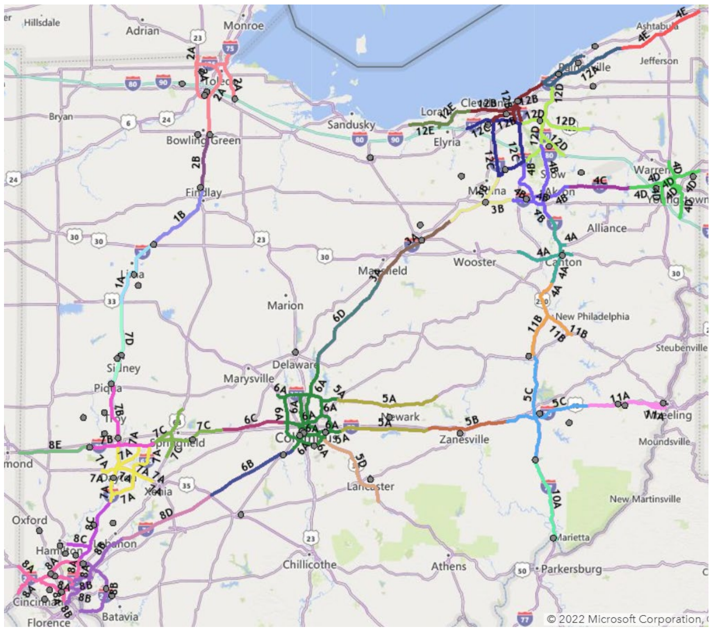
Division of Operations Research On-Call (ROC) Task #3 - Measuring ODOT's Towing Recovery Incentive Payment (TRIP) Program



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Final Report

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16. Abstract

ODOT funded this study to quantify the benefits of the Towing Recovery Incentive Payments (TRIP) program (user delay, safety, and environmental impact) and to obtain a comparison of ODOT's TRIP Program performance relative to other states, especially in regards to commercial vehicle clearance times. The tasks for this project included:

- **Create a repeatable methodology and implementation to quantify the benefit in dollars of TRIP incidents in Ohio.**
  - **The methodology and tool shall determine benefits under the following classifications and attributes:**
    - **incidents in urban areas vs. rural areas;**
    - **TRIP vs. TRIP-Lite incidents; and,**
    - **Incidents in work zones vs. non-work-zone areas (for TRIP only).**
- **Compare Ohio's TRIP Program performance to nationwide commercial vehicle clearance times, including:**
  - **A nationwide average;**
  - **Comparable-program state averages; and,**
  - **Averages for states without quick clearance programs.**

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EXECUTIVE SUMMARY

Under the Ohio Department of Transportation (ODOT) Towing and Recovery Incentive Payment (TRIP) program, qualified vendors provide heavy-duty towing and recovery services to expedite the clearance of large commercial vehicles that are blocking one or more travel lanes. The goal of the TRIP Program is to reduce traffic congestion and the likelihood of secondary incidents, thereby increasing safety to the motoring public. Incentive payments are made to vendors meeting the TRIP Program requirements.

ODOT's TRIP Program was found to have a benefit-cost ratio of 20.98 when evaluated for mobility, safety, and environmental benefits. The total benefits were estimated as $7,903,484 in fiscal year 2019, and 74 percent of the benefits were estimated to be safety related (primarily due to a reduction in secondary crashes). Additionally, the TRIP events were categorized into urban and rural events and work zone and non-work zone events. TRIP events in urban areas had higher benefit-cost ratios than TRIP events in rural areas. TRIP events in non-work zones had the highest benefit-cost ratios. The lower benefit-cost ratio of work zone events is most likely due to the existing congestion present in work zones.

It is difficult to estimate a nationwide average benefit-cost ratio for rapid towing programs given the variability among states, crashes, data availability, and benefit-cost calculation methodologies. DOT programs comparable to ODOT's TRIP Program have reported benefit-cost ratios ranging from 6:1 to 11:1, which indicates a positive return on investment. The estimated benefit-cost ratio of ODOT's TRIP Program for fiscal year 2019 was greater than this range, largely because the evaluation included safety benefits and the reduction in secondary crashes.

PROJECT BACKGROUND

Under ODOT's Towing and Recovery Incentive Payment (TRIP) program, qualified vendors provide heavy-duty towing and recovery services to expedite the clearance of large commercial vehicles that are blocking one or more travel lanes. The goal of the TRIP Program is to reduce traffic congestion and the likelihood of secondary incidents, thereby increasing safety to the motoring public. Incentive payments are made to vendors meeting the TRIP Program requirements.

ODOT additionally maintains a TRIP-Lite program where qualified vendors provide towing and recovery services to expedite the clearance of passenger vehicles involved in a crash and/or disabled in identified work zones. This program launched with one pilot location in calendar year 2020. For calendar year 2021, ODOT anticipates having six to eight work zones in the program.

ODOT funded this study to quantify the benefits of both TRIP programs (user delay, safety, and environmental impact) and to obtain a comparison of ODOT's TRIP Program performance relative to other states, especially in regards to commercial vehicle clearance times. The tasks for this project included:

- Creating a repeatable methodology and implementation to quantify the benefit in dollars of TRIP incidents in Ohio.
    - The methodology and tool shall determine benefits under the following classifications and attributes:
        - incidents in urban areas vs. rural areas;
        - TRIP vs. TRIP-Lite incidents; and,
        - Incidents in work zones vs. non-work-zone areas (for TRIP only).
- Comparing Ohio's TRIP Program performance to nationwide commercial vehicle clearance times, including:
    - A nationwide average;
    - Comparable-program state averages; and,
    - Averages for states without quick clearance programs.

RESEARCH BACKGROUND

Literature Review: Performance Evaluation Methods of Incident Clearance Programs

In the broader traffic incident management (TIM) context, incident clearance programs are the practice of rapidly and safely removing temporary obstructions. These obstructions can include disabled or wrecked vehicles, debris, and spilled cargo on the roadway. The goals of TIM are to minimize the exposure of incident responders to adjacent passing traffic, reduce the probability of secondary crashes, and relieve overall congestion levels and delay. Incident clearance programs currently in operation in the United States include the Safety Service Patrol (SSP) program, which assists motorists on designated routes, and the Towing and Recovery Incentive Payment (TRIP) program, which facilitates the safe, quick clearance of large commercial vehicle crashes. This section reviews different types of incident clearance programs and summarizes the performance evaluation methodologies used in the previous studies.

Incident Clearance Programs

Safety Service Patrol

Safety Service Patrol (SSP) is an incident management program that assists disabled vehicles along congested roadway segments to reduce peak-period non-recurring congestion via detection, verification, and incident removal. Various SSP programs have been implemented in different states, including

- **Freeway Service Patrol (FSP) in California**: California's FSP is a congestion mitigation program managed in partnership with metropolitan planning organizations, the California Highway Patrol, and Caltrans. This program utilizes a fleet of roving tow and service trucks to reduce traffic congestion by efficiently getting disabled vehicles running again or by quickly towing those vehicles off the freeways to a safe location.
- **Highway Emergency Local Patrol (HELP) in New York**: The HELP program provides free roadside emergency services during peak-period on many major roads throughout the state. This program helps manage incidents involving disabled vehicles and supports emergency services by performing services like changing tires, jump starting batteries, and temporarily repairing radiator hoses.
- **Freeway Incident Response Safety Team (FIRST) in Minnesota**: The FIRST has the primary purpose to minimize congestion and prevent secondary crashes by quickly responding to and removing incidents. This program reduces congestion by locating, assisting, and removing stalled vehicles, crashes, and debris from freeways.
- **Highway Helper (HH) in Iowa**: The HH program provides incident response and free assistance to stranded motorists on roadways in four of Iowa's metro

areas. The focus of the HH program is to provide travelers and emergency responders with a safe and efficient transportation system. HH services can quickly address the needs of stranded motorists by providing jump starts, tire changes, up to two gallons of fuel, and transportation to a safe location. In addition, each truck is equipped to provide traffic control and quick clearance for emergency responders.

Towing and Recovery Incentive Program

TRIP provides monetary incentives to qualified towing operators for the quick clearance of incidents involving large commercial vehicles. TRIP programs have been implemented in several states, including

- **Rapid Incident Scene Clearance (RISC) in Florida**: The RISC program is a heavy-duty towing and recovery program that supports Florida's Open Roads Policy, which establishes a 90-minute goal for clearance of motor vehicle crashes and incidents on Florida's roadways. Florida's Turnpike Enterprise developed and implemented the RISC program in 2004. The program expanded statewide in 2007. RISC provides monetary bonuses to qualified and participating towing companies when they meet quick-clearance goals for more complex traffic incidents.
- **Towing and Recovery Incentive Payment (TRIP) program in Georgia**: The Georgia Department of Transportation introduced the TRIP in early 2008 to provide monetary incentives to qualified towing operators for the quick clearance of large commercial vehicle incidents. It is a critical component of Atlanta's traffic incident management quick clearance program.
- **Towing and Recovery Incentive Payment (TRIP) program in Virginia**: The Virginia Department of Transportation's Richmond District began the TRIP pilot in December 2017. In this TRIP, tow companies receive a monetary bonus for clearing commercial vehicle crashes within 90 minutes. Richmond's TRIP pilot was developed with similar operating characteristics and protocols as incentive programs developed and implemented in Georgia, Florida, and Ohio.
- **Major Incident Tow (MIT) Program in Washington**: The Washington State Department of Transportation implemented the Blok-Buster Major Incident Tow program in 2007 to expedite the removal of heavy truck collisions and meet the 90-minute clearance goal. The initial pilot program was funded for the 2007–2009 biennium in King, Pierce, and Snohomish Counties. The program name was later changed to the Major Incident Tow (MIT) program, and coverage has been extended to include all of Interstate 5 and all major state highways in the Puget Sound area.

Incident-Induced Delay Evaluation Methods

Queuing Theory

Incident-induced delay (IID) can be estimated using deterministic queuing theory from two primary inputs: (1) the approach volume, and (2) the available capacity of the roadway during each incident. As illustrated in **Figure 1** and **Figure 2**, the IID is the area between the arrival (demand) curve and the capacity curve, designated by the shaded region in the figures. States have used two approaches to calculate IID using queuing theory.

- **Approach A: Calculate IID using the average incident duration.**
  This approach first calculates the average incident duration by incident type. Then, the average IID for each incident type is estimated based on the average incident duration. Finally, the total IID is calculated by multiplying the average IID per incident type by the number of incidents of that type.
- **Approach B: Calculate of IID for each incident.**
  This approach calculates IID for each incident based on the arrival and capacity curves associated with the specific incident.

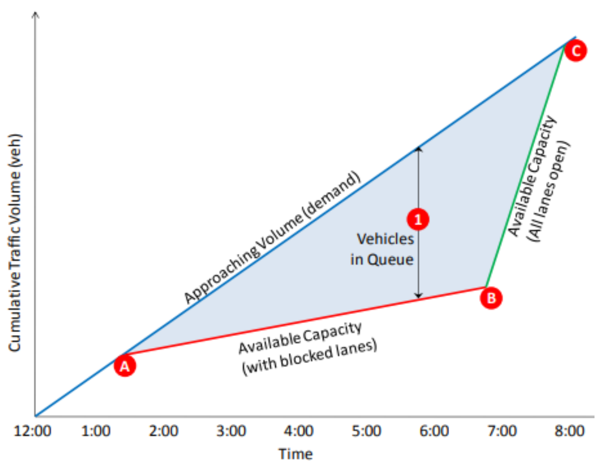


Figure 1. Queuing Theory Based Delay Calculation
(The shaded area represents the vehicle delay.)
[GDOT (2011)]

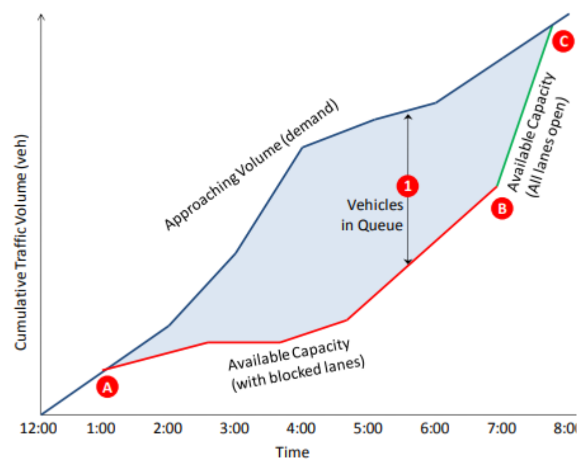


Figure 2. Representative Incident in Georgia
[GDOT (2011)]

The benefit of the incident clearance programs can be estimated by comparing the delay cost savings before and after implementation. **Table 1** lists the delay calculation results from four states. Although data sources and delay calculation methods vary by state, all four states reported a benefit-cost (B/C) ratio greater than one. Some states have used hourly traffic volumes, while others estimated benefits based on the Average Annual Daily Traffic (AADT).

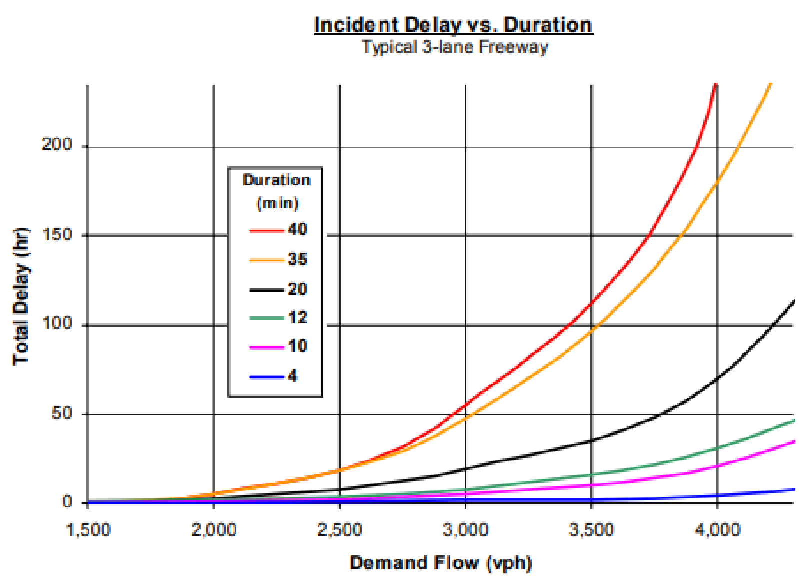
Table 1. IID Calculation and B/C Ratio Comparison
[UC-ITS (2019), FHWA (2021), NJIT (2013), and GDOT (2011)]

Program Name	State	Benefit-cost Ratio	Delay Calculation	Traffic Volume Data
Freeway Service Patrol	California	6.0	Average Incident Duration	Hourly traffic volume
Freeway Safety Patrol	Ohio	11.0	Average Incident Duration	AADT
Safety Service Patrol	New Jersey	1.3 - 26.1	Average Incident Duration	AADT
TRIP	Georgia	10.96	Each Incident Duration	Hourly traffic volume

Simulation-Based Method

Simulation tools estimate IID by simulating vehicle delays in various scenarios. For example, to evaluate the performance of the FIRST in Minnesota, scenarios with varying incident durations and traffic demands were simulated using Paramics to estimate the total vehicle delay. In **Figure 3**, the x-axis shows the demand flow in vehicles per hour on a typical three-lane freeway section in the Twin Cities. The y-axis shows total delay (in hours). Each curve on the graph corresponds to a specific incident duration.

