit | 2nd exit | 3rd exit | U-Turn | Average |
|---|---|---|---|---|---|
| SB IA 1 | 5 | 5 | 5 | 5 | 5 |
| EB US 30 | 8 | 8 | 8 | 8 | 8 |
| NB IA 1 | 5 | 5 | 5 | 5 | 5 |
| WB US 30 | 7 | 7 | 7 | 7 | 7 |
| Average | 6 | 6 | 6 | 6 | - |

### Geometry and Analysis Results

| Leg | SB IA 1 | EB US 30 | NB IA 1 | WB US 30 |
|---|---|---|---|---|
| V - Approach road half-width (ft) | 12.00 | 12.00 | 12.00 | 12.00 |
| E - Entry width (ft) | 14.00 | 14.00 | 14.00 | 14.00 |
| l' - Effective flare length (ft) | 130.0 | 130.0 | 130.0 | 130.0 |
| R - Entry radius (ft) | 75.0 | 75.0 | 75.0 | 75.0 |
| D - Inscribed circle diameter (ft) | 130.0 | 140.0 | 140.0 | 140.0 |
| PHI - Conflict (entry) angle (deg) | 20.0 | 20.0 | 20.0 | 20.0 |
| Exit only | ☐ | ☐ | ☐ | ☐ |
| Leg has bypass | ☑ | ☑ | ☐ | ☑ |
| Percentage intercept adjustment (%) | 85.00 | 85.00 | 95.00 | 85.00 |
| Average Demand (Veh/hr) | 366 | 782 | 468 | 317 |
| Max delay (s) | 5.43 | 38.58 | 27.68 | 6.22 |
| Max LOS | A | E | D | A |
| Max 95th percentile Queue (Veh) | 1.2 | 21.7 | 13.9 | 1.3 |
| Max V/C Ratio | 0.33 | 0.82 | 0.80 | 0.32 |

**Year 2018**

**PM Peak Hour**

**Single Lane**

***By-lane Results for Southbound Yielding Right-turn Bypass***

### *Volumes*

| From \ To | 1st exit | 2nd exit | 3rd exit | U-turn | Total |
|---|---|---|---|---|---|
| SB IA 1 | 103 | 0 | 0 | 0 | 103 |
| EB US 30 | [illegible] | [illegible] | 208 | 0 | 783 |
| NB IA 1 | [illegible] | [illegible] | [illegible] | 0 | 468 |
| WB US 30 | [illegible] | [illegible] | [illegible] | [illegible] | 317 |
| Total | 353 | 1018 | [illegible] | 5 | [illegible] |

### *Truck Percentages*

| From \ To | 1st exit | 2nd exit | 3rd exit | U-Turn | Average |
|---|---|---|---|---|---|
| SB IA 1 | 5 | 5 | 5 | 5 | 5 |
| EB US 30 | 8 | 8 | 8 | 8 | 8 |
| NB IA 1 | 5 | 5 | 5 | 5 | 5 |
| WB US 30 | 7 | 7 | 7 | 7 | 7 |
| Average | 6 | 6 | 6 | 6 | - |

### *Geometry and Analysis Results*

| Leg | SB IA 1 | EB US 30 | NB IA 1 | WB US 30 |
|---|---|---|---|---|
| V - Approach road half-width (ft) | 12.00 | 12.00 | 12.00 | 12.00 |
| E - Entry width (ft) | 14.00 | 14.00 | 14.00 | 14.00 |
| l' - Effective flare length (ft) | 130.0 | 130.0 | 130.0 | 130.0 |
| R - Entry radius (ft) | 75.0 | 75.0 | 75.0 | 75.0 |
| D - Inscribed circle diameter (ft) | 130.0 | 130.0 | 130.0 | 130.0 |
| PHI - Conflict (entry) angle (deg) | 30.0 | 20.0 | 20.0 | 20.0 |
| Exit only | ☐ | ☐ | ☐ | ☐ |
| Leg has bypass | ☐ | ☑ | ☐ | ☑ |
| Percentage intercept adjustment (%) | 15.00 | 15.00 | 15.00 | 15.00 |
| Average Demand (Veh/hr) | 103 | 783 | 468 | 317 |
| Max delay (s) | 4.06 | 10.22 | 16.45 | 6.23 |
| Max LOS | A | B | C | A |
| Max 95th percentile Queue (Veh) | 0.1 | 6.2 | 9.7 | 1.3 |
| Max V/C Ratio | 0.11 | 0.73 | 0.70 | 0.32 |

**Year 2018**
**PM Peak Hour**
**Single Lane**
***By-lane Results for Eastbound Yielding Right-turn Bypass***

### *Volumes*

| From \ To | 1st exit | 2nd exit | 3rd exit | U-Turn | Total |
|---|---|---|---|---|---|
| SB IA 1 | 103 | [illegible] | [illegible] | 0 | 309 |
| EB US 30 | [illegible] | 0 | 0 | 0 | 51 |
| NB IA 1 | [illegible] | [illegible] | [illegible] | 0 | 468 |
| WB US 30 | [illegible] | [illegible] | [illegible] | 0 | 317 |
| Total | [illegible] | [illegible] | 243 | 0 | - |

### *Truck Percentages*

| From \ To | 1st exit | 2nd exit | 3rd exit | U-Turn | Average |
|---|---|---|---|---|---|
| SB IA 1 | 5 | 5 | 5 | 5 | 5 |
| EB US 30 | 8 | 8 | 8 | 8 | 8 |
| NB IA 1 | 5 | 5 | 5 | 5 | 5 |
| WB US 30 | 7 | 7 | 7 | 7 | 7 |
| Average | 6 | 6 | 6 | 6 | - |

### *Geometry and Analysis Results*

| Leg | SB IA 1 | EB US 30 | NB IA 1 | WB US 30 |
|---|---|---|---|---|
| V - Approach road half-width (ft) | 12.00 | 12.00 | 12.00 | 12.00 |
| E - Entry width (ft) | 14.00 | 14.00 | 14.00 | 14.00 |
| l' - Effective flare length (ft) | [illegible] | [illegible] | [illegible] | [illegible] |
| R - Entry radius (ft) | 75.0 | 75.0 | 75.0 | 75.0 |
| D - Inscribed circle diameter (ft) | [illegible] | [illegible] | [illegible] | [illegible] |
| PHI - Conflict (entry) angle (deg) | 30.0 | 30.0 | 30.0 | 30.0 |
| Exit only | ☐ | ☐ | ☐ | ☐ |
| Leg has bypass | ☑ | ☐ | ☐ | ☑ |
| Percentage intercept adjustment (%) | [illegible] | [illegible] | [illegible] | [illegible] |
| Average Demand (Veh/hr) | 309 | 51 | 468 | 317 |
| Max delay (s) | [illegible] | 3.57 | 5.36 | 5.08 |
| Max LOS | A | A | A | A |
| Max 95th percentile Queue (Veh) | 1.2 | [illegible] | 2.2 | 1.3 |
| Max V/C Ratio | 0.31 | [illegible] | 0.46 | 0.27 |

## Year 2018
## PM Peak Hour
## Single Lane
## *By-lane Results for Westbound Yielding Right-turn Bypass*

### *Volumes*

| From \ To | 1st exit | 2nd exit | 3rd exit | U-Turn | Total |
|---|---|---|---|---|---|
| SB IA 1 | [illegible] | [illegible] | [illegible] | [illegible] | 389 |
| EB US 30 | [illegible] | [illegible] | [illegible] | [illegible] | 702 |
| NB IA 1 | [illegible] | [illegible] | [illegible] | [illegible] | 468 |
| WB US 30 | 75 | [illegible] | [illegible] | [illegible] | 75 |
| Total | 353 | 549 | 412 | 0 | |

### *Truck Percentages*

| From \ To | 1st exit | 2nd exit | 3rd exit | U-Turn | Average |
|---|---|---|---|---|---|
| SB IA 1 | 5 | 5 | 5 | 5 | 5 |
| EB US 30 | 8 | 8 | [illegible] | 8 | 8 |
| NB IA 1 | 5 | 5 | 5 | 5 | 5 |
| WB US 30 | 7 | 7 | 7 | 7 | 7 |
| Average | 6 | 6 | 6 | 6 | |

### *Geometry and Analysis Results*

| Arm | SB IA 1 | EB US 30 | NB IA 1 | WB US 30 |
|---|---|---|---|---|
| V - Approach road half-width (ft) | 12.00 | 12.00 | 12.00 | 12.00 |
| E - Entry width (ft) | 14.00 | 14.00 | 14.00 | 14.00 |
| l' - Effective flare length (ft) | [illegible] | [illegible] | [illegible] | 120.0 |
| R - Entry radius (ft) | 75.0 | 75.0 | 75.0 | 75.0 |
| D - Inscribed circle diameter (ft) | 140.0 | 140.0 | 140.0 | 140.0 |
| PHI - Conflict (entry) angle (deg) | 20.0 | 20.0 | 20.0 | 20.0 |
| Exit only | ☐ | ☐ | ☐ | ☐ |
| Leg has bypass | ☑ | ☑ | ☐ | ☐ |
| Percentage intercept adjustment (%) | 35.00 | 35.00 | 35.00 | 35.00 |
| Average Demand (Veh/hr) | 389 | 702 | 468 | 75 |
| Max delay (s) | 4.22 | 17.74 | 27.72 | [illegible] |
| Max LOS | A | [illegible] | D | A |
| Max 95th percentile Queue (Veh) | 1.2 | 19.5 | 18.9 | 0.5 |
| Max V/C Ratio | 0.37 | 0.80 | 0.90 | [illegible] |

# Year 2040
# AM Peak Hour
# Single Lane

## *Volumes*

| From \ To | 1st exit | 2nd exit | 3rd exit | U-Turn | Total |
|---|---|---|---|---|---|
| SB IA 1 | 17 | 432 | 3 | 0 | 457 |
| EB US 30 | 4 | 32 | 4 | 0 | 40 |
| NB IA 1 | 32 | 232 | 3 | 0 | 267 |
| WB US 30 | 5 | 110 | 125 | 9 | [illegible] |
| Total | 58 | 1013 | 131 | 0 | |

## *Truck Percentages*

| From \ To | 1st exit | 2nd exit | 3rd exit | U-Turn | Average |
|---|---|---|---|---|---|
| SB IA 1 | 5 | 5 | 5 | 5 | 5 |
| EB US 30 | 5 | 5 | 5 | 5 | 5 |
| NB IA 1 | 5 | 5 | 5 | 5 | 5 |
| WB US 30 | 5 | 5 | 5 | 5 | 5 |
| Average | 5 | 5 | 5 | 5 | |

## *Geometry and Analysis Results*

| Leg | SB IA 1 | EB US 30 | NB IA 1 | WB US 30 |
|---|---|---|---|---|
| V - Approach road half-width (ft) | 12.00 | 12.00 | 12.00 | 12.00 |
| E - Entry width (ft) | 14.00 | 14.00 | 14.00 | 14.00 |
| l' - Effective flare length (ft) | 130.0 | 130.0 | 130.0 | 130.0 |
| R - Entry radius (ft) | 150.0 | 100.0 | 100.0 | 100.0 |
| D - Inscribed circle diameter (ft) | 140.0 | 140.0 | 140.0 | 140.0 |
| PHI - Conflict (entry) angle (deg) | 30.0 | 20.0 | 20.0 | 20.0 |
| Exit only | ☐ | ☐ | ☐ | ☐ |
| Leg has bypass | ☑ | ☑ | ☐ | ☑ |
| Percentage intercept adjustment (%) | 35.00 | 35.00 | 35.00 | 35.00 |
| Average Demand (Veh/hr) | 657 | 40 | 257 | 228 |
| Max delay (s) | 5.49 | 5.09 | 4.10 | 4.34 |
| Max LOS | A | A | A | A |
| Max 95th percentile Queue (Veh) | 3.3 | 0.5 | 1.4 | 1.3 |
| Max V/C Ratio | 0.55 | 0.05 | 0.25 | 0.22 |

## Year 2040
## AM Peak Hour
## Single Lane
### *By-lane Results for Southbound Yielding Right-turn Bypass*

### *Volumes*

| From \ To | 1st exit | 2nd exit | 3rd exit | U-Turn | Total |
|---|---|---|---|---|---|
| SB IA 1 | 37 | 0 | [illegible] | 0 | 37 |
| EB US 30 | 4 | 32 | [illegible] | [illegible] | 40 |
| NB IA 1 | 32 | 232 | 3 | [illegible] | 267 |
| WB US 30 | 5 | 115 | [illegible] | 0 | 238 |
| Total | 58 | [illegible] | [illegible] | 0 | [illegible] |

### *Truck Percentages*

| From \ To | 1st exit | 2nd exit | 3rd exit | U-Turn | Average |
|---|---|---|---|---|---|
| SB IA 1 | 5 | 5 | 5 | 5 | 5 |
| EB US 30 | 5 | 5 | 5 | 5 | 5 |
| NB IA 1 | 5 | 5 | 5 | 5 | 5 |
| WB US 30 | 5 | 5 | 5 | 5 | 5 |
| Average | 5 | 5 | 5 | 5 | - |

