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Four-Lane to Three-Lane Conversions: An Update and a Case Study

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ABSTRACT

A presentation at the first Urban Street Symposium promoted the more widespread consideration and examination of four- to three-lane roadway cross section conversions. At the second Urban Street Symposium a set of guidelines for their implementation, along with other relevant ongoing and completed projects, were summarized. Several additional four- to three-lane conversion analyses have been completed since that time. This paper summarizes some of the key text from the conversion guidelines mentioned above and also presents the results of several recently completed projects that add to the current state-of-the-knowledge in this subject area. The feasibility determination factors for a potential four- to three-lane case study conversion location are then described and evaluated. The factors of special interest along this case study roadway were its desired and actual roadway function and vehicle speed, intersection operations and design, business access, truck traffic, pedestrians, right-of-way availability, and a nearby parallel railroad track. The characteristics of these and other factors are discussed and a list of observations and lessons learned from this case study application are provided. Some of the roadway factors and characteristics that should be considered early in the cross section comparison process (before more detailed design, etc.) are noted.

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INTRODUCTION

Four-lane undivided roadways have been converted to three lanes (See Figure 1) with little or no guidance for many years (See Figure 1). A presentation at the 1999 Urban Street Symposium introduced the idea that this type of conversion could be successfully implemented within a number of situations (*1*). It proposed more evaluation of this conversion approach (*1*). In 2001, a set of four-lane to three-lane cross section conversion feasibility guidelines were produced for the Iowa Department of Transportation (IaDOT) (*2*). This document supported the conclusion that this type of conversion could be successful for a wide range of traffic flow volumes and access densities (*2*). For background purposes, the feasibility determination factors (with key implementation considerations) and recommendations proposed in these guidelines are briefly summarized in this paper (*2*). This information was presented and documented in more detail at the 2003 Urban Street Symposium (*3*).

Since 2002/2003, four-lane to three-lane cross section conversion research has primarily focused on the safety and livability factors identified in the 2001 four-lane to three-lane conversion guidelines (and repeated in Table 1 of this paper) (*4*, *5*, *6*, *7*, *8*, *9*, *10*, *11*, *12*). In 2002, researchers completed the first project that included a scientifically-designed statistical evaluation of the safety impacts due to four-lane undivided to three-lane cross section conversions (*4*, *5*). However, the results of this study did not generally agree with some of simple or “naïve” before-and-after crash reductions observed in the field. Additional safety data analyses have been completed during the last two years (*6*, *7*, *10*). The results of the projects completed in Iowa are briefly summarized in this document and in more detail within another paper at this symposium (*6*, *7, 9*). The results of a study that investigated the livability impacts of four-lane undivided to three-lane conversions are also provided and the evaluation of this alternative at a case study location discussed (*8*).

