Roundabouts in Central Connecticut

CCRPA

Evaluation of the potential installation of two roundabouts in Bristol and Plainville. Analysis of congestion reduction and air quality improvements.

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Introduction

Roundabouts are becoming more widespread in American communities. While they are common in Europe, they are still widely underutilized in America. Roundabouts offer several advantages over traffic lights and all-way stops.

First, they reduce the delay of vehicles at busy intersections by facilitating a continuous flow of traffic. Since roundabouts do not force cars to stop (only yield), they better handle the traffic peaks and lulls throughout the day. During peak hours, roundabouts help maintain a continuous traffic flow. During off peak hours, cars are not forced to stop at a stop sign or wait at a traffic light. Both of these scenarios offer significant delay reduction. Delay reduction also reduces fuel consumption and emissions of air pollutants, including greenhouse gases (GHG). Growing concerns about pollution and reliance on foreign oil only make the case for roundabouts stronger.

Second, roundabouts improve safety for both pedestrians and drivers. Because roundabouts limit turning movements and force traffic to drive in the same direction, they greatly reduce conflict among vehicles and pedestrians. (See Figure 1). In addition, the geometry of roundabouts forces drivers to slow down, reducing the severity of accidents. Roundabouts have been shown to reduce intersection accidents by 35 percent; injuries by 75 percent; and severe, incapacitating injuries by 89 percent.

Third, roundabouts offer aesthetic improvements. Center islands and splitter islands (which deflect traffic) provide an aesthetically pleasing environment to drivers and pedestrians. Roundabouts also eliminate the need for turning lanes, decreasing the size of some multi-lane intersections and reducing the total paved area. Landscaped center islands that create a pleasing environment serve as 'gateways' for communities.

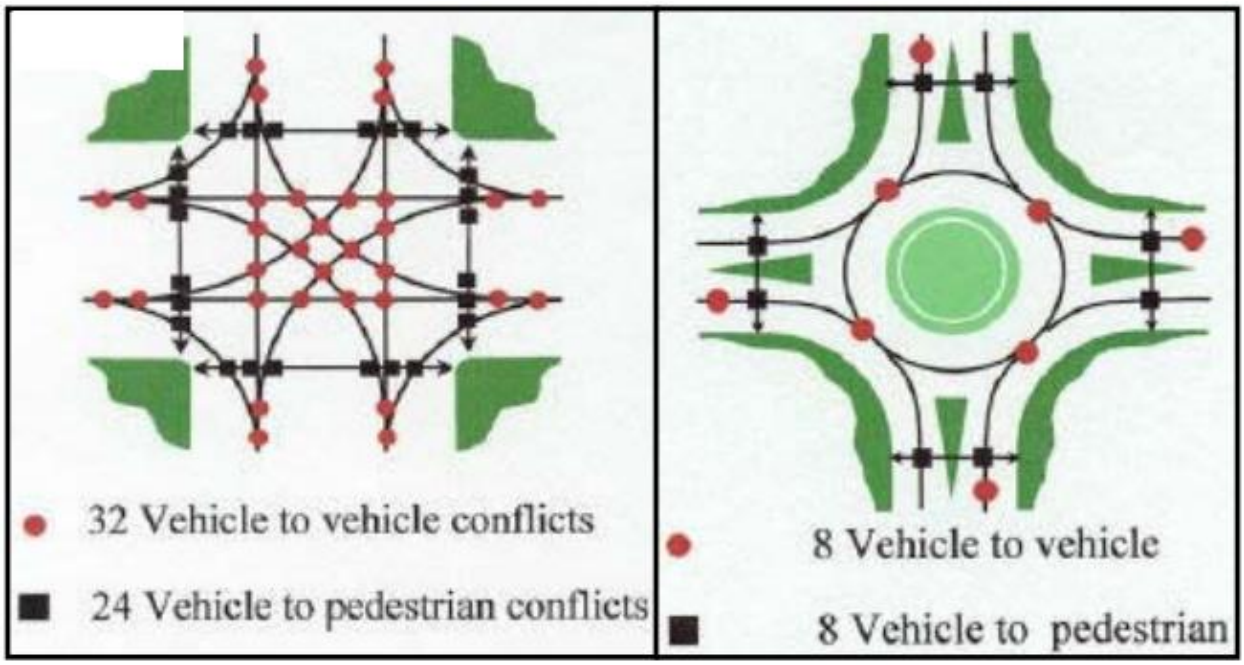
Finally, because roundabouts do not require traffic lights or use electricity, they can generate cost savings over signalized intersections.

