BLOOMINGTON • MONROE COUNTY

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Mr. Scott Robinson, AICP
City of Bloomington Planning Department
401 N. Morton St., Suite 160
Bloomington, IN 47402

April 30, 2007

Dear Mr. Robinson:

Urban Engineering is pleased to provide you the final report for the 10th Street Extension and Modernization project. Our final report details our project approach, a description of the work completed and our recommendations.

Contained within the report is a design for the 10th Street and Law Lane corridors, and a proposed construction method for the replacement of the 10th Street overpass. Also included are geometric designs for the proposed new alignments of 10th Street and Law Lane and pavement designs for any road upgrades. Finally, a detailed breakdown estimating the cost of materials and construction for the project is included.

We have enjoyed working on this project and appreciate all the assistance and feedback you, the City Engineer's office, and the Citizens Advisory Committee have given us. Please contact us with any questions or comments you may have about this report.

Sincerely,

Rob Adolph
Client Liaison

Andrew Lopshire
Project Manager

David Massey
Project Editor

Ryan Robinson
Project Engineer

Todd Stout
CAD Technician

Enclosed: Final Report

Final Report

10th Street Extension and Modernization

Prepared for

Bloomington Metropolitan Planning Organization

By

URBAN ENGINEERING

Rose-Hulman Institute of Technology
5500 Wabash Ave., CM 2403
Terre Haute, IN 47803

April 30, 2007

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Executive Summary

The Bloomington Metropolitan Planning Organization (MPO) is interested in solutions to alleviate long-standing traffic issues in and around the 10th Street corridor through the Indiana University campus. The MPO would also like to improve the effectiveness of public transit and alternative transportation methods in the area. This report proposes two options for addressing these issues as a result of input from the major stakeholders in the area.

In both solution options, an extension of Law Lane eastward to 10th Street is proposed. The Law Lane extension and the existing 10th Street will meet at a roundabout. This will require a realignment of 10th Street between Law Lane and the SR 45/46 bypass. In addition, both designs incorporate a replacement of the existing railroad overpass on 10th Street between Union Street and the SR 45/46 bypass. The new bridge will be longer and have a higher clearance, allowing for larger buses and emergency vehicles to travel under the bridge. 10th Street will be realigned underneath the overpass to decrease the deflection angle in the road.

Realignments of Law Lane near Jordan Street and Union Street near Law Lane are proposed to remove existing curvatures. In addition, turning lanes are proposed for the intersections of Law Lane at Jordan Street and Union Street in order to accommodate increased traffic.

Also in both options, 10-foot-wide shared-use sidepaths for pedestrians and bicyclists are proposed on the southern sides of both 10th Street and Law Lane. These sidepaths will be upgrades from the existing sidewalk facilities, providing safer means for both pedestrians and bicyclists to travel the 10th Street and Law Lane corridors.

The most significant difference between the two options is in relation to 10th Street. One option proposes the widening of 10th Street into three lanes, with two 12-foot travel lanes and one 14-foot center turn lane. The other option recommends an increase in the turning radius at the intersections of 10th Street and Woodlawn Avenue and 10th Street and Union Street.

If the 10th Street widening option is chosen, the estimated cost is 12.5 million dollars. The steam line utility relocation accounts for 5.2 million of the 12.5 million dollars. However, if the intersection upgrade option is chosen., the estimated cost is 6.6 million dollars.

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1.0 Project Description

1.1 Background

Bloomington, Indiana, located in Monroe County, is 60 miles southwest of Indianapolis (Figure 1). Bloomington is in the center of the county (Figure 2), and is home to Indiana University (IU) and 38,000 students during the academic year. 10th Street is the main east-west corridor through the IU campus and downtown Bloomington. IU students and Bloomington public transportation services have combined to make 10th Street a difficult road on which to travel due to the daily vehicular and pedestrian congestion. The problems that occur on a daily basis include bottlenecking at an "S-curve" underneath a railroad overpass, small turning radii that hinder the bus services, and traffic congestion due to the need for left-hand turns during rush hour.

1.2 Site Location and History

The portion of 10th Street that Urban Engineering will investigate runs from the State Rd. 46 bypass to Dunn Street. Figure 3 is a map of the streets within and surrounding the IU campus. Just recently, the Bloomington and IU bus services set records for the number of riders. Additionally, high traffic volume adds to the number of vehicles in the vicinity of 10th Street. Also present in the project area is an active railroad that runs diagonally through the IU campus.

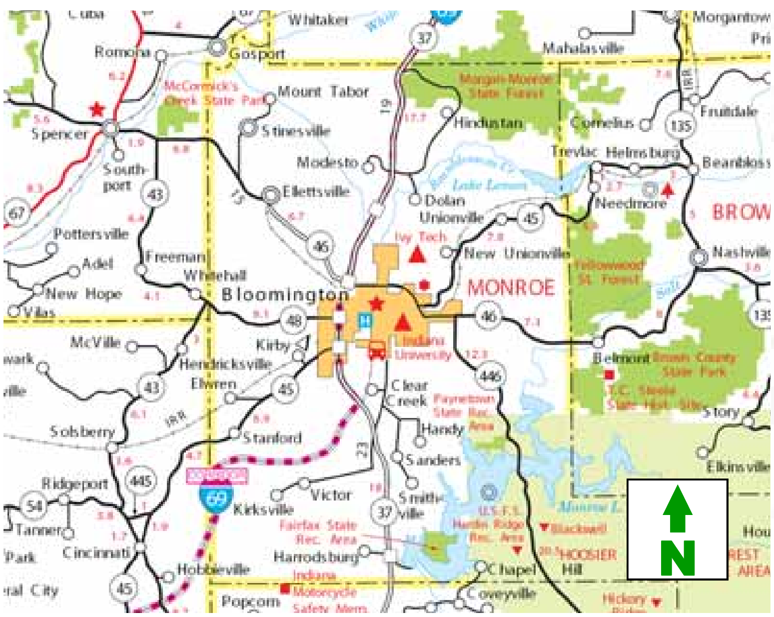

Figure 1 (Right): Map of Monroe County relative to the state of Indiana. (Adapted from City of Bloomington, 2006)
Figure 2 (Above): Map of Bloomington, Indiana showing its local establishments and surrounding communities within Monroe County. (Adapted from INDOT, 2006)