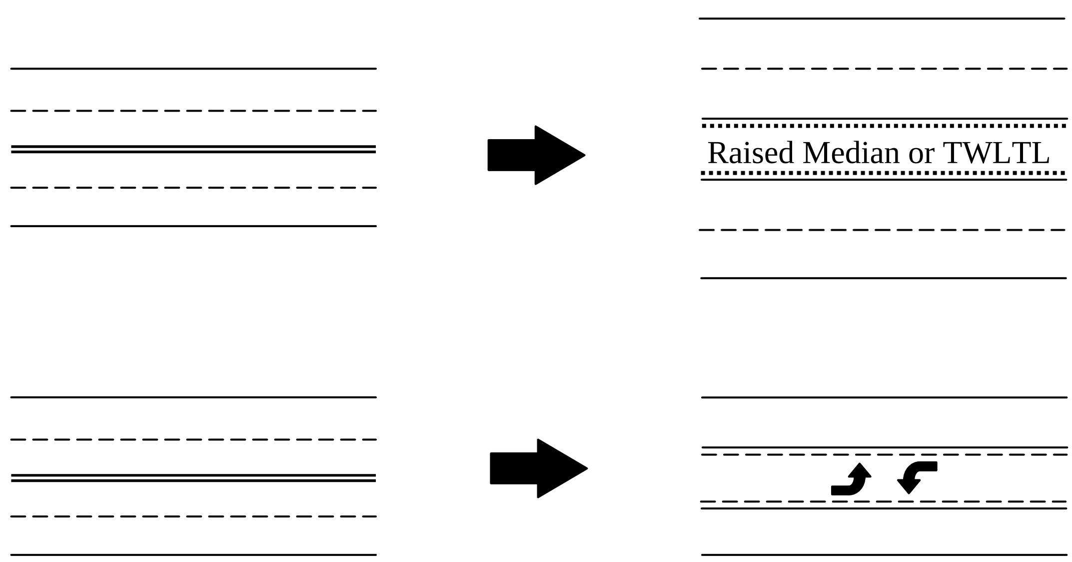

FIGURE 1 Four-lane undivided to five-lane and three-lane cross sections.

BACKGROUND: FEASIBILITY GUIDELINES

At the 2003 Urban Street Symposium the results of several four-lane undivided to three-lane cross section conversion research projects were summarized *(3).* However, the specific focus of that 2003 paper was the content of a set of four- to three-lane conversion feasibility guidelines produced for the IaDOT (*2*). The case study results and feasibility determination factors in these guidelines were also described. A brief summary of these case study results and feasibility determination factors (along with their key implementation considerations) are presented below and in Table 1. These IaDOT guidelines are available at www.ctre.iastate.edu/pubs/trafficsafety.htm.

Case Study Results

A series of references were used to create a list of 13 case study locations in the IaDOT cross section conversion guidelines (*2*). The before-and-after impacts of these 13 four-lane undivided to three-lane conversions from Montana, Minnesota, Iowa, California, and Washington were summarized (*2*). The roadways included in this summary had an average daily traffic volume between 8,400 and 24,000 vehicles per day (vpd) and experienced the following benefits:

- Average or 85^{th} percentile speed reduction (typically less than 5 mph),
- Excessive speeding reduction (up to a 60 to 70 percent reduction in the number of vehicles traveling 5 mph faster than the posted speed limit), and
- Total crash reduction (between 17 to 62 percent).

The data used in the summary were collected by numerous agencies and researchers. The results above are only intended to be a general indication of the past impacts due to successful four-lane undivided to three-lane conversions. In other words, there was no consistency or statistical robustness to the above results. More recently, however, additional case locations have been noted and more closely evaluated by several authors (*4, 6, 7, 8, 10*). The results of some of these projects are discussed later in this paper.

Feasibility Determination Factors

Four-lane undivided to three-lane conversions must be completed at the appropriate location and time to achieve positive results. A number of four-lane undivided to three-lane conversion feasibility determination factors are identified in the IaDOT guidelines. These factors are based on a review of past research, before-and-after case study results, and simulation sensitivity analyses (*2*). The existing and expected (i.e., design period) status of all these factors should be evaluated when determining whether a four-lane undivided to three-lane conversion is a feasible alternative at a location. The factors identified and discussed in the IaDOT guidelines, along with some key considerations for conversion implementation, are shown in Table 1. The consideration of these factors at a particular case study location is described later in this paper. Those factors that were most important to the decision-making process (i.e., alternatives comparison) at that location are identified.

TABLE 1 Feasibility Determination Factor Key **Implementation Considerations** (***Adapted from 2, 3, 4, 7, 8, 10***)