Figure 3. Incident Delay and Duration Curves from Simulation [MNDOT (2004)]



Performance Metrics

The benefit of an incident clearance program can be estimated using delay cost savings, fuel savings, emission reduction, and secondary crash reduction.

Delay Cost

The delay cost savings is estimated using the product of vehicle delays and the value of time (VOT). **Table 2** lists the VOT and average occupancy values used in three of the four program studies discussed above.

Table 2. VOT and Average Vehicle Occupancy Comparison [UC-ITS (2019), GDOT (2011), and NJIT (2013)]

State	California (Caltrans, 2017)	Georgia (GDOT, 2011)	New Jersey (NJIT, 2013)
Passenger vehicle VOT	$13.65	$18.07	$16.00
Truck VOT	$31.40	$69.49	$88.00
Vehicle occupancy	1.15	1.22	1.50

Fuel Cost

Fuel cost savings is generally estimated based on the gallons of fuel saved and the gasoline and diesel prices. For example, based on the Caltrans Mobility Performance Report (2011), 1.719 gallons of fuel is saved for each vehicle hour of delay saved. Georgia DOT (2011) calculated fuel cost based on miles of travel and average fuel economy as follows:

$$\text{Fuel} = \text{Miles of Travel} \times \text{Percent of Truck} \times \frac{\textit{Unit Diesel Price per Gallon}}{\textit{Truck Fuel Economy}} + \text{Miles of Travel} \times \text{Percent of Cars} \times \frac{\textit{Unit Gasoline Price per Gallon}}{\textit{Car Fuel Economy}}$$

Where

- $\text{Miles of travel} = \text{Total Delay (Vehicle Hours)} \times \text{Average Speed (mph)}$
- $\text{Average Speed} = \frac{\textit{Average Queue Length in Miles}}{\textit{Average Delay per Veh in Hours}}$

Emission Cost

Like fuel cost savings, emission cost savings can be estimated based on incident-induced delays.

$$\text{Emission Cost} = \text{Total Delay (Vehicle Hours)} \times \text{Emission Rate} \times \text{Unit Cost per Ton}$$

Table 3 and **Figure 4** list the emission factors used in Georgia (GDOT, 2011) and California (UCB-ITS, 2016).

Table 3. Emission Rates for Air Pollutants in Georgia

Emission	Emission Rate (Tons per Vehicle Hour of Delay)	Cost per Ton
HC	0.000025676	$6,700
CO	0.00033868	$6,360
NOx	0.000036064	$12,875

Figure 4. Emission Rates for Air Pollutants in California

EMISSION RATES (ADDED)			
Percent Trucks (%)		9	
[Source: 2009 Annual Average Daily Truck Traffic on the California State Highway System]			
N2O Running emission	(Auto)	0.235	gr/hr
N2O Running emission	(Truck)	0.652	gr/hr
CH4 Running emission	(Auto)	0.196	gr/hr
CH4 Running emission	(Truck)	0.374	gr/hr
N2O EMISSION RATE		0.23149	gr/hr
CH4 EMISSION RATE		0.62698	gr/hr
[Source: Update of Methane and Nitrous Oxide Emission Factors for On-Highway Vehicles (2004), U.S. Environmental Protection Agency]			
CO2 EMISSION RATE		8.8	kg/gallons
[Source: 2009 Mobility Performance Report]			

Secondary Crash

Previous studies have shown that the probability of a secondary crash occurring is a function of the duration of the primary incident (Raub, 1997). Because incident management programs are intended to reduce clearance duration, the expected reduction in secondary crashes can be used to estimate safety benefit. For example, Guin et al. (2000) estimated the decrease in secondary crashes due to the reduction in incident duration and then computed the cost savings by multiplying the number of secondary crashes reduced by the program with the average cost of a crash.

$$c = X \times p \times \frac{T_1}{T_2} \times cc$$

- c : cost saving due to secondary crashes reduced
- p: percentage of secondary crashes, typically 15–25 percent of freeway incidents are secondary crashes
- X : total number of crashes
- T_1: average incident duration saving (minutes)
- T_2: average incident duration before TRIP (minutes)
- cc: average cost of a crash (dollars)

Similarly, the Washington State Department of Transportation (WSDOT, 2016) estimated the economic benefits of avoiding secondary crashes by assuming a 20 percent secondary crash rate. The cost savings from secondary crash reduction is calculated by multiplying the incident clearance time saved and the average cost per minute of a crash.

$$\text{c} = \sum_{n=1}^{Number\ of\ incidents} (Incident\ clearance\ time\ \times 0.2_{(1)} \times \$286\ per\ minute\ of\ secondary\ incident_{(2)})$$

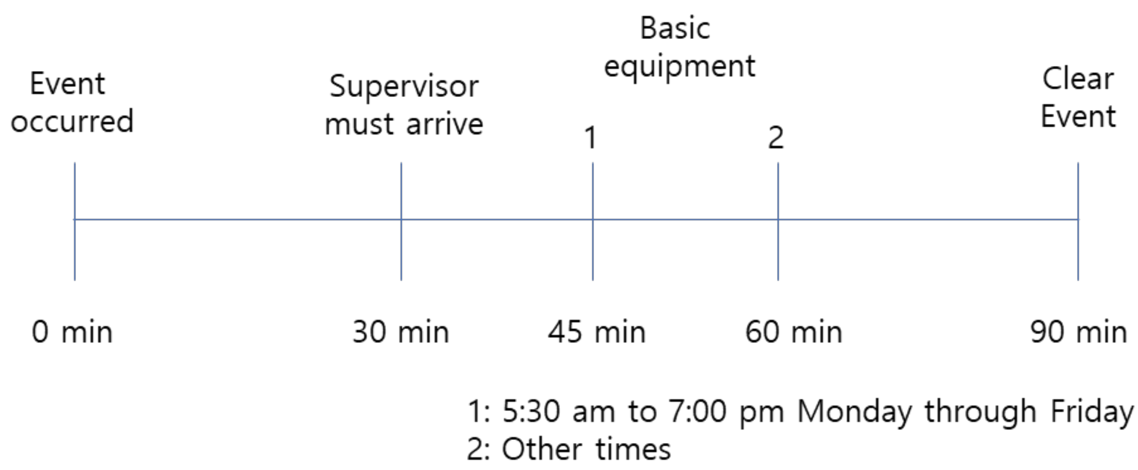
(1) The Federal Highway Administration (FHWA) estimates that on average there are 20 percent or more secondary incidents occurring on the system due to the primary incidents (FHWA Traffic Incident Management Manual - https://ops.fhwa.dot.gov/aboutus/one_pagers/tim.htm, accessed May 2022).
(2) WSDOT (2021) estimates an average cost of $286 per minute of crash scene duration, which is applied to calculate the final cost.

Literature Review: Other States' TRIP Benefit-Cost Analysis

Georgia (GDOT, 2011) & Virginia (VDOT, 2019) (TRIP)

Incidents that qualify for TRIP involve large vehicles and complicated debris or hazardous material spills. For states who adopted TRIP, the goal is to clear such incidents within 90 minutes using the following timeline (**Figure 5**).

Figure 5. TRIP Timeline



The incentive structure has the following monetary incentives and fines:

- Incentives:
  - $600 if the TRIP company is called, responds within the specified time, but is ultimately not needed
  - $2,500 if the TRIP company is called, responds within the specified time, and has the roadway cleared and opened to traffic within 90 minutes after the event occurred
  - An extra $1,000 if additional special equipment was required and provided and all-time requirements were met
- Fines:
  - $600 in liquidated damages and an additional $10 per minute if the roadway is not cleared and opened to traffic within three hours and the fault is considered due to the TRIP company

Florida (FDOT, 2018)

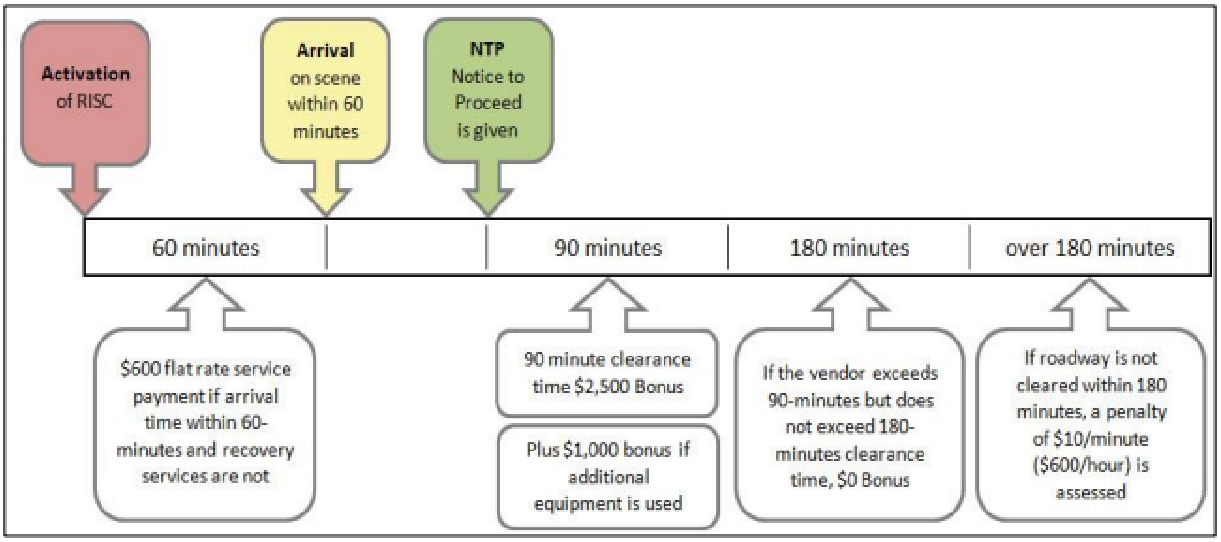
In 2004, Florida Department of Transportation (FDOT) developed and implemented a traffic incident management enhancements program, Rapid Incident Scene Clearance (RISC), to help reduce the impact of major traffic incidents. The RISC contract vendor has the responsibility to respond to the incident within 60 minutes of the activation request. Once on scene and provided with a Notice to Proceed by the lead official on scene, the vendor will have 90 minutes to open the travel lanes for traffic. If the proper equipment arrives on scene within 60 minutes and the tower clears the lanes within 90 minutes, they are eligible for the bonus.

RISC is activated for the following types of incidents:

- Tractor-trailer combinations
- Truck over 16,000 pounds
- Motor homes and motor coaches
- Busses capable of carrying 16 or more passengers
- Aircraft
- Large yacht-type boats and mobile homes
- Any complex or extended incident where vehicles cannot be easily towed from the scene or are creating a hazard to traffic

The RISC contract requires the vendor to have specific extra equipment on hand or available 24 hours a day, 7 days a week to respond to these major incidents. The tower vendors can receive an extra incentive for the staging and/or use of this extra equipment in the incident clearance process. The RISC incident timeline is outlined in **Figure 6**.

Figure 6. RISC Incident Timeline



Washington (WSDOT, 2021)

The Washington State Department of Transportation (WSDOT) launched the Major Incident Tow (MIT) program in 2007. The MIT program has cleared over 10,000 incidents and saved Washington residents over $10.7 million in time and fuel that would have been spent on incident-related congestion.

MIT is activated for the following types of incidents:

- Tractor-trailer combination
- Trucks over 40,000 gross vehicle weight (GVW)
- Busses (commercial/motor coach)
- Any other collision or incident deemed by WSDOT to command a major incident response deployment of equipment listed in the agreement

Benefit-Cost Comparison

Table 4 lists the benefit-cost analysis results from Georgia, Virginia, and Florida. Given the different operational conditions, methodologies, data, and assumptions used in the benefit-cost analysis, these benefit-cost ratios should not be used to directly compare the effectiveness of different TRIPs across various DOTs. However, all the DOTs that have implemented a TRIP have reported a benefit-cost ratio greater than one, which indicates a positive return on the investment.

Table 4. Each TRIP Program's Performance [GDOT (2011), VDOT (2019), and FDOT (2018)]

States	Georgia (GDOT)	Virginia (VDOT)	Florida (FDOT)[1]
Number of Events	110	64	303
Study Period	2008-2009	2018	2017
Clearance Time Reduction (minutes)	165 minutes (60 minutes in benefit estimation)	65.8 minutes	
Total Benefit	$9,154,431.00	$5,473,895.20	
Delay Cost Savings	✓	✓	
Fuel Cost Savings	✓	✓	
Emission Savings	✓	✓	
Safety Savings	-	-	
Total Cost	$835,000.00	$698,685.49	
Administrative Cost	$551,000.00 (2007~2010)	$563,485.49	
Incentive Cost	$284,000.00 (2008~2009)	$135,200.00	$617,900.00
Benefit-cost Ratio	10.96:1	6:1~7.8:1	x

Available Data

The two primary data sources for this study were the TRIP Event Log and the OH-1 crash reports. The TRIP Event Log provided by ODOT has records of all TRIP events and contains information regarding the crash location, arrival and clearance times, the cost, and other pertinent details used in the cost-benefit analysis.

The OH-1 crash reports provided by ODOT were used to identify non-TRIP events or property-damage-only (PDO) heavy-duty vehicle crashes that occurred in a TRIP zone. The information detailed in the crash reports was essential to evaluating the TRIP Program's performance in comparison to similar crashes that were cleared without using the TRIP Program.

[1] The greyed columns indicate information that was unavailable for FDOT.

Additional data available from ODOT's Transportation Information Mapping System (TIMS) that was used for this analysis includes the WGIS Traffic Count Segment and the WGIS Road Inventory. These datasets are used to accurately measure the average annual daily traffic (AADT) on roadways and to provide roadway geometry information such as the number of lanes.

Data that was analyzed for this study, but was not used to evaluate the TRIP Program, includes historic vehicle speed data from RITIS and from INRIX. These datasets were excluded because an easily-repeatable and user-friendly process for incorporating this data was not found. In the team's review, other states did not use these datasets for similar reasons. Accordingly, the HCM analysis methodology used for this report and by other agencies is adopted for consistency and to allow for better comparisons across states.

Definitions

The following is a list of terms and definitions used in this report:

- **TRIP Event:** A TRIP event is a crash that used ODOT's Towing and Recovery Incentive Payment (TRIP) program to respond to and clear the crash.
- **Non-TRIP Event:** A non-TRIP event refers to a crash that had similar characteristics to a TRIP event (i.e., heavy-duty vehicle involved, property damage only, non-hazmat, occurred during peak hours in TRIP zone) but did not use the TRIP Program to respond to and clear the crash.
- **Arrival Time:** Arrival time is the time between when the towing company is notified of the crash and when they arrive at the crash. The TRIP goal is to have the arrival time be less than 45 minutes.
- **Clearance Time:** Clearance time is the time between when the towing company receives notice to proceed with clearance and when the crash has been cleared and normal traffic flow can resume. The TRIP goal is to have the clearance time be less than 90 minutes.