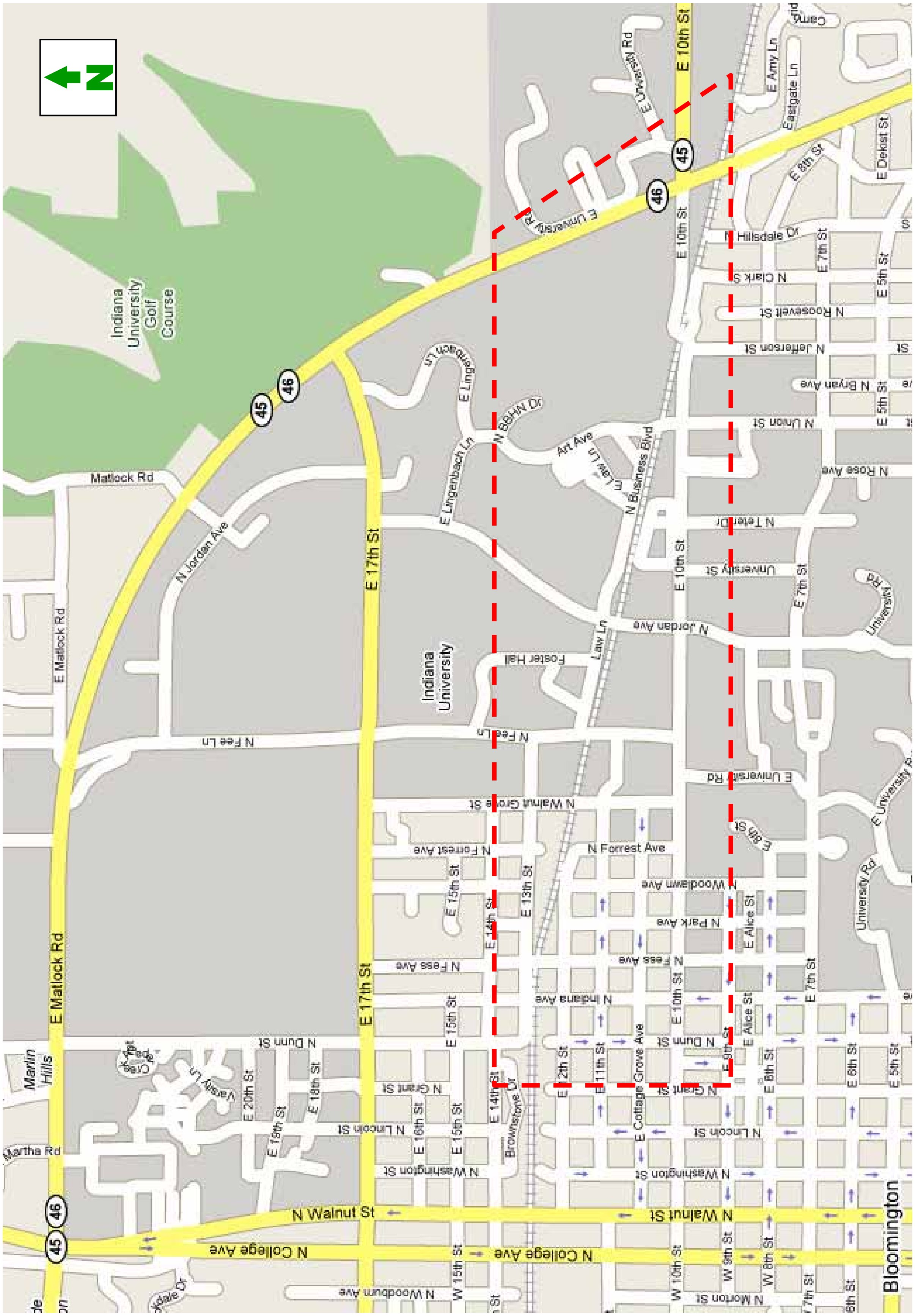

Figure 3: Map of the streets within and surrounding the IU campus. The red dotted line represents the relative scope of the project. (Adapted from Google Maps, 2006)

1.0 Project Description (cont.)

1.3 Client and Project

The Metropolitan Planning Organization (MPO) of Bloomington, Indiana, is responsible for the planning and improvement of transportation services in Bloomington. Their transportation responsibilities include not only local roads, but bike paths, walking paths, and public transportation. Scott Robinson, Long Range/Transportation Manager, and Joshua Desmond, Assistant Director, of MPO contacted us about this project.

The purpose of this project is to develop alternative vehicular and/or pedestrian routes that will alleviate problems associated with the heavy use that is currently placed on 10th Street. The surrounding corridor of the IU campus, particularly to the north, is being suggested as locations for alternate routes. This proposal is being submitted to address the request of Mr. Robinson and Mr. Desmond. Urban Engineering will perform the research and design that will provide a viable solution to the 10th Street corridor bottleneck and overuse.

2.0 Design Requirements

The Metropolitan Planning Organization (MPO) has chosen to investigate the multimodal transportation system along the north perimeter of the IU campus. The MPO would like to increase safety and efficiency within the study area by modernizing key east-west corridors from 10th to 14th Streets. The study area begins at Dunn Street and extends 1.5 miles east to SR45/46 Bypass. The MPO has concerns about meeting the high demand transportation needs in the area consisting of through traffic, emergency vehicles, thirty-eight thousand IU students, commercial vehicles, public transportation vehicles, pedestrians, and bicyclists. A plan of action is necessary to alleviate the congestion that 10th Street and connecting corridors are experiencing.

2.1 Requests

In an effort to compile the most favorable, creative, and unique solution for the City of Bloomington's traffic congestion problem, there are few requirements and virtually no restrictions on the scope of Urban Engineering's 10th Street Extension and Modernization plan. The MPO's requests are:

- Phase the project and provide several design options for each phase
- Provide green engineering when applicable
- Be creative but not unrealistic
- Minimize costs when providing design options
- Hold a meeting for the Citizens Advisory Committee (CAC)

2.2 Constraints

A major constraint that Urban Engineering anticipates is the limited right-of-way. In addition, the client indicated the following restrictions:

- The railroad is an economic asset and must remain active
- The power plant is a permanent fixture that must be incorporated into Urban Engineering's design solutions
- Trees are valued in Bloomington; therefore, removing trees to accommodate for new designs should be an important consideration
- Most of the study area is already developed, however applicable environmental permits should be submitted through the Indiana Department of Environmental Management.