### *Geometry and Analysis Results*

| Leg | SB IA 1 | EB US 30 | NB IA 1 | WB US 30 |
|---|---|---|---|---|
| V - Approach road half-width (ft) | 12.00 | 12.00 | 12.00 | 12.00 |
| E - Entry width (ft) | 14.00 | 14.00 | 14.00 | 14.00 |
| l' - Effective flare length (ft) | 130.0 | 130.0 | 130.0 | 130.0 |
| R - Entry radius (ft) | 200.0 | 100.0 | 100.0 | 200.0 |
| D - Inscribed circle diameter (ft) | 130.0 | 150.0 | 140.0 | 140.0 |
| PHI - Conflict (entry) angle (deg) | 20.0 | 30.0 | 30.0 | 30.0 |
| Exit only | ☐ | ☐ | ☐ | ☐ |
| Leg has bypass | ☐ | ☑ | ☐ | ☑ |
| Percentage intercept adjustment (%) | 85.00 | 85.00 | 85.00 | 85.00 |
| Average Demand (Veh/hr) | 37 | 40 | 267 | 238 |
| Max delay (s) | 3.38 | 3.24 | 3.98 | 4.34 |
| Max LOS | A | A | A | A |
| Max 95th percentile Queue (Veh) | 0.2 | 0.5 | 1.4 | 1.2 |
| Max V/C Ratio | [illegible] | [illegible] | 0.25 | 0.24 |

# Year 2040
# AM Peak Hour
# Single Lane
## *By-lane Results for Eastbound Yielding Right-turn Bypass*

### *Volumes*

| From \ To | 1st exit | 2nd exit | 3rd exit | U-Turn | Total |
|---|---|---|---|---|---|
| SB IA 1 | 17 | 631 | 9 | 0 | [illegible] |
| EB US 30 | 4 | [illegible] | 0 | [illegible] | 4 |
| NB IA 1 | [illegible] | [illegible] | 3 | [illegible] | [illegible] |
| WB US 30 | 5 | [illegible] | [illegible] | [illegible] | [illegible] |
| Total | 58 | [illegible] | [illegible] | [illegible] | - |

### *Truck Percentages*

| From \ To | 1st exit | 2nd exit | 3rd exit | U-Turn | Average |
|---|---|---|---|---|---|
| SB IA 1 | 5 | 5 | 5 | 5 | 5 |
| EB US 30 | 5 | 5 | 5 | 5 | 5 |
| NB IA 1 | 5 | 5 | 5 | 5 | 5 |
| WB US 30 | 5 | 5 | 5 | 5 | 5 |
| Average | 5 | 5 | 5 | 5 | - |

### *Geometry and Analysis Results*

| Leg | SB IA 1 | EB US 30 | NB IA 1 | WB US 30 |
|---|---|---|---|---|
| V - Approach road half-width (ft) | [illegible] | [illegible] | [illegible] | [illegible] |
| E - Entry width (ft) | [illegible] | [illegible] | 14.00 | 14.00 |
| l' - Effective flare length (ft) | [illegible] | [illegible] | [illegible] | [illegible] |
| R - Entry radius (ft) | [illegible] | [illegible] | [illegible] | 200.0 |
| D - Inscribed circle diameter (ft) | [illegible] | [illegible] | [illegible] | [illegible] |
| PHI - Conflict (entry) angle (deg) | [illegible] | [illegible] | [illegible] | [illegible] |
| Exit only | ☐ | ☐ | ☐ | ☐ |
| Leg has bypass | ☑ | ☐ | ☐ | ☑ |
| Percentage intercept adjustment (%) | [illegible] | [illegible] | [illegible] | [illegible] |
| Average Demand (Veh/hr) | [illegible] | 0 | [illegible] | [illegible] |
| Max delay (s) | [illegible] | [illegible] | 3.30 | [illegible] |
| Max LOS | A | A | A | A |
| Max 95th percentile Queue (Veh) | [illegible] | [illegible] | [illegible] | [illegible] |
| Max V/C Ratio | [illegible] | [illegible] | [illegible] | [illegible] |

**Year 2040**
**AM Peak Hour**
**Single Lane**
***By-lane Results for Westbound Yielding Right-turn Bypass***

*Volumes*

| From \ To | 1st exit | 2nd exit | 3rd exit | U-Turn | Total |
|---|---|---|---|---|---|
| SB IA 1 | [illegible] | [illegible] | 9 | [illegible] | [illegible] |
| EB US 30 | [illegible] | 32 | 4 | 0 | [illegible] |
| NB IA 1 | [illegible] | [illegible] | 3 | 0 | [illegible] |
| WB US 30 | 5 | [illegible] | 0 | [illegible] | [illegible] |
| Total | 58 | 895 | 16 | 0 | |

*Truck Percentages*

| From \ To | 1st exit | 2nd exit | 3rd exit | U-Turn | Average |
|---|---|---|---|---|---|
| SB IA 1 | 5 | 5 | 5 | 5 | 5 |
| EB US 30 | 5 | 5 | 5 | 5 | 5 |
| NB IA 1 | 5 | 5 | 5 | 5 | 5 |
| WB US 30 | 5 | 5 | 5 | 5 | 5 |
| Average | 5 | 5 | 5 | 5 | |

*Geometry and Analysis Results*

| Leg | SB IA 1 | EB US 30 | NB IA 1 | WB US 30 |
|---|---|---|---|---|
| V - Approach road half-width (ft) | [illegible] | [illegible] | [illegible] | [illegible] |
| E - Entry width (ft) | [illegible] | [illegible] | [illegible] | [illegible] |
| l' - Effective flare length (ft) | [illegible] | [illegible] | [illegible] | [illegible] |
| R - Entry radius (ft) | [illegible] | [illegible] | [illegible] | [illegible] |
| D - Inscribed circle diameter (ft) | [illegible] | [illegible] | [illegible] | [illegible] |
| PHI - Conflict (entry) angle (deg) | [illegible] | [illegible] | [illegible] | [illegible] |
| Exit only | ☐ | ☐ | ☐ | ☐ |
| Leg has bypass | ☑ | ☑ | ☐ | ☐ |
| Percentage intercept adjustment (%) | [illegible] | [illegible] | [illegible] | [illegible] |
| Average Demand (Veh/hr) | [illegible] | [illegible] | [illegible] | [illegible] |
| Max delay (s) | [illegible] | [illegible] | [illegible] | [illegible] |
| Max LOS | A | A | [illegible] | [illegible] |
| Max 95th percentile Queue (Veh) | [illegible] | [illegible] | [illegible] | [illegible] |
| Max V/C Ratio | [illegible] | 0.05 | [illegible] | [illegible] |

## Year 2040
## PM Peak Hour
## Single Lane

### *Volumes*

| From \ To | 1st exit | 2nd exit | 3rd exit | U-Turn | Total |
|---|---|---|---|---|---|
| SB IA 1 | 8 | 330 | [illegible] | 0 | [illegible] |
| EB US 30 | 3 | [illegible] | 44 | [illegible] | 131 |
| NB IA 1 | [illegible] | 264 | [illegible] | [illegible] | [illegible] |
| WB US 30 | [illegible] | 46 | 53 | [illegible] | [illegible] |
| Total | 157 | 1444 | 102 | 0 | - |

### *Truck Percentages*

| From \ To | 1st exit | 2nd exit | 3rd exit | U-Turn | Average |
|---|---|---|---|---|---|
| SB IA 1 | 5 | 5 | 5 | 5 | 5 |
| EB US 30 | 5 | 5 | 5 | 5 | 5 |
| NB IA 1 | 5 | 5 | 5 | 5 | 5 |
| WB US 30 | 5 | 5 | 5 | 5 | 5 |
| Average | 5 | 5 | 5 | 5 | - |

### *Geometry and Analysis Results*

| Leg | SB IA 1 | EB US 30 | NB IA 1 | WB US 30 |
|---|---|---|---|---|
| V - Approach road half-width (ft) | 12.00 | 12.00 | 12.00 | 12.00 |
| E - Entry width (ft) | 14.00 | 14.00 | 14.00 | 14.00 |
| l' - Effective flare length (ft) | 130.0 | 130.0 | 130.0 | 130.0 |
| R - Entry radius (ft) | 180.0 | 100.0 | 100.0 | 200.0 |
| D - Inscribed circle diameter (ft) | 130.0 | 150.0 | 140.0 | 140.0 |
| PHI - Conflict (entry) angle (deg) | 20.0 | 20.0 | 20.0 | 20.0 |
| Exit only | ☐ | ☐ | ☐ | ☐ |
| Leg has bypass | ☑ | ☑ | ☐ | ☑ |
| Percentage intercept adjustment (%) | 95.00 | 95.00 | 95.00 | 95.00 |
| Average Demand (Veh/hr) | 355 | 131 | 898 | 335 |
| Max delay (s) | 6.38 | 5.09 | 26.01 | [illegible] |
| Max LOS | A | A | D | A |
| Max 95th percentile Queue (Veh) | 1.5 | 0.5 | 36.0 | 0.5 |
| Max V/C Ratio | 0.52 | 0.17 | 0.88 | 0.35 |

**Year 2040**
**PM Peak Hour**
**Single Lane**
***By-lane Results for Southbound Yielding Right-turn Bypass***

### *Volumes*

| From \ To | 1st exit | 2nd exit | 3rd exit | U-Turn | Total |
|---|---|---|---|---|---|
| SB IA 1 | [illegible] | [illegible] | 0 | 0 | 8 |
| EB US 30 | 3 | [illegible] | [illegible] | 0 | 131 |
| NB IA 1 | 130 | [illegible] | 4 | 0 | 898 |
| WB US 30 | 16 | [illegible] | 53 | 0 | 115 |
| Total | [illegible] | [illegible] | 71 | [illegible] | - |

### *Truck Percentages*

| From \ To | 1st exit | 2nd exit | 3rd exit | U-Turn | Average |
|---|---|---|---|---|---|
| SB IA 1 | 5 | 5 | 5 | 5 | 5 |
| EB US 30 | 5 | 5 | 5 | 5 | 5 |
| NB IA 1 | 5 | 5 | 5 | 5 | 5 |
| WB US 30 | 5 | 5 | 5 | 5 | 5 |
| Average | 5 | 5 | 5 | 5 | |

### *Geometry and Analysis Results*

| | SB IA 1 | EB US 30 | NB IA 1 | WB US 30 |
|---|---|---|---|---|
| V - Approach road half-width (ft) | [illegible] | [illegible] | [illegible] | [illegible] |
| E - Entry width (ft) | [illegible] | [illegible] | [illegible] | [illegible] |
| l' - Effective flare length (ft) | [illegible] | [illegible] | [illegible] | [illegible] |
| R - Entry radius (ft) | [illegible] | [illegible] | [illegible] | [illegible] |
| D - Inscribed circle diameter (ft) | [illegible] | [illegible] | [illegible] | [illegible] |
| PHI - Conflict (entry) angle (deg) | [illegible] | [illegible] | [illegible] | [illegible] |
| Exit only | ☐ | ☐ | ☐ | ☐ |
| Leg has bypass | ☐ | ☑ | ☐ | ☑ |
| Percentage intercept adjustment (%) | [illegible] | [illegible] | [illegible] | [illegible] |
| Average Demand (Veh/hr) | 8 | 131 | [illegible] | 115 |
| Max delay (s) | [illegible] | 3.43 | 22.35 | 5.77 |
| Max LOS | A | [illegible] | [illegible] | A |
| Max 95th percentile Queue (Veh) | [illegible] | [illegible] | 30.3 | 0.5 |
| Max V/C Ratio | [illegible] | [illegible] | 0.87 | [illegible] |

## Year 2040
## PM Peak Hour
## Single Lane
### *By-lane Results for Eastbound Yielding Right-turn Bypass*

### *Volumes*

| From \ To | 1st exit | 2nd exit | 3rd exit | U-Turn | Total |
|---|---|---|---|---|---|
| SB IA 1 | 5 | 524 | 21 | 0 | 550 |
| EB US 30 | 3 | 0 | 0 | 0 | 3 |
| NB IA 1 | [illegible] | [illegible] | 4 | 0 | 898 |
| WB US 30 | 14 | 46 | [illegible] | 0 | 115 |
| Total | [illegible] | 1330 | 88 | 0 | - |

### *Truck Percentages*

| From \ To | 1st exit | 2nd exit | 3rd exit | U-Turn | Average |
|---|---|---|---|---|---|
| SB IA 1 | 5 | 5 | 5 | 5 | 5 |
| EB US 30 | 5 | 5 | 5 | 5 | 5 |
| NB IA 1 | 5 | 5 | 5 | 5 | 5 |
| WB US 30 | 5 | 5 | 5 | 5 | 5 |
| Average | 5 | 5 | 5 | 5 | - |