It is noted that there may be a lag between when the towing vehicle arrives on the crash scene (measured by arrival time) and when the tower begins clearing the incident. This can occur when the site has not been secured or otherwise deemed safe for clearance by emergency response personnel on site.

METHODOLOGY

A methodology to quantify the benefits of ODOT's TRIP Program was developed based on a literature review and assessment of available data. The methodology assesses the mobility, safety, and environmental benefits of the TRIP Program by comparing the impacts on safety and operations during a TRIP and non-TRIP event.

The methodology to quantify the benefits of TRIP has seven steps:

- Step 1. Identifying non-TRIP events
- Step 2. Calculating the mobility benefits of TRIP
- Step 3. Calculating the safety benefits of TRIP

- Step 4. Calculating the environmental benefits of TRIP
- Step 5. Calculating the total benefits of TRIP
- Step 6. Calculating the total cost of TRIP
- Step 7. Calculating the benefit-cost ratio of TRIP

Step 1. Identifying Non-TRIP Events

Non-TRIP events were identified from the OH-1 crash reports using the following method:

1. Mapped the ODOT-provided TRIP zones into GIS for analysis
2. Mapped all crashes using latitude and longitude shown in OH-1 crash reports
3. Selected only crashes that occurred within 500 feet of a TRIP zone using the select by location tool in GIS
    a. Confirmed associated crashes were on roadways in TRIP zones through manual review of route numbers
4. Filtered crashes in the TRIP zones to only crashes that involved a semi-truck using the select by attribute tool in GIS
    a. Used semi-truck field in OH-1 crash reports
5. Filtered crashes by severity (property damage only) using the select by attribute tool in GIS
    a. Used crash severity field in OH-1 crash reports
6. Filtered crashes by time of day to only include crashes that occurred during the TRIP Program hours of operation using the select by attribute tool in GIS
7. Filtered out any crashes identified as 'hazmat' in the OH-1 crash reports using the select by attribute tool in GIS
8. Assigned a TRIP zone to each crash using the select by location tool in GIS
    a. Added field in GIS to attribute table
    b. Selected a TRIP zone
    c. Selected all crashes within 500 feet of that TRIP zone
    d. Used the field calculator to update the new field for all selected crashes
    e. Repeated for each TRIP zone
9. Removed crashes identified as TRIP events by ODOT
    a. ODOT provided crash report numbers for TRIP events
10. Exported the attribute table to Microsoft Excel

Figure 7 shows the TRIP and non-TRIP events that occurred in TRIP Zone 6A, which covers the freeway system in Columbus, OH. The patterns shown in this figure are representative of patterns observed in the other TRIP zones. TRIP events were generally concentrated in areas with high concentrations of non-TRIP events. Maps for all TRIP zones are shown in **Appendix B.**

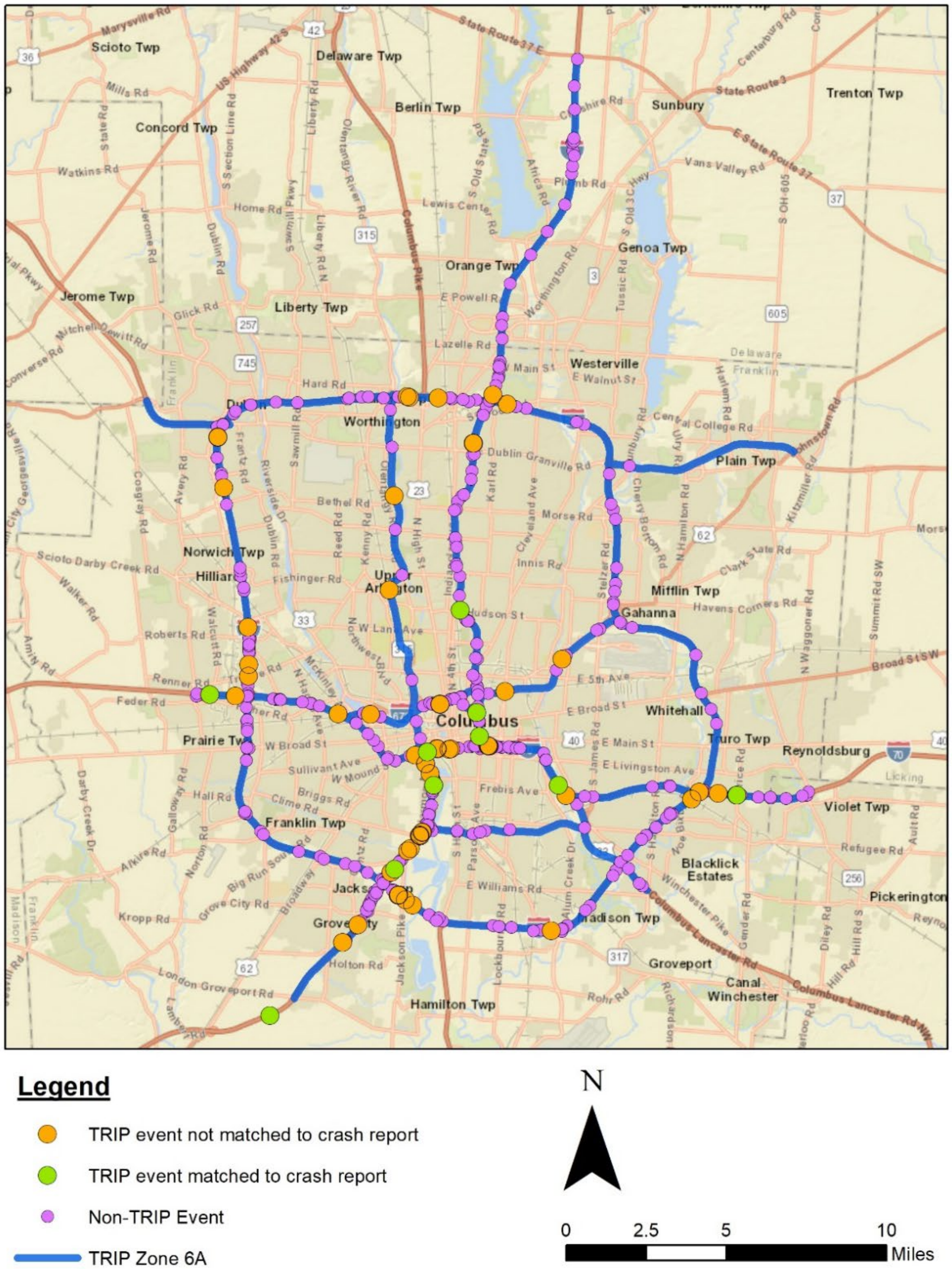


Figure 7. TRIP Zone 6A—Columbus, OH region

The identified non-TRIP events and corresponding crash reports were used to calculate the total clearance time of non-TRIP events for each TRIP zone. The total clearance time is the time from which an operator is alerted of the crash to when the crash is cleared and normal traffic flow resumes. The total clearance time was calculated for TRIP events using the information from the TRIP Events Log. **Table 5** shows the total clearance times for TRIP and non-TRIP events and the difference between the total clearance times for each TRIP zone. On average, the total clearance time for a TRIP event was approximately 22 minutes faster than the total clearance time for a non-TRIP event.

Table 5. Total Clearance Time of TRIP & Non-TRIP Events

TRIP Zone	Number of TRIP Events	Rural/ Urban	Total Time TRIP (minutes)	Total Time Non-TRIP (minutes)	Difference (minutes)
6A	68	Urban	54.7	79.6	24.9
8A	16	Urban	31.1	58.0	26.9
2A	15	Urban	58.9	74.7	15.8
12D	9	Urban	40.1	54.9	14.8
8B	9	Urban	53.7	62.7	9.0
7A	6	Urban	53.8	75.4	21.6
4B	5	Urban	57.4	68.0	10.6
6C	5	Rural	71.8	79.3	7.5
2B	4	Rural	39.5	84.2	44.7
1B	3	Rural	29.0	85.0	56.0
4A	3	Rural	106.0	69.4	-36.6
6B	3	Rural	51.0	116.1	65.1
12B	2	Urban	37.0	50.3	13.3
12A	1	Rural	407.0	65.5	22.1[2]
12C	1	Rural	---	57.6	22.1[3]
1A	1	Rural	33.0	84.8	51.8
7C	1	Rural	79.0	91.9	12.9

Step 2. Calculating Mobility Benefits of TRIP

The difference between total clearance time served as the foundation for estimating the mobility benefits of the TRIP Program. Mobility benefits are the vehicle hours of delay (VHD) saved by using the TRIP Program converted to dollars based on the reported value of travel time (VOTT). To estimate mobility benefits, each TRIP event from fiscal year 2019 was analyzed individually. The county, facility identification, and mile marker of each TRIP event from TIMS was used to identify the average annual daily traffic (AADT) and number of facility lanes impacted by direction. The AADT and number of lanes were used to calculate the peak hour volume by lane using the peak hour factor (K) and directional split of traffic (D) (**Equation 1**).

[2] TRIP event was removed due to long duration (exceeding five hours). There were no other TRIP events or non-TRIP events that exceeded five hours.

[3] TRIP log did not include the total time. The average difference in clearance time between non-TRIP and TRIP events weighted by the number of events in each zone was used in the analysis.

The peak hour factor was assumed to be 0.1, and the directional split of traffic was assumed to be 0.55.

Equation 1. Peak Hour Volume per Lane

$$Peak\ hour\ volume\ per\ lane = \frac{AADT \times K \times D}{Number\ of\ lanes}$$

The peak hour volume per lane had to be adjusted for TRIP events that occurred in work zones. Lane closures associated with work zones reduce the available capacity of a lane. The peak hour volumes per lane for TRIP events that occurred in work zones were adjusted using the capacity adjustment factors shown in **Table 6**. Of all 152 TRIP events in fiscal year 2019, 37 percent (56) occurred in a work zone as indicated in the TRIP Events Log.

Table 6. Work Zone Capacity Adjustment Factors[4]

Directional Lanes (One Direction, Before Work Zone)	1 Lane Closed	2 Lanes Closed	3 Lanes Closed
2	0.62	N/A	N/A
3	0.64	0.64	N/A
4	0.67	0.64	0.60

Next, capacity was adjusted to account for lanes blocked due to a TRIP event. Like lane closures associated with work zones, lanes blocked due to a crash reduce overall capacity. Base lane capacity was assumed to be 2,000 vehicles per hour during typical conditions. The adjusted capacity was calculated using typical lane capacity, the number of facility lanes in the impacted direction, and the number of blocked lanes due to the crash (**Equation 2**). The equation also uses capacity adjustment factors (CAF) based on the number of lanes and the number of blocked lanes to model the reduced capacity. The CAFs are shown in **Table 7**.

Equation 2. Overall Incident Capacity

$$Overall\ incident\ capacity = \\ (Number\ of\ lanes - Number\ of\ blocked\ lanes) \times Lane\ capacity \times CAF$$

[4] https://ops.fhwa.dot.gov/publications/fhwahop13042/appd.htm

Table 7. Incident Capacity Adjustment Factors[5]

Facility Lanes in Impacted Direction	Lanes Closed				
	Shoulder	1	2	3	4
2	0.81	0.7	---	---	---
3	0.83	0.74	0.51	---	---
4	0.85	0.77	0.5	0.52	
5	0.87	0.81	0.67	0.5	0.5
6	0.89	0.85	0.75	0.52	0.52
7	0.91	0.88	0.8	0.63	0.63
8	0.93	0.89	0.84	0.66	0.66

The incident capacity was used to calculate the volume-to-capacity (v/c) ratio for each TRIP event. The v/c ratios were needed to determine delay savings, which were later used to estimate the overall mobility benefits of the TRIP Program. The incident v/c ratio for TRIP events was calculated by dividing the peak hour volume by the incident capacity (**Equation 3**). The incident v/c ratios ranged from 0.63 to 2.86 and had an average of 1.48. Most TRIP events had v/c ratios greater than one, which indicated congestion and volumes exceeded available capacity. V/c ratios greater than one are expected for crashes that block lanes and reduce overall capacity.

Equation 3. Incident Volume-to-Capacity Ratio

$$Incident\ v/c\ ratio = \frac{(Peak\ hour\ volume\ per\ lane \times Number\ of\ lanes)}{Incident\ capacity}$$

The incremental delay equation (**Equation 4**) from the Highway Capacity Manual (HCM) was then used to calculate the delay savings per vehicle in seconds using the difference between total clearance times for TRIP and non-TRIP events (*T*), the incident capacity (C_A), and the incident v/c ratio (*X*) calculated previously. To determine the overall mobility benefits of the TRIP Program, the delay per vehicle estimate was converted to total vehicle hours of delay, and then converted from hours to dollars.

Equation 4. Incremental Delay (HCM Equation 19-26)

$$d = 900T[(X_A - 1) + \sqrt{(X_A - 1)^2 + \frac{8kIX_A}{C_A T}}$$

[5] https://ops.fhwa.dot.gov/publications/fhwahop13042/appc.htm

The incremental delay equation produced delay savings per vehicle. To calculate the total vehicle hours of delay (VHD) saved for each TRIP event, the delay savings per vehicle was converted to *VHD saved* by multiplying by the peak hour volume per lane and the number of lanes (**Equation 5**). The sum of the VHD saved of all TRIP events in fiscal year 2019 was 76,237 hours. There were an additional 56 hours of time saved due to reduced incident durations (T_{total}). To calculate the mobility benefits of the TRIP Program in dollars, the total VHD and time saved due to reduced incident durations was multiplied by the VOTT for cars and for trucks (**Table 8**). The fleet composition (i.e., percentage of trucks) was determined for each roadway segment where there was a TRIP event. The estimated mobility benefits of the TRIP Program were $1,852,178 (**Equation 6**).

Equation 5. Total Vehicle Hours of Delay Saved

$$VHD\ Saved = \frac{d}{3{,}600} \times Peak\ hour\ volume\ per\ lane \times Number\ of\ lanes$$

Table 8. Assumed Hourly Cost for Road Users[6]

Road User	VOTT
Car	$20.17 per hour
Truck	$55.24 per hour

Equation 6. Total Mobility Benefits

$$Mobility\ Benefits = (VHD\ saved + T_{total}) \times (0.9 \times \$20.17 + 0.1 \times \$55.24)$$

Step 3. Calculating Safety Benefits of TRIP

In addition to mobility benefits, there are safety benefits of the TRIP Program. The TRIP Program reduces the duration of crashes and therefore reduces the expectance of secondary crashes, or crashes that occur at an incident scene or in the queue caused by an incident.[7] Approximately eight percent of crashes are secondary crashes. The number of secondary crashes was determined by performing spatial analysis using the OH-1 crash data. Crashes that occurred within 10 miles of another crash, on the same day, and at relatively same time were classified as secondary crashes. Based on the literature review of other states' rapid towing contracts, TRIPs

[6] https://static.tti.tamu.edu/tti.tamu.edu/documents/mobility-report-2021.pdf

[7] https://ops.fhwa.dot.gov/publications/fhwahop10010/presentation.htm#:~:text=%22Secondary%20Crashes%22%20are%20defined%20as,resulting%20from%20the%20original%20incident.

are expected to reduce secondary crashes by approximately 11 percent. This reduction is largely due to a reduction of incident duration, which limits the formation of queues and the risk of back-of-queue secondary crashes.
The distribution of crash severity observed along the TRIP zones was used to estimate the reduction of secondary crashes. The reduction of secondary crashes was calculated for each crash severity by multiplying the expected percentage of secondary crashes by the number of crashes along TRIP zones. The estimated average reduction of secondary crashes by severity is shown in **Table 9**.

