

Exit 186
Intersection Study
Bangor, Maine

Prepared By

Maine Department of Transportation

Bureau of Planning

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Acknowledgements

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Introduction

The Maine Department of Transportation and the City of Bangor have partnered in a joint effort to study the intersection of I-95 Exit 186 and Stillwater Avenue. With regional support from the Bangor Area Comprehensive Transportation System, the metropolitan transportation planning organization, MaineDOT and the City undertook the Exit 186 Intersection Study to evaluate the feasibility of lifting the left-turn prohibition from the Exit 186 approach to Stillwater Avenue. This report presents the results of this study. The study area and the intersection are highlighted in Figure 1.

Figure 1. Stillwater Avenue, Bangor Maine - Study area



Background

As the Hogan Road and Stillwater Avenue areas were developing commercially around the Bangor Mall during the 1980s and 1990s, traffic growth in the area made clear a need to relieve the congestion occurring at the I-95 Hogan Road interchange, now known as Exit 187. Of particular concern was the heavy volume of traffic and congestion at the northbound off-ramp at this interchange. Although improvements were made to increase capacity at the Hogan Road interchange, a planning study completed in 1999 concluded that a new I-95 interchange on Stillwater Avenue was needed to relieve Hogan Road. This new interchange, now known as Exit 186, was completed in 2001. One of the features of the signalized T-intersection of Exit 186 with Stillwater Avenue was a prohibition of left turns from the off-ramps onto Stillwater Avenue. This feature, which emerged from the planning process, was incorporated into the intersection design to discourage traffic growth in the predominantly residential part of Stillwater Avenue south of Exit 186.

As development continued around the Bangor Mall in the 2000s, a new retail development, anchored by Kohl's, was built west of the Exit 186 intersection. The major access for this development was located at the Exit 186 intersection, converting the T-intersection to a 4-way intersection. Although the left-turn prohibition was retained, off-ramp traffic would be allowed to proceed straight across Stillwater Avenue into the retail development. Over time, other commercial properties developed on Stillwater Avenue, both north and south of Exit 186. Sensing a changing attitude toward the left-turn prohibition, the City of Bangor approached MaineDOT to study the feasibility of lifting the left-turn prohibition from the Exit 186 intersection.

Purpose and Need

The purpose of this study is to investigate the feasibility of changes at the intersection of Stillwater Avenue and Exit 186 to allow left turns from the Exit 186 approach. While the left-turn prohibition was well intended, recent experience indicates that motorists who would prefer to turn left at this location are meeting their needs either by turning left illegally or circumventing the left-turn prohibition by using the Kohl's shopping plaza driveway and parking lot. A situation where a traffic regulation is commonly ignored in fact or in spirit undermines the respect that the traffic regulation should have. This, in turn, can lead to reduced respect for traffic regulations in general, creating a less safe environment for the traveling public. Finding a feasible solution to the left-turn prohibition would improve the safety and efficiency of operations at this intersection.

Study Process

The study process involved a combination of technical analysis and public involvement. First, the study team gathered readily available information on public surveys, traffic counts, crash statistics, and physical conditions at the study location. This information was supplemented by turning movement counts at five Stillwater Avenue intersections and speed data collected along Stillwater Avenue. A public meeting was held on February 19, 2015, to present existing conditions information and obtain public input on the left-turn prohibition issue and other matters related to the Exit 186 intersection.

With the public input received, the study team continued to analyze existing conditions and the potential impacts of removing the left-turn prohibition. From the findings of the analysis, the team developed a study report with a set of recommendations presented at a City public works meeting.

Existing Conditions

The I-95 Exit 186 off-ramp intersects Stillwater Avenue across from the Kohl’s shopping plaza in Bangor, Maine. The ramp approach has two, right-turn lanes onto Stillwater Avenue and one through lane to the Kohl’s shopping plaza. A left turn from this approach onto Stillwater Avenue is prohibited.

Traffic Volumes

Weekday traffic volume data was collected on Stillwater Avenue in June, 2014. Turning movement counts were collected at the intersection of Stillwater Avenue and Exit 186 and at other nearby intersections on Stillwater Avenue. Based on the turning movements, approximately 2700 vehicles enter the Exit 186/Stillwater Avenue intersection during the PM peak hour. The distribution of these vehicles can be seen in Table 1. An estimated additional 104 vehicles exit the Kohl’s plaza via the Kohl’s southern access drive during this hour and approximately 18 vehicles enter the Kohl’s plaza via this southern location. The southern access drive has a right-turn in and right-turn out only, with a raised median preventing left turns. All vehicles exiting at this location turn southbound on Stillwater Avenue. Approximately 800 vehicles from the Exit 186 intersection and the southern Kohl’s exit travel southbound toward the residential area during the PM peak hour.