### *Geometry and Analysis Results*

| Leg | SB IA 1 | EB US 30 | NB IA 1 | WB US 30 |
|---|---|---|---|---|
| V - Approach road half-width (ft) | [illegible] | [illegible] | [illegible] | [illegible] |
| E - Entry width (ft) | [illegible] | [illegible] | [illegible] | [illegible] |
| l' - Effective flare length (ft) | [illegible] | [illegible] | [illegible] | [illegible] |
| R - Entry radius (ft) | [illegible] | [illegible] | [illegible] | [illegible] |
| D - Inscribed circle diameter (ft) | [illegible] | [illegible] | [illegible] | [illegible] |
| PHI - Conflict (entry) angle (deg) | [illegible] | [illegible] | [illegible] | [illegible] |
| Exit only | ☐ | ☐ | ☐ | ☐ |
| Leg has bypass | ☑ | ☐ | ☐ | ☑ |
| Percentage intercept adjustment (%) | [illegible] | [illegible] | [illegible] | [illegible] |
| Average Demand (Veh/hr) | [illegible] | 0 | [illegible] | 115 |
| Max delay (s) | [illegible] | [illegible] | [illegible] | [illegible] |
| Max LOS | A | A | C | A |
| Max 95th percentile Queue (Veh) | 1.5 | [illegible] | 22.6 | 0.5 |
| Max V/C Ratio | [illegible] | 0.00 | 0.82 | 0.15 |

**Year 2040**

**PM Peak Hour**

**Single Lane**

***By-lane Results for Westbound Yielding Right-turn Bypass***

*Volumes*

| From \ To | 1st exit | 2nd exit | 3rd exit | U-Turn | Total |
|---|---|---|---|---|---|
| SB IA 1 | [illegible] | [illegible] | 31 | 0 | [illegible] |
| EB US 30 | 3 | 114 | 19 | 0 | [illegible] |
| NB IA 1 | 130 | 764 | [illegible] | 0 | [illegible] |
| WB US 30 | 16 | 0 | [illegible] | 0 | 16 |
| Total | 157 | 1353 | 49 | 0 | |

***Truck Percentages***

| From \ To | 1st exit | 2nd exit | 3rd exit | U-Turn | Average |
|---|---|---|---|---|---|
| SB IA 1 | 5 | 5 | 5 | 5 | 5 |
| EB US 30 | 5 | 5 | 5 | 5 | 5 |
| NB IA 1 | 5 | 5 | 5 | 5 | 5 |
| WB US 30 | 5 | 5 | 5 | 5 | 5 |
| Average | 5 | 5 | 5 | 5 | - |

*Geometry and Analysis Results*

| Leg | SB IA 1 | EB US 30 | NB IA 1 | WB US 30 |
|---|---|---|---|---|
| V - Approach road half-width (ft) | [illegible] | [illegible] | [illegible] | [illegible] |
| E - Entry width (ft) | [illegible] | [illegible] | [illegible] | 14.00 |
| l' - Effective flare length (ft) | [illegible] | [illegible] | [illegible] | [illegible] |
| R - Entry radius (ft) | [illegible] | [illegible] | [illegible] | [illegible] |
| D - Inscribed circle diameter (ft) | [illegible] | [illegible] | [illegible] | [illegible] |
| PHI - Conflict (entry) angle (deg) | [illegible] | [illegible] | 20.0 | 20.0 |
| Exit only | ☐ | ☐ | ☐ | ☐ |
| Leg has bypass | ☑ | ☑ | ☐ | ☐ |
| Percentage intercept adjustment (%) | [illegible] | [illegible] | [illegible] | [illegible] |
| Average Demand (Veh/hr) | [illegible] | [illegible] | [illegible] | 16 |
| Max delay (s) | 5.72 | 4.55 | [illegible] | [illegible] |
| Max LOS | [illegible] | [illegible] | [illegible] | A |
| Max 95th percentile Queue (Veh) | [illegible] | 0.5 | 36.0 | [illegible] |
| Max V/C Ratio | [illegible] | 0.25 | [illegible] | 0.02 |

## Residual Capacity

### AM Peak Hour

| AM | | | | | | | |
|---|---|---|---|---|---|---|---|
| | 95% Queue (Veh) | Delay (s) | V/C Ratio | LOS | Intersection Delay (s) | Intersection LOS | Network Residual Capacity |
| Single Lane - 2040 | | | | | | | |
| SB IA 1 | 3.2 | 9.49 | 0.65 | A | 7.11 | A | 33 % [SB IA 1] |
| EB US 30 | 0.5 | 5.03 | 0.05 | A | | | |
| NB IA 1 | 1.4 | 4.00 | 0.25 | A | | | |
| WB US 30 | 1.3 | 4.34 | 0.24 | A | | | |

***With an increase of 33% traffic on all approaches, SB IA 1 will begin to experience failing results (LOS E, >35 sec of delay).***

### PM Peak Hour

| PM | | | | | | | |
|---|---|---|---|---|---|---|---|
| | 95% Queue (Veh) | Delay (s) | V/C Ratio | LOS | Intersection Delay (s) | Intersection LOS | Network Residual Capacity |
| Single Lane - 2040 | | | | | | | |
| SB IA 1 | 1.5 | 6.38 | 0.52 | A | 16.59 | | 4 % [NB IA 1] |
| EB US30 | 0.5 | 5.09 | 0.17 | A | | | |
| NB IA 1 | 36.0 | 26.01 | 0.88 | D | | | |
| WB US30 | 0.5 | 5.76 | 0.15 | A | | | |

***With an increase of 4% traffic on all approaches, NB IA 1 will begin to experience failing results (LOS E, >35 sec of delay).***

# HCS7 Roundabouts Report

| General Information | | Site Information | |
|---|---|---|---|
| Analyst | NRC | Intersection | IA 1 at US 30 |
| Agency or Co. | MSA | E/W Street Name | US 30 |
| Date Performed | 4/27/2018 | N/S Street Name | IA 1 |
| Analysis Year | 2018 | Analysis Time Period (hrs) | 0.25 |
| Time Analyzed | AM Peak | Peak Hour Factor | 0.92 |
| Project Description | | Jurisdiction | Mt Vernon, IA |

## Volume Adjustments and Site Characteristics

| Approach | EB | | | | WB | | | | NB | | | | SB | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Movement | U | L | T | R | U | L | T | R | U | L | T | R | U | L | T | R |
| Number of Lanes (N) | 0 | 0 | 2 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 1 | 0 |
| Lane Assignment | LT | | T | | | | LT | | LT | | TR | | | | LT | |
| Volume (V), veh/h | 0 | 66 | 144 | 55 | 0 | 66 | 548 | 24 | 0 | 40 | 80 | 19 | 0 | 40 | 182 | 236 |
| Percent Heavy Vehicles, % | 8 | 8 | 8 | 8 | 9 | 9 | 9 | 9 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 |
| Flow Rate ($v_{PCE}$), pc/h | 0 | 77 | 169 | 65 | 0 | 78 | 649 | 28 | 0 | 47 | 94 | 22 | 0 | 47 | 214 | 277 |
| Right-Turn Bypass | Yielding | | | | Yielding | | | | None | | | | Yielding | | | |
| Conflicting Lanes | 1 | | | | 2 | | | | 2 | | | | 1 | | | |
| Pedestrians Crossing, p/h | 0 | | | | 0 | | | | 0 | | | | 0 | | | |

## Critical and Follow-Up Headway Adjustment

| Approach | EB | | | WB | | | NB | | | SB | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Lane | Left | Right | Bypass | Left | Right | Bypass | Left | Right | Bypass | Left | Right | Bypass |
| Critical Headway (s) | 4.5436 | 4.5436 | 4.9763 | | 4.3276 | 4.3276 | 4.6453 | 4.3276 | | | 4.9763 | 4.9763 |
| Follow-Up Headway (s) | 2.5352 | 2.5352 | 2.6087 | | 2.5352 | 2.5352 | 2.6667 | 2.5352 | | | 2.6087 | 2.6087 |

## Flow Computations, Capacity and v/c Ratios

| Approach | EB | | | WB | | | NB | | | SB | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Lane | Left | Right | Bypass | Left | Right | Bypass | Left | Right | Bypass | Left | Right | Bypass |
| Entry Flow ($v_e$), pc/h | 116 | 130 | 65 | | 727 | 28 | 77 | 86 | | | 261 | 277 |
| Entry Volume veh/h | 107 | 121 | 60 | | 667 | 26 | 71 | 80 | | | 242 | 256 |
| Circulating Flow ($v_c$), pc/h | 339 | | | 218 | | | 293 | | | 774 | | |
| Exiting Flow ($v_{ex}$), pc/h | 238 | | | 696 | | | 171 | | | 292 | | |
| Capacity ($c_{pce}$), pc/h | 1043 | 1043 | 1025 | | 1180 | 1228 | 1031 | 1107 | | | 627 | 679 |
| Capacity (c), veh/h | 966 | 966 | 949 | | 1082 | 1127 | 955 | 1025 | | | 580 | 628 |
| v/c Ratio (x) | 0.11 | 0.12 | 0.06 | | 0.62 | 0.02 | 0.07 | 0.08 | | | 0.42 | 0.41 |

## Delay and Level of Service

| Approach | EB | | | WB | | | NB | | | SB | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Lane | Left | Right | Bypass | Left | Right | Bypass | Left | Right | Bypass | Left | Right | Bypass |
| Lane Control Delay (d), s/veh | 4.7 | 4.9 | 4.4 | | 11.6 | 3.4 | 4.4 | 4.2 | | | 12.6 | 11.7 |
| Lane LOS | A | A | A | | B | A | A | A | | | B | B |
| 95% Queue, veh | 0.4 | 0.4 | 0.2 | | 4.4 | 0.1 | 0.2 | 0.3 | | | 2.0 | 2.0 |
| Approach Delay, s/veh | 4.7 | | | 11.3 | | | 4.3 | | | 12.1 | | |
| Approach LOS | A | | | B | | | A | | | B | | |
| Intersection Delay, s/veh \| LOS | 9.7 | | | | | | A | | | | | |

# HCS7 Roundabouts Report

| General Information | | Site Information | |
|---|---|---|---|
| Analyst | NRC | Intersection | IA 1 at US 30 |
| Agency or Co. | MSA | E/W Street Name | US 30 |
| Date Performed | 4/27/2018 | N/S Street Name | IA 1 |
| Analysis Year | 2018 | Analysis Time Period (hrs) | 0.25 |
| Time Analyzed | PM Peak | Peak Hour Factor | 0.92 |
| Project Description | | Jurisdiction | Mt Vernon, IA |

## Volume Adjustments and Site Characteristics

| Approach | EB | | | | WB | | | | NB | | | | SB | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Movement | U | L | T | R | U | L | T | R | U | L | T | R | U | L | T | R |
| Number of Lanes (N) | 0 | 0 | 2 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 1 | 0 |
| Lane Assignment | LT | | T | | | | LT | | LT | | TR | | | | LT | |
| Volume (V), veh/h | 0 | 201 | 530 | 51 | 0 | 32 | 210 | 75 | 0 | 66 | 278 | 124 | 0 | 145 | 141 | 103 |
| Percent Heavy Vehicles, % | 8 | 8 | 8 | 8 | 7 | 7 | 7 | 7 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 |
| Flow Rate ($v_{PCE}$), pc/h | 0 | 236 | 622 | 60 | 0 | 37 | 244 | 87 | 0 | 75 | 317 | 142 | 0 | 165 | 161 | 118 |
| Right-Turn Bypass | Yielding | | | | Yielding | | | | None | | | | Yielding | | | |
| Conflicting Lanes | 1 | | | | 2 | | | | 2 | | | | 1 | | | |
| Pedestrians Crossing, p/h | 0 | | | | 0 | | | | 0 | | | | 0 | | | |

## Critical and Follow-Up Headway Adjustment

| Approach | EB | | | WB | | | NB | | | SB | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Lane | Left | Right | Bypass | Left | Right | Bypass | Left | Right | Bypass | Left | Right | Bypass |
| Critical Headway (s) | 4.5436 | 4.5436 | 4.9763 | | 4.3276 | 4.3276 | 4.6453 | 4.3276 | | | 4.9763 | 4.9763 |
| Follow-Up Headway (s) | 2.5352 | 2.5352 | 2.6087 | | 2.5352 | 2.5352 | 2.6667 | 2.5352 | | | 2.6087 | 2.6087 |