2.3 Deliverables

To fulfill client requests, Urban Engineering is providing an electronic copy of the final report in PDF format. This report contains 11”x17” design drawings in AutoCAD 2004 and PDF formats, a phased implementation plan with detailed cost estimates, and photographs in JPEG format.

3.0 Project Approach

Urban Engineering completed all of the MPO's requests for the 10th Street Extension and Modernization project based upon the following project approach:

- **Preliminary Feasibility Study** – Determine current site conditions and evaluate feasibility of construction
- **Codes and Regulations** – Research all applicable codes and regulations and determine impact on project
- **Design Options** – Provide various options to relieve traffic congestion and meet client requests
- **Photographic Survey** – Document current site conditions with pictures of key locations throughout the site
- **Assessment of Options** – Analyze design options and choose optimal design
- **Intersection Design** – Create geometric design of reconstructed intersections to increase capacity and safety
- **Alignment Design** – Create geometric design of two alignment options to increase capacity and promote pedestrian safety
- **Roundabout Design** – Create geometric design of roundabout intersection to accommodate current and expected traffic volumes
- **Utilitiy Locations** – Locate and propose solutions for any utilities which may impact construction of proposed designs
- **Material Selection** – Create an asphalt pavement design for road reconstruction and new road alignment construction
- **Signs and Signals** – Identify locations for proper signage and signals for road reconstruction and new road construction according to accepted standards
- **Pavement Markings** – Determine proper pavement markings for road reconstruction and new road construction according to accepted standards
- **Sidepaths** – Design shared-use sidepaths to provide better facilities for pedestrians and bicyclists throughout project area
- **Railroad Overpass** – Create a construction method for replacing the existing 10th Street railroad overpass with a minimum of interference to railroad operations
- **Engineering Plans** – Draft plans for new 10th Street and Law Lane alignments
- **Cross Sections** – Draft typical cross sections for new road alignments

- **Construction Phasing** – Determine a phased construction process to meet client requirements and provide a means of construction with less impact on the community
- **Cost Estimate** – Produce a detailed estimated cost breakdown for construction of proposed designs

4.0 Design Solution

4.1 Preliminary Feasibility Study

For the preliminary feasibility study, Urban Engineering conducted research on the site and made a site visit to observe current conditions along and in the vicinity of the 10th Street corridor. This study was performed so that designs for roadway extensions and improvements would take into account any existing conditions that could adversely affect the implementation of any improvements to the site. While conducting the feasibility study, several resources were consulted. These resources included a soil survey of Monroe County, GIS information provided to us by the MPO, and a meeting with the Bloomington City Engineer. The site inspection was conducted by a member of Urban Engineering who visited the site and took pictures, noting the locations of above-ground utilities, trees, sidewalks, existing buildings abutting the roads, and other visible conditions which could affect expansion of existing roads and construction of new roads.

After conducting the feasibility study, several areas of concern were noted. The most important areas to the project are 10th Street near Woodlawn Avenue and Law Lane. The area immediately surrounding the intersection of 10th Street and Woodlawn Avenue is closely abutted by existing construction on three of the four corners. In addition, there are buildings, utilities, and trees in close proximity to the 10th Street right-of-way west of Woodlawn Avenue. This will make any expansion of 10th Street difficult. In addition, the western half of Law Lane has right-angle parking on one or both sides of the travel lanes. If bicycle lanes are to be added to Law Lane or the road is to be widened, the existing parking spots could be converted to parallel parking spots with some loss of capacity. The railroad underpass along 10th Street is also of concern, since currently there is a sharp S-curve in the vicinity of the underpass, and the bridge itself is substandard, with low clearance and a dangerous concrete support located between the two 10th Street travel lanes. Additional information resulting from the preliminary feasibility study can be found in Appendix A.

4.2 Codes and Regulations

Urban Engineering reviewed the *Indiana Department of Transportation Standards and Specifications Manual* (INDOT, 2006), the *AASHTO Manual on Uniform Traffic Control Devices* (FHWA, 2003), and the *American Association of State Highway and Transportation Officials Guide for the Development of Bicycle Facilities* (AASHTO, 1999) in order to assist in the design of the 10th Street

Extension and Modernization project. The state and federal codes will be used to ensure that Urban Engineering's completed design is safe, accessible, in compliance with state and federal regulations, and eligible to receive state and federal funding for future design and construction. Urban Engineering reviewed the aforementioned codes as they apply to earthwork, bases, pavements, incidental construction, traffic control devices, and provisions for bike paths. The codes applicable to this project provide information on acceptable construction methods, materials, and equipment that can be used for the design and construction. More detailed information regarding codes and regulations can be found in Appendix B.

4.3 Design Options

Appendix C provides a brief summary for each option that is being considered for the 10th Street corridor. This appendix fulfills the request of the Bloomington Metropolitan Planning Office who asked us to compile a "menu" of options from which Urban Engineering could select our final design recommendation. Urban Engineering divided up the project into different street sections and created options for each section.

10th Street Options

- Widening and Realignment
- Sidepaths
- Temporary Bus Parking Stalls
- One Way Pair Corridor (Figure 1)
- Intersection Improvements

Figure 1: Map depicting one-way pair corridor option (Adapted from Google Earth, 2006)

Law Lane from Fee Lane to Union Street Options

- Widening and Realignment with Parking Lot
- Sidepath
- Crosswalk Improvements
- Intersection Improvements

Dunn Street to Fee Lane Options

- Law Lane Western Extension
- Improvements to Adjoining Roads
- Relocation of Fire Station

Union Street to SR 45/46 Bypass Options

- Law Lane Eastern Extension
- Railroad Underpass Renovation
- New Railroad At-Grade Crossing

Full details of the various options, including maps depicting each option considered, along with advantages and disadvantages, can be found in Appendix C.

4.4 Photographic Survey

Appendix D is a photographic survey to provide the reader with a general background of the project site. This appendix consists of several different photos that present the key features of the project (i.e.: underpass, limited right-of-way, etc.). The majority of the pictures highlight existing problems or features that will affect proposed solutions. For example, the underpass pictures highlight the low clearance and tight turns needed to maneuver through the underpass (Figure 2).