Table 1. June 2014 turning movement volumes for the intersection of I-95 Exit 186 and Stillwater Avenue

	NB (Stillwater)	SB (Stillwater)	WB (From Kohl’s)	EB (From I-95)
Left	62	331	118	10
Through	635	637	49	88
Right	52	128	66	488
Total	749	1096	233	586

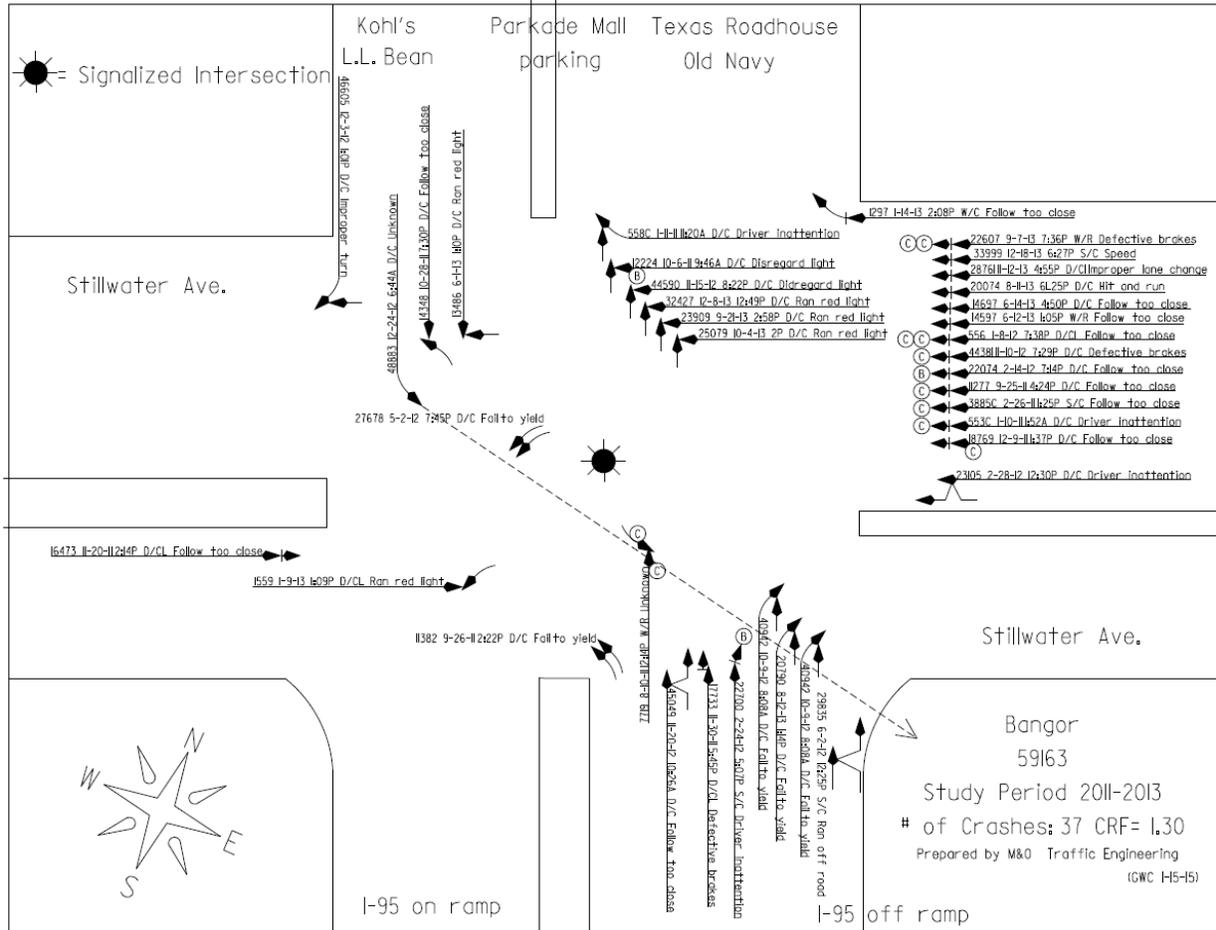
Although the left turn from the Exit 186 ramp onto Stillwater is prohibited, approximately 160 vehicles make an illegal left hand turn from the ramp in a 12-hour period (6 AM to 6 PM). Ten of these left turning vehicles were observed during the PM peak hour, as shown in Table 1.