## Flow Computations, Capacity and v/c Ratios

| Approach | EB | | | WB | | | NB | | | SB | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Lane | Left | Right | Bypass | Left | Right | Bypass | Left | Right | Bypass | Left | Right | Bypass |
| Entry Flow ($v_e$), pc/h | 403 | 455 | 60 | | 281 | 87 | 251 | 283 | | | 326 | 118 |
| Entry Volume veh/h | 373 | 421 | 56 | | 263 | 81 | 239 | 270 | | | 310 | 112 |
| Circulating Flow ($v_c$), pc/h | 363 | | | 628 | | | 1023 | | | 356 | | |
| Exiting Flow ($v_{ex}$), pc/h | 929 | | | 319 | | | 553 | | | 198 | | |
| Capacity ($c_{pce}$), pc/h | 1021 | 1021 | 1128 | | 833 | 887 | 527 | 595 | | | 960 | 997 |
| Capacity (c), veh/h | 945 | 945 | 1044 | | 778 | 829 | 502 | 567 | | | 914 | 949 |
| v/c Ratio (x) | 0.40 | 0.45 | 0.05 | | 0.34 | 0.10 | 0.48 | 0.48 | | | 0.34 | 0.12 |

## Delay and Level of Service

| Approach | EB | | | WB | | | NB | | | SB | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Lane | Left | Right | Bypass | Left | Right | Bypass | Left | Right | Bypass | Left | Right | Bypass |
| Lane Control Delay (d), s/veh | 8.3 | 9.1 | 3.9 | | 8.7 | 5.3 | 15.9 | 14.4 | | | 7.6 | 4.9 |
| Lane LOS | A | A | A | | A | A | C | B | | | A | A |
| 95% Queue, veh | 1.9 | 2.3 | 0.2 | | 1.5 | 0.3 | 2.5 | 2.5 | | | 1.5 | 0.4 |
| Approach Delay, s/veh | 8.4 | | | 7.9 | | | 15.1 | | | 6.9 | | |
| Approach LOS | A | | | A | | | C | | | A | | |
| Intersection Delay, s/veh \| LOS | 9.6 | | | | | | A | | | | | |

# HCS7 Roundabouts Report

| General Information | | Site Information | |
|---|---|---|---|
| Analyst | NRC | Intersection | IA 1 at US 30 |
| Agency or Co. | MSA | E/W Street Name | US 30 |
| Date Performed | 4/27/2018 | N/S Street Name | IA 1 |
| Analysis Year | 2018 | Analysis Time Period (hrs) | 0.25 |
| Time Analyzed | AM Peak | Peak Hour Factor | 0.92 |
| Project Description | | Jurisdiction | Mt Vernon, IA |

## Volume Adjustments and Site Characteristics

| Approach | EB | | | | WB | | | | NB | | | | SB | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Movement | U | L | T | R | U | L | T | R | U | L | T | R | U | L | T | R |
| Number of Lanes (N) | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 |
| Lane Assignment | | | LT | | | | LT | | | | LTR | | | | LT | |
| Volume (V), veh/h | 0 | 66 | 144 | 55 | 0 | 66 | 548 | 24 | 0 | 40 | 80 | 19 | 0 | 40 | 182 | 236 |
| Percent Heavy Vehicles, % | 8 | 8 | 8 | 8 | 9 | 9 | 9 | 9 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 |
| Flow Rate ($v_{PCE}$), pc/h | 0 | 77 | 169 | 65 | 0 | 78 | 649 | 28 | 0 | 47 | 94 | 22 | 0 | 47 | 214 | 277 |
| Right-Turn Bypass | Yielding | | | | Yielding | | | | None | | | | Yielding | | | |
| Conflicting Lanes | 1 | | | | 1 | | | | 1 | | | | 1 | | | |
| Pedestrians Crossing, p/h | 0 | | | | 0 | | | | 0 | | | | 0 | | | |

## Critical and Follow-Up Headway Adjustment

| Approach | EB | | | WB | | | NB | | | SB | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Lane | Left | Right | Bypass | Left | Right | Bypass | Left | Right | Bypass | Left | Right | Bypass |
| Critical Headway (s) | | 4.9763 | 4.9763 | | 4.9763 | 4.9763 | | 4.9763 | | | 4.9763 | 4.9763 |
| Follow-Up Headway (s) | | 2.6087 | 2.6087 | | 2.6087 | 2.6087 | | 2.6087 | | | 2.6087 | 2.6087 |

## Flow Computations, Capacity and v/c Ratios

| Approach | EB | | | WB | | | NB | | | SB | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Lane | Left | Right | Bypass | Left | Right | Bypass | Left | Right | Bypass | Left | Right | Bypass |
| Entry Flow ($v_e$), pc/h | | 246 | 65 | | 727 | 28 | | 163 | | | 261 | 277 |
| Entry Volume veh/h | | 228 | 60 | | 667 | 26 | | 151 | | | 242 | 256 |
| Circulating Flow ($v_c$), pc/h | 339 | | | 218 | | | 293 | | | 774 | | |
| Exiting Flow ($v_{ex}$), pc/h | 238 | | | 696 | | | 171 | | | 292 | | |
| Capacity ($c_{pce}$), pc/h | | 977 | 1025 | | 1105 | 1159 | | 1023 | | | 627 | 679 |
| Capacity (c), veh/h | | 904 | 949 | | 1014 | 1063 | | 948 | | | 580 | 628 |
| v/c Ratio (x) | | 0.25 | 0.06 | | 0.66 | 0.02 | | 0.16 | | | 0.42 | 0.41 |

## Delay and Level of Service

| Approach | EB | | | WB | | | NB | | | SB | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Lane | Left | Right | Bypass | Left | Right | Bypass | Left | Right | Bypass | Left | Right | Bypass |
| Lane Control Delay (d), s/veh | | 6.6 | 4.4 | | 13.4 | 3.6 | | 5.3 | | | 12.6 | 11.7 |
| Lane LOS | | A | A | | B | A | | A | | | B | B |
| 95% Queue, veh | | 1.0 | 0.2 | | 5.2 | 0.1 | | 0.6 | | | 2.0 | 2.0 |
| Approach Delay, s/veh | 6.1 | | | 13.0 | | | 5.3 | | | 12.1 | | |
| Approach LOS | A | | | B | | | A | | | B | | |
| Intersection Delay, s/veh \| LOS | 10.8 | | | | | | B | | | | | |

# HCS7 Roundabouts Report

| General Information | | Site Information | |
|---|---|---|---|
| Analyst | NRC | Intersection | IA 1 at US 30 |
| Agency or Co. | MSA | E/W Street Name | US 30 |
| Date Performed | 4/27/2018 | N/S Street Name | IA 1 |
| Analysis Year | 2018 | Analysis Time Period (hrs) | 0.25 |
| Time Analyzed | PM Peak | Peak Hour Factor | 0.92 |
| Project Description | | Jurisdiction | Mt Vernon, IA |

## Volume Adjustments and Site Characteristics

| Approach | EB | | | | WB | | | | NB | | | | SB | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Movement | U | L | T | R | U | L | T | R | U | L | T | R | U | L | T | R |
| Number of Lanes (N) | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 |
| Lane Assignment | | | LT | | | | LT | | | | LTR | | | | LT | |
| Volume (V), veh/h | 0 | 201 | 530 | 51 | 0 | 32 | 210 | 75 | 0 | 66 | 278 | 124 | 0 | 145 | 141 | 103 |
| Percent Heavy Vehicles, % | 8 | 8 | 8 | 8 | 7 | 7 | 7 | 7 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 |
| Flow Rate ($v_{PCE}$), pc/h | 0 | 236 | 622 | 60 | 0 | 37 | 244 | 87 | 0 | 75 | 317 | 142 | 0 | 165 | 161 | 118 |
| Right-Turn Bypass | Yielding | | | | Yielding | | | | None | | | | Yielding | | | |
| Conflicting Lanes | 1 | | | | 1 | | | | 1 | | | | 1 | | | |
| Pedestrians Crossing, p/h | 0 | | | | 0 | | | | 0 | | | | 0 | | | |

## Critical and Follow-Up Headway Adjustment

| Approach | EB | | | WB | | | NB | | | SB | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Lane | Left | Right | Bypass | Left | Right | Bypass | Left | Right | Bypass | Left | Right | Bypass |
| Critical Headway (s) | | 4.9763 | 4.9763 | | 4.9763 | 4.9763 | | 4.9763 | | | 4.9763 | 4.9763 |
| Follow-Up Headway (s) | | 2.6087 | 2.6087 | | 2.6087 | 2.6087 | | 2.6087 | | | 2.6087 | 2.6087 |

## Flow Computations, Capacity and v/c Ratios

| Approach | EB | | | WB | | | NB | | | SB | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Lane | Left | Right | Bypass | Left | Right | Bypass | Left | Right | Bypass | Left | Right | Bypass |
| Entry Flow ($v_e$), pc/h | | 858 | 60 | | 281 | 87 | | 534 | | | 326 | 118 |
| Entry Volume veh/h | | 794 | 56 | | 263 | 81 | | 509 | | | 310 | 112 |
| Circulating Flow ($v_c$), pc/h | 363 | | | 628 | | | 1023 | | | 356 | | |
| Exiting Flow ($v_{ex}$), pc/h | 929 | | | 319 | | | 553 | | | 198 | | |
| Capacity ($c_{pce}$), pc/h | | 953 | 1128 | | 727 | 785 | | 486 | | | 960 | 997 |
| Capacity (c), veh/h | | 882 | 1044 | | 680 | 734 | | 463 | | | 914 | 949 |
| v/c Ratio (x) | | 0.90 | 0.05 | | 0.39 | 0.11 | | 1.10 | | | 0.34 | 0.12 |

## Delay and Level of Service

| Approach | EB | | | WB | | | NB | | | SB | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Lane | Left | Right | Bypass | Left | Right | Bypass | Left | Right | Bypass | Left | Right | Bypass |
| Lane Control Delay (d), s/veh | | 32.6 | 3.9 | | 10.5 | 6.1 | | 100.8 | | | 7.6 | 4.9 |
| Lane LOS | | D | A | | B | A | | F | | | A | A |
| 95% Queue, veh | | 12.6 | 0.2 | | 1.8 | 0.4 | | 17.0 | | | 1.5 | 0.4 |
| Approach Delay, s/veh | 30.7 | | | 9.5 | | | 100.8 | | | 6.9 | | |
| Approach LOS | D | | | A | | | F | | | A | | |
| Intersection Delay, s/veh \| LOS | 39.3 | | | | | | E | | | | | |

# HCS7 Roundabouts Report

| General Information | | Site Information | |
|---|---|---|---|
| Analyst | NRC | Intersection | IA 1 at US 30 |
| Agency or Co. | MSA | E/W Street Name | US 30 |
| Date Performed | 4/27/2018 | N/S Street Name | IA 1 |
| Analysis Year | 2040 | Analysis Time Period (hrs) | 0.25 |
| Time Analyzed | AM Peak | Peak Hour Factor | 0.92 |
| Project Description | | Jurisdiction | Mt Vernon, IA |

## Volume Adjustments and Site Characteristics

| Approach | EB | | | | WB | | | | NB | | | | SB | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Movement | U | L | T | R | U | L | T | R | U | L | T | R | U | L | T | R |
| Number of Lanes (N) | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 |
| Lane Assignment | | | LT | | | | LT | | | | LTR | | | | LT | |
| Volume (V), veh/h | 0 | 4 | 32 | 4 | 0 | 115 | 118 | 5 | 0 | 3 | 232 | 32 | 0 | 9 | 631 | 17 |
| Percent Heavy Vehicles, % | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 |
| Flow Rate ($v_{PCE}$), pc/h | 0 | 5 | 37 | 5 | 0 | 131 | 135 | 6 | 0 | 3 | 265 | 37 | 0 | 10 | 720 | 19 |
| Right-Turn Bypass | Yielding | | | | Yielding | | | | None | | | | Yielding | | | |
| Conflicting Lanes | 1 | | | | 1 | | | | 1 | | | | 1 | | | |
| Pedestrians Crossing, p/h | 0 | | | | 0 | | | | 0 | | | | 0 | | | |

## Critical and Follow-Up Headway Adjustment

| Approach | EB | | | WB | | | NB | | | SB | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Lane | Left | Right | Bypass | Left | Right | Bypass | Left | Right | Bypass | Left | Right | Bypass |
| Critical Headway (s) | | 4.9763 | 4.9763 | | 4.9763 | 4.9763 | | 4.9763 | | | 4.9763 | 4.9763 |
| Follow-Up Headway (s) | | 2.6087 | 2.6087 | | 2.6087 | 2.6087 | | 2.6087 | | | 2.6087 | 2.6087 |

## Flow Computations, Capacity and v/c Ratios

| Approach | EB | | | WB | | | NB | | | SB | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Lane | Left | Right | Bypass | Left | Right | Bypass | Left | Right | Bypass | Left | Right | Bypass |
| Entry Flow ($v_e$), pc/h | | 42 | 5 | | 266 | 6 | | 305 | | | 730 | 19 |
| Entry Volume veh/h | | 40 | 5 | | 253 | 6 | | 290 | | | 695 | 18 |
| Circulating Flow ($v_c$), pc/h | 861 | | | 273 | | | 52 | | | 269 | | |
| Exiting Flow ($v_{ex}$), pc/h | 84 | | | 138 | | | 270 | | | 851 | | |
| Capacity ($c_{pce}$), pc/h | | 573 | 579 | | 1045 | 1048 | | 1309 | | | 1049 | 1199 |
| Capacity (c), veh/h | | 546 | 552 | | 995 | 998 | | 1246 | | | 999 | 1142 |
| v/c Ratio (x) | | 0.07 | 0.01 | | 0.25 | 0.01 | | 0.23 | | | 0.70 | 0.02 |