The photographic survey also helps the reader visualize the different options and their descriptive summary. Urban Engineering has found that the photographic essay is the easiest way to communicate the condition of the project scope to the reader instead of using lengthy discussion. Using the underpass pictures as an example again, Urban Engineering was able to rely on the picture to communicate effectively the condition of the underpass to the reader. Please refer to Appendix D to see the photographic essay in its entirety.

Figure 2: Railroad overpass picture highlighting low clearance and tight turns

4.5 Intersections

Because of concerns with turning radii and pedestrian safety at key intersections within the project area, Urban Engineering has redesigned certain intersections with additional turning lanes and improvements to turning radii and pedestrian safety. Intersection improvements are provided at 10th Street and Woodlawn Avenue, 10th Street and Walnut Grove Street, 10th Street and Union Street, Law Lane and Jordan Avenue, and Law Lane and Union Street.

The intersection of 10th Street and Woodlawn Avenue has been redesigned to incorporate increased turning radii and pedestrian crossings. Left and right turning lanes from westbound 10th Street are also added to increase traffic flow and accommodate public transit and emergency vehicles. The intersection of 10th Street and Walnut Grove Street has been redesigned to incorporate a left turn lane from eastbound 10th Street and a right turn lane from westbound 10th Street. In addition, left and right turn lanes will be added to Walnut Grove Street. The intersection of 10th Street and Union Street has been redesigned to incorporate increased turning radii. In addition, left turn lanes will be added in all directions.

The intersection of Law Lane and Jordan Avenue will be realigned as a result of the removal of a curve in Law Lane. In addition, left turning lanes will be added along Law Lane. The intersection of Law Lane and Union Street has been redesigned so that Union Street will not curve as it does now.

Left turn lanes will be added in all directions, and a right turn lane will be added from northbound Union Street.

Full details of proposed intersection improvements can be found in Appendix E.

4.6 Alignments

In order to improve traffic flow through the project area, Urban Engineering created alignment designs for the 10th Street and Law Lane corridors. These alignments are designed to improve both traffic flow and pedestrian safety. After receiving feedback from stakeholders, Urban Engineering is providing two alignment options for the 10th Street corridor. One of these options involves widening and the addition of a center turning lane on 10th Street from Woodlawn Avenue to Union Street. The other option does not require widening; however, designs for improvements to key intersections along 10th Street are provided.

Other key features of the alignment designs include an extension of Law Lane eastward to meet 10th Street, a roundabout to be located at the new Law Lane-10th Street intersection, and shared-use side-paths along 10th Street and Law Lane to increase pedestrian and bicycle safety.

Details of these alignments can be found in Appendix F.

4.7 Roundabout Design

In order to provide both an effective and creative solution to the new intersection of Law Lane and 10th Street, Urban Engineering is proposing the construction of a roundabout (Figure 3) at this intersection. Roundabouts provide many benefits over traditional intersection designs at the traffic volumes which are expected for this intersection. These benefits include fewer conflict points in comparison to conventional intersections and higher operational efficiency.

The roundabout is designed to accommodate both the traffic volumes and types of vehicles expected to travel through the intersection. In addition, the roundabout is designed to accommodate a future extension of 14th Street to the north, which has been planned by Indiana University. The roundabout features a 130 foot inscribed circle, a single 14 foot travel lane, and an 8 foot truck apron. Pedestrian and bicycle traffic will be accommodated through the use of designated crosswalks and advance signage to warn motorists of the presence of pedestrians and bicyclists. Full details of the roundabout design can be found in Appendix G.

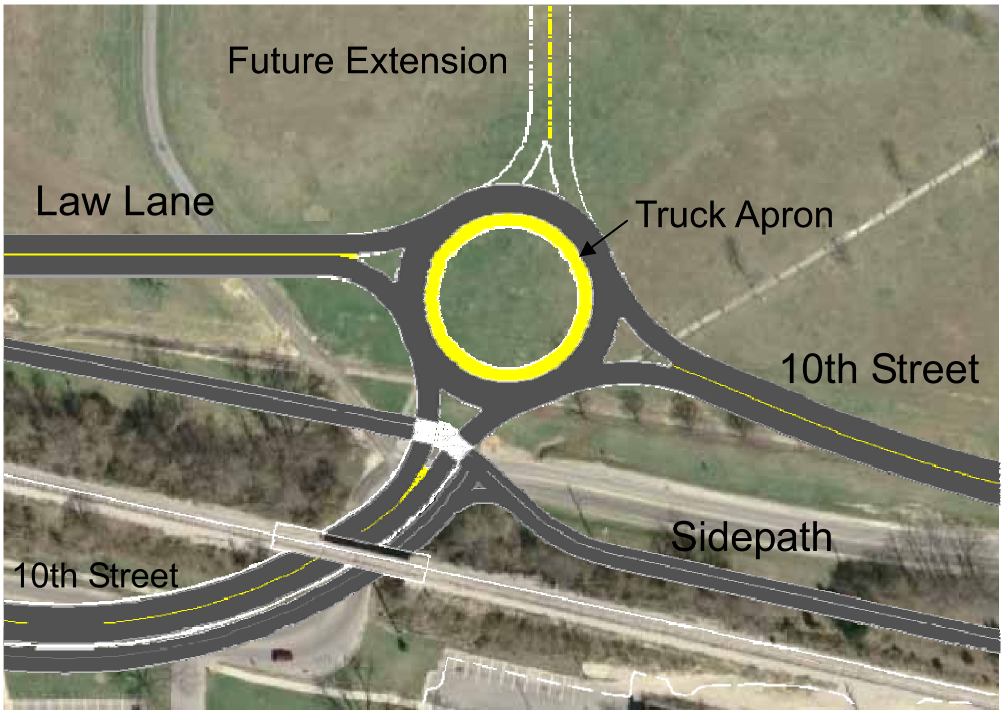

Figure 3: Design of roundabout with realigned 10th Street and sidepaths

4.8 Utilities

Because the 10th Street Extension and Modernization project is located within an area with a large amount of existing development, many different utility lines run throughout the area and will affect any construction. These utility lines include water pipes, sewer pipes, stormwater pipes, steam and condensate lines, electric power transmission lines, and fiber optic communications lines.

The biggest concern involving utilities is the steam line located on the south side of 10th Street. This steam line runs from east of Walnut Grove Street to about halfway between Sunrise Drive and Union Street. IU has expressed that, should any widening of 10th Street occur, they would like the steam line to be relocated.