Safety

A high crash location (HCL) is a location that has had eight or more traffic crashes and a critical rate factor (CRF) of greater than one in a three year period. The data collected at the intersection of the Exit 186 off-ramp and Stillwater Avenue shows that there were 37 crashes from 2011 to 2013. With a CRF of 1.30, this intersection is a HCL. A pattern of rear end crashes can be seen on the southbound approach of the Exit 186/Stillwater intersection. Of the 37 crashes, 13 were rear end crashes on this approach and 6 were right-angle crashes caused by drivers on this approach running or disregarding the red light. Of the 19 crashes on the southbound approach, all but two occurred in the PM hours, with 10 occurring after 4:00 PM. Lighting and visibility of the signal heads on this approach may be a factor in this pattern.

Five of the remaining crashes were associated with the double right-hand turn off of the Exit 186 ramp. The remaining 13 crashes are not associated with any sort of crash pattern. Only one of the 37 accidents was associated with vehicles making an illegal left-hand turn from the Exit 186 off ramp. A collision diagram showing the crash patterns at this intersection is shown in Figure 2.

Figure 2. Collision diagram at the intersection of Stillwater Avenue & Kohl's plaza/Exit 186 off ramp



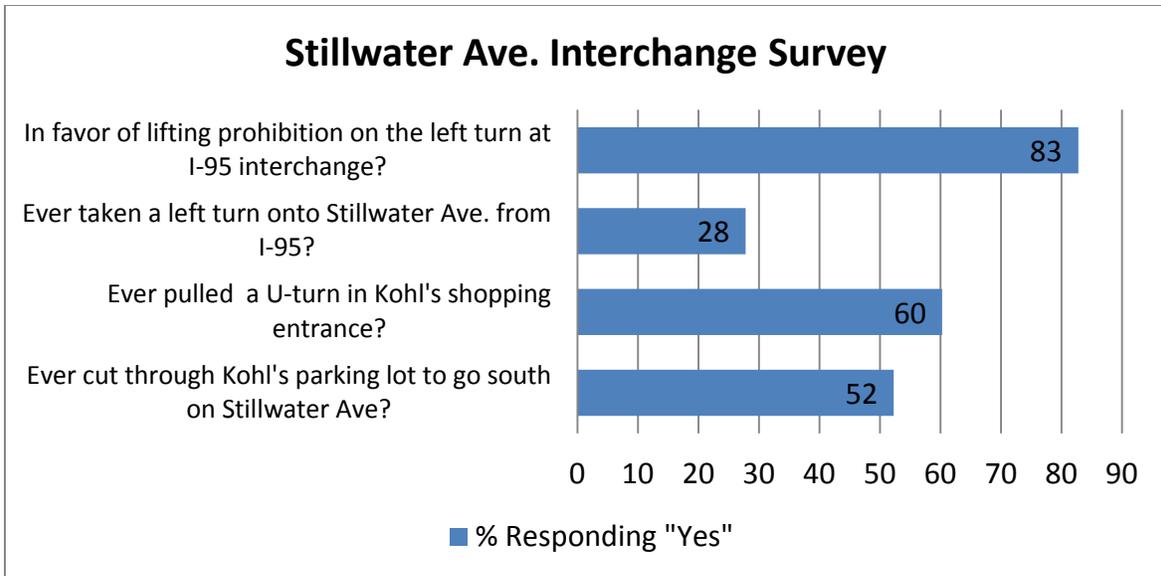
Operating Conditions

The traffic signals on Stillwater Avenue north of and including the Stillwater/Exit 186 intersection currently operate on a 140-second signal cycle length. This allows for greater queue clearing along Stillwater Avenue and shorter delays for vehicles travelling on this route. Because of this, the side roads and businesses experience greater, more frequent delays. At the Exit 186/Stillwater Avenue intersection, the ramp and Kohl's exit signals have split phasing. This means that the left turn from the Kohl's plaza is protected and that there are no conflicts between the eastbound and westbound traffic.