Table 9. Estimated Average Reduction of Secondary Crashes

Crash Severity	Number of Secondary Crashes Reduced
Reduction of secondary fatal crashes	0.2
Reduction of secondary injury crashes	2.6
Reduction of secondary PDO crashes	5.2

The HSM crash costs by severity (**Table 10**) were used to convert the estimated reduction of secondary crashes to monetary benefits (**Equation 7**). To make the safety benefits comparable to the mobility benefits, the HSM crash costs provided by the FHWA Safety Program had to be converted to 2021 dollars using inflation rates.[8] The estimated annual safety benefits for ODOT's TRIP Program were found to be $5,835,641.

Table 10. HSM Crash Costs by Severity (2021 Dollars)

Crash Severity	Crash Costs
Fatal	$6,116,801
Injury	$126,032
PDO	$11,291

Equation 7. Safety Benefits of TRIP

$$\begin{aligned} &Safety\ benefits\ of\ TRIP\ (dollars) = \\ &(Reduction\ of\ secondary\ fatal\ crashes \times Cost\ of\ fatal\ crash) \\ &+ (Reduction\ of\ secondary\ injury\ crashes \times Cost\ of\ injury\ crash) \\ &+ (Reduction\ of\ secondary\ PDO\ crashes \times Cost\ of\ PDO\ crash) \end{aligned}$$

[8] Crash Costs for Highway Safety Analysis (cmfclearinghouse.org)

Step 4. Calculating Environmental Benefits of TRIP

The final component of the benefit calculations was estimating the environmental benefits. Environmental benefits account for the emissions and fuel cost reductions associated with reduced crash durations. Recall that for mobility benefits, the delay savings for the TRIP Program were assumed to be 76,237 vehicle hours. To find the total emission cost, the vehicle hours of delay were multiplied by the emission rates (in tons per vehicle hour of delay) and by the cost per ton of hydrocarbon (HC), carbon monoxide (CO), and nitrogen oxides (NOx). **Table 11** shows the emission rates, costs per ton, and total emission cost reductions. The total emission cost reduction for ODOT's TRIP Program in fiscal year 2019 was $212,738.

Table 11. Emission Cost Reduction

Emission	Emission Rate (tons per vehicle hour of delay)	Cost per Ton	Emission Cost
HC	0.00002568	$6,700	$13,115.07
CO	0.00033868	$6,360	$164,215.88
NOx	0.00003606	$12,878	$35,417.14
Total Emission Cost Reduction			**$212,738.09**

Environmental benefits also include fuel cost reduction. The fuel cost reduction calculation depends on assumed miles of travel. The assumed miles of travel are the miles of travel saved due to faster incident clearance times. For this study, the estimated *miles of travel* was determined to be 18,554 miles, calculated from the total average queue length, average speed in the queue, and vehicle hours of delay as described below.

The total average queue length (Q) was calculated using HCM Equation 20-60 that converts control delay (d) and flow rate (v) to queue length (**Equation 8**). Control delay and flow rate had been calculated while estimating the mobility benefits.

Equation 8. Average Queue Length (HCM 20-60)

$$Q = \frac{d \times v}{3600}$$

The average queue length (in miles) was then divided by the vehicle hours of delay saved to calculate average speed (in miles per hour). The average speed, 0.2 miles per hour, was multiplied by the vehicle hours of delay saved to find the assumed miles of travel. The miles of travel were then used to calculate the cost of fuel that would be required to travel that distance.

Fuel cost further depends on the fleet composition, which was assumed to be the average composition of the TRIP events: 85 percent passenger vehicles and 15 percent trucks. Other assumptions used to calculate the fuel cost for trucks (**Equation 9**) and for cars (**Equation 10**) are shown in **Table 12**. The total fuel cost saved due to reduced incident response time was calculated to be $2,927 (**Equation 11**).

Equation 9. Fuel Cost for Trucks (Diesel)

$$Fuel\ cost\ for\ trucks =$$

$$Percentage\ of\ trucks \times \frac{Miles\ of\ travel \times Price\ of\ diesel\ per\ gallon}{Truck\ fuel\ economy}$$

Equation 10. Fuel Cost for Cars (Gasoline)

$$Fuel\ cost\ for\ cars =$$

$$Percentage\ of\ cars \times \frac{Miles\ of\ travel \times Price\ of\ gasoline\ per\ gallon}{Car\ fuel\ economy}$$

Equation 11. Total Fuel Cost

$$Total\ fuel\ cost = Fuel\ cost\ for\ trucks + Fuel\ cost\ for\ cars$$

Table 12. Fuel Cost Assumptions

Miles of Travel	18,556 miles
Unit Diesel Price per Gallon[9]	$3.00 per gallon
Truck Fuel Economy[10]	6.60 miles per gallon
Unit Gasoline Price per Gallon[11]	$2.54 per gallon
Car Fuel Economy[12]	24.10 miles per gallon

The total environmental benefits were calculated by combining the emission cost reductions ($212,738) and the fuel cost reductions ($2,927). The total environmental benefits for the TRIP Program in fiscal year 2019 were estimated to be $215,665.

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[9] https://www.eia.gov/dnav/pet/pet_pri_gnd_dcus_nus_a.htm

[10] https://www.eia.gov/totalenergy/data/browser/index.php?tbl=T01.08#/?f=M&start=200001%20Gas%20and%20diesel%20price:%20https://www.eia.gov/dnav/pet/pet_pri_gnd_dcus_nus_a.htm

[11] https://www.eia.gov/dnav/pet/pet_pri_gnd_dcus_soh_a.htm

[12] https://www.eia.gov/totalenergy/data/browser/index.php?tbl=T01.08#/?f=M&start=200001%20Gas%20and%20diesel%20price:%20https://www.eia.gov/dnav/pet/pet_pri_gnd_dcus_nus_a.htm

Step 5. Calculating the Total Benefits of the TRIP Program

The total benefits of ODOT's TRIP Program include the mobility, safety, and environmental benefits previously discussed. To calculate the total benefits of the program, the mobility, safety, and environmental benefits were added together. The total benefits in fiscal year 2019 were estimated to be $7,903,484. The distribution of the different benefits is shown in **Table 13**. Of the total benefits, 74 percent were estimated to be safety benefits from secondary crash reduction on TRIP corridors.

Table 13. Total Benefits of TRIP

Benefit	Estimated Value
Mobility	$1,852,178
Safety	$5,835,641
Environmental	$215,665
Total	**$7,903,484**

Step 6. Calculating the Total Cost of TRIP

The total cost of the TRIP Program for fiscal year 2019 was calculated to be $376,780. The total cost is composed of the cost of each TRIP event paid to the contractors and the overhead cost of each TRIP event. The average cost of a TRIP event was $2,500, with $2,200 due to the contractor and $265 in overhead costs for ODOT. The $2,200 due to the contractor takes into consideration times when the towing companies were paid $600 as a "show up" fee or $0 for an unsuccessful TRIP event. The overhead costs to ODOT had been calculated previously based on the percent of the day spent on TRIP and labor and facility costs. The distribution of the different costs is shown in **Table 14**.

Table 14. Total Cost of TRIP

Cost	Estimated Value
Contractors	$336,500
Overhead	$40,280
Total	**$376,780**

Step 7. Calculating the Benefit-Cost Ratio of TRIP

The benefit-cost ratio for the TRIP Program was calculated by dividing the total estimated benefits ($7,903,484) by the total costs of the program ($376,780). The resulting benefit-cost ratio was 20.98. A benefit-cost ratio of 20.98 means that for every dollar ODOT spent on the TRIP Program in fiscal year 2019, the public received $20.98 in combined mobility, safety, and environmental benefits.

COMPARISON OF ODOT'S TRIP PERFORMANCE

Given the vast variability among crashes throughout the United States, it is difficult to estimate a nationwide average clearance time. Clearance times can vary significantly within a state and depending on crash characteristics. In Ohio, there were variable clearance times for crashes in urban and rural areas within the same year.

Although a nationwide average clearance time is unavailable, many states with rapid towing programs work to have clearance times of less than 90 minutes. ODOT also shares this goal and requires TRIP events to be cleared in 90 minutes or less. In fiscal year 2019, the average TRIP event was cleared in 75 minutes, which met the goal of the program.

Nationwide Average

As with nationwide clearance times, it is difficult to estimate a nationwide average benefit-cost ratio for rapid towing programs given the variability among states, crashes, data availability, and benefit-cost calculation methodologies. Due to variability among states, benefit-cost ratios should not be used directly to compare the effectiveness of different states' rapid towing response programs. Nevertheless, all DOTs with comparable programs to ODOT's TRIP Program have reported benefit-cost ratios greater than one. These benefit-cost ratios range from 6:1 to 11:1, indicating a positive return on investment. The estimated benefit-cost ratio of ODOT's TRIP Program for fiscal year 2019 was greater than this range, however, other DOTs did not include their programs' safety benefits in their evaluations. The safety benefits (through a reduction of secondary crashes) were included in the ODOT TRIP program evaluation presented here, which explains the greater benefit-cost ratio.

Comparable TRIP Program State Averages

The literature review identified Georgia (GDOT), Virginia (VDOT), and Florida (FDOT) as having comparable programs to the TRIP Program. As shown in **Table 15**, ODOT's TRIP Program was estimated to have a greater benefit-cost ratio than the other programs due to inclusion of safety benefits. Of the TRIP Program's benefits, 74 percent were estimated to be safety benefits from secondary crash reduction on TRIP corridors. The other states' analyses did not monetize secondary crash reduction.

VDOT and GDOT did not include estimated safety benefits in their analyses. If safety benefits were excluded from this analysis, ODOT's TRIP Program would have a benefit-cost ratio of 5.49 (mobility and environmental benefits only) as opposed to 20.98 (mobility, environmental, and safety benefits). The greater mobility and environmental benefits estimated by GDOT and VDOT most likely correspond to greater reduction in clearance time by GDOT and VDOT. Both GDOT and VDOT estimated the reduction in clearance time to be 60 minutes or more. On average, ODOT's TRIP Program reduced clearance time by 22.1 minutes.

ODOT's TRIP Program had a much lower cost per event than GDOT and VDOT. ODOT's cost per TRIP event was approximately $2,479, whereas GDOT's cost per event was $7,591. VDOT's cost exceeded $10,000 per event. Overhead or administrative costs were significantly lower for ODOT (11 percent of the total program cost) than the other programs (66 percent of the total GDOT program cost and 81 percent of the total VDOT program cost).

FDOT's program had a similar cost per event as ODOT's TRIP Program. However, the estimated benefits of FDOT's program are unknown and cannot be compared to the benefits of the TRIP Program.

Table 15. Comparison of TRIP Program to Other State Programs

States	Georgia (GDOT)	Virginia (VDOT)	Florida (FDOT)[13]	Ohio (ODOT)
Number of Events	110	64	303	152
Study Period	2008–2009	2018	2017	2019
Reduction in Clearance Time	165 minutes (60 minutes in benefit estimation)	65.8 minutes		22.1 minutes
Total Benefit	$9,154,431	$5,473,895		$7,903,484
Total Cost	$835,000	$698,686	$617,900	$376,780
B/C ratio	10.96	6:1–7:8		20.98

[13] Benefit-cost data was not available for FDOT.

ANALYSIS RESULTS

In addition to overall program benefits, the TRIP Program benefits were also assessed by the following classifications:

- Urban and rural areas
- Work Zones and non-work zone TRIP events
- TRIP and TRIP-Lite events

Urban and Rural Areas

TRIP serves both urban and rural areas. One component of this analysis was examining the difference in clearance times and benefit-cost ratios for TRIP events in urban and rural areas. In fiscal year 2019, there were 130 TRIP events in urban areas and only 22 TRIP events in rural areas. Urban areas tend to experience more crashes than rural areas, whereas rural areas tend to have more severe crashes than urban areas.

As shown in **Table 16**, the average clearance times for TRIP and non-TRIP events were shorter in urban areas than in rural areas. However, the average difference in clearance times between non-TRIP and TRIP events was the largest in rural areas.

Table 16. Clearance Times for Urban and Rural TRIP and Non-TRIP Events[14]

	All TRIP Events	Urban TRIP Events	Rural TRIP Events
Average Clearance Time TRIP Event (minutes)	53.10	50.99	59.35
Average Clearance Time Non-TRIP Event (minutes)	75.24	72.43	86.07
Average Difference in Clearance Time (minutes)	22.10	21.44	26.72

[14] Averages are weighted by the number of events in each TRIP zone.

As shown in **Table 17**, TRIP events in urban areas had higher benefit-cost ratios than TRIP events in rural areas. In fiscal year 2019, TRIP events in urban areas accounted for 86 percent of all TRIP events and approximately 90 percent of all estimated benefits of the program.

Table 17. Benefit-Cost Ratios of Urban and Rural TRIP Events

	All TRIP Events	Urban TRIP Events	Rural TRIP Events
Number of Events	152	130	22
Mobility Benefits	$1,852,178	$1,864,879	-$12,701
Safety Benefits	$5,835,641	$4,991,008	$844,632
Environmental Benefits	$215,665	$184,451	$31,214
Cost	$376,780	$327,250	$49,530
Benefit-Cost Ratio	20.98	21.51	17.43

Work Zones and Non-Work Zones

In fiscal year 2019, 56 of the 152 total TRIP events (37 percent) occurred in work zones. As shown in **Table 18,** TRIP events that occurred in work zones had faster average arrival times and faster average clearance times compared to TRIP events that did not occur in work zones. On average, TRIP events that occurred in work zones were cleared about seven minutes faster than TRIP events that did not occur in work zones.

Table 18. Arrival and Clearance Times for TRIP Events in Work Zones and Non-Work Zones

	TRIP Events in Work Zones	TRIP Events in Non-work Zones
Average Arrival Time (minutes)	19.98	23.09[15]
Average Clearance Time (minutes)	30.80	37.11

However, TRIP events in work zones had a lower benefit-cost ratio (16.05) than both all TRIP events (20.98) and TRIP events in non-work zones (23.97) (**Table 19**). The lower benefit-cost ratio is most likely due to the existing congestion present in work zones. Work zones typically reduce roadway capacity, and then that capacity is reduced further when a crash occurs. Such reduced capacity results in more congestion.

[15] TRIP event in TRIP Zone 6A with arrival time of 5,781 minutes was removed.

TRIP events in non-work zones had the highest benefit-cost ratio. In fiscal year 2019, TRIP events in non-work zones accounted for 63 percent of all TRIP events and 71 percent of the estimated benefits from the TRIP Program.

Table 19. Benefit-Cost Ratios of TRIP Events in Work Zones and Non-Work Zones

	All TRIP Events	TRIP Events in Work Zones	TRIP Events in Non-Work Zones
Number of Events	152	56	96
Mobility Benefits	$1,852,178	$52,937	$1,799,241
Safety Benefits	$5,835,641	$2,149,973	$3,685,668
Environmental Benefits	$215,665	$79,456	$136,209
Cost	$376,780	$142,240	$234,540
Benefit-Cost Ratio	20.98	16.05	23.97

TRIP and TRIP-Lite Events

ODOT additionally maintains a TRIP-Lite program in which qualified vendors provide towing and recovery services to expedite the clearance of passenger vehicles involved in a crash and/or disabled in identified work zones. This program launched with one pilot location in calendar year 2020. The program is expected to continue to expand.