However, roundabouts are not appropriate in all situations. Appropriate conditions for installation include:

- Locations with high delays
- Locations where traffic signals are not warranted
- Four-way stop intersections
- Intersections with more than four legs
- Intersections with high left-turn flows
- Intersections with unusual geometry
- Intersections with changing traffic patterns
- Locations where storage capacities for signalized intersections are restricted
- Intersections that are important from an urban design or visual point of view

To help familiarize the reader with the various elements of a roundabout, Figure 2 offers a diagram showing the components of the typical roundabout.

FIGURE 1: ROUNDABOUT SAFETY IMPROVEMENTS

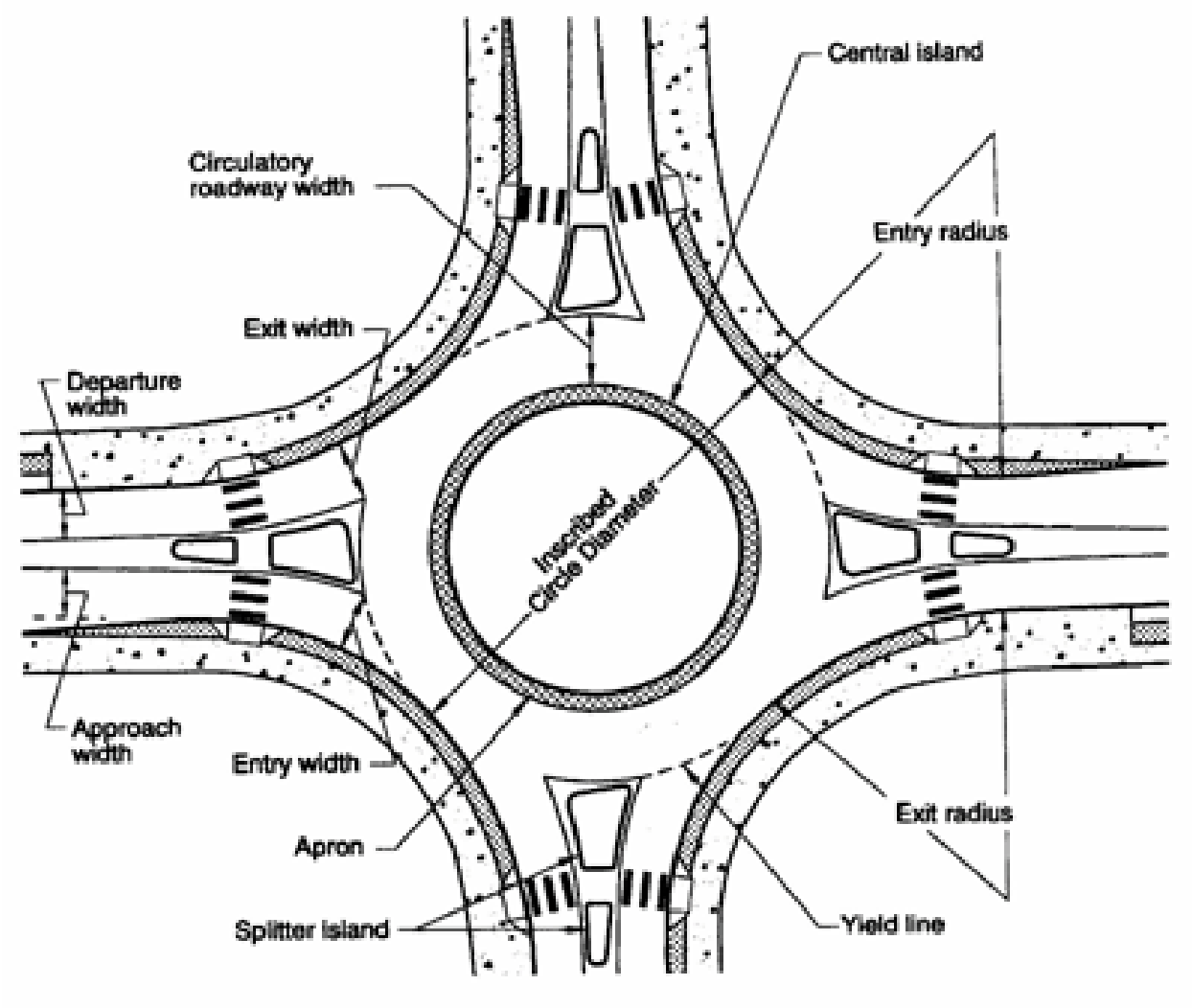


Roundabouts in Connecticut

Roundabouts have become more prominent in Connecticut over the last decade. Several towns around Hartford, including Coventry, Ellington, Mansfield, South Windsor, and Windsor have successfully installed roundabouts in the last few years. CONNDOT published a roundabout policy in 2004 making several suggestions for installing roundabouts in Connecticut. These are:

- Single lane roundabouts should be considered first when installing roundabouts in an area. They are simpler then multi-lane roundabouts and allow drivers to get used to driving them.
- Single lane roundabouts can handle, at a maximum, 1800 - 2000 vehicles per hour.
- VC ratios of all approaching legs should be under 0.85. If the ratio exceed this threshold, the roundabout will basically operate as an all-way stop and is not recommended.
- Queuing analysis should compare the queues of roundabout installation with all-way stop or light controlled intersections.
- Right-of-way impacts need to be assessed.
- The signal warrants should be provided. Intersections that just meet or almost meet the warrants should be considered for a roundabout. Intersections that are, or are proposed to be all-way stops are good locations for a roundabout.