In 2013, the City of Bangor conducted a citywide survey regarding the left-turn prohibition on the Exit 186 (westbound) approach to Stillwater Avenue. The survey asked residents a series of questions about

the left-turn prohibition issue. Over 3000 responses to the survey were received. The results of the survey can be seen in Figure 3.

Figure 3. Stillwater Avenue interchange survey results



This survey shows that 83% of the survey population is in favor of lifting the left turn prohibition. Also, despite the left-turn prohibition, 28% of the respondents have made the illegal left turn, and a majority of the respondents have either made a U-turn in the Kohl’s entrance and/or used the Kohl’s parking lot to head south on Stillwater after exiting I-95.

Bicycle and Pedestrian Issues

Though not directly related to the left-turn prohibition, the initial public meeting and review of existing conditions did bring up issues for bicyclists and pedestrians on Stillwater Avenue. Existing shoulders are narrow (around 2') in some locations, particularly in the northbound direction between Drew Lane and the Bangor Mall entrance drive, and in the southbound direction between the Bangor Mall and Kohl’s. In the study area, the sidewalk is continuous on easterly side of Stillwater Avenue, but on the westerly side, the sidewalk exists only between Kohl’s southern access drive and Drew Lane.

At the Exit 186 intersection, there are crosswalks with pedestrian signals across the eastern and southern legs of the intersection, but the Kohl’s end of the southern crosswalk has no sidewalk beyond the crosswalk landing. South of this location is a vehicle turnout that could be used for passenger pick-ups or drop-offs but there is no sidewalk to connect to other pedestrian facilities or to the Kohl’s shopping plaza.

Higher Volume Conditions

Analyses of higher volume conditions help to understand how an intersection will operate as traffic volumes increase seasonally or into the future. For the analysis of the Exit 186/Stillwater Avenue intersection and Stillwater Avenue corridor, a 10% increase in traffic volumes was used. This traffic volume level would be the equivalent of conditions during busier months of the year or a 1% per year increase in June traffic over 10 years.

Analysis

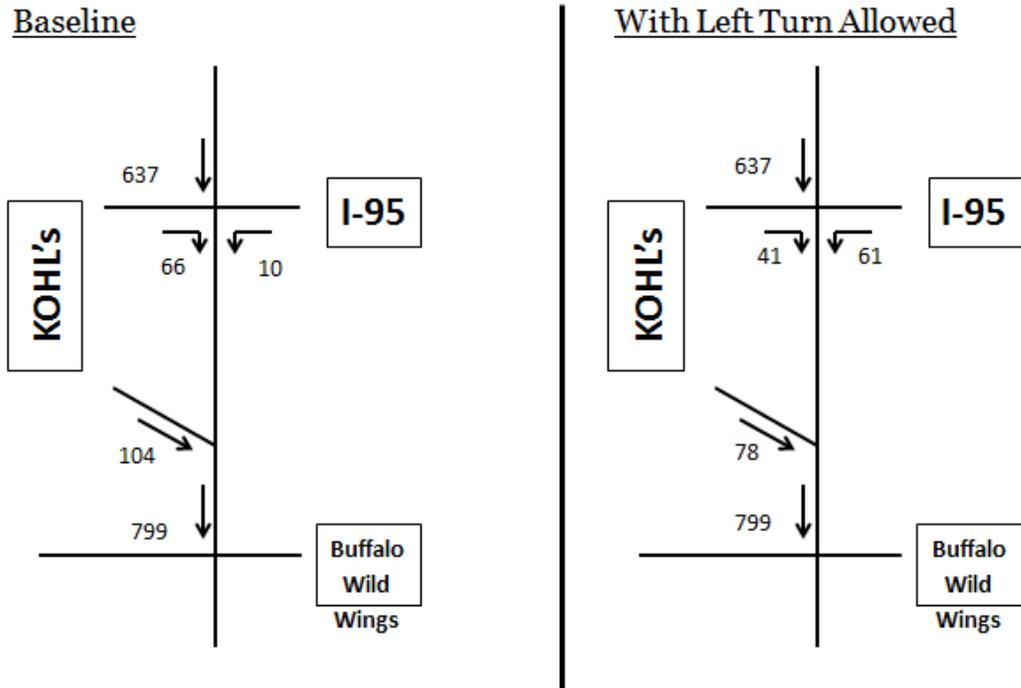
The intersection of the I-95 Exit 186 ramp and Stillwater Avenue was analyzed using Synchro/SimTraffic 8. Four models were created for this analysis. Each model included the Stillwater Avenue corridor from Fern Street to the southern exit of the Bangor Mall. The models included the intersections of Fern St, Howard St, Drew Lane, the southern Kohl's exit, Exit 186, and the southern Bangor Mall exit. These six intersections were modelled to analyze the delays and queues associated with the traffic flow patterns in the area. Field data was also collected to validate the speed and delays associated with the corridor.