The benefit-cost analysis for the TRIP-Lite program can use the same spreadsheet tool as the TRIP Program. It is expected that the program's arrival and clearance times and benefit-cost ratio will be similar to those of TRIP events that occurred in work zones. TRIP events that occurred in work zones had a positive benefit-cost ratio that resulted in more than sixteen dollars saved for every dollar spent on the TRIP Program.

TRIP Zone Utilization

A byproduct of this study was determining the utilization of each TRIP zone. Because TRIP and non-TRIP events (property damage only crashes that involved a semi-truck) were mapped for each TRIP zone, the utilization of each zone could be easily calculated. TRIP zone utilization is the percentage of possible TRIP events (TRIP events and non-TRIP events combined) that used the TRIP Program (**Equation 12**).

Equation 12. TRIP Zone Utilization

$$TRIP\ Zone\ Utilization\ (\%) =$$

$$\frac{Number\ of\ TRIP\ events}{Number\ of\ TRIP\ events + Number\ of\ non-TRIP\ events} \times 100$$

The TRIP zone utilizations show the effectiveness of the TRIP Program throughout the state and help identify areas for potential program growth. Of the TRIP zones with TRIP events in fiscal year 2019, the zone utilizations ranged from 2 percent to 13 percent (**Table 20**). Four TRIP zones (2B, 6A, 6C, 6B) had utilizations of more than 10 percent. However, three of these zones (2B, 6C, 6B) had five or fewer TRIP events and are rural areas that experience fewer crashes overall.

It is important to note that the 152 TRIP events occurred in just 17 of the 36 designated TRIP zones. In fiscal year 2019, 52 percent of TRIP Zones (19 out of 36) were not used.

Table 20. Utilization of TRIP Zones

TRIP Zone	TRIP Events	Non-TRIP Events	Utilization
2B	4	26	13%
6A	68	464	13%
6C	5	38	12%
6B	3	25	11%
12D	9	107	8%
2A	15	194	7%
4A	3	42	7%
8A	16	262	6%
8B	9	172	5%
1B	3	60	5%
7A	6	132	4%
12A	1	27	4%
4B	5	158	3%
1A	1	38	3%
12B	2	79	2%
7C	1	53	2%
12C	1	59	2%

Summary of Findings

ODOT’s TRIP Program was found to have a benefit-cost ratio of 20.98 when evaluated for mobility, safety, and environmental benefits. The total benefits in fiscal year 2019 were estimated as $7,903,484, with 74 percent of the benefits estimated to be safety benefits related to secondary crash reduction.

This benefit-cost analysis can be replicated in future years to continue to evaluate the TRIP Program. Future TRIP events can be input into the spreadsheet tool created by this study, and the results will populate automatically.

CONCLUSION

When evaluated for mobility, safety, and environmental benefits, ODOT's Towing and Recovery Incentive Payment (TRIP) Program was found to have a benefit-cost ratio of 20.98. The total benefits for fiscal year 2019 were estimated as $7,903,484, with 74 percent of the benefits estimated to be safety benefits related to secondary crash reduction. Additionally, TRIP events were categorized into urban and rural events and work zone and non-work zone events. TRIP events in urban areas had higher benefit-cost ratios than TRIP events in rural areas. TRIP events in non-work zones had the highest benefit-cost ratio. The lower benefit-cost ratio of work zone TRIP events is likely due to the existing congestion present in work zones.

It is difficult to estimate a nationwide average benefit-cost ratio for rapid towing programs given the variability among states, crashes, data availability, and benefit-cost calculation methodologies. As such, benefit-cost ratios should not be used directly to compare the effectiveness of different states' rapid towing response programs. With that caveat, other DOT programs comparable to ODOT's TRIP Program have reported benefit-cost ratios ranging from 6:1 to 11:1, which indicates a positive return on investment. The estimated benefit-cost ratio of ODOT's TRIP Program for fiscal year 2019 was greater than this range; however, other DOTs did not evaluate their programs' safety benefits.

Further opportunities to continue the TRIP Program and increase utilization across Ohio can be beneficial. Additional research opportunities can be explored to refine the program zones, incentives, and utilization.

APPENDIX A—REFERENCES

National Work Zone References:

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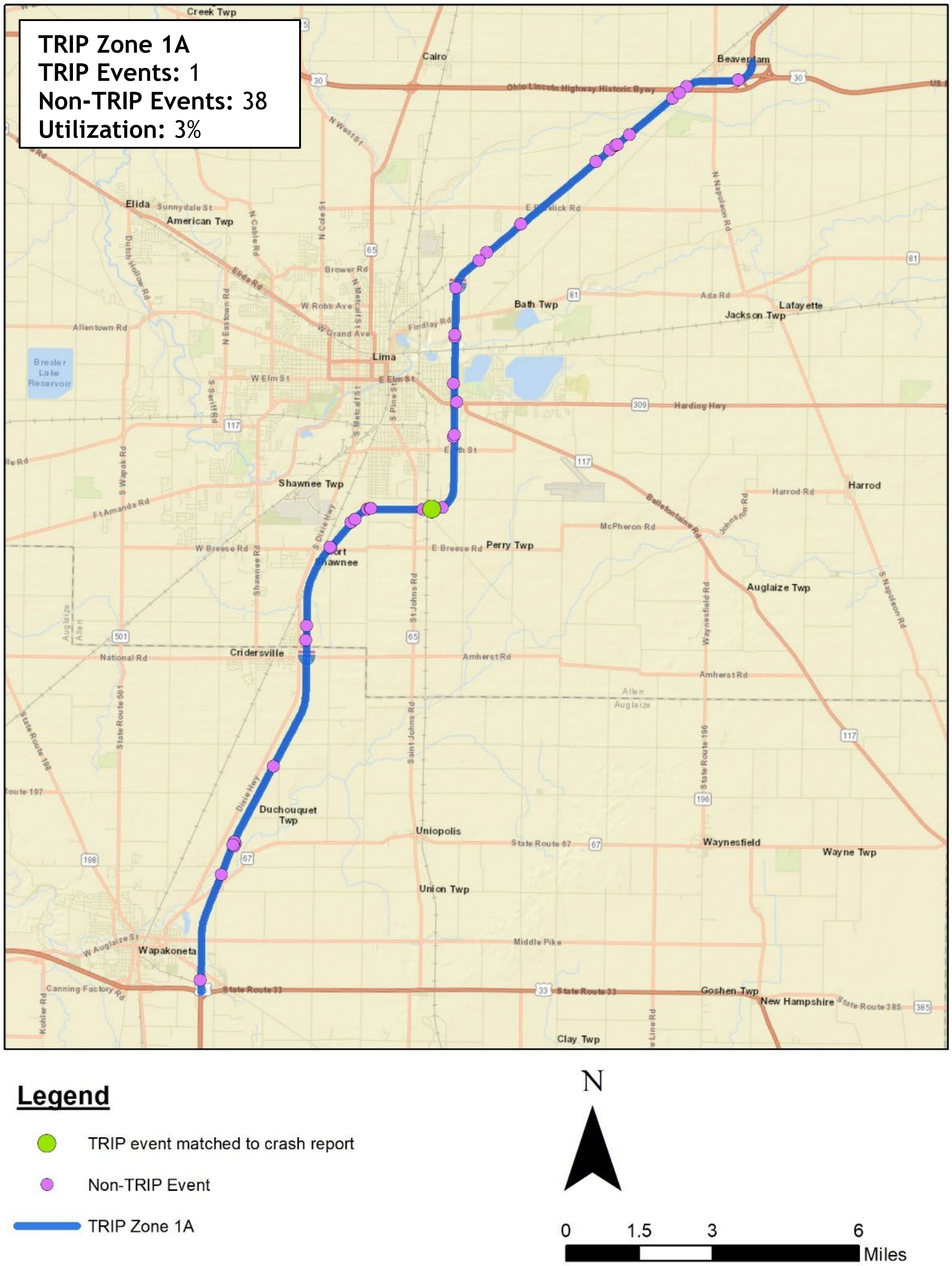
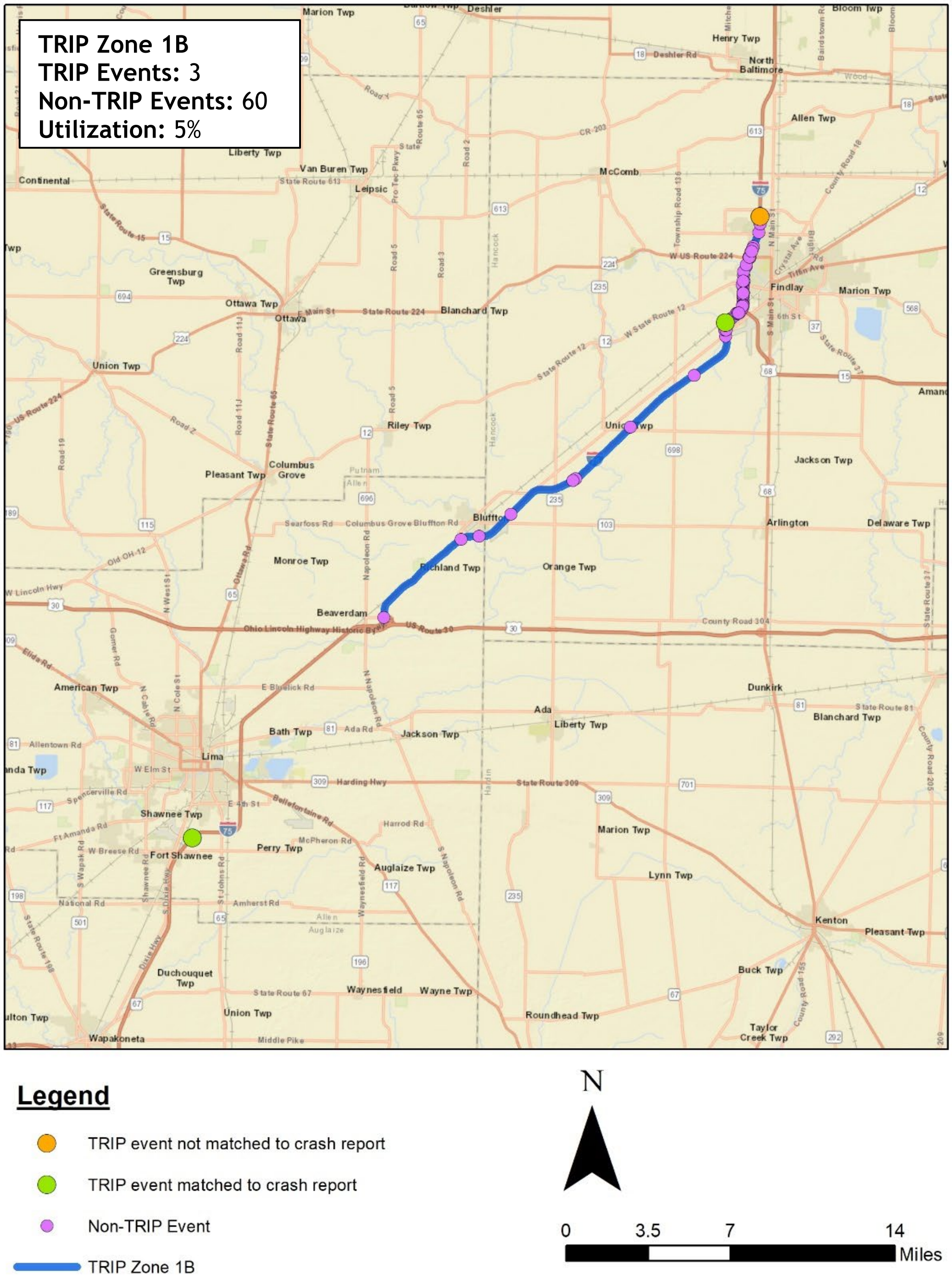
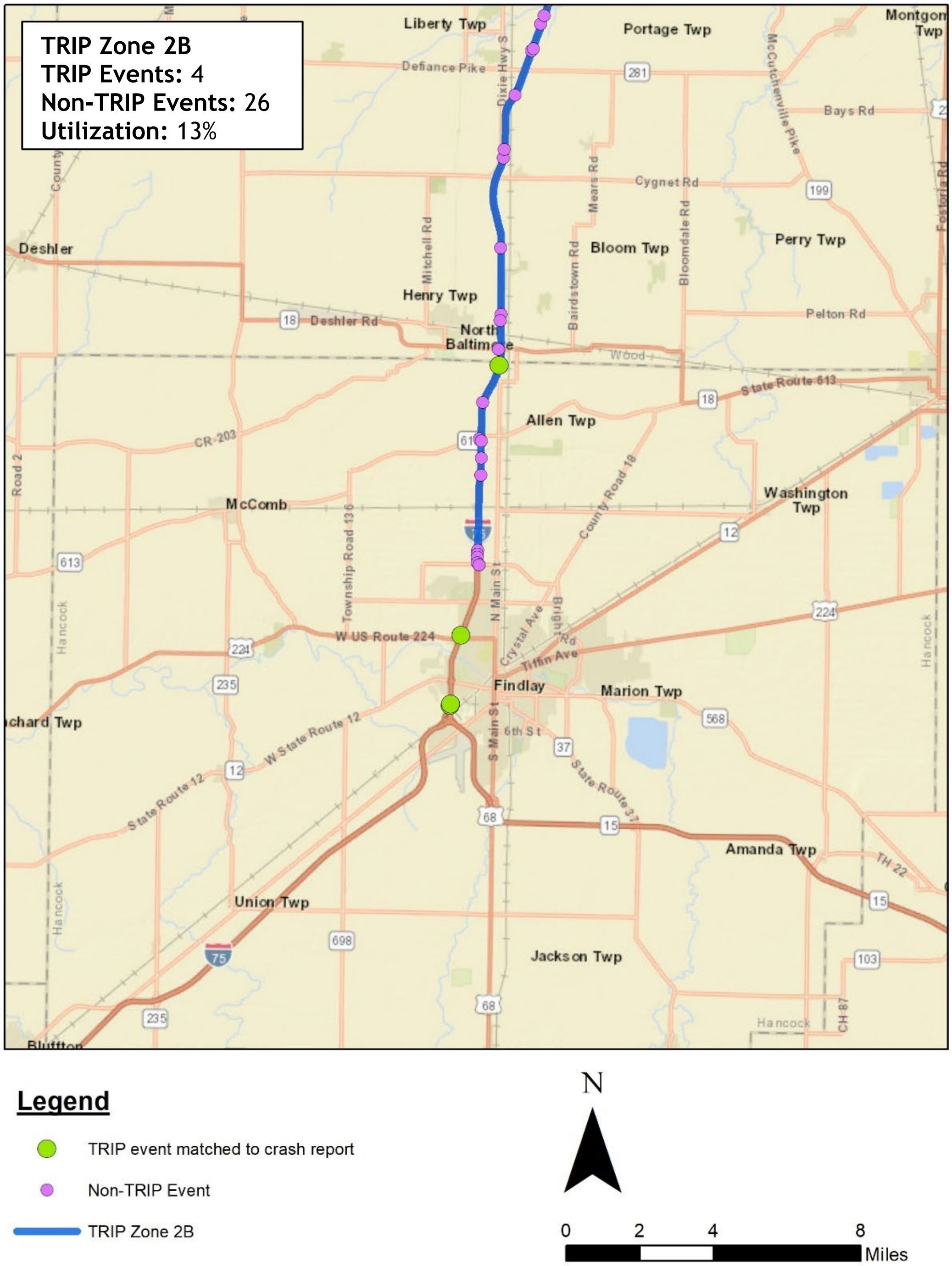
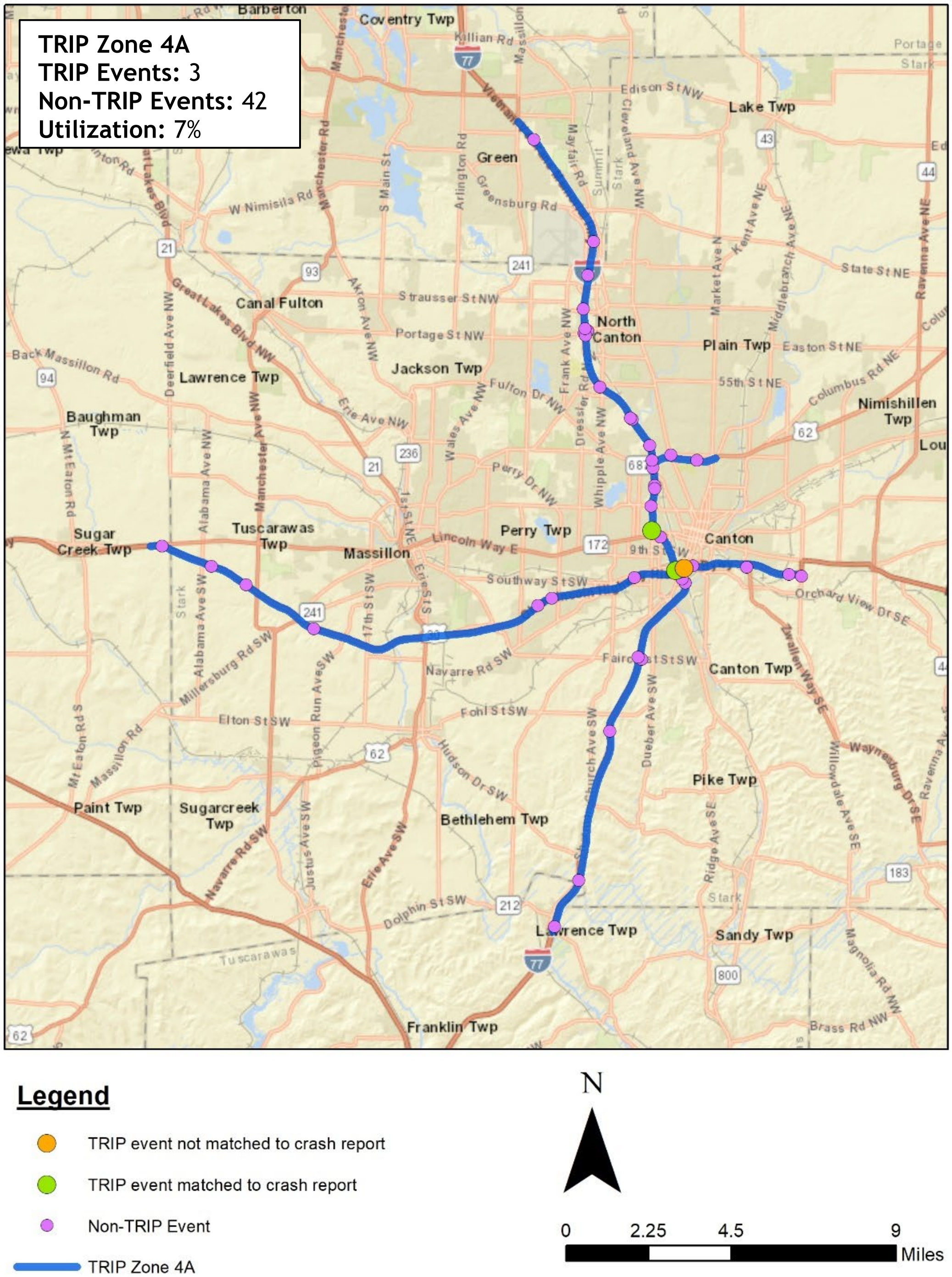
APPENDIX B—TRIP ZONE MAPS