- The accident history of an intersection needs to be evaluated. Accidents may be reduced with the installation of a roundabout, especially head on and left turning collisions.
- A cost comparison, comparing the cost of installing a roundabout versus other alternatives needs to be provided.
- Adequate sight lines must be provided. Drivers should have good visibility to other vehicles, bicyclists and pedestrians.
- Grades of the approaching legs of the intersection should not exceed 4 degrees. Higher

FIGURE 2: DESIGN COMPONENTS OF A TYPICAL ROUNDABOUT



grades limit visibility and cause difficulties for larger vehicles.

- The functional classification of all intersecting roadways must be considered. Because a roundabout equally distributes right of way, consideration must be given to delays added to arterial roadways.
- None of the approach legs should exceed 80 percent of the total intersection volume.
- High percentages of left turning vehicles make roundabouts more advantageous than traditional intersections.
- Roundabouts should not be installed when the intersection is part of a signal system.
- A bottleneck downstream (such as a drawbridge or rail crossing) may back up traffic into the roundabout.
- Pedestrian activity needs to be considered. High pedestrian activity can back traffic up into the roundabout. Sight-impaired pedestrians should also be considered.
- The number of bicyclists should also be considered. Bicycle accidents may change after roundabout installation.

- Illumination is essential to light up the inner circle and pedestrian crossings.
- An intersection with a large number of legs or where a major move makes a 90 degree turn may be better served by a roundabout.
- Roundabouts should not be used as the sole traffic calming measure and should be used in conjunction with other traffic calming strategies.