The locations of utility lines, possible conflicts with construction, and proposed relocations of utilities are detailed in Appendix H.

4.9 Material Selection

Urban Engineering has created a pavement design for the reconstruction and improvement of existing roads and all new road construction. This design has been created using modern AASHTO and INDOT design standards for asphalt paved roads. Urban Engineering has created a pavement design utilizing Hot Mix Asphalt (HMA), which will provide a long-lasting quality road surface and remain consistent with currently accepted construction practices throughout the city of Bloomington and the state of Indiana.

The pavement design for reconstruction along 10th Street and the newly constructed Law Lane extension will provide a 1.5-inch HMA surface course, 2 inches of HMA intermediate course, and 3.5 inches of HMA base on top of a minimum of 8.0 inches of aggregate gravel sub-base. The pavement design for the shared-use sidepaths includes a 1.5-inch HMA surface course, 2 inches of HMA intermediate course, 4 inches of aggregate treated base on top of a prepared sub-base. The full design process for the surface course, intermediate course, base course and gravel sub-base has been provided in Appendix I.

4.10 Signs and Signals

It is important that proper signage and signaling be placed throughout the project area after any road construction and reconstruction. Urban Engineering has determined the locations of necessary signs that may not already be placed within the project area due to existing roads.

Most of the intersections within the project area already have proper signage and signaling. However, any upgraded or new intersections will need new signage and signaling. Urban Engineering recommends the intersection of Union Street and Law Lane be signalized with semiprotected left turns. Because many motorists will not be familiar with roundabouts, it is important that all proper signage be placed along roads approaching the 10th Street-Law Lane roundabout and within the roundabout itself. Further details on signs and signals can be found in Appendix J.

4.11 Pavement Markings

For all road construction and reconstruction, it is important for the proper pavement markings to be placed to meet current standards for roadways and ensure the safety of motorists, bicyclists and pedestrians traveling through the project area. Urban Engineering has determined the locations and types of pavement markings needed by using INDOT standards and the Manual of Uniform Traffic Control Devices (FHWA, 2003).

Mainline pavement for both 10th Street and Law Lane will require center and edge lines. Center lines should be solid double yellow lines, and edge lines should be solid single white lines. Turning lanes should have a minimum downstream taper of 50 feet and a solid white line separating turn lanes from through lanes. Intersections should be marked with solid white stop lines. Crosswalks should be marked with solid white lines on both sides. Railroad crossing markings should be placed no less than 50 feet from the railroad crossing. Full details of necessary pavement markings are set out in Appendix K.

4.12 Sidepaths

Since the MPO and the city of Bloomington place a high value on pedestrian and bicycle facilities, Urban Engineering has designed shared-use sidepaths for the 10th Street and Law Lane corridors (Figure 4). These sidepaths were designed using the AASHTO Bike Guide, so that they would meet all modern standards for bicycle and pedestrian facilities.

The sidepaths will be located on the south side of 10th Street and the south side of Law Lane parallel to the railroad right-of-way. At the locations of roadway crossings, proper signage and crosswalk signals will be provided on both the path itself and the intersecting roadways to ensure the safety of path users and motorists. Further details on the design of these shared-use paths can be found in Appendix L.

Figure 4: Location of sidepaths shown in yellow (Adapted from Google Earth, 2007)

4.13 Overpass

The railroad overpass on 10th Street is quite old and is far below modern standards for clearance and safety. However, an average of four trains a day use the railroad, The Indiana Rail Road Company (which operates the railroad line) have expressed opposition to any lengthy shutdowns. Because of this, Urban Engineering is proposing a construction method for replacement of the overpass which would allow for construction work to be done on weekends, decreasing the amount of shutdown time needed.

The proposed construction method involves four phases that take place on consecutive weekends. This would allow the railroad to be open during the weekdays of the four week construction process. The first phase requires the construction of temporary supports on the existing overpass to help support it during the next phases of construction. The second phase involves removal of existing abutments on either side and the placement of temporary supports and railway. The third phase involves the construction of the new prefabricated overpass to the north of the site. The final phase will be the removal of the temporary supports and the existing overpass and placement of the new overpass. Figure 5 displays a 3D rendering of what the new bridge might look like, including the decreased angle of curvature as 10th Street passes under the new bridge. Further details of the construction process can be found in Appendix M.