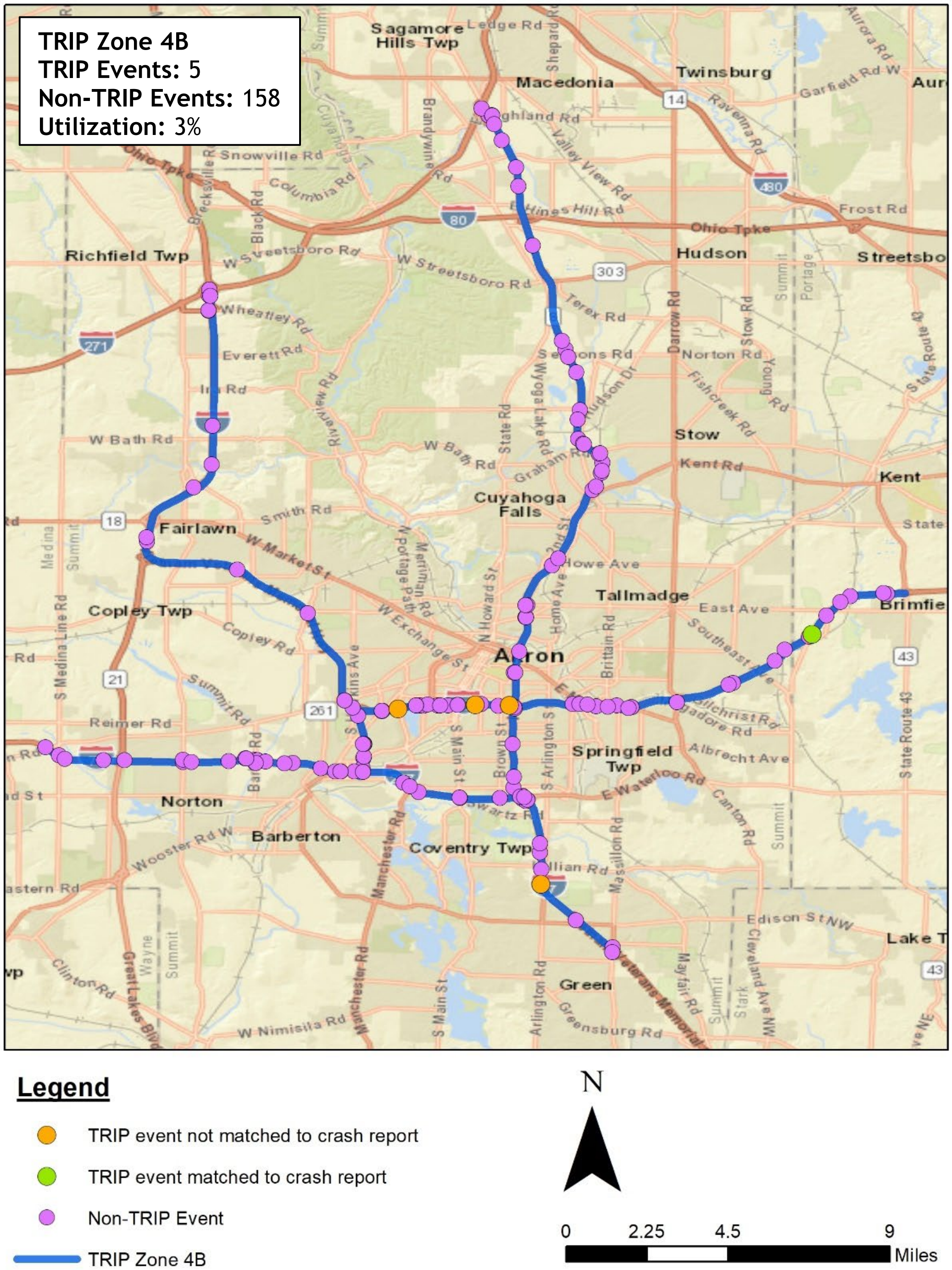

TRIP Zone 1A
TRIP Events: 1
Non-TRIP Events: 38
Utilization: 3%
Lima
Cairo
Elida
American Twp
Bath Twp
Jackson Twp
Lafayette
Shawnee Twp
Perry Twp
Cridersville
Auglaize Twp
Harrod
Duchouquet Twp
Uniopolis
Union Twp
Waynesfield
Wayne Twp
Wapakoneta
Goshen Twp
New Hampshire
Clay Twp
Legend
TRIP event matched to crash report
Non-TRIP Event
TRIP Zone 1A
N
0
1.5
3
6
Miles

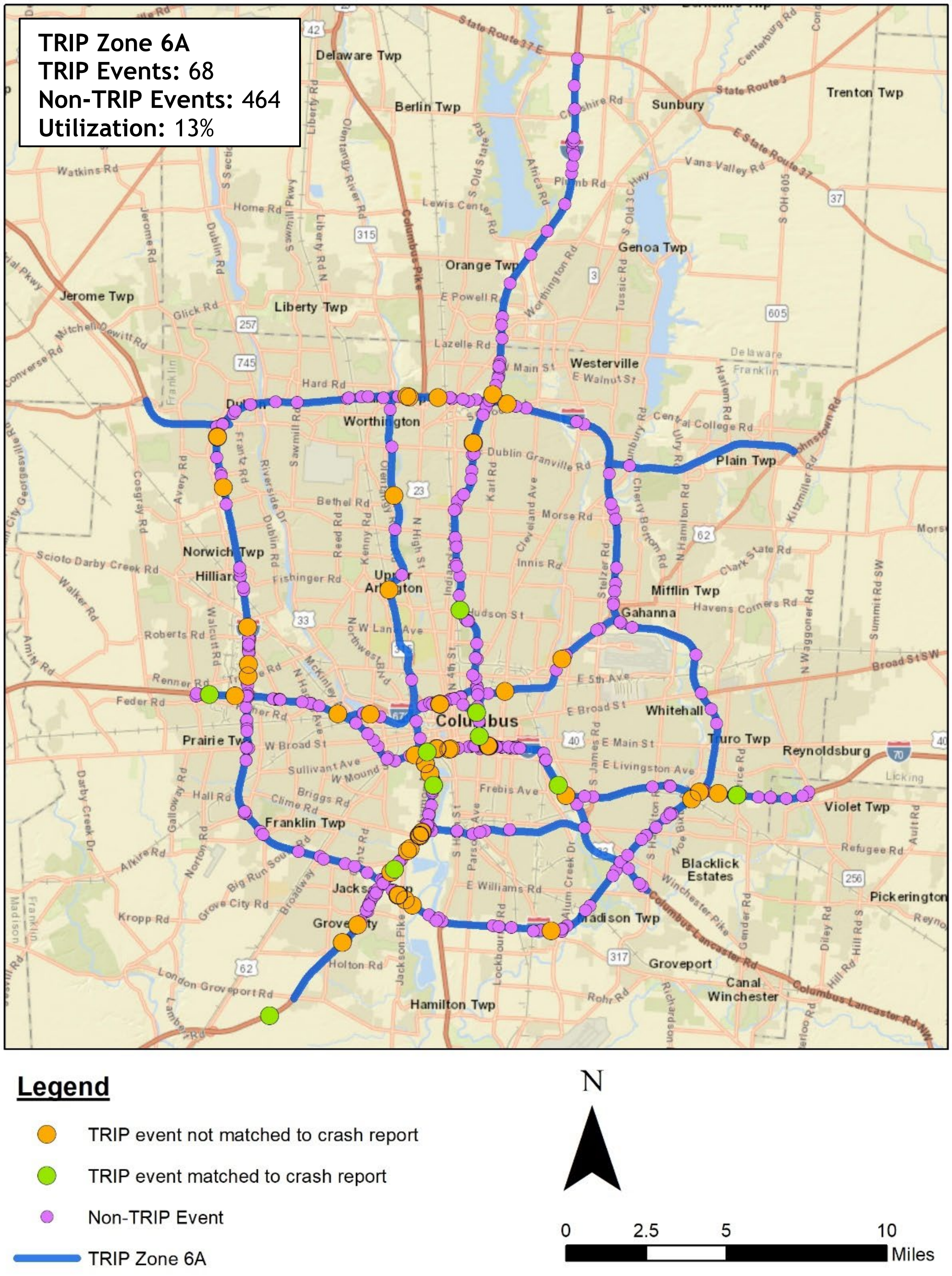

TRIP Zone 1B
TRIP Events: 3
Non-TRIP Events: 60
Utilization: 5%
Findlay
Lima
Kenton
Legend
TRIP event not matched to crash report
TRIP event matched to crash report
Non-TRIP Event
TRIP Zone 1B
N
0
3.5
7
14
Miles