Policies on climate change & greenhouse gas reduction

Connecticut has several policies relating to climate change and GHG reduction. The state released the Connecticut Climate Action Plan (CCAP) in 2005. The CCAP made 38 recommendations to counteract climate change that fall into five categories:

1. Transportation and Land Use
2. Residential, Commercial and Industrial
3. Agriculture, Forestry and Waste
4. Electricity
5. Education

Transportation and land use are projected to make up just under twenty percent of the state's total GHG reduction by 2020. While several transportation recommendations were made, there was no direct mention of roundabouts or intersections. The most applicable section pertains to the reduction of gasoline consumption. Because roundabouts reduce delays and vehicle idling times, they help reduce fuel consumption. The goals and objectives of the CCAP can be seen in Figure 3 below.

The state also passed the Connecticut Global Warming Solutions Act (GWSA) in 2008. The GWSA created a longer term GHG reduction plan that aims to reduce emissions by 80 percent of the 2001 level by 2050. The GWSA mentions reducing speed on highways in order to increase fuel efficiency. However, the plan omits improving fuel efficiency by decreasing intersection delays. While funding opportunities are limited at the state level, the pertinence of roundabouts to the achievement of the state's GHG reduction goals may help improve the strength of other grant applications.

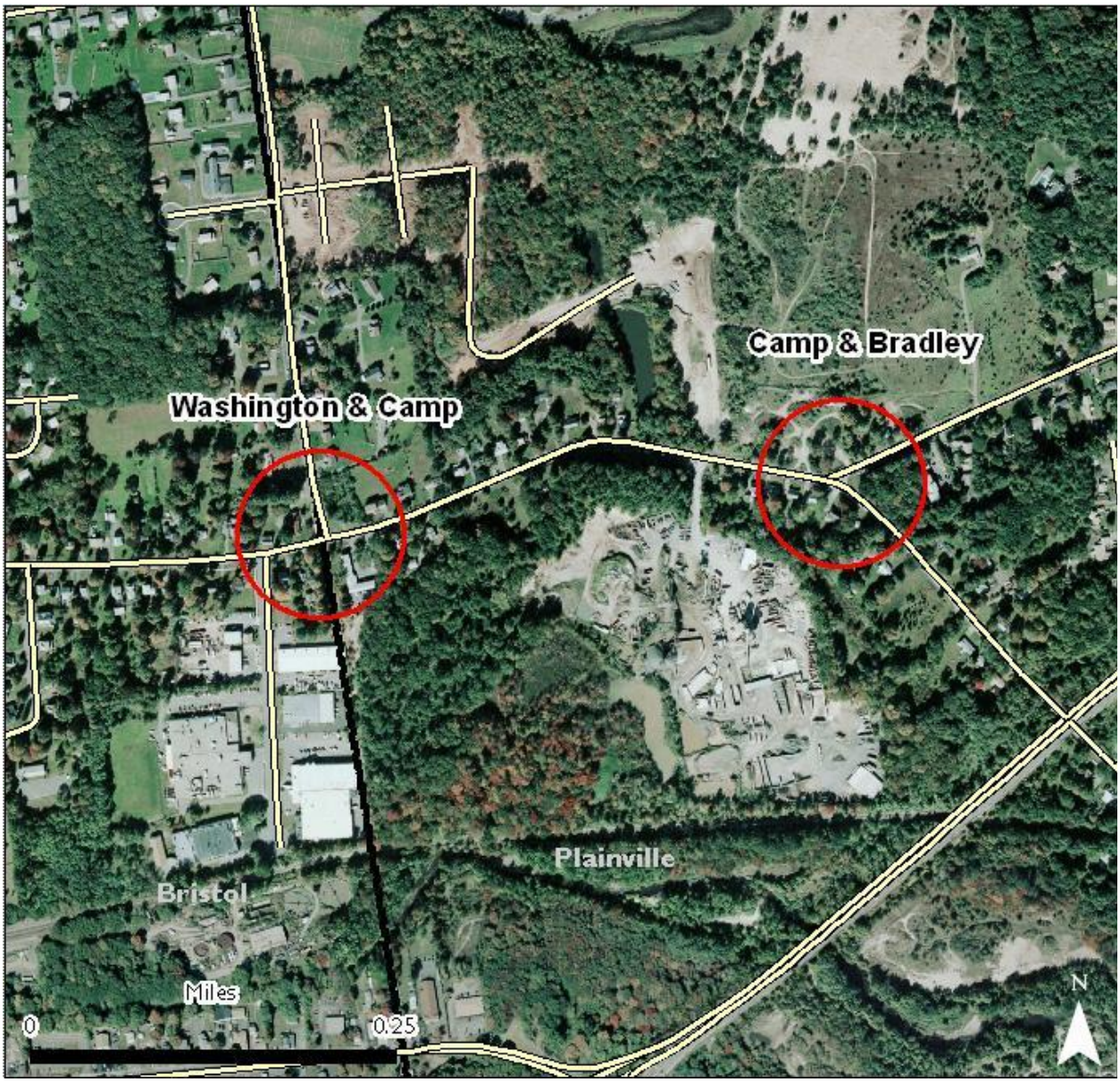
FIGURE 3: SUMMARY OF CCAP GHG REDUCTIONS WITH RECOMMENDATIONS (IN MILLION METRIC TONS)