Determination Factor	Key Implementation Considerations
Roadway function and environment	• Match roadway environment with function • Define *existing and intended* function of candidate roadway
Overall traffic volume and level of service	• Successful roadway case study volumes (previously noted) ranged from 8,500 to 24,000 vpd • Simulation suggests operational impacts may be minimal at volumes less 750 vehicles per hour per direction (vphpd), that these impacts should be more closely considered between 750 to 875 vphpd, and that volumes above 875 to 1,000 vphpd may introduce operational changes and concerns • Assuming a 50% directional split and a 10% peak hour factor the volumes above are equivalent to 15,000, 17,500, and 20,000 vpd
Turning volumes and patterns	• Estimate and/or compare service to current/forecast (i.e., design period) turn volumes • Simulation indicates that the difference between average arterial travel speed for comparable four-lane undivided and three-lane roadways decreases as access point left-turn volumes and access point density increases • Simulated average arterial travel speeds decreased with increases in access point left-turn volumes along four-lane undivided roadways, but increased along 3-lane roadways
Frequent-stop and slow-moving vehicles	• Simulations including heavy vehicles show a reduction in average arterial travel speed along three-lane roadways 3 times that along four-lane undivided roadways • Approximately 50 percent of the simulated speed reduction above, however, occurred at and above 20 percent heavy vehicles • Impact of bus activities on average arterial travel speed is greater along the three-lane roadways
Weaving, speed, and queues	• Changes that occur (especially for speed and queuing) are dependent upon the current operation of the four-lane undivided roadway • Weaving or lane changing (other than vehicles entering the two-way left-turn lane (TWLTL)) should not occur along a three-lane roadway • Typical case study and simulated reduction in 85^{th} percentile and/or average speeds are 3 to 5 miles per hour • Minor roadway or driveway approach delay may increase and should be considered
Crash type and patterns	• Case studies discussed above show total crash reduction of 17 to 62 percent • Minnesota data indicate that three-lane roadways have a crash rate 27 percent lower than the rate for four-lane undivided roadways • Huang, et al. analysis shows lower levels of crash reduction, but others find reductions similar to the above (discussed below)
Pedestrian and bike activity	• Case study results generally support conclusion that pedestrians/bicyclists/adjacent landowners prefer the corridor environment of a three-lane cross section to that of a four-lane undivided roadway • Recent Rosales investigation supports above conclusions (discussed below)
ROW avail., cost, & acquisition impacts	• Four-lane to three-lane conversions typically require little additional right-of-way and limit cost and acquisition impacts
General characteristics	• Consider potential diversion to parallel roadways, but should be limited if speed reduction is small (see above) • High volume on offset crossing roadways can impact main roadway operations • Consider amount and impact of parallel parking on operation of roadway • Ensure acceptable turning capabilities and truck turning needs on an as-needed basis • Queue of vehicles waiting for train on three-lane roadway only has one lane for storage

	• Operational impact of parallel railroad tracks should also be considered (see case study below)

The characteristics of the factors listed in Table 1 must be considered during the analysis of alternative roadway cross section improvements. A more detailed discussion of each factor can be found in the IaDOT guidelines, the summary paper from the second Urban Street Symposium, and the *Road Diet Handbook: Setting Trends for Livable Streets* document by Rosales (*2*, *3*, *8*). Two of these documents also contain a series of sample evaluative questions that may be helpful in the consideration of these factors (*2*, *8*).

IaDOT Guideline Recommendations

Several of the recommendations provided in the IaDOT guidelines were particularly relevant to the implementation of four-lane undivided to three-lane cross section conversions (2, 3). These are recommendations are presented below.

- The feasibility of replacing a four-lane undivided roadway with a three-lane cross section needs to be considered on a case-by-case basis. An investigation of the community goals for the roadway and a comparison of the expected conversion impacts to what is locally acceptable must be completed.

- Both the existing and expected (e.g., design period) characteristics of the factors noted in Table 1 should be investigated in future research (projects focused on safety and livability factors are discussed below) and considered for the feasibility of a four-lane undivided to three-lane cross section conversion.

- Simulation results suggest that four-lane undivided to three-lane cross section conversions along roadways with peak-hour volumes less than 750 vphpd may experience few operational impacts, but that more caution should be exercised when the roadway has a peak-hour volume between 750 and 875 vphpd. At and above 875 vphpd, the simulations indicated a more severe reduction in average arterial travel speed and greater operational concerns.

- The results of the work summarized in the IaDOT guidelines appears to indicate that four-lane undivided to three-lane conversions can be successful for a wide range of roadway characteristics, but the roadway environment should preferably remain relatively stable during the design period (e.g., traffic volumes won't increase dramatically). The conversion is also likely to be more successful if the current four-lane undivided roadway is already operating as a "defacto" three-lane roadway (See Figure 2).

- It has been observed that the general distribution and range of spot vehicle speeds are different before-and-after a four-lane undivided to three-lane conversion. The reduction in vehicles traveling 5 mph over the speed limit, for example, has been reduced dramatically in several instances. The feasibility analysis of four-lane undivided to three-lane conversions should not only consider average arterial travel speed, but also the range and distribution of vehicle speeds.

FIGURE 2 Four-lane undivided roadway/intersection operating as a "defacto" three-lane cross section.