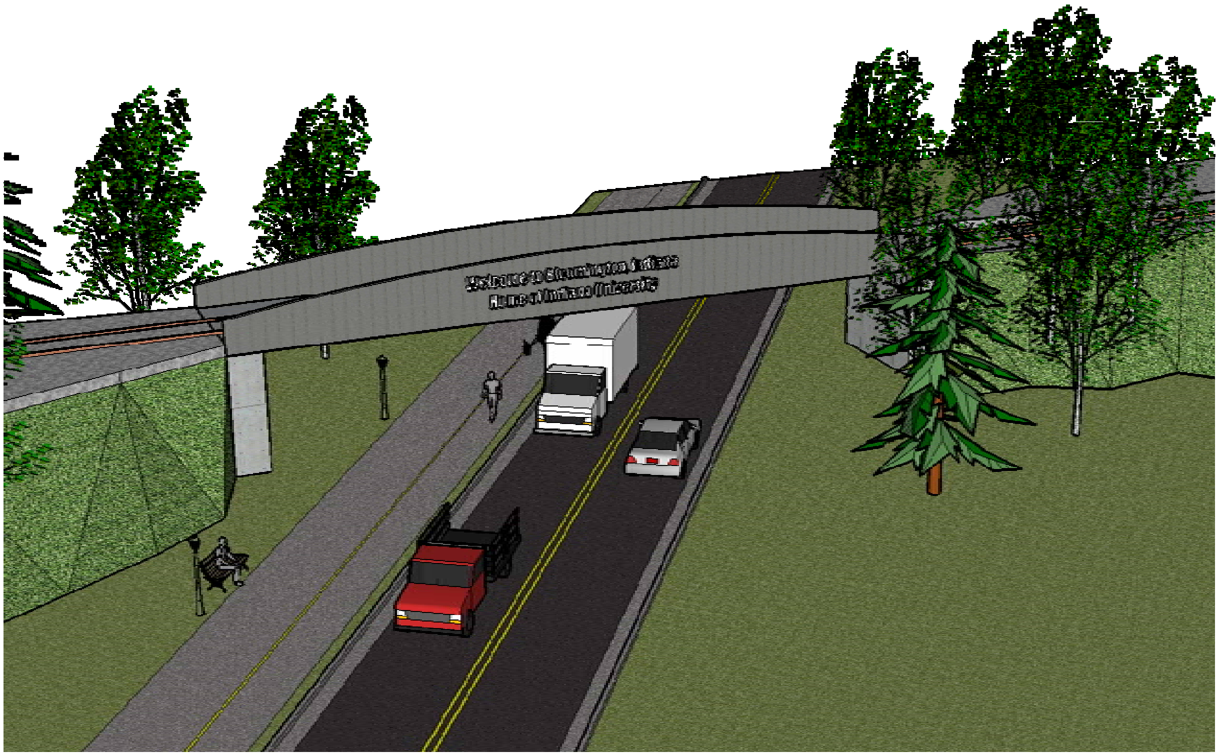

Figure 5: A 3D rendering of the overpass once construction is completed

4.14 Engineering Plans

Urban Engineering has created engineering plans for the new 10th Street and Law Lane alignments. These drawings show the proposed alignments and pavement markings necessary for these alignments. In addition, the drawings show the relationship of the new alignments with existing roadways and the proposed placement of the new roundabout intersection. The complete set of engineering plans can be found in Appendix N.

4.15 Cross Sections

Urban Engineering has created typical cross sections for each of the proposed new alignments. These cross sections show the widths of each alignment and the sloping of pavement for drainage purposes. These cross sections can be found in Appendix O.

4.16 Construction Phasing

To fulfill one of the MPO's main requests, Urban Engineering has created a construction phasing plan for the different sections of the project area. This plan splits the project into three phases, which will allow for the effective construction of the design with minimal impact on the community and the surrounding area.

The first phase of the project includes the building of the Law Lane extension and the roundabout at the new Law Lane-10th Street intersection. Also included in this phase is the Law Lane sidepath and relocation of utilities in preparation for the next two phases.

The second phase of the project requires the closure of 10th Street to thru traffic between Union Street and the Law Lane roundabout. During this phase, thru traffic will be detoured onto the Law Lane extension and Union Street while the 10th Street railroad overpass is replaced.

The final phase of the project will involve construction along 10th Street. How this construction proceeds depends on which alignment option the City of Bloomington chooses. Regardless of the option chosen, the sidepath to the south of 10th Street will be constructed during this phase. Full details of the construction phasing can be found in Appendix P.

4.17 Cost Estimate

Urban Engineering has created a detailed cost estimate based upon INDOT's unit price averages and information from FHWA. The final cost estimate for the project if the 10th Street widening option is chosen is 12.5 million dollars. This option includes the widening of 10th Street from two lanes to three, the Law Lane eastward extension, the roundabout at the new 10th Street-Law Lane intersection, and the replacement of the 10th Street railroad overpass. If the client chooses to maintain the existing 10th Street alignment but implement the other upgrades, the cost estimate is 6.6 million dollars. This option includes upgrades to key intersections along 10th Street, the Law Lane extension, the roundabout, and the replacement of the 10th Street railroad overpass. A full breakdown of costs is provided in Appendix Q.

Table 1: Final Cost Estimate -- 10th Street Widening

Section	Cost
10th Street from Woodlawn Ave to Union St	$6,227,000
10th Street from Union St to SR 45/46 Bypass	207,000
Railroad Overpass Replacement	5,240,000
Law Lane Upgrades and Extension	446,000
Roundabout	47,000
Sidepaths	351,000
Total	**$12,518,000**

Table 2: Final Cost Estimate -- 10th Street Upgrade

Section	Cost
10th Street from Woodlawn Ave to Union St	$345,000
10th Street from Union St to SR 45/46 Bypass	207,000
Railroad Overpass Replacement	5,240,000
Law Lane Upgrades and Extension	446,000
Roundabout	47,000
Sidepaths	351,000
Total	**$6,636,000**

4.18 Assessment of Design Options

The Metropolitan Planning Organization (MPO) requested Urban Engineering provide a "menu" of options to be considered for providing a solution to the traffic congestion problems experienced along the northern perimeter of Indiana University's campus. The options provided were evaluated quantitatively using decision matrices (Tables 3-6) which were created by Urban Engineering and then approved by the MPO. The weights used in the decision matrices were provided by the MPO. The factors deemed most important by the MPO are bicycle safety, pedestrian safety, and transit. Based on the quantitative analysis provided by the decision matrices, Urban Engineering has provided detailed designs for the optimum solution. For complete details about the decision matrices, see Appendix R.

TABLE 3		10th Street Options					
Criteria	**Importance Weight**	**Widen and Realign**	**Existing condition plus Side-path**	**Existing condition plus Temporary Bus stalls**	**One way corridor paired with Law Lane**	**Intersection Improvements**	**Do Nothing**
Transit	2	3	1	2	2	3	1
Pedestrian/Bicycle Safety	2	2	3	2	2	3	1
Feasibility	1	3	3	3	1	3	1
Green Engineering	0.2	2	2	2	1	3	3
Historic Preservation	0.2	2	2	2	2	3	3
Total Score		13.8	11.8	11.8	9.6	16.2	6.2

TABLE 4		Law Lane Rehabilitation Options			
Criteria	**Importance Weight**	**Widen and Realign with parking lot**	**Existing condition plus Side-path**	**Existing condition plus Cross walk improvements**	**Intersection improvements**
Transit	2	3	1	1	3
Pedestrian/Bicycle Safety	2	2	3	3	3
Feasibility	1	1	1	2	3
Green Engineering	0.2	1	2	3	3
Historic Preservation	0.2	2	2	3	3
Total Score		11.6	9.8	11.2	16.2

TABLE 5		Roadway Rehabilitation from Dunn Ave. to Fee Lane Options			
Criteria	**Importance Weight**	**Law Lane Extension - West**	**Adjoining roads (Connection of Woodlawn between 12th & 13th Streets**	**Relocation of Fire Station**	**One way corridor with 10th Street**
Transit	2	3	2	2	2
Pedestrian/Bicycle Safety	2	2	2	1	3
Feasibility	1	2	1	1	1
Green Engineering	0.2	2	1	1	2
Historic Preservation	0.2	1	1	1	2
Total Score		12.6	9.4	7.4	11.8