	2010	2020
Future Baseline (CCAP projections from fuel use)	48.14	56.15
NEG/ECP Targets (1990 in 2010, 10% below in 2020)	42.40	38.16
Reductions Needed to Meet NEG/ECP Targets	5.74	17.99
Projected Reductions By Sector		
Transportation	0.35	3.84
Residential, Commercial, Industrial	4.03	7.29
Agriculture, Forestry, Waste	1.21	1.30
Electricity	3.07	6.89
2005 CCCAP Total Reductions	**8.66**	**19.32**
2003 CT Stakeholder Report Total Reductions	4.07	12.82
Total NEW or REVISED Reductions	**4.59**	**6.50**

Implementation challenges

Public perception is one of the biggest challenges to roundabout installation. Several reports have noted the opposition to roundabouts before the construction process begins. However, once a roundabout is put in place, public favor is generally more favorable. A New York State DOT survey concluded that before construction, only 12% of people had a high acceptance of roundabouts compared to 29% with low acceptance. After the roundabout was constructed, 55% of respondents had a high acceptance as opposed to only 3% with a low acceptance. One of the causes of initial opposition is peoples' unfamiliarity with driving roundabouts. However, after driving them and witnessing the improvements in delays and congestion, drivers often have a more favorable view. Because roundabouts are still relatively uncommon in Connecticut, residents may oppose roundabouts prior to their installation. An effort should be made to engage officials and

FIGURE 4: PROJECT STUDY AREA



residents and to explain the benefits of roundabouts to the public.

Pedestrians and bicyclists may also be unfamiliar with roundabouts. Children and those with cognitive and visual impairments may have difficulty navigating roundabouts. Where pedestrian and motorist volumes are high, conflict *may* result. Because vehicles are not forced to stop, pedestrians may be unable to cross a busy intersection. Conversely, high numbers of pedestrian could also lead to vehicle queuing in the roundabout. It is therefore advisable to examine pedestrian and bicyclist use before installation.