RECENT FEASIBILITY DETERMINATION FACTOR INFORMATION

Crash Type and Patterns

Based on the case study results previously summarized, it is expected that a roadway with a three-lane cross section will have a lower crash frequency and/or rate than a comparable four-lane undivided roadway. These results, however, are based on "naïve" before-and-after crash analysis and other "in-the-field" observations. Several statistically robust safety analyses of four-lane undivided to three-lane conversions have been completed to generally test these results (*4, 6, 7, 9, 10*). The approaches, case study locations, and analysis approaches used by these research projects have varied and are discussed below.

In 2002 Huang, et al. published what was the first attempt at a statically robust safety impact analysis of four-lane undivided to three-lane cross section conversions (*4*). This research considered the crash data from as many as 12 four-lane undivided to three-lane conversion sites and 25 non-conversion comparison roadways. The conclusions of the analysis done by Huang, et al. included the following:

- Six percent fewer total crashes after the conversion at the treatment sites than at the comparison sites. This analysis used a before-and-after yoked comparison approach.
- Lower crash rates along the conversion roadway segments, but no statistically significant difference found in the crash rate before-and-after the conversions. The safety

experiences along the converted roadways were not better or worse than those along the comparison roadways. This analysis, because of data restrictions, was based on 8 conversion roadways and 14 comparison sites.

- No significant impact of the conversions on crash severity or the type of crashes. The conversion sites had a statistically higher and lower number of angle crashes and rear-end collisions, respectively, than the comparison sites.

The results of the Huang, et al. project were presented at the Second Urban Street Symposium and published in the *Transportation Research Record* (*4, 11*). A summary of the work was also included as an insert in the *ITE Journal* (*5*). The difference in the results of this study and the crash reductions observed along many converted roadways was significant (*4, 5, 11*).

More recently, additional safety analyses of four-lane undivided to three-lane cross section conversions have been completed (*6, 7, 9*). One study used typical before-and-after comparisons and a matched-pair (or yoked-pair) safety analysis technique to evaluate 14 four-lane undivided to three-lane conversions (*6*). A before-and-after comparison of the average annual crashes along the converted roadways showed a reduction of 17 to 75 percent (*6*). The overall average reduction at these sites was 50 percent (*6*). However, an adjustment to account for the overall crash experience in the cities within which the roadways were located reduced this value to 21 percent. A matched-pair comparison of the treated and non-treated roadways, on the other hand, produced an average reduction of 38 percent (*6*). A basic before-and-after comparison by crash characteristic showed a reduction in serious injury crashes, older driver crash risk, and many types of crashes (e.g., left-turn and stopped vehicle crashes) (*6*). All of the results from this study are much more similar to the case study observations previously discussed.

Two additional four-lane undivided to three-lane conversion safety analyses were also recently completed (*7*, *10*). First, Gates, et al. used an Empirical Bayes (EB) statistical approach on crash data from seven conversion sites (*10*). A total crash reduction of approximately 37 to 54 percent (with an average of approximately 44 percent) was found at these sites (*10*). The EB statistical approach is currently the most widely accepted analysis methodology of safety data. A Grouped Comparison approach by Gate, et al. also found reductions in non-injury and right-angle crashes due to four-lane undivided to three-lane conversions (*10*). Pawlovich, et al. took what is believed to be an even more robust statistical approach and used a full Bayes analysis to evaluate and compare the safety trends at 15 converted and comparison roadways (*7*). The study considered 23 years of monthly crash data (*7*) This analysis found a reduction in crash frequency per mile and crash rate due to four-lane undivided to three-lane conversions of approximately 25 and 19 percent, respectively (*7*). The results from the Gates, et al. and Pawlovich, et al. studies are similar to the crash reductions found by practitioners and through the “naïve” before-and-after studies previously discussed (*7, 10*). It is proposed that the differences between these results and those produced by Huang, et al. are due to, among other things, the modeling approach used, the inclusion of seasonal impacts, and the amount of data available (*7*). A study that includes data from the treatment and comparison sites used in all of these research projects might be of interest. The details of the Pawlovich, et al. study are described in another paper presented at this symposium (*9*).