TABLE 6		Underpass Rehabilitation Options		
Criteria	**Importance Weight**	**Law Lane Extension - West**	**Adjoining Roads (Connection of Woodlawn between 12th & 13th Streets)**	**Relocation of Fire Station**
Transit	2	3	3	1
Pedestrian/Bicycle Safety	2	1	3	1
Feasibility	1	3	2	1
Green Engineering	0.2	1	3	2
Historic Preservation	0.2	2	1	1
Total Score		11.6	14.8	5.6

5.0 Future Considerations

5.1 Cost

The cost breakdown provided by Urban Engineering is only an estimate, and is based off of an average of costs taken from INDOT unit price averages and information from FHWA. For a more accurate cost, a professional engineer should be consulted to create a proper engineer's estimate. In addition, Urban Engineering has not included a cost estimate for the acquisition of right-of-way or relocation of utilities other than the steam line. This added cost may significantly influence the total cost of construction.

5.2 Social Concerns

The construction will not impact residential areas, as most of the construction occurs within the Indiana University campus. However, there will be many traffic impacts from the construction, especially during the closure of 10th Street from Union Street to the Law Lane extension during the replacement of the railroad overpass. Citizens of Bloomington should have the opportunity to give input on the possible impacts of the project through public meetings or other means which the client and the city normally uses.

5.3 Environmental Concerns

The project will not have heavy environmental impact, as the project is not located in or near any wetlands or other environmentally sensitive areas. However, as the City of Bloomington has expressed a desire to preserve green areas and existing trees, it is important to note that this project will have some small impacts on existing vegetation. However, the Law Lane Extension may provide a place for planting an additional line of trees or other forms of landscaping to improve the aesthetics of the new construction.

5.4 Construction Concerns

The main concern which needs to be addressed in further depth is the location of utilities and mitigation of impacts on utilities caused by construction. Indiana University Engineering Services and all affected utilities should be contacted before any construction takes place.

5.5 Maintenance Concerns

As with any road project, there will be continued costs associated with maintaining roads so that they continue to be usable in the future. However, since there is not a large amount of new road construction proposed, the continuing costs of the project should not be significantly higher than the current road maintenance budget of the city of Bloomington. The highest additional costs will come from maintenance of the Law Lane Extension and the 10th Street-Law Lane roundabout.

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A.1 Overview

The purpose of the 10th Street Extension and Modernization project is to design alternative vehicular and/or pedestrian routes that will alleviate the problems associated with heavy use that is currently placed on 10th Street. The surrounding corridor of the IU campus, particularly to the north, is being suggested as locations for alternate routes.

In order to ensure all site details and considerations for the 10th Street extension and modernization are taken into account, Urban Engineering has performed a preliminary feasibility study. This study involves research into soil conditions, environmental conditions, stormwater management requirements, and adjacent landowners. In addition, a physical inspection of the site was performed to find any pre-existing conditions which would not be apparent in research but would affect any construction on the site. This appendix contains is the results of this study.

A.2 Soil Conditions

Bedrock in the Bloomington area is relatively shallow and can be seen in outcroppings in certain places such as the area immediately surrounding the railroad track north of Woodlawn Avenue (depicted in Figure A.1). The proposed construction will not require much excavation, but any excavation will possibly require rock cutting.

According to the Soil Conservation Service's soil survey of Monroe County (United States Department of Agriculture 1974), the soils on the site are Crider soils mixed with urban land development. Crider soil is weak for local road construction, so any new road construction will require the replacement of the top layer of soil with a higher-strength soil.

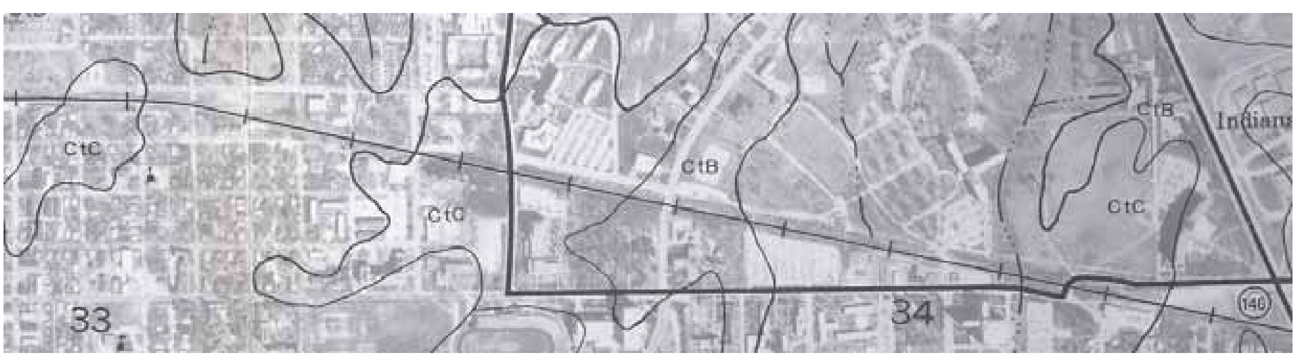


Figure A.1: Soil survey for project site, CtB and CtC are Crider soils mixed with urban land (United States Department of Agriculture 1972).

A.3 Wetlands and Floodplains

There are no wetlands on the site, and none of the site is located within a floodplain.

A.4 Underground Storage Tanks

According to Indiana University Engineering Services, all leaking underground storage tanks within the project area have either been removed or otherwise remediated (Kaden, 2007).

A.5 Water, Sewer, and Stormwater Systems

As the site is located within extensively developed land, there is an existing network of water and sewer pipelines in place in and around the locations of existing and proposed roadway alignments. During any widening or new roadway alignment construction, care must be taken to avoid any disruption to water and sewer services. Figures A.3 through A.5 depict the locations of water lines, sanitary sewer lines, and storm sewer lines respectively.

Since most of the project is expanding existing roads, stormwater management will be handled by existing drainage. Any new road construction will occur in close proximity to existing roads and stormwater drainage will be tied into existing drainage systems. At the locations of both proposed Law Lane extensions there are stormwater drainage pipes which can be accessed in the event of new road construction on those locations.