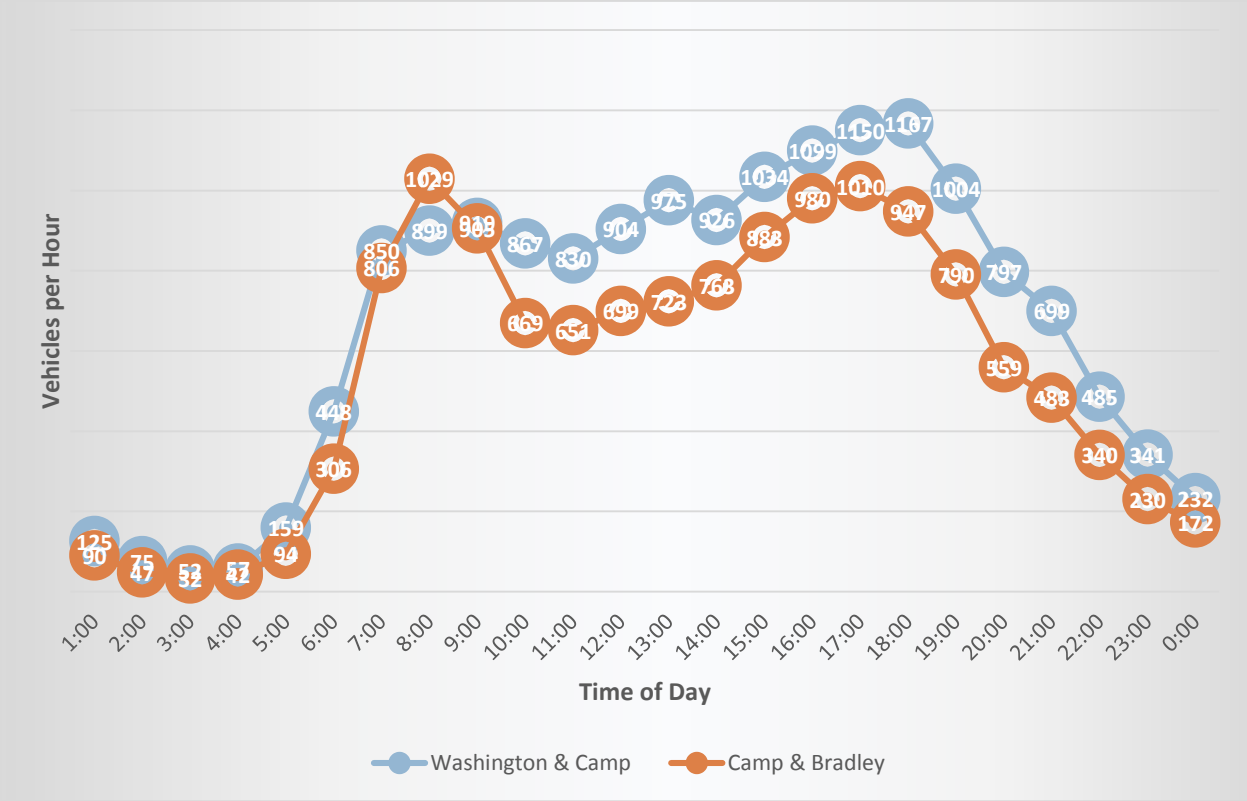
Finally, the location of the intersection can prove to be a constraint to roundabout installation. The typical one lane roundabout ranges from 80 to 130 feet in diameter. Smaller diameters may reduce the intersection capacity. Smaller intersections that lack turning lanes need to be closely examined, as additional land from neighboring properties could be needed. The locations of public utilities such as sewer lines, telephone/electric poles, and other public utilities may complicate roundabout installation. Finally, roundabouts can only be installed where grades of the approaching roadways are relatively low. All of these factors should be considered before a roundabout is installed.

Study overview

CCRPA completed this study in 2011, but the following sections have been updated with 2013 traffic data.

This study evaluates potential roundabouts at two intersections in the City of Bristol and the Town of Plainville. Currently, both intersections have all-way stop signs on three legs.

FIGURE 5: AVERAGE VEHICLES PER HOUR FOR WEEKDAYS



The first intersection is Washington Street and Camp Street on the Bristol-Plainville town line. The intersection has three legs with Washington Street comprising the west leg, and Camp Street both north and east legs. The town line runs north-south along Camp Street.

The second intersection is Camp Street and Bradley Street located in Plainville, less than a half mile to the east of the first intersection. Camp Street comprises the west and southeast leg, while Bradley Street makes up the east leg. Both roads serve as feeders into Route 177 and its intersection with Route 72. Both intersections meet several of the aforementioned conditions for roundabout installation.