Livability Factors (e.g., Environment, Economics, Pedestrians and Bicyclists, etc.)

In September 2006 Parsons Brinckerhoff published the monograph "*Road Diet Handbook: Setting Trends for Livable Streets*" by Rosales (*8*). As part of that research project, Rosales investigated the livability benefits of converting four-lane undivided roadways to a three-lane cross section (*8*). On-line and door-to-door surveys were completed to determine the opinions of those living and working along roadways that had experienced this type of conversion (*8*, *12*). Three of the roadway locations considered were in the states of Washington, Iowa, and Georgia. The other two roadways were in Toronto, Ontario, Canada and Dunedin, New Zealand (*8*, *12*).

The surveys completed along the converted roadways showed relatively similar results (*8*, *12*). In most cases, the respondents to the survey noticed an improvement in the roadway environment and agreed with the change. In other cases, the responses were somewhat mixed in nature, but the difference in opinions was likely a result of the diversity in the characteristics of the locations considered (e.g., rural versus urban), where the respondents lived (e.g., adjacent to the roadway or blocks away), the unique challenges of applying each conversion and its details, and/or the typical variability and application issues related to surveys. Overall, one or more of the following livability benefits were found along each of the case study roadways:

- Improved walkability and easier street crossing,
- Increased pedestrian and bicycle use,
- Slower vehicle speeds,
- Users feeling "safer" and more "comfortable" along the roadway,
- Economic growth in adjacent and nearby businesses,
- Increased new home and business improvement projects,
- Redevelopment and renovation work at a quicker pace, and
- Increased front yard activity.

The monograph produced by Rosales is currently the most complete discussion of four-lane undivided to three-lane roadway conversions (*8*). It is a comprehensive guide that was designed to assist transportation planners and engineers trying to determine the applicability of this type of conversion at particular locations (*8*). The guide summarizes research in the subject area, identifies gaps in the state-of-the-knowledge, and analyses and summarizes the safety, operations, and livability impacts of four-lane undivided to three-lane conversions (*8*). It contains evaluations and "lesson learned" from each case study location and includes guidelines for identifying/evaluating potential conversion sites and conversion implementation (*8*).

CASE STUDY CONVERSION DISCUSSION

In 2005 the feasibility determination factor guidelines in Table 1 were applied by Knapp to a one-mile segment of four-lane undivided roadway in Colby, Wisconsin (See Figure 3) (*2*). Colby is in central Wisconsin and has a population of less then 2,000. The roadway, State Highway 13, is a principal arterial with an average daily traffic (ADT) volume of about 10,300 vehicles per day (vpd). The existing cross section of the segment considered has a 12-foot and 10-foot lane in each direction and right-of-way is limited. There is a parallel railroad immediately to the west of State Highway 13 in Colby.

The State Highway 13 segment that is the focus of the following discussion has been proposed for resurfacing. This is an efficient and effective time to consider alternative cross sections for a roadway. A brief discussion of the feasibility determination factors (See Table 1) as they exist along State Highway 13 in Colby is provided below along with a series of observations or lessons learned from this evaluation activity.

FIGURE 3 Existing cross section: State Highway 13, Colby Wisconsin.

State Highway 13 Feasibility Determination Factors

Roadway Function and Environment

State Highway 13 is a principal arterial that primarily serves a mobility function through Colby. However, the roadway segment being considered also has a relatively low posted speed limit of 30 mph and currently serves a number of minor street intersections and driveway access points. Converting this segment from the existing four-lane undivided cross section to three lanes should be expected to create a more urban street environment. An operational analysis by Traffic Analysis & Design, Incorporated showed that the overall average speed along State Highway 13 would decrease by 3 miles per hour or less after a conversion to three lanes. Therefore, the mobility function of the current cross section would be reduced.

Overall Traffic Volume and Level of Service

State Highway 13 in Colby currently serves an ADT of approximately 10,300 vpd and is expected to carry about 13,800 vpd in 2028. This range of total daily traffic volumes, based on past case study experiences and the operational analysis results from State Highway 13, suggests that a conversion from the existing four-lane undivided cross-section to three lanes is "operationally feasible". However, a little additional vehicle delay on some of the minor roadway approaches should be expected (with a three-lane cross section). The level of service (LOS) on the westbound movements of three intersecting roadways will, respectively, be at LOS B and C rather than LOS A and B. The movements along State Highway 13, however, are expected to remain at LOS A for both cross sections in 2006 and 2028. The LOS analysis also does not show that additional through lanes would be needed at any new signalized intersections that might be installed along a three-lane State Highway 13.