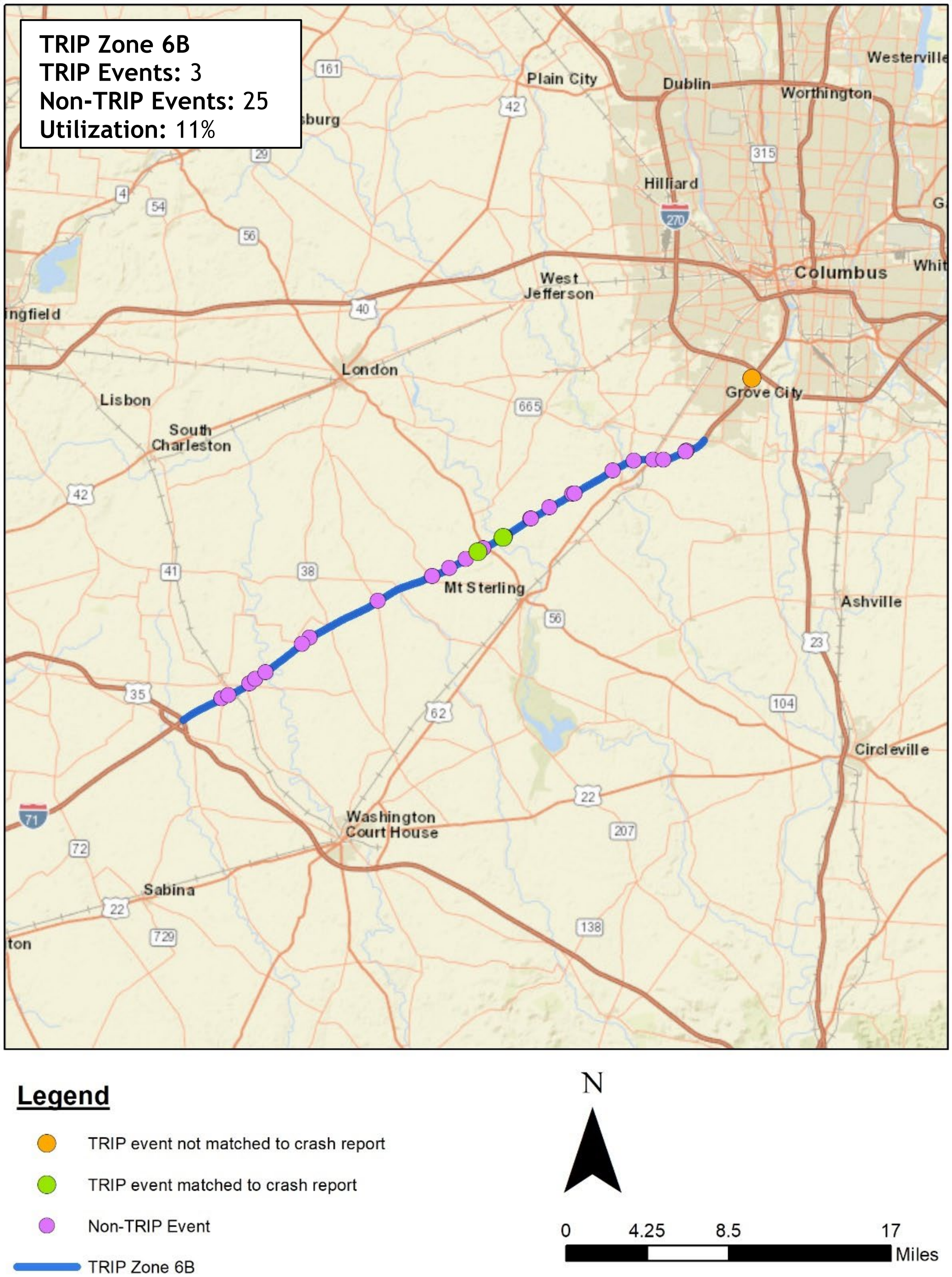

TRIP Zone 2A
TRIP Events: 15
Non-TRIP Events: 194
Utilization: 7%
Toledo
Ottawa Hills
Oregon
Northwood
Spencer Twp
Springfield Twp
Monclova Twp
Maumee
Perrysburg
Perrysburg Twp
Lake Twp
Whitehouse
Waterville Twp
Waterville
Middleton Twp
Plain Twp
Webster Twp
Troy Twp
Freedom Twp
Bowling Green
Weston Twp
Weston
Maumee Bay
Legend
TRIP event not matched to crash report
TRIP event matched to crash report
Non-TRIP Event
TRIP Zone 2A
N
0
2.25
4.5
9
Miles

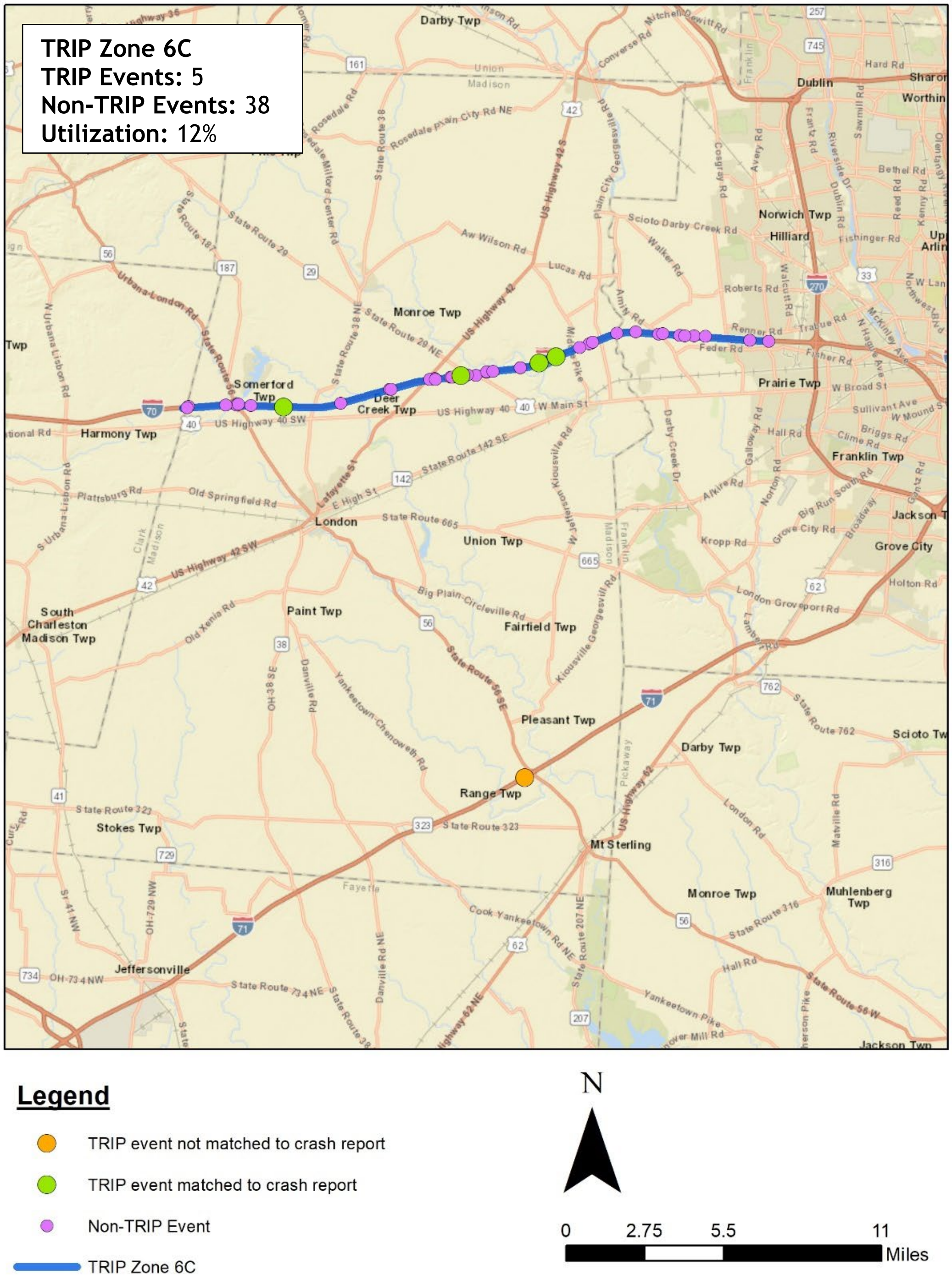

TRIP Zone 2B
TRIP Events: 4
Non-TRIP Events: 26
Utilization: 13%
Liberty Twp
Portage Twp
Montgomery Twp
Defiance Pike
Dixie Hwy S
McCutchenville Pike
Bays Rd
Cygnet Rd
Mears Rd
Deshler
Mitchell Rd
Bloom Twp
Bloomdale Rd
Perry Twp
Fostoria Rd
Henry Twp
Bairdstown Rd
Pelton Rd
Deshler Rd
North Baltimore
Wood
State Route 613
Allen Twp
CR 203
County Road 18
Washington Twp
McComb
Township Road 136
N Main St
Crystal Ave
Bright Rd
W US Route 224
Tiffin Ave
Findlay
Marion Twp
Hancock
W State Route 12
State Route 12
6th St
S Main St
State Route 37
Amanda Twp
TH 22
Union Twp
Jackson Twp
Bluffton
CH 87
Legend
TRIP event matched to crash report
Non-TRIP Event
TRIP Zone 2B
N
0
2
4
8
Miles


TRIP Zone 4A
TRIP Events: 3
Non-TRIP Events: 42
Utilization: 7%
Barberton
Coventry Twp
Green
Lake Twp
Canal Fulton
North Canton
Plain Twp
Lawrence Twp
Jackson Twp
Nimishillen Twp
Baughman Twp
Sugar Creek Twp
Tuscarawas Twp
Massillon
Perry Twp
Canton
Canton Twp
Pike Twp
Paint Twp
Sugarcreek Twp
Bethlehem Twp
Lawrence Twp
Sandy Twp
Franklin Twp
Legend
TRIP event not matched to crash report
TRIP event matched to crash report
Non-TRIP Event
TRIP Zone 4A
N
0
2.25
4.5
9
Miles

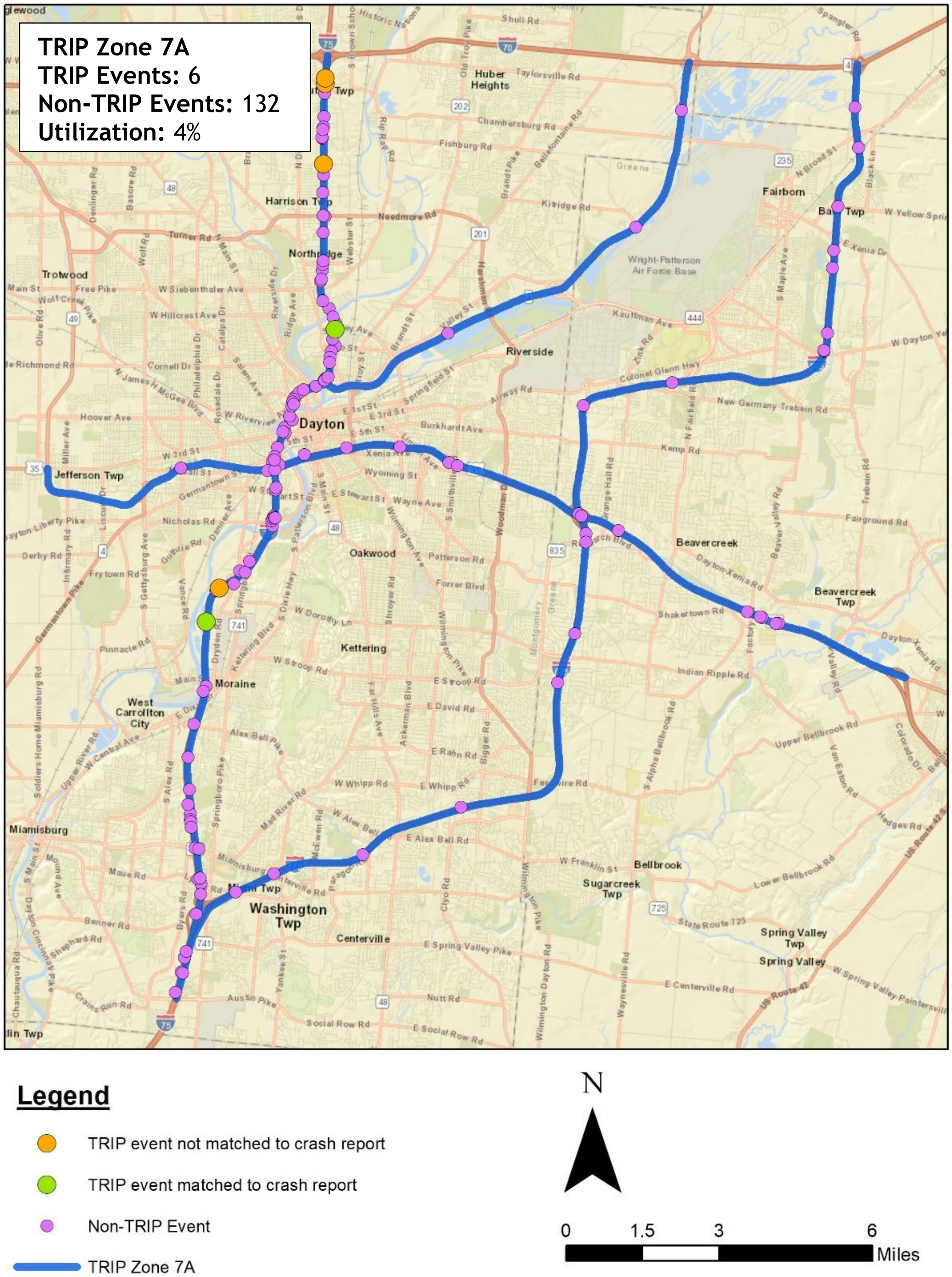

TRIP Zone 4B
TRIP Events: 5
Non-TRIP Events: 158
Utilization: 3%
Sagamore Hills Twp
Macedonia
Twinsburg
Richfield Twp
Hudson
Streetsbo
Stow
Kent
Cuyahoga Falls
Fairlawn
Copley Twp
Tallmadge
Brimfie
Akron
Springfield Twp
Norton
Barberton
Coventry Twp
Green
Lake T
Legend
TRIP event not matched to crash report
TRIP event matched to crash report
Non-TRIP Event
TRIP Zone 4B
N
0
2.25
4.5
9
Miles

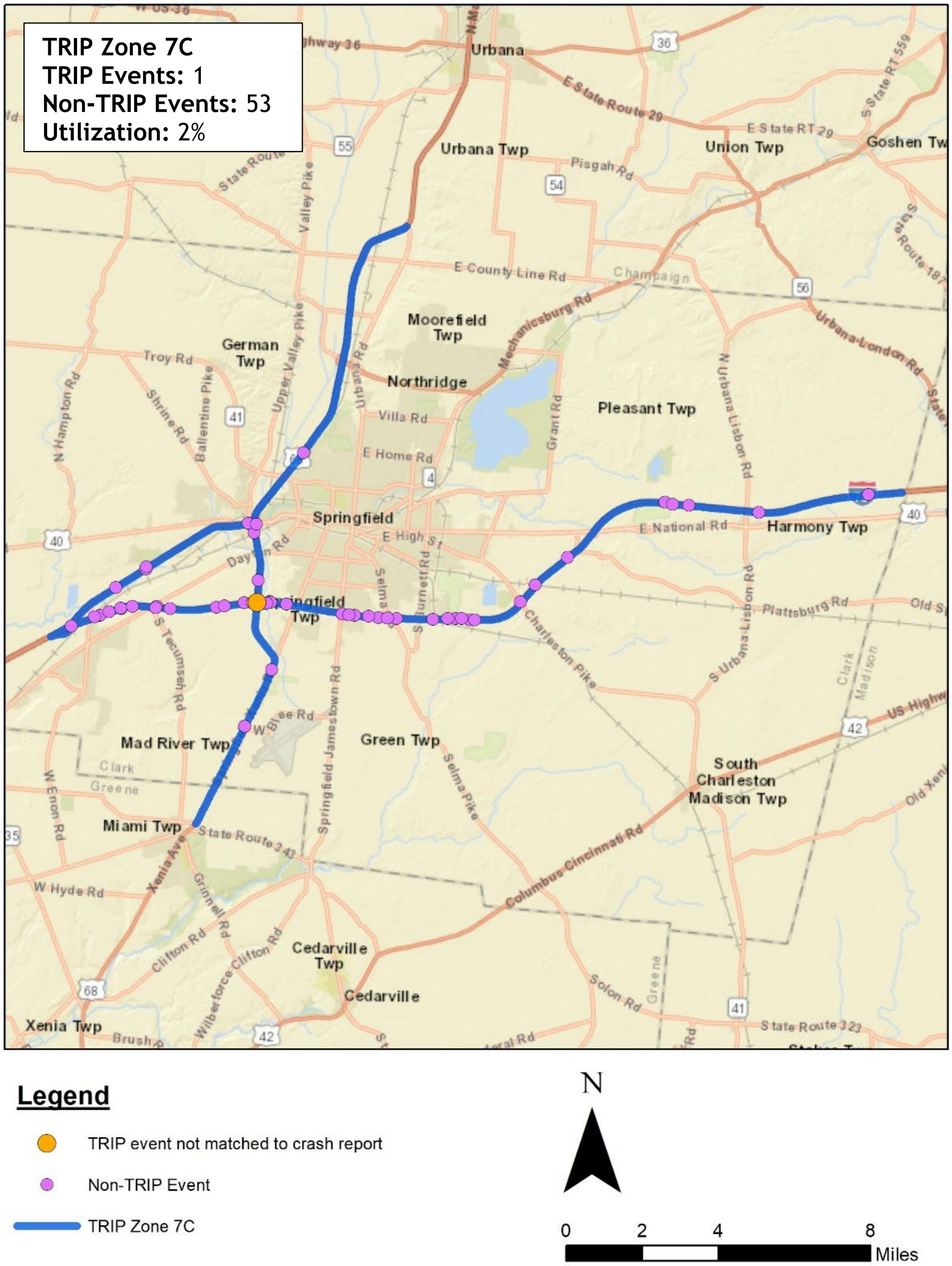

TRIP Zone 6A
TRIP Events: 68
Non-TRIP Events: 464
Utilization: 13%
Columbus
Worthington
Westerville
Gahanna
Whitehall
Reynoldsburg
Upper Arlington
Grove City
Groveport
Canal Winchester
Pickerington
Sunbury
Legend
TRIP event not matched to crash report
TRIP event matched to crash report
Non-TRIP Event
TRIP Zone 6A
N
0
2.5
5
10
Miles