- The location near a town/city border provides the opportunity to create a 'gateway' to and from the respective municipalities. This could include a landscaped center islands with a welcome sign.
- There are no sidewalks or bicycle routes near the intersections. Guidelines have suggested initially installing roundabouts in locations that lack high pedestrian and bicycle traffic.
- Both intersections are single lane and would contain single lane roundabouts. Guidelines recommend initially installing single lane roundabouts so that drivers can get used to them.
- Each intersection is only a three-way intersection, making the roundabout less confusing than four-or-more-way intersections (allowing drivers to get used to driving them).
- The intersections have fluctuating traffic flows with periods of high AM and PM peaks and periods of lesser traffic during the afternoon and overnight hours. A roundabout would help improve traffic flow at all hours of the day.
- When measured at peak hour, vehicles per hour and vehicle/capacity (V/C) ratios are both well under the recommended maximum for all legs of both intersections.

FIGURE 6: PEAK HOUR V/C RATIOS

Camp & Bradley	Eastbnd	Westbnd	Northbnd
AM	0.70	0.14	0.10
PM	0.40	0.45	0.26

Washington & Camp	Eastbnd	Westbnd	Northbnd
AM	0.74	0.22	0.44
PM	0.40	0.58	0.52

Analysis & Calculations

This report analyzes the benefits (in vehicle delay, level of service, and emission reductions) with a roundabout at each location.

Delay analysis

Delay per vehicle and total intersection delay are calculated using traffic simulation software (HCS 2010 and TRANSYT-7F).

First, average daily traffic (ADT) data is collected on each leg of both intersections. A turning movement count is also conducted during the busiest (peak) hour to determine whether vehicles are turning left/right or going straight.

The data is totaled over 15-minute and 1-hour time intervals. The peak hour factor is calculated, which is a measure of how concentrated or spread out the traffic is during the hour.

$$Peak\ hour\ factor = \frac{T_{1\ hour}}{4(T_{max\ 15})}$$

$T_{1\ hour}$ = Total traffic over a one hour period
$T_{max\ 15}$ =Max traffic over a 15-minute period

Traffic simulation required the following inputs to calculate delay:

FIGURE 7: DELAY ANALYSIS

Camp & Bradley	AM Current Conditions	AM with Roundabout	PM Current Conditions	PM with Roundabout
Delay (Sec/Vehicle)	20.97	11.90	16.4	8.06
Delay (Hours/Hour)	5.31	3.01	4.77	2.34
Percent Reduction in Delay		43.25%		50.85%

Washington & Camp	AM Current Conditions	AM with Roundabout	PM Current Conditions	PM with Roundabout
Delay (Sec/Vehicle)	47.81	13.67	40.88	10.77
Delay (Hours/Hour)	14.30	4.09	15.13	3.98
Percent Reduction in Delay		71.41%		73.65%

- The number of lanes in each leg (turning lanes included).
- The peak hour factor for each leg (for in-bound vehicles).
- The number of vehicles going left, right and through the intersection for each leg.
- The percentage of heavy vehicles (calculated to be 1% from traffic count data).

Using the software, delay is calculated at both intersections for current all-way stop conditions and potential roundabout conditions as seen in Figure 7. Delay is shown in seconds per vehicle and hours per hour. The second measure is the total delay of all vehicles during the peak hour.

Level of service analysis

The traffic simulation software also calculated level of service for each leg and for the intersection as a whole as seen in Figure 8. Currently, Washington and Camp has a peak intersection LOS of E/F while the intersection at Camp and Bradley receives a C. Both of these improve with the installation of a roundabout. In addition, each leg also sees an improvement in level of service with the installation of a roundabout.

FIGURE 8: LEVEL OF SERVICE (LOS) FOR INTERSECTION LEGS

Camp & Bradley	All-way Stop	With Roundabout
AM Peak LOS	C	B
PM Peak LOS	C	A
Worst leg LOS	C	B

Washington & Camp	All-way Stop	With Roundabout
AM Peak LOS	E	B
PM Peak LOS	E	B
Worst leg LOS	F	C

GHG reduction analysis

Emissions are calculated for peak hour based on vehicle delays at each intersection. Carbon dioxide emissions are calculated based on vehicle class as a function of time in grams per hour, as seen in Figure 9.