Turn Volumes and Patterns

Currently there is not a significant amount of turning traffic flow along State Highway 13 in Colby. No major operational issues with turning traffic and/or their LOS impacts are apparent based on the operational analysis. Also, only a few driveways exist that may produce significant peak-hour left- and/or right-turn traffic. If additional driveways of this type are introduced proper access control and intersection/driveway designs would need to be implemented. The introduction of a three-lane cross section may also require some driver education and enforcement to ensure the proper use of the cross section (e.g., to discourage the illegal use of the TWLTL for passing).

It may be possible, within the current 44 feet of pavement width, to add right-turn lanes to a three-lane cross section at some of the intersections along State Highway 13 by shifting and narrowing all the lanes (e.g., four lanes with 44 feet). The ability of vehicles to safely and properly turn into these driveways/intersections should be closely considered with this type of cross section.

Frequent-Stop and/or Slow-Moving Vehicles

Heavy vehicles appear to represent about 7 to 10 percent of the traffic volume along State Highway 13 (based on turning movement counts). Past simulations (See Table 1 and previous discussions) indicate that this amount of heavy vehicles is not likely to have an impact large enough to produce different arterial levels of service for the two cross sections being compared. The impact of heavy or slow-moving vehicles on through traffic flow (with or without signals) along a three-lane roadway, however, is higher because it has only one through lane in each direction (e.g., heavy vehicles turn and accelerate/decelerate more slowly than passenger cars). Intersections and driveways where heavy vehicles may turn should also be properly designed.

Of special interest along State Highway 13 is the adjacent feedmill that produces truck traffic. The efficiency of vehicles entering and exiting this facility (which is in close proximity to the roadway and between it and the railroad) would be critical to the proper operation of a three-lane cross section if it were implemented. The single through lane that would exist in each direction along a three-lane cross section could not be blocked (it encourages the improper use of the TWLTL).

Weaving, Speed, and Queues

There is some weaving along the current four-lane undivided State Highway 13, but almost no queuing. There should also be no weaving along a three-lane cross section, but anecdotal evidence from previous conversions suggests that some education and enforcement may be necessary to reduce the misunderstanding or misuse of the TWLTL. The operational analysis of this section of State Highway 13, however, did show that a four-lane undivided to three-lane cross section conversion would decrease average arterial vehicle speeds by one to three miles per hour. The 85th percentile speed measured along State Highway 13 was 36 mph (in the section posted for 30 mph) and 47 mph (in the section posted for 40 mph). Past conversions have shown that a four-lane undivided to three-lane cross section conversion would likely reduce the number of vehicles traveling at higher speeds.

There does not appear to be a significant amount of queuing along the current State Highway 13. With a three-lane cross section, however, the impact of the train tracks parallel to the roadway would require the addition of right-turn lanes with adequate storage at those side streets that cross the tracks (due to the potential for vehicles to queue). Blocking through lanes on a roadway with stopped vehicles should be avoided. It should also be recognized that the introduction of any signalization along State Highway 13 would introduce queues that do not currently occur. While the operation of vehicles along State Highway 13 will be similar along both cross sections, with or without the signals, the general public may believe that this new queuing is due to the cross section change (if it were to occur) rather than the signalization. This confusion should be avoided if possible.

Crash Type and Patterns

A review of the existing conditions shows that the crash rate for the roadway segment is above the state average and that a high percentage of the 65 crashes recorded along this segment are of a type that could be directly improved by its conversion to a three-lane cross section (or the addition of a TWLTL). The type of crashes that can be reduced with the introduction of a three-lane roadway include left-turn, rear-end, and sideswipe.