## Delay and Level of Service

| Approach | EB | | | WB | | | NB | | | SB | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Lane | Left | Right | Bypass | Left | Right | Bypass | Left | Right | Bypass | Left | Right | Bypass |
| Lane Control Delay (d), s/veh | | 7.5 | 6.6 | | 6.1 | 3.7 | | 4.9 | | | 14.9 | 3.3 |
| Lane LOS | | A | A | | A | A | | A | | | B | A |
| 95% Queue, veh | | 0.2 | 0.0 | | 1.0 | 0.0 | | 0.9 | | | 5.9 | 0.0 |
| Approach Delay, s/veh | 7.4 | | | 6.1 | | | 4.9 | | | 14.6 | | |
| Approach LOS | A | | | A | | | A | | | B | | |
| Intersection Delay, s/veh \| LOS | 10.5 | | | | | | B | | | | | |

 HCS7™ Roundabouts Version 7.5 Generated: 5/21/2018 10:53:11 AM

Single Lane 2040 AM Peak Future Analysis.xro

# HCS7 Roundabouts Report

## General Information

| | |
|---|---|
| Analyst | NRC |
| Agency or Co. | MSA |
| Date Performed | 4/27/2018 |
| Analysis Year | 2040 |
| Time Analyzed | PM Peak |
| Project Description | |

## Site Information

| | |
|---|---|
| Intersection | IA 1 at US 30 |
| E/W Street Name | US 30 |
| N/S Street Name | IA 1 |
| Analysis Time Period (hrs) | 0.25 |
| Peak Hour Factor | 0.92 |
| Jurisdiction | Mt Vernon, IA |

## Volume Adjustments and Site Characteristics

| Approach | EB | | | | WB | | | | NB | | | | SB | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Movement | U | L | T | R | U | L | T | R | U | L | T | R | U | L | T | R |
| Number of Lanes (N) | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 |
| Lane Assignment | | | LT | | | | LT | | | | LTR | | | | LT | |
| Volume (V), veh/h | 0 | 14 | 114 | 3 | 0 | 53 | 46 | 16 | 0 | 4 | 764 | 130 | 0 | 31 | 520 | 8 |
| Percent Heavy Vehicles, % | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 |
| Flow Rate ($v_{PCE}$), pc/h | 0 | 16 | 130 | 3 | 0 | 60 | 52 | 18 | 0 | 5 | 872 | 148 | 0 | 35 | 593 | 9 |
| Right-Turn Bypass | Yielding | | | | Yielding | | | | None | | | | Yielding | | | |
| Conflicting Lanes | 1 | | | | 1 | | | | 1 | | | | 1 | | | |
| Pedestrians Crossing, p/h | 0 | | | | 0 | | | | 0 | | | | 0 | | | |

## Critical and Follow-Up Headway Adjustment

| Approach | EB | | | WB | | | NB | | | SB | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Lane | Left | Right | Bypass | Left | Right | Bypass | Left | Right | Bypass | Left | Right | Bypass |
| Critical Headway (s) | | 4.9763 | 4.9763 | | 4.9763 | 4.9763 | | 4.9763 | | | 4.9763 | 4.9763 |
| Follow-Up Headway (s) | | 2.6087 | 2.6087 | | 2.6087 | 2.6087 | | 2.6087 | | | 2.6087 | 2.6087 |

## Flow Computations, Capacity and v/c Ratios

| Approach | EB | | | WB | | | NB | | | SB | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Lane | Left | Right | Bypass | Left | Right | Bypass | Left | Right | Bypass | Left | Right | Bypass |
| Entry Flow ($v_e$), pc/h | | 146 | 3 | | 112 | 18 | | 1025 | | | 628 | 9 |
| Entry Volume veh/h | | 139 | 3 | | 107 | 17 | | 976 | | | 598 | 9 |
| Circulating Flow ($v_c$), pc/h | 688 | | | 893 | | | 181 | | | 117 | | |
| Exiting Flow ($v_{ex}$), pc/h | 313 | | | 57 | | | 888 | | | 653 | | |
| Capacity ($c_{pce}$), pc/h | | 684 | 709 | | 555 | 558 | | 1147 | | | 1225 | 1302 |
| Capacity (c), veh/h | | 652 | 675 | | 529 | 531 | | 1093 | | | 1166 | 1240 |
| v/c Ratio (x) | | 0.21 | 0.00 | | 0.20 | 0.03 | | 0.89 | | | 0.51 | 0.01 |

## Delay and Level of Service

| Approach | EB | | | WB | | | NB | | | SB | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Lane | Left | Right | Bypass | Left | Right | Bypass | Left | Right | Bypass | Left | Right | Bypass |
| Lane Control Delay (d), s/veh | | 8.1 | 5.4 | | 9.5 | 7.2 | | 27.4 | | | 8.9 | 3.0 |
| Lane LOS | | A | A | | A | A | | D | | | A | A |
| 95% Queue, veh | | 0.8 | 0.0 | | 0.7 | 0.1 | | 13.2 | | | 3.0 | 0.0 |
| Approach Delay, s/veh | 8.0 | | | 9.2 | | | 27.4 | | | 8.8 | | |
| Approach LOS | A | | | A | | | D | | | A | | |
| Intersection Delay, s/veh \| LOS | 18.6 | | | | | | C | | | | | |

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Single Lane 2040 PM Peak Future Analysis.xro

# APPENDIX B – Colored Pavement Markings Product Sheets

# Color - Safe™

## Color Pavement Marking with Anti-Skid Surface


TRAN SAFE
Transportation Safety Products

# Color - Safe™

**INCREASED SAFETY WITH COLOR PAVEMENT MARKINGS**

Cities and municipalities throughout the world are looking for long-term solutions to color pavement markings. Color pavement markings increase safety by alerting motor vehicle operators of special use lanes and increasing visibility in all transportation modals.

**Paint and epoxies do not have the bright color or durability needed and thermoplastic is expensive......... COLOR - SAFE™ IS THE SOLUTION**

Color-Safe™ is an acrylic-based material with great adhesion to concrete and asphalt surfaces. It is available in a variety of high-definition colors and aggregate sizes; has excellent color retention; glass beads can be added for increased retro-reflectivity, and its fast cure time allows the surface to be opened to traffic in as little as one hour. Applications are capable of obtaining full cure in a wide range of temperatures and no special equipment is needed.

## FEATURES AND ADVANTAGES

- **Variety of Colors and Aggregate Sizes**
- **Durable Skid-Resistant Surface**
- **Alerts Drivers to Special-Use Traffic Lanes**
- **Excellent Color Retention**
- **Easy Application & Fast Cure**
- **Low Life Cycle Cost**
- **Strong Adhesion to Concrete & Asphalt Surfaces**
- **Enhances Traffic Calming**

## Color - Safe™
## Durable, High-Definition Color is your solution to creating and maintaining color pavements.

## USES

- BICYCLE PATHS
- BUS LANES
- CROSSWALKS
- PEDESTRIAN PLAZAS
- AIRFIELD MARKING
- SCHOOL ZONES
- TOLL LANES
- SPEED ZONES
- HAZARDOUS ROAD AREAS
- AIRFIELD MARKINGS
- UNIVERSITIES
- HOSPITALS

## PHYSICAL PROPERTIES

| Properties | Unit of Measure | Test |
|---|---|---|
| **Neat Resin** | | |
| Elongation | 70% | ASTM D638 |
| Hardness | 15-20 shore D | ASTM D2240 |
| Water Absorption | <0.25% | ASTM D570 |
| Pot Life@72D F(22C) | 15 Minutes | AASHTO T237 |
| Solids Content | 100% | ASTM D1844 |

1625 Spectrum Drive, Suite 100 / Lawrenceville, GA 30043
800.969.5103 / 770.962.2222 / Fax: 770.513.8881

# Color-Safe™

# CROSSWALK SAFETY

[ PHOTO © Transpo Industries ]

## Sharing the road with Pedestrians

Transportation authorities around the world have recently been placing a greater emphasis on improving pedestrian safety and are finding MMA acrylic resin based road markings to be an ideal solution, creating visual awareness for all road users. In recent years the number of Americans who use walking as a regular mode of travel has risen to over 107 million. Without counting recreational trips, walking makes up roughly 10.9% of the total 388 billion trips taken by Americans each year. This rising trend makes it important to focus on the safety of the facilities available for pedestrians nationwide. Known for their high durability, increased wet-night visibility, skid resistance and optimal color stability, contrast area markings are increasingly being used to apply bright crosswalks to high traffic areas. These markings not only offer increased safety to pedestrians, but also provide local authorities with a cost-efficient alternative to other road marking systems in the industry. Due to their high durability, road markings based on MMA acrylic resin cost less in maintenance and material costs over the extended lifecycle of the markings. In this newsletter, you will learn how the Colorado Department of Transportation is saving the lives of their pedestrians through a network of highly visible crosswalks using the MMA acrylic resin Color-Safe™ pavement marking and anti-skid surface.

1625 Spectrum Drive, Suite 100 Lawrenceville, GA 30043 / 770-962-2222

# Color-Safe™

## Bright markings getting the attention of drivers

[ PHOTO © Transpo Industries ]

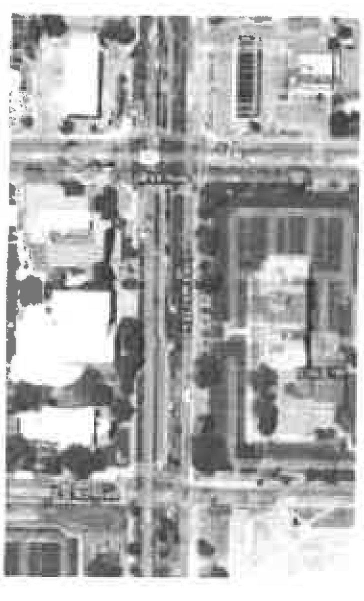
Color-Safe™ area markings were recently applied at three intersections along one of the busiest roads in Colorado to increase pedestrian safety. The color stability of the area markings and the retained retro reflectivity of the accent stripes are getting the attention of drivers passing by and are expected to reduce the number of pedestrian vs. vehicle accidents at these locations.

The Colorado Department of Transportation (CDOT) installed, Color-Safe™ bright red crosswalks this past summer at three major intersections in the Denver Metro Area (Colorado Boulevard & East Colfax Avenue, East 14th Avenue, and East Montview Boulevard). These red crosswalks and white accent stripes cover an area of 4,750 ft2 (441.2 m2), with the largest of the three crosswalks spanning six lanes of traffic.

In 2008, similar markings were applied to the intersection of Colorado Boulevard and Louisiana Avenue. Based on the reduction of crashes documented at these crosswalks, CDOT saw an opportunity to evaluate how a more durable area marking would perform at other intersections with high crash statistics. Having had experience using MMA acrylic resin road marking for various other applications and impressed with the thin millage at which the MMA acrylic resin area markings could be applied, CDOT determined this system would be the most beneficial system for the three additional crosswalks along Colorado Boulevard. "The new friction-grip material is more for durability," said Bryan Allery, CDOT Traffic Engineer, PE II. "We want that to stand out and to last longer."

CDOT has stated that the newly applied bright red crosswalks are getting the attention of drivers. They have received many calls commenting on the brightness of the markings, to which CDOT replied "We are glad you noticed. It's supposed to get your attention." The awareness generated by these crosswalks has led to a decrease in pedestrian vs. vehicle accidents since the first installation in 2008. "It's certainly not going to solve all the problems," Bryan Allery stated. "It does draw attention to motorists as they are approaching these crosswalks, and it's also proven through Colorado Boulevard and Louisiana Avenue that they are helping."

## Saving lives one crosswalk at a time



The number of pedestrian vs. vehicle crashes have been documented by CDOT over the years and a decrease has been seen since the installation of bright red crosswalks at the various intersections in Colorado. Prior to 2008, when the red crosswalks were initially installed at the intersection of Colorado Boulevard and Louisiana Avenue, there was an average of two people struck each year by oncoming vehicles, with one year having five people struck. Since installed, the red crosswalks have alerted drivers and, as a result, there has only been three people hit within the past three years. Although more years of post-installation data is needed, CDOT is optimistic that the use of these area markings for visual awareness will continue to increase safety.

At the intersection of Colorado Boulevard and East Colfax Avenue, where Color-Safe™ was recently applied, there have been five people hit while crossing the road within the last three years. CDOT foresees that the newly applied crosswalks will have the same effect seen at the intersection of Colorado Boulevard and Louisiana Avenue. In addition to the interest generated by pedestrians and motorists traveling through these intersections, the red crosswalks based on wet-night visibility, skid resistance and optimal color sparked local news coverage in the months following their application. Highlighting the brightness and safety aspects of these markings, various local news stations recognized CDOT for their dedication to improving the safety of all road users at intersections in Denver.