Other GHG pollutants (nitrous oxide, carbon monoxide, and hydrocarbons) are calculated based on emissions software, aaSIDRA, as a percentage of total emissions. (See Figure 10.) For example, for every 1 gram of emissions, 92.41% is expected to be CO_2, 0.21% NO_x, 7.23% CO, and 0.15% HC.

FIGURE 9: CO_2 EMISSION CALCULATIONS

Vehicle types	Vehicle classes	CO_2 emissions
Cars, light trucks, motorcycles	1-3, 5-7	4991 G/HR
Medium and heavy trucks	8-13	5438 G/HR
Buses	4	13243 G/HR

FIGURE 10: VEHICLE EMISSIONS COMPONENTS

Gas	% of Total
Carbon Dioxide (CO_2)	92.41%
Nitrous Oxide (NO_X)	0.21%
Carbon Monoxide (CO)	7.23%
Hydrocarbons (HC)	0.15%

Using the percentages in Figure 10, the GHG emissions are calculated as seen in Figure 11. The total GHG emissions are calculated by multiplying the emissions of each vehicle class by the amount of delay and the percentage of vehicles in that class. (See equation to the right). Using this method, the percent reduction in emissions is the same as the percent reduction in delay.

This analysis shows that a roundabout could significantly reduce vehicle delay and GHG emissions. During the peak hour, emissions could be reduced by nearly 75 percent. Since this analysis only covers the peak hour, the total amount of greenhouse gas reduction (in pounds) is actually even greater when considering the delay reduction throughout the entire day.

$$\textit{Total emissions} = D \times G_1 \times E_1 + D \times G_2 \times E_2 + D \times G_3 \times E_3$$

Where:
D = Total intersection delay (in hours)
G_i = % of total vehicles in that vehicle class (keep as a ratio)
E_i = Emission rate for vehicle class (in lbs per hour)

FIGURE 11: GREENHOUSE GAS EMISSION ANALYSIS (IN POUNDS PER HOUR)

Camp & Bradley	Current AM Peak Hour	Roundabout AM Peak Hour	Current PM Peak Hour	Roundabout PM Peak Hour
CO_2	58.53	33.22	52.51	25.81
NO_X	0.13	0.08	0.12	0.06
CO	4.58	2.60	4.11	2.02
HC	0.10	0.05	0.09	0.04
Total GHG	63.34	35.94	56.83	27.93
Reduction in Emissions		43.25%		50.85%

Washington & Camp	Current AM Peak Hour	Roundabout AM Peak Hour	Current PM Peak Hour	Roundabout PM Peak Hour
CO2	157.41	45.01	166.45	43.85
NOX	0.36	0.10	0.38	0.10
CO	12.32	3.52	13.02	3.43
HC	0.26	0.07	0.27	0.07
Total GHG	170.34	48.70	180.12	47.45
Reduction in Emissions		71.41%		73.65%

Conclusions

This report found that reconstruction of two three-way stop intersections as roundabouts would offer significant benefits. Delays and GHG emissions with roundabouts were determined to be between 40 and 75 percent lower than those of existing conditions. In addition, roundabouts at each location would substantially improve the level of service of all legs of the intersection.

While this report helped show the benefits of roundabouts, additional work should address implementation challenges. Greenhouse gas reduction continues to be a challenge across the country. Creative solutions are needed in order to decrease our impact on the communities in which we live and on the environment as a whole. Roundabouts are often overlooked in GHG reduction plans, yet offer countless benefits to the environment. Even more importantly, roundabouts improve the environment without sacrificing quality of service for intersections. In many cases, the benefits that roundabouts offer in cost savings, delay reduction and pedestrian and motorist safety alone warrant their construction. Finally, it is hoped that this study serve as a regional catalyst for roundabouts. While roundabouts are growing in popularity, they have yet to be used in Central Connecticut. Successful implementation of these (or other) roundabouts could spur more towns in the region to begin installing roundabouts themselves.

Project team

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Links to figures

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