Models and Delays

Two traffic models were developed to test the impact of lifting the left-turn prohibition. The first model represented existing conditions including traffic volumes, signal timings, and the prohibited left-turn from the Exit 186 ramp. The left-turn prohibition was lifted in the second model. Since the phasing at the Exit 186/Stillwater Avenue intersection is split phasing for the eastbound/westbound directions, the signal timings were not altered. The left-turning traffic from Exit 186 would be able to move freely with the thru traffic during the ramp's traffic signal phase. In this model, the existing through lane was converted to a through-left lane to accommodate the left turning traffic.

From the survey results and turning movement data, an estimate was made as to the increase in left-hand turns from the ramp and decrease in right-hand turns from the Kohl's exits. Figure 4 shows the affected turning volumes. It was estimated that there would be a 51 vehicle increase in left-turning traffic from the I-95 Exit 186 ramp for the PM peak hour. From the survey results, it was concluded that the drivers who wanted to turn left from the ramp were either doing so or maneuvering through the Kohl's plaza. Therefore, the decrease in right-hand turns from the Kohl's exits is proportional to the increase in left-hand turns from the ramp. This means that there would be little to no increase in southbound traffic from the Exit 186 intersection.

Figure 4. Study area turning movements with and without left turn prohibition



The third and fourth models have a 10% increase in traffic volumes with the same lane configuration and signal timings as the first and second models, respectively. These models showed the increases in delays and queue lengths along the corridor due to the increase in traffic with the existing signal timings and lane configurations. This allowed for the comparison of the effects of the additional traffic with and without the left-hand turn from the ramp. LOS and delay results from the four models can be seen in Table 2. As shown, with the existing PM volumes, adding the left-hand turn at the I-95 Exit 186 ramp intersection has an increase in delay per vehicle of less than one second for the entire corridor. The existing LOS for the I-95 Exit 186 intersection is B/C based on field data speeds and HCM criteria for urban streets. The LOS drops to a C based on the model speeds when adding the left turn and remains LOS C with the 10% increase in traffic volumes for both models. The LOS for the WB approach drops from LOS E to LOS F at the Exit 186 intersection with the increase in traffic volumes for both cases. The Drew Lane intersection is also displayed in Table 2. This is shown as a representation of the intersections south of the Exit 186 intersection. The delays for all approaches for the southern intersections change insignificantly when adding the left turn from Exit 186 and increase slightly when adding the future growth.

Table 2. SimTraffic LOS and delay results for the Stillwater Avenue and Exit 186 off-ramp intersection with and without the left turn prohibition for existing and future traffic volumes

		Existing	With Left Turns	Existing + 10%	With Left Turns + 10%
Entire System	PM Entering Volume	3272	3217	3572	3521
	Vehicles Denied Entry	0	0	0	0
	Overall Delay per Vehicle (s)	52.7	53.6	62.4	63.0
	Overall LOS	B/C	C	C	C
	Total Delay (hr)	49.6	49.6	64.2	63.9
I-95 Exit 186 Intersection	NB Approach Delay (s)	19.2	19.8	21.0	21.9
	SB Approach Delay (s)	29.6	29.6	30.9	33.0
	EB Approach Delay (s)	59.8	67.0	64.0	70.2
	WB Approach Delay (s)	64.2	62.2	97.4	94.2
	NB Approach LOS	B/C	B/C	C	C
	SB Approach LOS	C	C	C	C
	EB Approach LOS	E	E	E	E
	WB Approach LOS	E	E	F	F
	Intersection Delay (s)	36.4	36.6	40.1	40.4
	Overall Intersection LOS	D	D	D	D
Drew Lane	NB Approach Delay (s)	7.4	6.8	7.8	8.2
	SB Approach Delay (s)	8.6	8.0	10.0	9.1
	EB Approach Delay (s)	13.4	12.2	15.5	12.6
	WB Approach Delay (s)	8.6	7.1	8.8	9.4
	NB Approach LOS	A	A	A	A
	SB Approach LOS	A	A	B/A	A
	EB Approach LOS	B	B	B	B
	WB Approach LOS	A	A	A	A/B
	Intersection Delay (s)	9.1	9.1	10.7	10.7
	Overall Intersection LOS	A/B	A/B	B/A	B/A