TRAN SAFE
Transportation Safety Products

**Transpo Industries, Inc.** manufactures a variety of innovative products and materials designed for improving road safety and bridge preservation. The company's reputation as an expert in rehabilitation preservation and safety products has made Transpo a leading supplier since 1968.

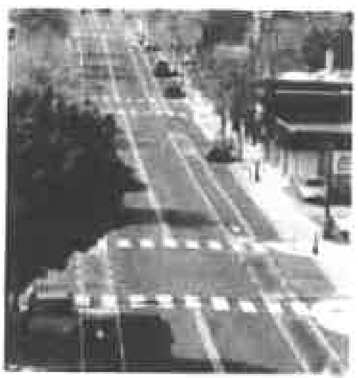
www.transafeproducts.com

# Color-Safe®
## PAVEMENT MARKING

### Durable and High Definition Color

**Color-Safe® is a Methyl Methacrylate (MMA) based material used for color pavement marking.**

**Color-Safe® is typically used for demarcation of bike lanes, pedestrian areas, bus lanes and other specially designated areas. A variety of supplied aggregates will create appropriate skid resistance for the application, vehicular traffic and specification requirements.**



**Color-Safe® can be applied by hand with squeegees and rollers or with automatic spray equipment and cures without requiring external heat sources.**

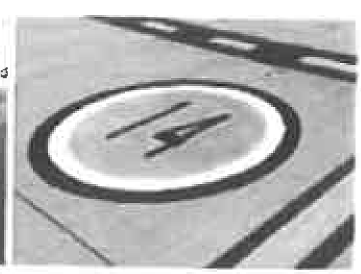
**Color-Safe® is capable of full cure in a wide range of temperatures allowing for a longer marking season.**

**PHYSICAL PROPERTIES***

| Properties | Unit of Measure | Test |
|---|---|---|
| | Neat Resin | |
| Tensile Strength | 500-1000 psi (3.4-6.9 MPa) | ASTM D638 Type I |
| Elongation | >30% | ASTM D638 Type I |
| Hardness | 55-60 Shore D | ASTM D2240 |
| Water Absorption | <0.25% | ASTM D570 |
| Pot Life @72°F (22°C) | 15 Minutes | AASHTO T237 |
| Solids Content | 100% | ASTM D1644 |
| | Aggregate | |
| Hardness | 7.0 | Mohs Scale |

***To be used as general guidelines only**

Color-Safe® enhances your safety program with high visibility color and increased service life.



**SAFER TRANSPORTATION THROUGH INNOVATION**
1625 Spectrum Drive, Suite 100 / Lawrenceville, GA 30043 / 800 969 5103

# Color-Safe®
## PAVEMENT MARKING

### Features and Advantages
- Excellent Color Retention and Durability
- High Visibility Color Increases Motorist Awareness
- Available in a Variety of Colors and Aggregate Sizes
- Easy Application
- Fast Cure Time (30 min at 70° F)
- Wide Application Temperature Range (40°-100° F)
- Low Life Cycle Cost
- Ability to Adhere to Both Concrete and Asphalt Surfaces

### Application Process
Surfaces receiving Color-Safe® must be thoroughly cleaned and free of all dirt. Contaminates that might interfere with the proper adhesion of the material must be removed by sand blasting or shot blasting.

Color-Safe® is made up of resin, powder hardener and aggregate. These components must be mixed thoroughly for uniform curing and performance.

Color-Safe® is applied by either the mixed resin and aggregate method or the spray/broadcast aggregate method. Refer to the technical data sheet for application details.

**No special equipment is required for installation.**

### Applications
Transpo's Color-Safe® can be used as an anti-skid surface and/or for demarcation.

- Bike Lanes and Bike Boxes
- Pedestrian Refuge and Plaza
- Toll Lanes
- Bus Lanes
- Airfields
- Crosswalks
- Roundabouts
- High Friction Surface Treatments

### Standard and Custom Colors
Transpo's Color-Safe® has many standard color options as well as custom colors available upon request.

- Bike Lane Green
- Bus Lane Red
- Buff
- Traffic Yellow
- White
- Black
- Pink
- Handicap Blue
- Orange
- Red

TRAN SAFE
Transportation Safety Products

Need More Information?

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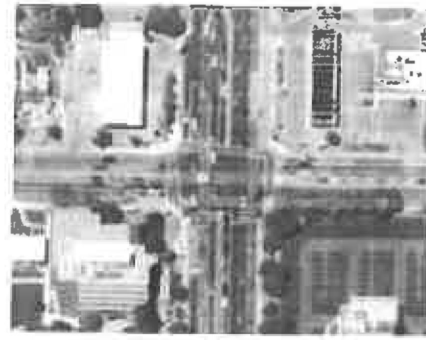
SYRACUSE, NY

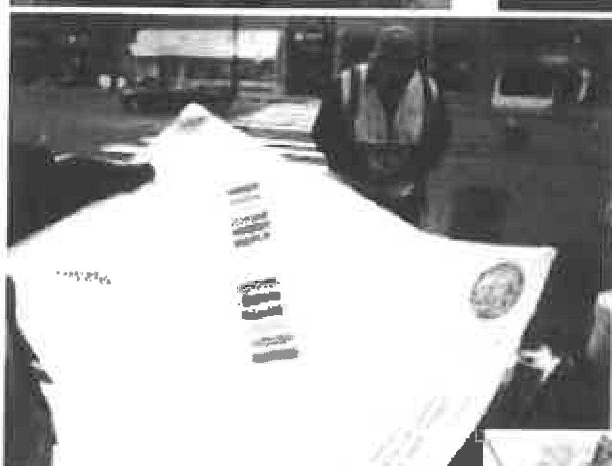
Color-Safe


Color-Safe

16 lanes - BEFORE Color-Safe

16 lanes - AFTER Color-Safe





**STANDARD COLORS AND CUSTOM COLORS!**

TRAN SAFE
transportation Safety Products

# Color-Safe®
# Methyl Methacrylate (MMA) Resin System

## Why Choose Color-Safe® MMA over Thermoplastic?

### COMPARISON

**Color-Safe® MMA**
**vs.**
**Hot applied Thermoplastic**

| | COLOR-SAFE® MMA | Applied Thermoplastic |
|---|---|---|
| Adhesion to Concrete | EXCELLENT | Poor |
| Life Cycle | 6 - 10 YEARS | 3 - 5 Years |
| Refresh or Removal | REFRESH | Full Removal |
| UV Stable | YES | No |
| Cure Time | 20 - 40 MIN. | Wait for Cooling |
| Adhesion to Self | YES | No |
| Working Hazards | NONE | Potential Burns |
| Specialized Equipment Needed | NO | Yes |

Call today to find out how cost effective Color-Safe® MMA can be.

**TRANSAFE, INC**
**1625 Spectrum Drive, Suite 100**
**Lawrenceville, GA 30043**
**770.962.2222 / 800.969.5103**

# Technical Data Sheet

## COLOR-SAFE® Color Pavement Marking and Anti-Skid Surfacing

Color-Safe® is a Methyl Methacrylate (MMA) resin system used for pavement area markings and anti-skid surfacing. It is a plural component, liquid applied MMA and catalyst, capable of full cure in a wide range of temperatures without requiring external heat sources. Color-Safe® is typically used for demarcation of crosswalks, bicycle paths, bus lanes and other specially designated areas. It can also be used as a surface to enhance skid resistance on hazardous turns and other areas prone to accidents. It can be applied to either concrete or asphalt using two different methods: mixed resin/aggregate method or spray/broadcast aggregate method. Resin formulations are available in 98:2 and 1:1 ratios to accommodate different types of application equipment. If using glass beads, they must be coated for use with MMA materials.

**Application Procedure**

Surface Preparation: All surfaces that are to receive Color-Safe® must be thoroughly clean, dry, and free of all dirt, grease, and other contaminates that might interfere with proper adhesion. Clean the pavement surface using high sand blasting or shot blasting. All damaged or deteriorated surfaces must be repaired before applying Color-Safe®. The surface should be visibly dry and the moisture content should be tested according to ASTM D4263 (modified to 2 hours). New asphalt shall have been placed for a minimum of 30 days prior to installation of Color-Safe® and surface oils should not be present. The temperature of the pavement and air should be between 40°F-100°F and 5°F above the Dew Point temperature. Relative humidity should be 75% RH maximum. For colder or warmer application temperatures contact a Transpo representative for recommendations on hardener mix ratios.

### Mixed Resin and Aggregate Application Method

**Mixing and Application**

Primer Application [For Concrete Applications ONLY]:
All areas to be coated with Color-Safe® should be masked prior to application. Mix the un-pigmented Color-Safe® primer and hardener (refer to Table 1 for appropriate hardener quantities) for approximately 30 seconds and apply it to the surface that will receive the Color-Safe®. Primer can be applied using 1/4" nap rollers. Application rate should be approximately 80 square feet per gallon however coverage on rough or porous surfaces will be less. After the primer is applied and before it cures, remove all masking.

Mixing: Transpo Color-Safe® resin comes in three components (Color-Safe® pigmented resin, powder hardener, and supplied pre-packaged aggregate). Thorough and complete mixing of these components with a drill mounted paddle mixer is vital for uniform curing and performance. Air/substrate temperature determines the amount of hardener used; refer to Table 1 for the appropriate amount of hardener to be added to the Color-Safe® resin. Using clean, dry plastic buckets, add hardener to Color-Safe® resin and mix until dissolved (approximately 30 seconds) and then add and thoroughly mix the pre-packaged aggregate. After mixing, the Color-Safe® must be applied to the pavement immediately.

**Table 1: Hardener per 2 Gallons of Color-Safe® Primer or Resin**

| Temp °F(°C) | Weight % | Grams | Packets (120 g each) |
|---|---|---|---|
| 40-59 (0-15) | 3 | 360 | 3 |
| 60-89 (15-32) | 2 | 240 | 2 |
| 90-100 (32-38) | 1 | 120 | 1 |

Resin/Aggregate Application: Before mixing and applying the Color-Safe®/Aggregate apply the masking to the area to be coated. Pour the mixed material onto the pavement surface and spread evenly with 3/16" notched squeegees at a rate of approximately 24 square feet per gallon. The surface can be back rolled with 1/4" nap rollers to give a uniform even finish. After the application and before the material cures, remove the masking. At the onset of rain, installation shall cease until the substrate is sufficiently dry to the satisfaction of the engineer. Application of markings** must be completed before contamination of the substrate occurs.

**Before applying any line striping or symbols; confirm compatibility of materials with manufacturer**
Color-Safe® may be used for application of line striping and symbols

### Spray/Broadcast Aggregate Application Method

**Mixing and Application**

It is important to use the resin formulation that matches the mixing ratio of the equipment that will be used for the application.

Spray applications using a 98:2 formulation with equipment that does not automatically proportion the hardener requires the resin and hardener to be premixed. It is very important that small quantities be mixed as the time available to spray the material is limited and further reduced by high ambient temperatures. The Color-Safe® resin and the powder hardener should be mixed for 30 seconds before adding to the spray equipment. Refer to Table 2 for hardener mixing ratios. If there is an interruption in the spray application the equipment should be cleaned with solvent to prevent material from curing and creating clogging.

Spray applications using a 98:2 formulation with equipment that automatically adds proportioned hardener does not require premixing. The Color-Safe® resin is the same for all 98:2 applications however for this type of equipment the hardener will be a liquid. Random checks should be performed to make sure the hardener ratio is consistent. Application interruptions do not require the equipment to be cleaned prior to the resumption of application.

Spray applications using a 1:1 formulation with equipment that mixes equal parts of resin with hardener prior to the spray head require resin different than 98:2 material. Color-Safe® part A resin will be added to the equipment without any hardener added. Color-Safe® part B is a completely different resin and the powder hardener is to be added to this resin and mixed for 30 seconds prior to adding to the equipment. Refer to Table 3 for the hardener mixing ratios. Applications do not require the equipment to be cleaned prior to the resumption of application.

Primer Application [For Concrete Applications ONLY]:
All areas to be coated with Color-Safe® should be masked prior to application. Refer to Tables 2 and 3 for the appropriate hardener/primer mixing ratios. Application rate should be approximately 80 square feet per gallon however coverage on rough or porous surfaces will be less. After the primer is applied and before it cures, remove all masking. Immediately after primer application, broadcast the supplied aggregate onto the surface at a rate of ½ pound per square foot. After the aggregate is applied and before the material cures, remove all masking

Base Coat/Aggregate Application [For Asphalt Applications ONLY]: All areas to be coated with Color-Safe® should be masked prior to application. Note that the Color-Safe® resin and hardener are identical for both pigmented base coat and pigmented top coat applications. Refer to Hardener Mix Ratio Tables for the appropriate hardener/resin mixing ratios. Base coat application rate should be approximately 60 square feet per gallon however coverage on rough or porous surfaces will be less. Under compacted asphalt will absorb the base coat and coverage could be 40 square feet per gallon or less. Immediately after base coat application, broadcast the supplied aggregate onto the surface at a rate of ½ pound per square foot, assuring all coated areas are covered with aggregate. After the Base Coat/Aggregate is applied and before it cures remove all masking.