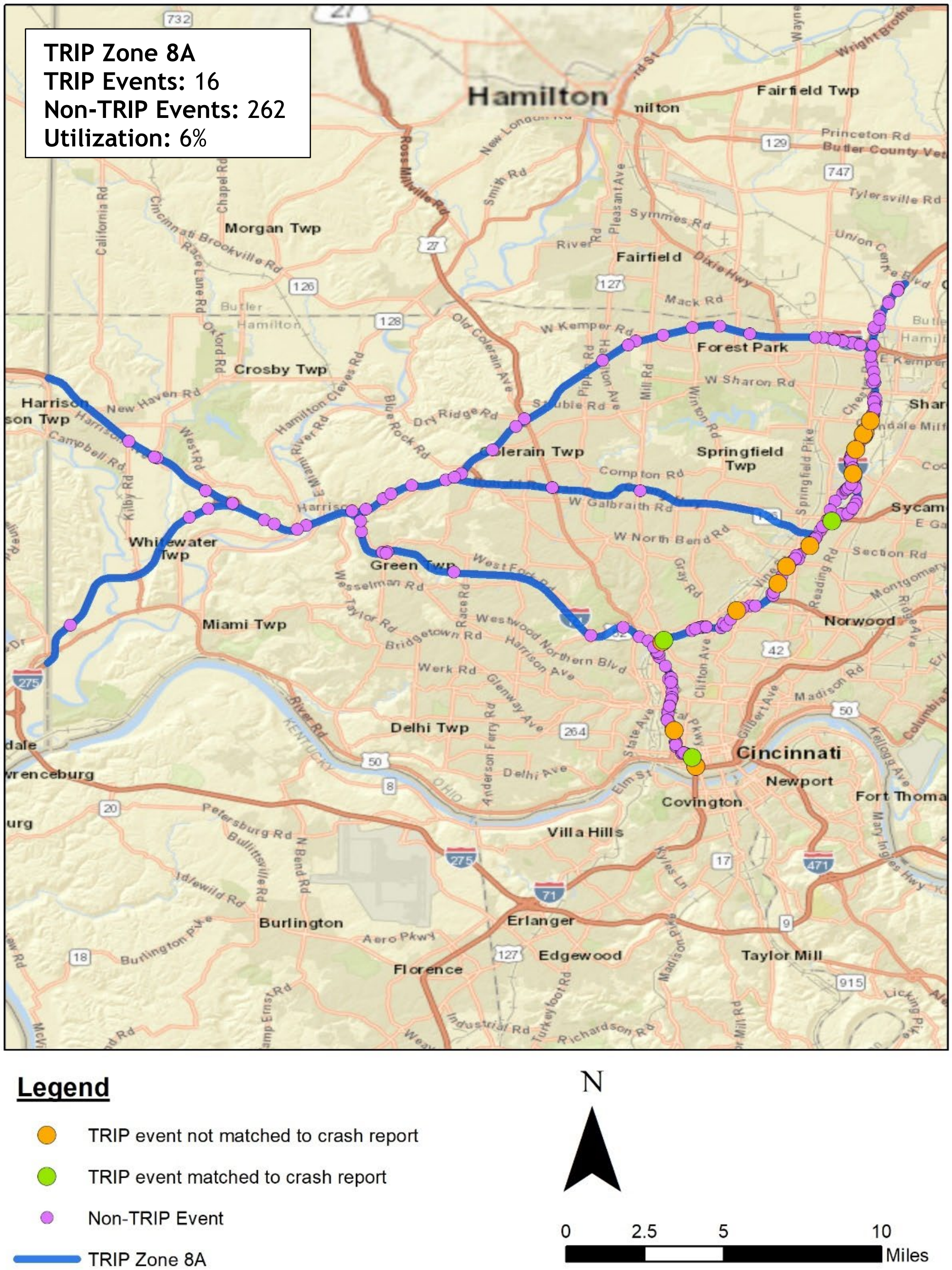

TRIP Zone 6B
TRIP Events: 3
Non-TRIP Events: 25
Utilization: 11%
Plain City
Dublin
Worthington
Westerville
Hilliard
Columbus
West Jefferson
London
Lisbon
South Charleston
Grove City
Mt Sterling
Ashville
Circleville
Washington Court House
Sabina
Legend
TRIP event not matched to crash report
TRIP event matched to crash report
Non-TRIP Event
TRIP Zone 6B
N
0
4.25
8.5
17
Miles

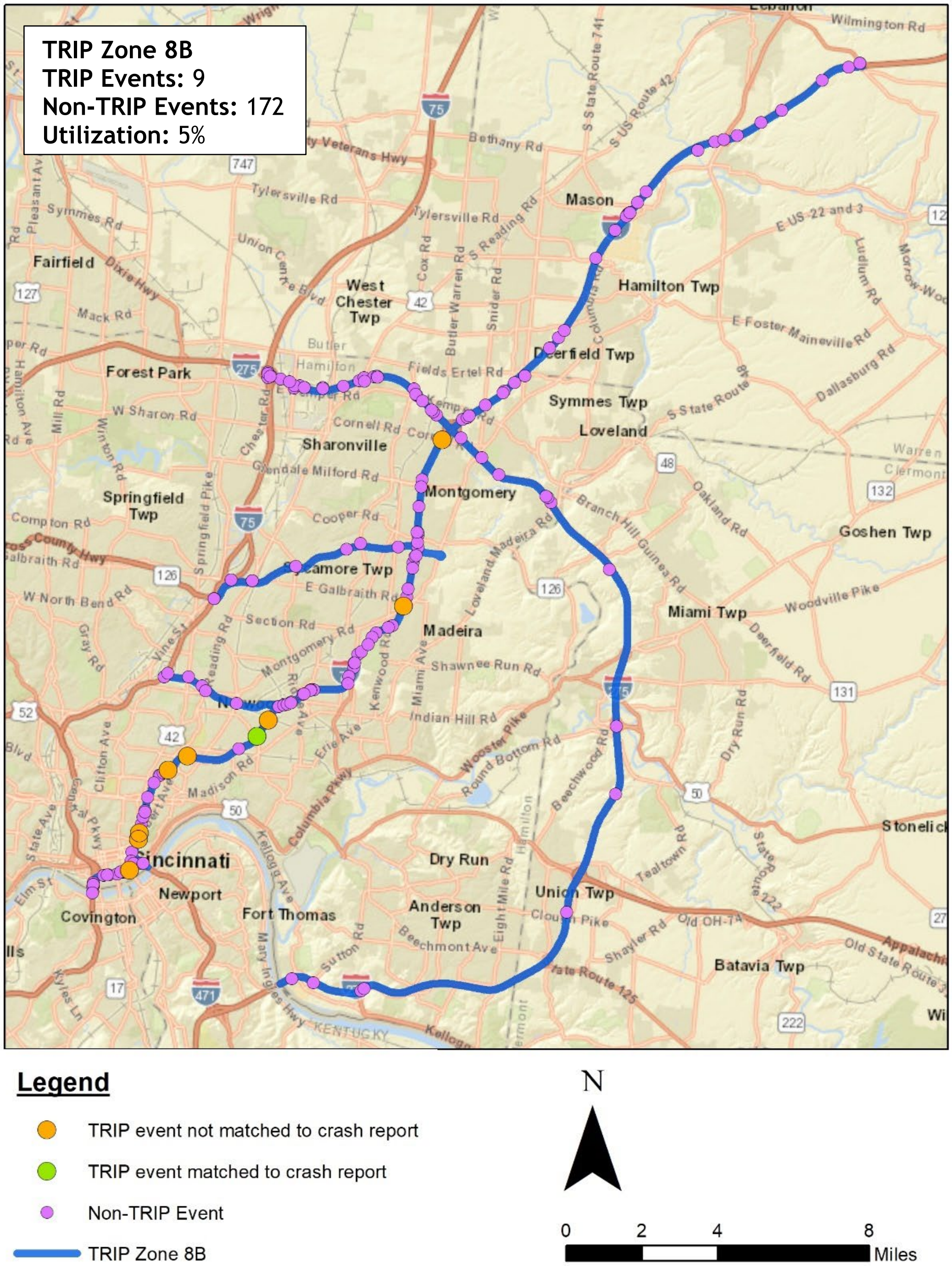


TRIP Zone 6C
TRIP Events: 5
Non-TRIP Events: 38
Utilization: 12%
Darby Twp
Dublin
Norwich Twp
Hilliard
Monroe Twp
Somerford Twp
Deer Creek Twp
Harmony Twp
Prairie Twp
Franklin Twp
London
Union Twp
Grove City
South Charleston
Madison Twp
Paint Twp
Fairfield Twp
Pleasant Twp
Darby Twp
Range Twp
Stokes Twp
Mt Sterling
Monroe Twp
Muhlenberg Twp
Jeffersonville
US Highway 40 SW
US Highway 42 SW
State Route 323
Legend
TRIP event not matched to crash report
TRIP event matched to crash report
Non-TRIP Event
TRIP Zone 6C
N
0
2.75
5.5
11
Miles


TRIP Zone 7A
TRIP Events: 6
Non-TRIP Events: 132
Utilization: 4%
Legend
TRIP event not matched to crash report
TRIP event matched to crash report
Non-TRIP Event
TRIP Zone 7A
N
0 1.5 3 6
Miles


TRIP Zone 7C
TRIP Events: 1
Non-TRIP Events: 53
Utilization: 2%
Urbana
Urbana Twp
Union Twp
Goshen Twp
Moorefield Twp
Northridge
German Twp
Pleasant Twp
Springfield
Harmony Twp
Springfield Twp
Mad River Twp
Green Twp
South Charleston
Madison Twp
Miami Twp
Cedarville Twp
Cedarville
Xenia Twp
Legend
TRIP event not matched to crash report
Non-TRIP Event
TRIP Zone 7C
N
0
2
4
8
Miles


TRIP Zone 8A
TRIP Events: 16
Non-TRIP Events: 262
Utilization: 6%
Hamilton
Fairfield Twp
Fairfield
Morgan Twp
Crosby Twp
Forest Park
Springfield Twp
Colerain Twp
Whitewater Twp
Green Twp
Miami Twp
Delhi Twp
Norwood
Cincinnati
Newport
Covington
Villa Hills
Burlington
Erlanger
Edgewood
Florence
Taylor Mill
Legend
TRIP event not matched to crash report
TRIP event matched to crash report
Non-TRIP Event
TRIP Zone 8A
N
0
2.5
5
10
Miles


TRIP Zone 8B
TRIP Events: 9
Non-TRIP Events: 172
Utilization: 5%
Mason
Hamilton Twp
West Chester Twp
Fairfield
Forest Park
Sharonville
Deerfield Twp
Symmes Twp
Loveland
Springfield Twp
Montgomery
Sycamore Twp
Madeira
Miami Twp
Goshen Twp
Cincinnati
Newport
Covington
Fort Thomas
Dry Run
Anderson Twp
Union Twp
Batavia Twp
Legend
TRIP event not matched to crash report
TRIP event matched to crash report
Non-TRIP Event
TRIP Zone 8B
N
0 2 4 8
Miles


TRIP Zone 12A
TRIP Events: 1
Non-TRIP Events: 27
Utilization: 4%
Madison Twp
Perry Twp
Perry
Madison
Painesville
Painesville Twp
Mentor
Eastlake
Willoughby
Concord Twp
Leroy Twp
Thompson Twp
Hambden Twp
Chardon
Claridon Twp
Huntsburg Twp
Chester Twp
Mayfield Heights
Beachwood
Burton Twp
Middlefield
Middlefield Twp
Legend
TRIP event matched to crash report
Non-TRIP Event
TRIP Zone 12A
N
0
2.25
4.5
9
Miles


TRIP Zone 12B
TRIP Events: 2
Non-TRIP Events: 79
Utilization: 2%
Euclid
Bratenahl
East Cleveland
South Euclid
Cleveland Heights
University Heights
Cleveland
Lakewood
Bay Village
Westlake
Rocky River
Shaker Heights
Warrensville Heights
Garfield Heights
Maple Heights
Bedford
Bedford Heights
North Olmsted
Olmsted Twp
Parma Heights
Parma
Berea
Strongsville
North Royalton
Columbia Twp
Sagamore Hills Twp
Legend
TRIP event not matched to crash report
Non-TRIP Event
TRIP Zone 12B
N
0
2.25
4.5
9
Miles


TRIP Zone 12C
TRIP Events: 1
Non-TRIP Events: 59
Utilization: 2%
Legend
Non-TRIP Event
TRIP event matched to crash report
TRIP Zone 12C
N
0
1.75
3.5
7
Miles


TRIP Zone 12D
TRIP Events: 9
Non-TRIP Events: 107
Utilization: 8%
Bratenahl
East Cleveland
South Euclid
Cleveland Heights
University Heights
Mayfield Heights
Beachwood
Shaker Heights
Warrensville Heights
Garfield Heights
Maple Heights
Bedford
Bedford Heights
Solon
Bainbridge Twp
Chester Twp
Auburn Twp
Sagamore Hills Twp
Macedonia
Twinsburg
Aurora
Hudson
Streetsboro
Eagle Rd
Chardon Rd
Wilson Mills Rd
Mayfield Rd
Fairmount Rd
Kinsman Rd
Bell Rd
Cedar Rd
Shaker Blvd
Chagrin Blvd
Union Ave
Miles Ave
Emery Rd
Jackson Rd
Cannon Rd
Libby Rd
Pettibone Rd
Highland Rd
Snowville Rd
Valley View Rd
Hines Hill Rd
Ohio Tpke
Frost Rd
State Route 82
State Route 44
W Streetsboro Rd
Wheatley Rd
Legend
TRIP event not matched to crash report
TRIP event matched to crash report
Non-TRIP Event
TRIP Zone 12D
N
0
2
4
8
Miles