Queue Lengths

Queue lengths are important to the analysis at this intersection since the analysis includes an interstate off-ramp. It is important to assure that queues will not back up onto the interstate during the peak hours. It is also important to see how queue lengths will affect the other intersections along the corridor. Table 3 shows the 95th percentile queue lengths for the intersection of Exit 186 and Stillwater Avenue. As shown, queue lengths for all legs when lifting the left turn prohibition remain relatively close to the existing queue lengths, with some being slightly longer and some slightly shorter. The exit ramp (WB) queue lengths decrease when allowing the left turn. When adding the future growth to the volumes, queue lengths do increase, with the westbound right turn lanes having the greatest queue

lengths of 681 and 665 feet. The southbound Exit 186 off-ramp is approximately 1500 feet long and the northbound off-ramp is much longer, desirable deceleration lengths will be maintained on both off-ramps.

Table 3. 95th percentile queue lengths for the Stillwater Ave. and Exit 186 off ramp intersection with and without the left turn prohibition for existing and future traffic volumes

	Maneuver / Lane	Existing	With Left Turns	Existing + 10%	With Left Turns + 10%
EB from Kohl's	L	115	133	149	146
	LT	218	225	249	240
	T	127	138	166	154
	R	67	60	76	55
WB from Exit 186	LT	210	145	344	350
	R	502	483	657	681
	R	437	428	645	665
NB on Stillwater	L	100	104	120	120
	T	149	150	159	162
	T	163	158	169	171
	TR	146	146	160	175
SB on Stillwater	L	227	226	239	251
	L	250	262	283	286
	T	264	275	296	302
	R	99	115	150	115

Impact of Removing the Left-Turn Prohibition

From the analysis, it is apparent that lifting the westbound left-turn prohibition would not have significant effect on delays or queue lengths for the I-95 Exit 186 off-ramp. With the split phasing for the eastbound and westbound legs of this intersection, allowing the left turn would not necessitate a change in the traffic signal timings. The increase in left-turns would decrease the amount of vehicles entering the Kohl's plaza and pulling a U-turn or using the southern exit, so there would be little to no increase in the overall exit ramp volume, thus eliminating the need for an additional turn lane. The costs for lifting the prohibition would be associated mainly with restriping the through lane to a through-left lane, supporting signage, and modification of the traffic signal heads.

Potential Bicycle and Pedestrian Facility Enhancements

To address the concerns of bicyclists and pedestrians using the Stillwater Avenue corridor, there are potential changes that could improve upon existing conditions.

For pedestrians, although a sidewalk exists on the easterly side of Stillwater Avenue and crosswalks with pedestrian signals exist to get pedestrians to the westerly side at Kohl's, Drew Lane, and Howard Street,

none exists at the south entrance to the Bangor Mall for access to The Avenue plaza. Creation of a signalized crosswalk at this location and sidewalk access into The Avenue and Kohl's plazas would expand safer pedestrian access to retail services.

For bicyclists, the stretch of Stillwater Avenue from Drew Lane, through the Exit 186 intersection, to the south entrance of the Bangor Mall is an obstacle for bicyclists, due to narrow shoulders on one or both sides of Stillwater Avenue. One way of increasing shoulder width for bicycles in urban and suburban areas is to restripe 12' vehicular travel lanes to 11' in width. On a 4-lane arterial, this change can add 2' to each shoulder. Between Drew Lane and Exit 186, the existing travel lanes are 12' in width and a 4' northbound shoulder can be achieved. In this section, the southbound shoulder is already 5' to 7' in most locations.

Between Exit 186 and the Bangor Mall entrance, both shoulders are narrow and travel lanes average 11' in width. To widen the shoulders between these intersections, either widening the roadway or reducing the number of travel lanes would be necessary. However, reducing the number of through lanes on an arterial can have an adverse effect on capacity and level of service. One possible opportunity for this approach would be to reduce the number of northbound lanes between the intersections from three to two, with the possible allowance for right-turn lanes where needed.

Table 4 shows how reducing the number of northbound through lanes between Exit 186 and the south entrance to the Bangor Mall would affect delays and levels of service at those intersections. Based on the Synchro/SimTraffic analysis of existing June peak-hour volumes and volumes that are 10% higher, the reduction of northbound through lanes from three to two on this segment could be accomplished without a significant impact on delay and levels of service.