The location of the beginning and end of a potential three-lane cross section is also of particular interest. Transition areas introduce the possibility of vehicular conflict and should be located properly. It is generally recommended that these transitions not be located near complex or heavily used intersections or driveways. In Colby, the north transition could be located near the area where the roadway currently changes from a four-lane undivided to a four-lane divided cross section. However, the south transition should preferably be extended past the south end of the current resurfacing project limits to the existing two-lane cross section south of Colby. For consistency purposes, it would not be desirable for the State Highway 13 cross section to transition from a three-lane cross section to the existing four-lane undivided cross section (south of the current study segment) and then back to a two-lane rural cross section.

Pedestrian and Bike Activity

The existing four-lane undivided cross section along State Highway 13 in Colby has no bike lanes and no median protection for pedestrians crossing the roadway. The introduction of a TWLTL with a three-lane cross section conversion might allow the introduction of bike lanes (or wide through lanes) along the cross section. A TWLTL will also allow pedestrians to effectively cross the roadway in two parts, if necessary, using the turn lane as crossing refuge. While this type of crossing is not encouraged, it is typically better than a two-stage crossing on an undivided cross section.

A packaging plant adjacent to the study segment is also located across State Highway 13 from all or most of its employee parking. The introduction of a three-lane cross section near this plant could improve the safety of crossing pedestrians, but a more well-defined and focused crossing location for the employees is needed and the introduction of other geometrics or pedestrian crossing equipment may be necessary. For example, the introduction of a raised median in this area might be possible but would also impact access to adjacent properties.

Right-of-Way Availability, Cost, and Acquisition Impacts

The availability of additional right-of-way lane along State Highway 13 study segment is limited (especially at critical intersection locations). Considerable expense would likely be involved for the purchase of any additional right-of-way. The roadway *segments* of a three-lane cross section along State Highway 13 could consist of two 12-foot through lanes and a 14-foot TWLTL (a total width of 38-feet). The additional 6 feet of roadway width that is available might be used by bicycles or to shield most of a stalled/stopped vehicle. The shifting and narrowing of lanes at critical intersections could allow four lanes (i.e., two through lanes, one left-turn lane, and one right-turn lane) to be included in the current 44-foot pavement width (e.g., four 11-foot lanes). However, the ability to acquire even a few additional feet of right-of-way (e.g., 2 to 5 feet) at these locations would limit the amount of lane narrowing or shifting that would need to be done. The safety of the roadway and the ability of vehicles to turn appropriately at these locations (with this type of intersection approach cross section design) are of critical importance and need to be confirmed and ensured.

General Characteristics: Parallel Roadways; Offset Minor Street Intersections; Parallel Parking, Corner Radii, and At-Grade Railroad Crossings

A limited parallel roadway network does exist in the study area, however, most of the routes are discontinuous and can only be reached by crossing the parallel railroad tracks on the three to four crossing roadways that intersect with State Highway 13. It is not expected, especially given the low traffic volumes, that a four-lane to three-lane conversion along this segment of State Highway 13 will produce much traffic flow diversion to parallel routes.

The level of the traffic volumes along and crossing State Highway 13 does not appear to be large enough for significant concerns related to the existing offset intersection designs. In addition, there is no parallel parking provided on the existing cross-section. The introduction of parallel parking along this roadway segment does not appear to be appropriate.

The number of right-turn movements along this segment of State Highway 13 is currently small. Any impacts these movements may have on the future operation of the roadway will be based on the access management measures implemented and land uses developed. Turning traffic effects through traffic along both four-lane undivided and three-lane roadways, but based on the operational analysis this delay is likely to be small on State Highway 13. Some localized redesign of driveways and intersections, along with other access management measures, should be provided if necessary.

There are no railroad tracks that directly cross State Highway 13 in Colby, but there is a railway line parallel to the roadway. The use of this railway line will impact the operation of State

Highway 13. Adequate storage for vehicles that are waiting for the train is needed to allow through traffic to travel along State Highway 13 even as trains move through the area. Right-turn lanes would be needed along a three-lane cross section at the side streets that cross the railroad tracks. Along the current four-lane undivided cross section right-turning vehicles, if necessary, queue in the appropriate lane while waiting for a train.

Observations and Lessons Learned

The authors have both created detailed guidance for the evaluation and implementation of four-lane undivided to three-lane cross section conversions (*2*, *8*). The evaluation documented above was completed by Knapp (with the assistance of Traffic Analysis & Design, Incorporated and the Wisconsin Department of Transportation) to assist with the feasibility consideration of a potential four-lane undivided to three-lane cross section conversion. The observations and lessons learned that are listed below are based on Knapp's experience in the application of these guidelines to this case study roadway segment.