Top Coat Application: Before applying the Color-Safe® top coat remove all un-bonded aggregate from the primed surface using brooms or dry compressed air. Reapply the masking in the area to be coated. Make sure that all of the broadcast aggregate is covered with the Color-Safe® resin top coat; application rate should be approximately 40 square feet per gallon. The surface can be back rolled with ¼" nap rollers to give a uniform even finish. After the Color-Safe® is applied and before it cures, remove all masking. At the onset of rain, installation shall cease until the substrate is sufficiently dry to the satisfaction of the engineer. Application of markings** must be completed before contamination of the substrate occurs.

**Before applying any line striping or symbols; confirm compatibility of materials with manufacturer**
Color-Safe® may be used for application of line striping and symbols

**Table 2: Hardener per Gallon of Color-Safe® Primer and Resin**
**(98:2 spray equipment without automatic proportioning)**

| Temp °F(°C) | Weight % | Grams | 30 g Packets |
|---|---|---|---|
| 40-59 (4-15) | 4-3 | 240-180 | 8-6 |
| 60-89 (15-32) | 2-1 | 120-60 | 4-2 |
| 90-100 (32-38) | 1-.5 | 60-30 | 2-1 |

**Table 3: Hardener per Gallon of Color-Safe® Primer and Resin**
**(1:1 spray equipment)**

| Temp °F(°C) | Weight % | Grams | 120 g Packets |
|---|---|---|---|
| 40-59 (4-15) | 8-6 | 480-360 | 4-3 |
| 60-89 (15-32) | 6-4 | 360-240 | 3-2 |
| 90-100 (32-38) | 2 | 120 | 1 |

**Table 4: Physical Properties* of Color-Safe®**

| Property | Unit of Measure | Test |
|---|---|---|
| Resin | | |
| Elongation | 30% min | ASTM D638 Type I |
| Hardness | 55-60 Shore D | ASTM D2240 |
| Water Absorption | 0.25% max | ASTM D570 |
| Pot Life | 15 minutes @ 72°F (22°C) | AASHTO T237 |
| Flash Point | 50°F (10°C) | ASTM D1310 |
| Solids Content | 99% | ASTM D1644 |
| Aggregate | | |
| Specific Gravity | 2.65 | ASTM C128 |
| Hardness | 7.0 | Mohs Scale |

*To be used as general guidelines only

**Storage**

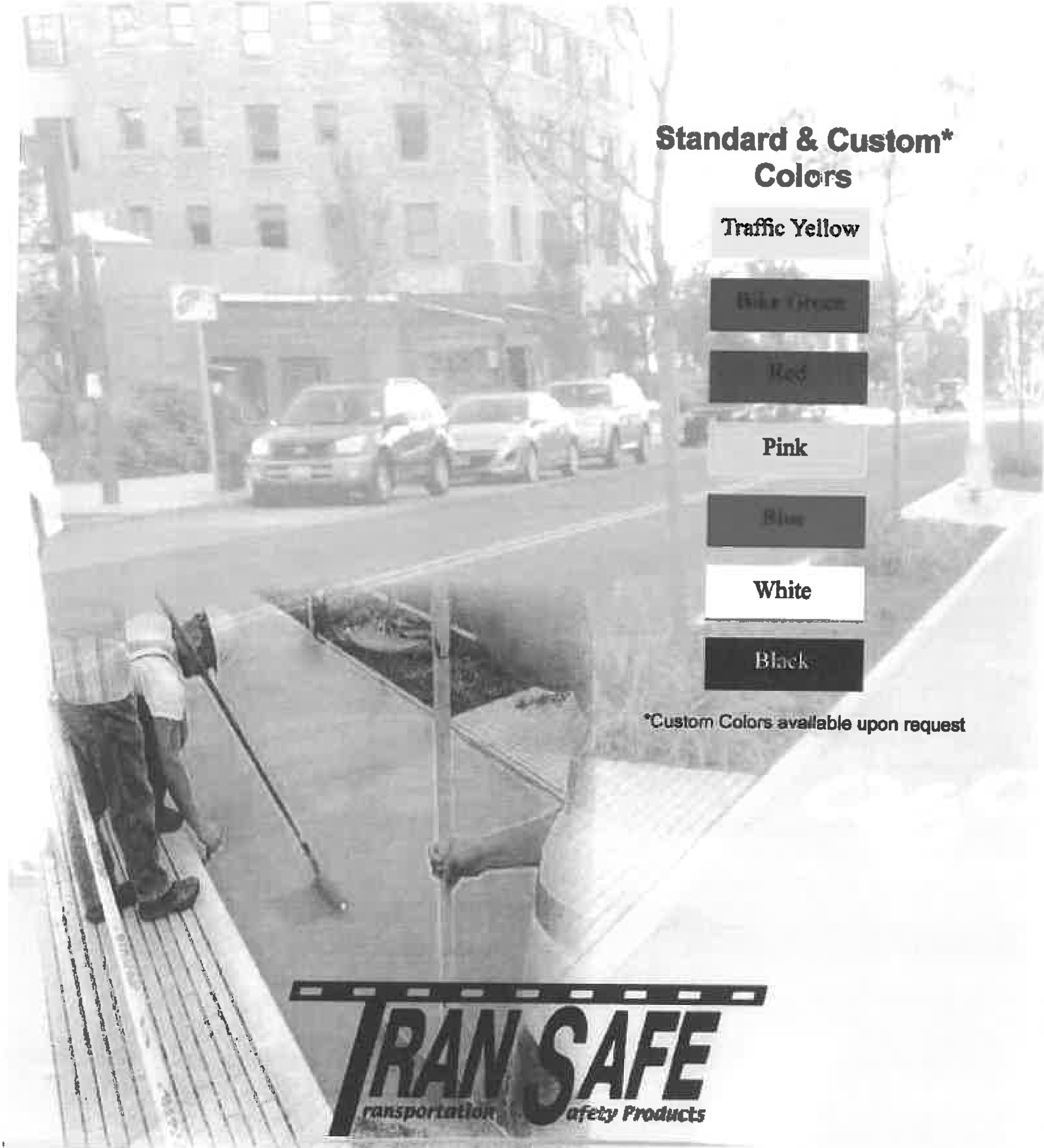
Materials shall be kept in dry protected areas between 40°F – 80°F out of direct sunlight, protected from open flame. Hardener component shall be stored separately from other materials. Manufacturer's specific label instructions and prudent safety practices for storage and handling shall be followed at all times. Materials shall be suitable for use for six months after the date of receipt when stored in accordance with the manufacturer's instructions.

**Caution**

The binder shall be 100% reactive, solvent-free, acrylic vehicle. Blends with other resins or liquid vehicles shall not be permitted. Coarse aggregate shall be part of the formulation to provide for skid resistance.

**Warranty**

The following warranty is made in lieu of all other warranties, either expressed or implied. This product is manufactured of select raw materials by skilled technicians. Neither seller nor manufacturer has any knowledge or control concerning the purchaser's use of the product and no warranty is made as to the result of any use. The only obligation of either seller or manufacturer shall be to replace any quantity of this product that proves to be defective. Neither seller nor manufacturer assumes any liability for injury, loss, or damage resulting from use of this product.



## Standard & Custom* Colors

- Traffic Yellow
- Bike Green
- Red
- Pink
- Blue
- White
- Black

*Custom Colors available upon request

TRANSAFE
Transportation Safety Products

1625 Spectrum Drive, Suite 100
Lawrenceville, GA 30043
770-962-2222 / 800-969-5103
www.transafeproducts.com

# MMAX Area Markings

## Specialized Lane delineation

# PRODUCT DATA

Product Type: MMA Area Markings with Anti-Skid
Product Code: 999660TC-KIT
Product Color: Terra Cotta
Effective Date: September 2014

**Product Description:**
MMAX Area Marking products conveniently combine state-of-the-art Methyl Methacrylate resins with hardwearing aggregate and premium pigments to deliver an extremely durable, highly visible and color stable lane delineation treatment that meets the non-slip requirements needed for pedestrians, cyclists and vehicles.

Terra Cotta colored MMAX Area Markings can be used to delineate bus lanes, or other specialty applications, where a durable area marking is required.

**Product Advantages:**
- Kitted for consistent on-site mixing and convenience
- Very Durable
- Color stable
- Fast back to traffic
- Non-slip surface
- Easy to apply
- Can be inlaid
- 100% solids

**Packaging:**
Each MMAX area marking kit mixes to approximately 2.79 gallons and covers approximately 45-50 sq. ft. @ 90 mils build thickness.

One Kit includes:
- MMAX Resin(Pre-pigmented) : 2 gallons / 7.57 liters
    - *Supplied in 5 gallon pail for easy mixing*
- MMAX Aggregate: 1 – 25.0 lbs / 11.34 kg bag
- Catalyst*: 8 fl. oz. / 236 ml (.52 lbs / 0.24 g)

**Storage:**
Keep Cool. Keep in dry protected areas between 40°F – 80°F, out of direct sunlight and protected from open flame. Use within six months of receipt.

| **Product Characteristics** | | **Test** |
|---|---|---|
| **Binder Resin** | | |
| Density | 8.1 +/- 35 | Lbs/Gal |
| Tensile | > 400 psi | ASTM D638 |
| Elongation | > 180% | ASTM D638 |
| Flash Point | > 10°C | ASTM D1310 |
| **Aggregate** | | |
| Hardness | 9 | Mohs Scale |
| **Preferential Lane Treatment** | | |
| Density | 18.5 +/- 0.5 | Lbs/Gal |
| Build Thickness | 90 +/- 10 | Mils |
| VOC | < 100 | Grams/Liter |
| Pot Life | ~15min | AASHTO T237 |
| Solids | > 99% (cured) | ASTM D2369 |
| Skid | > 60 | ASTM E303 |
| Hardness | 50-60 | ASTM D2240 |
| Water Absorption | < 0.25% | ASTM D570 |
| Cure Time | < 30 | Minutes |

**Other:**
*Amount of catalyst used is dependent on ambient and road temperatures. Each kit is supplied with the maximum amount of catalyst that would be required. Refer to Application Instructions.



ENNIS-FLINT
A Traffic Safety Solutions Company
800.331.8118 sales@ennisflint.com www.ennisflint.com

# APPENDIX C – Educational Brochure Examples

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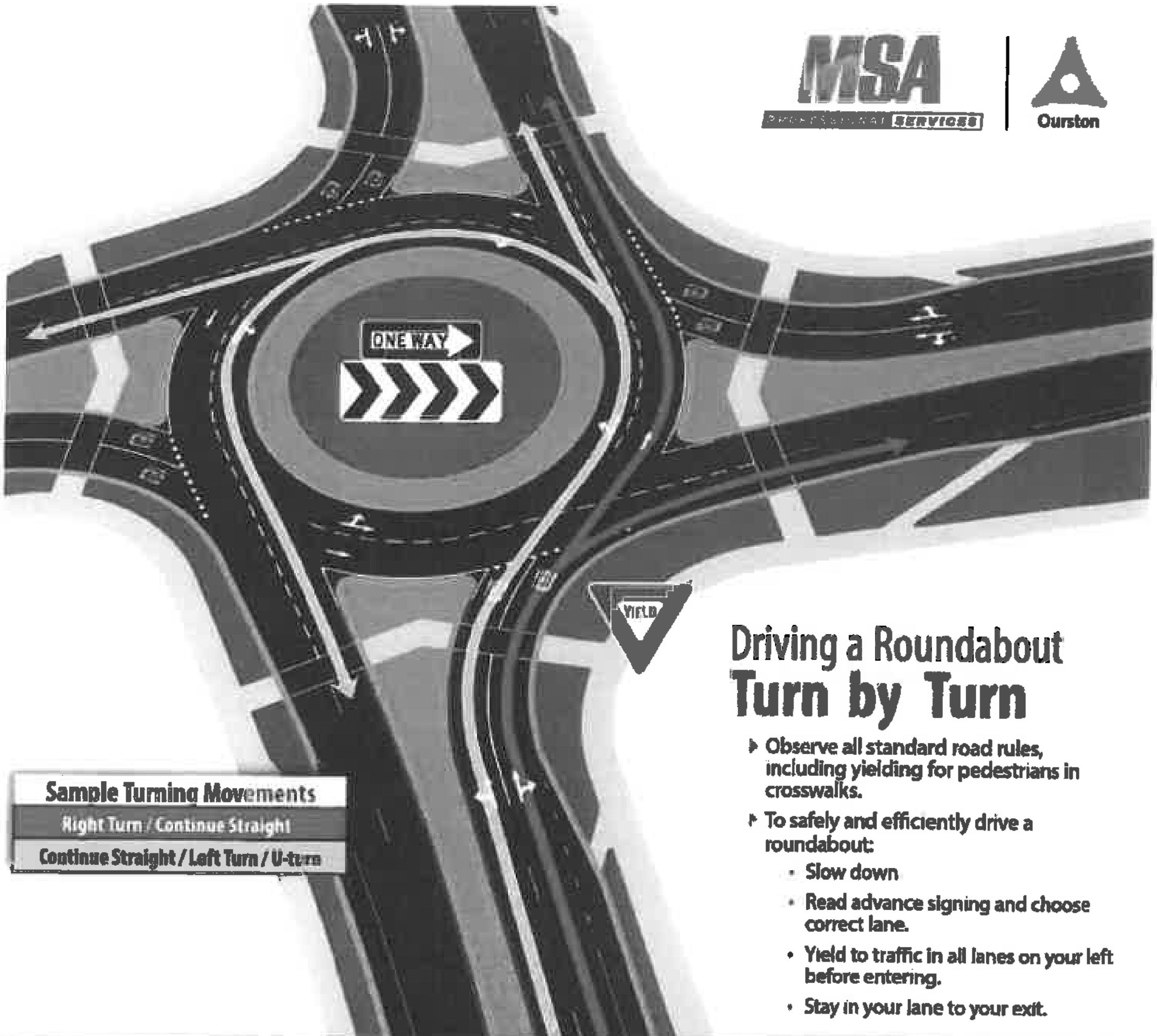