Table 4. SimTraffic LOS and delay results for alternative NB lane configurations at the Stillwater Avenue and Exit 186 off-ramp intersection with and without the left turn prohibition for existing and future traffic volumes

		With Left Turns	2 NB Thru Lanes w/Lefts	With Left Turns + 10%	2 NB Thru Lanes w/Lefts + 10%
Entire System	PM Entering Volume	3172	3232	3521	3531
	Vehicles Denied Entry	0	0	0	0
	Overall Delay per Vehicle (s)	48.2	50.0	53.3	53.9
	Overall LOS	B	B	C	C
	Total Delay (hr)	44.1	46.6	54.0	54.6
S Mall Intersection	NB Approach Delay (s)	10.4	10.5	11.1	11.1
	SB Approach Delay (s)	13.0	12.9	15.7	15.5
	EB Approach Delay (s)	38.8	34.3	36.1	36.9
	WB Approach Delay (s)	48.2	55.0	50.7	50.9
	NB Approach LOS	B/A	B/A	B	B
	SB Approach LOS	B	B	B	B
	EB Approach LOS	D	C	D	D
	WB Approach LOS	D	D/E	D	D
	Intersection Delay (s)	15.3	15.7	16.7	16.6
	Overall Intersection LOS	B	B	B	B
I-95 Exit 186 Intersection	NB Approach Delay (s)	19.7	20.6	19.6	20.9
	SB Approach Delay (s)	28.4	29.8	32.8	32.2
	EB Approach Delay (s)	61.4	65.9	71.5	70.8
	WB Approach Delay (s)	38.1	38.1	40.3	39.3
	NB Approach LOS	B/C	C/B	B/C	C/B
	SB Approach LOS	C	C	C	C
	EB Approach LOS	E	E	E	E
	WB Approach LOS	D	D	D	D
	Intersection Delay (s)	30.5	31.7	33.7	33.5
	Overall Intersection LOS	C	C	C	C

Recommendations

As a result of the analyses completed for the Exit 186 Intersection Study, the following recommendations are made. Figure 5 highlights these recommendations.

1. Lift the left-turn prohibition on the westbound intersection approach from Exit 186. The analyses show that this change will have no significant difference in the capacity or level of service of the intersection. There will be a need to modify the signing, signals, and markings on this to replace the single through lane with a shared through-left lane.
2. To address the strong pattern of rear-end crashes on the southbound approach to the Exit 186 intersection, the addition of an advance (nearside) traffic signal is recommended to give southbound traffic an earlier indication of the signal ahead. This could be a pedestal-mounted signal on the northwest corner of the intersection.
3. On the eastbound (Kohl's) approach to the Exit 186 intersection, consider restriping and resigning the four approach lanes to two left-turn lanes, one through lane, and one right-turn lane. This would convert the left-through lane to a left-turn lane. This change would improve the balance of volumes in the eastbound approach lanes, providing a modest improvement in intersection capacity.
4. Link the cross-Stillwater walk phase concurrently to the eastbound vehicular phase to avoid conflicts between pedestrians and westbound left-turning vehicles.
5. At the Exit 186 intersection, consider improved sidewalk continuity between the west end of the Stillwater Avenue crosswalk and pedestrian destinations such as the Kohl's plaza and the southbound pullover/drop-off space.
6. To increase the width of northbound shoulders for bicycle users between the Drew Lane and Exit 186 intersections, reduce the width of northbound through lanes from 12' to 11'.
7. To provide northbound shoulders for bicycle users between the Exit 186 and Bangor Mall intersections, replace the right-most through lane with a northbound shoulder and right-turn pockets located as necessary for the two intersections. The two northbound shoulder recommendations will provide better shoulder continuity along Stillwater Avenue without significantly affecting intersection capacity or level of service.
8. Although not evaluated in this study, consider the potential for cycle lengths for signals on Stillwater Avenue that are shorter than 140 seconds. Long cycle lengths can provide more traffic capacity than short cycle lengths and help enhance progressive movement through intersections for some users. However, short cycle lengths can provide shorter delays, shorter queue lengths, and better levels of service on side-street approaches, and shorter wait times for pedestrians crossing Stillwater Avenue.

Figure 5. Recommended improvements at the intersection of Stillwater Avenue and Exit 186 / Kohl's plaza.