- Understanding the expected and/or intended function of the roadway being considered for a four-lane undivided to three-lane conversion is critical to its feasibility as an alternative. Multiple jurisdictions are often involved in these discussions. Four-lane to three-lane conversions have been suggested as a "traffic calming" measure for highways entering urban areas. In these situations, an understanding of and agreement on the expected/intended function of the roadway is especially important.

- Not surprisingly, intersection operations are critical to the success or failure of any roadway cross section conversion. If the right-of-way at critical intersections is very limited (often one of the reasons for considering a four-lane undivided to three-lane conversion) the details of the geometrics and turning at these intersections becomes very important. Acquisition of even a foot or two of additional right-of-way at these locations may not be possible to alleviate problems with these characteristics.

- Combining a four-lane undivided to three-lane conversion with the addition of new signals may not be a desirable approach. The success or failure of the implementation of this type of conversion, especially for the first time in a jurisdiction, is sensitive to public opinion (similar to roundabout implementation). The queuing produced by the signal installation may actually be "blamed" on the four-lane to three-lane cross section conversion. It is suggested that, if possible, the conversion of a segment and the addition of new signals be completed separately. In either case, the location and timing of existing and new signals must be designed and optimized for the cross section used.

- The conversion of a roadway from a four-lane undivided to a three-lane cross section will result in larger impacts on and from heavy vehicles (at whatever percentage). The mobility of through trucks may be reduced slightly and those trucks entering/exiting businesses adjacent to a converted roadway need to be served properly. The impact of these heavy vehicles on the roadway operation should be minimized. The importance of this impact (especially at lower heavy vehicle percentages) is reduced if the intended and expected function of the roadway segment is access rather than mobility.

- The most appropriate project limits for a four-lane undivided to three-lane cross section conversion may not be the same as the project limits initially set for ongoing maintenance or reconstruction project purposes. It is a good time to evaluate alternative cross sections for a roadway during these activities, but the feasibility evaluation of a four-lane undivided to three-lane conversion must also consider how compatible this type of change is with the roadway segments on each end of the proposed project limits. Consistency in the number of through lanes along a significant length of roadway, along with safe and effective transition locations, is important.

- Pedestrians and bicyclists generally prefer the conversion of four-lane undivided roadways to three lanes. If there are few pedestrians or bicyclists along a roadway it may be the result of the service currently provided or a lack of demand. The conversion of roadways that have locations with a high number of pedestrian crossings, however, need to be closely considered. A three-lane cross section offers some refuge with a TWLTL (it's better than a four-lane undivided roadway), but it is not as good as having a raised median. Raised medians and/or other pedestrian crossing equipment are possible (mid-block and at major intersections) along many cross section designs. The implementation of a raised median, however, will limit access to adjacent properties. In addition, any potential impacts on vehicle safety and operations due to the addition of a raised median also need to be addressed. This type of improvement has been done successfully at many locations. A raised median design including a "jog" or "angle" that requires pedestrians to look at oncoming traffic is desirable.

- Railroad tracks crossing a roadway that is being considered for a four-lane undivided to three-lane cross section conversion can critically impact its feasibility. The queuing that takes place while vehicles wait for a train will have less storage space (i.e., one lane instead of two). However, the impacts of parallel railroad tracks in close proximity to a roadway being considered for this same type of conversion must also be evaluated. The presence of these parallel railroad tracks can introduce additional requirements for the proper operation of signals and the addition of right-turn lanes (for the safe storage of vehicles waiting for a train). The addition of this queuing storage along three-lane roadways is critical because only one through lane in each direction exists (and it may also require additional right-of-way).

- The conversion of a four-lane undivided roadway to three lanes is challenging and can take a significant amount of planning and public involvement. The implementation of this type of conversion for the first time in a jurisdiction should be done carefully and at a location where success is expected. If the first four-lane undivided to three-lane conversion completed in a jurisdiction is not successful, the ability to attempt a second conversion is very limited. The cumulative impacts of a potential conversion can also lead to it not being desirable at a particular location.

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