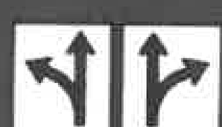

# Driving a Roundabout
# Turn by Turn

- Observe all standard road rules, including yielding for pedestrians in crosswalks.
- To safely and efficiently drive a roundabout:
  - Slow down
  - Read advance signing and choose correct lane.
  - Yield to traffic in all lanes on your left before entering.
  - Stay in your lane to your exit.

## Always obey the **signs and markings**

As you get closer to the roundabout entrance it is very important to observe the signs and arrows to determine which lane to use before entering a roundabout. Signs above the road and white arrows on the road will show the correct lane to use.

Roundabout ahead, slow down.



Guide signs near the entry to a roundabout show lane designations.

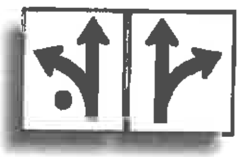

Yield to all traffic in the roundabout.


Roundabout traffic travels one-way.

How to Drive Through a Roundabout

# CHOOSE YOUR LANE

## BEFORE ENTERING A ROUNDABOUT

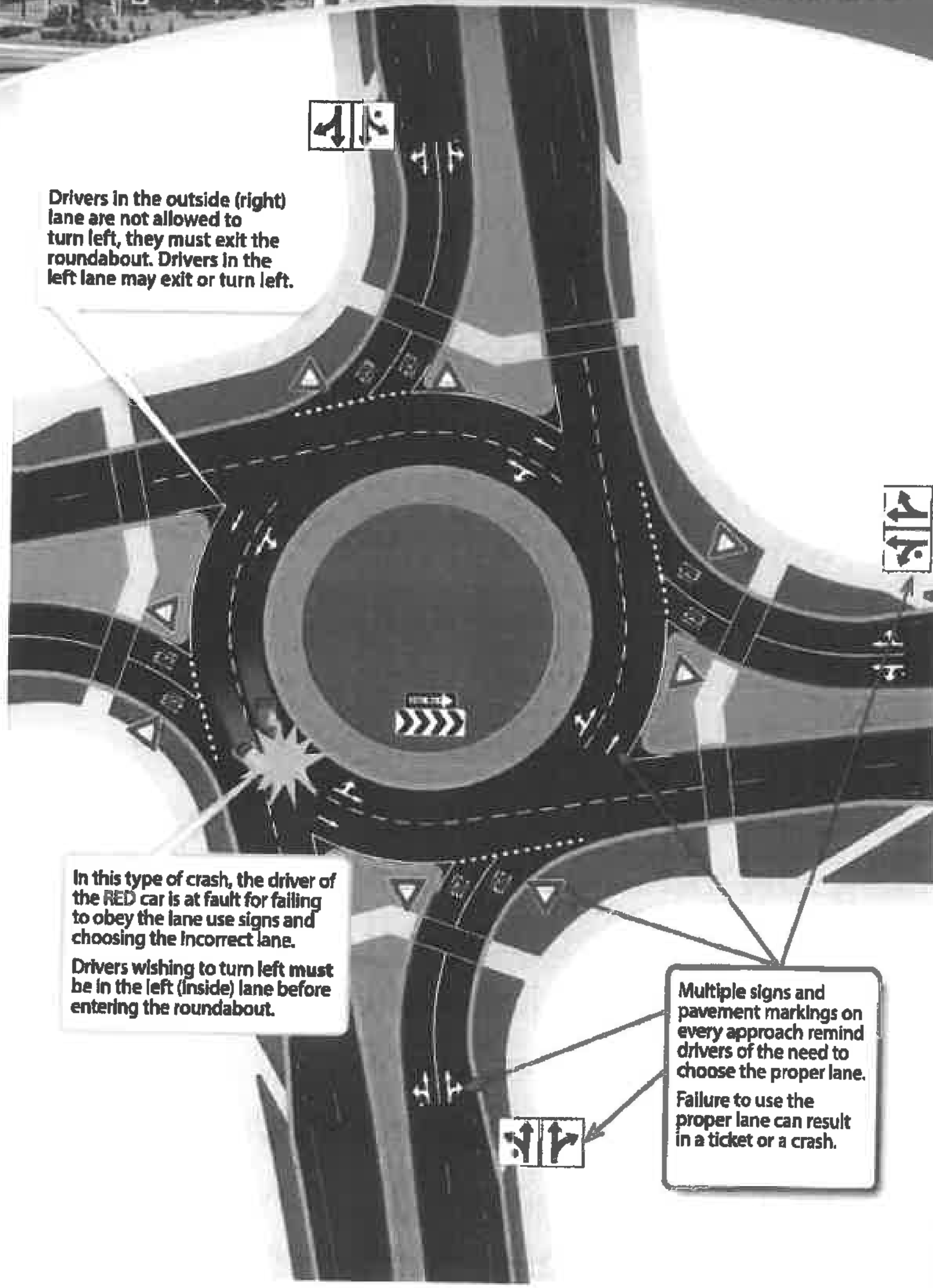



**As with any other intersection, the proper lane must be chosen before entering a roundabout.**

**In advance of the roundabout, signs and pavement markings will always indicate which lanes may be used for the direction you want to go.**

**Keep left to turn left through the roundabout and keep right to turn right.**

**Never change lanes within a roundabout.**

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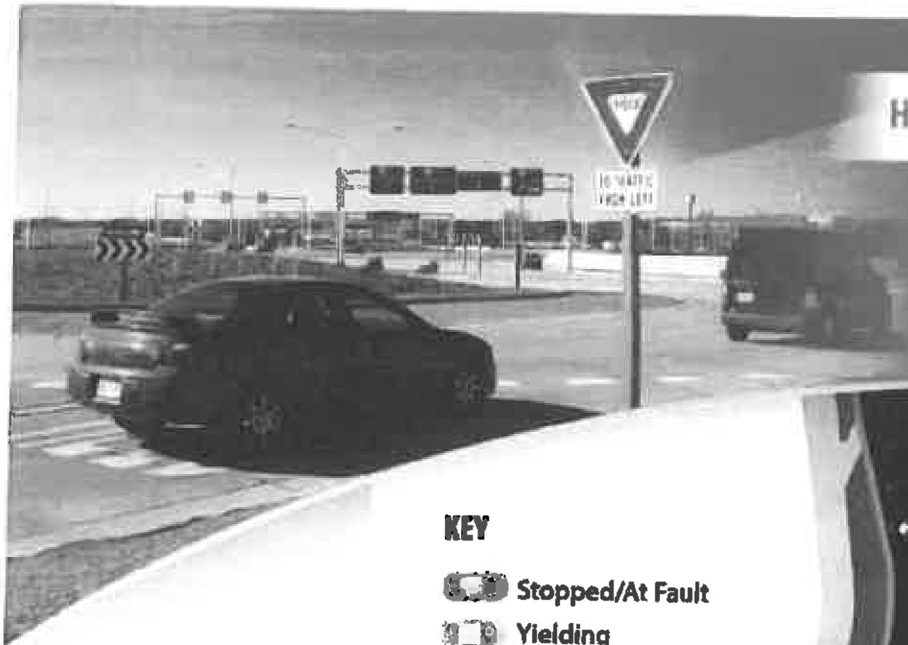
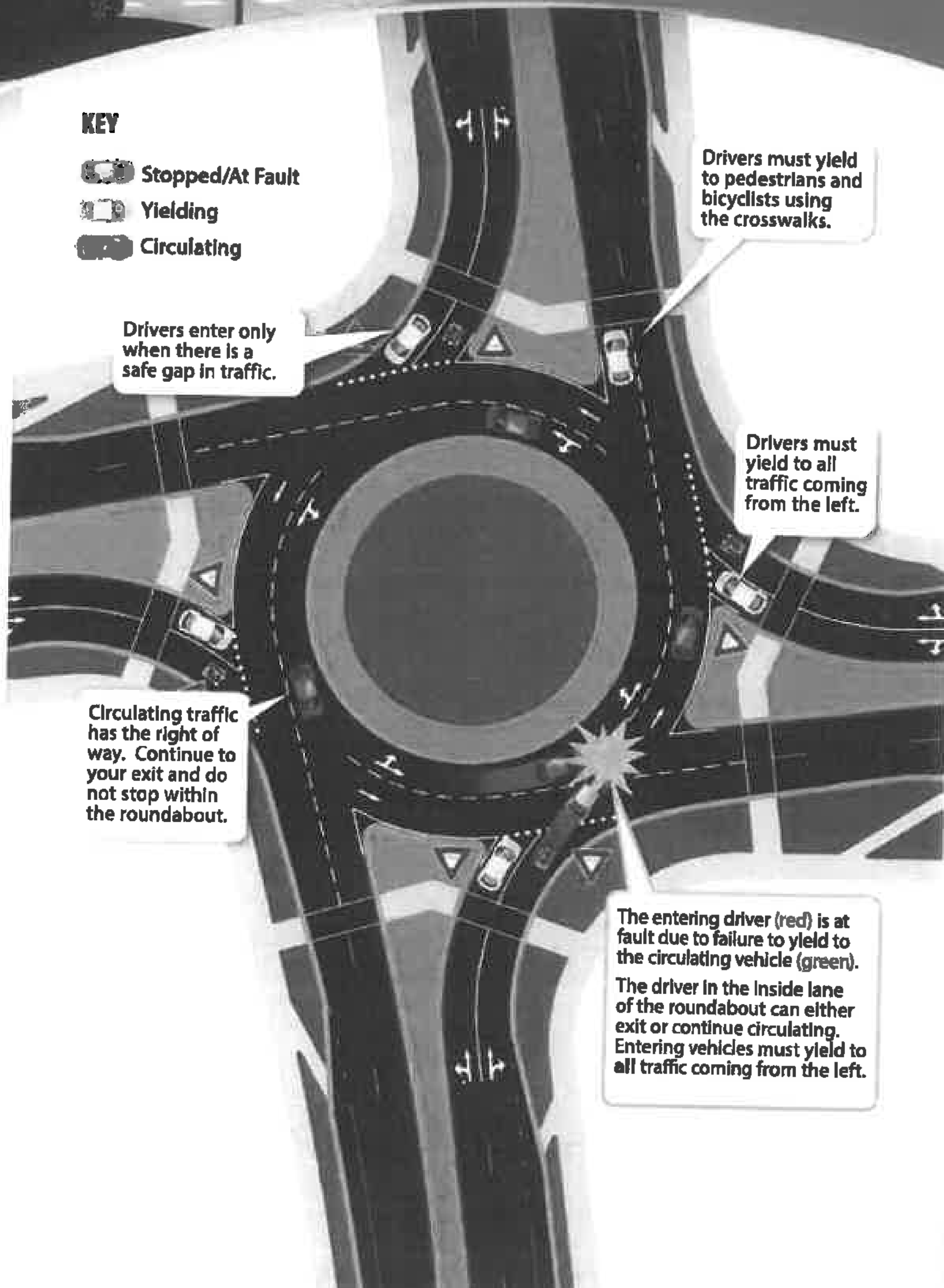
# How to Drive Through a Roundabout

# ALWAYS YIELD

## TO ALL CIRCULATING TRAFFIC







## YIELD

### The "Golden Rule" of roundabouts.

**Drivers entering a roundabout must yield to circulating traffic, pedestrians and bicyclists.**

**Drivers in the circle have the right of way. A motorist approaching a roundabout should wait for a safe gap in traffic before entering.**

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