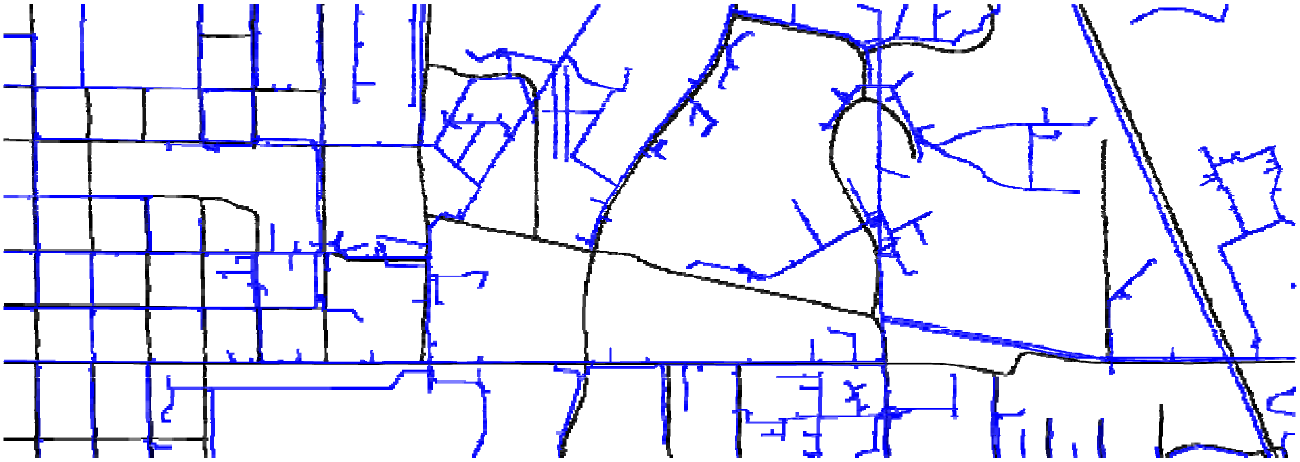


Figure A.3: Map showing locations of existing water pipelines in blue with roads in black (City of Bloomington Utilities 2006).

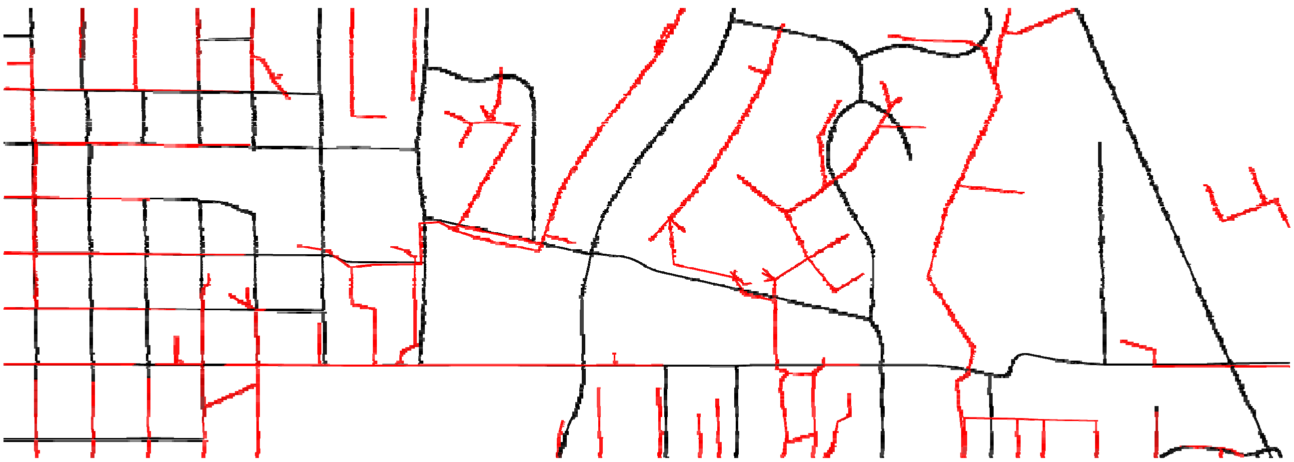


Figure A.4: Map showing locations of existing sewer pipelines in red with roads in black (City of Bloomington Utilities 2006).

Figure A.5: Map showing locations of existing storm sewer pipelines in green with roads in black (City of Bloomington Utilities 2006).

A.6 Adjacent Owners

Most of the land adjacent to the site is controlled by Indiana University (IU) or the State of Indiana. The railroad passing through the site is owned by the Indiana Rail Road Company. The land in the western portion of the site is mostly rented out to IU students and is controlled by rental agencies. A few businesses are located along 10th Street in the proximity of Union Street.

Both proposed Law Lane extensions pass through IU-controlled land and will require negotiations with the university to construct. Any replacement of the 10th Street railroad overpass will require approval of the Indiana Rail Road company and careful planning of construction, as there is a single track main line through Bloomington with no way to detour trains.

A.7 Site Inspection

A.7.1 10th Street

Currently, 10th Street is a two-lane road with no on-street parking. There are several intersections, and the intersections at Woodlawn Avenue, Fee Lane, Jordan Avenue, and Union Street are currently signalized. In the area between Union Street and Jordan Avenue and the area west of Fee Lane, there are businesses and other existing development closely abutting the 10th Street right-of-way (Figures D.5 and D.6).

10th Street passes under a railroad overpass at a sharp left-turning S curve between Union Street and the SR 45/46 bypass. This overpass has a low clearance (10 feet, 5 inches) and shows signs of age and many past collisions from oversized vehicles (Figure D.7).

A.7.2 10th Street & Woodlawn Intersection

Currently, the intersection of 10th Street and Woodlawn Avenue is signalized, with no turning lanes for any direction. The area immediately surrounding the intersection is closely abutted by signal poles, utility poles, sidewalks, trees, and existing construction (Figure D.8).

A.7.3 Woodlawn Avenue

Currently, Woodlawn Avenue is a somewhat narrow, two-way road with no line markings of any kind. Between 10th and 11th Streets, a grassy strip containing trees and utility poles separates the street from sidewalks on either side (Figure D.11). The road comes to an end at a 90-degree turn at 13th Street.

A northward extension of Woodlawn Avenue including an at-grade crossing of the railroad line would require some excavation and rock cutting, as the railroad line is currently cut a few feet into bedrock (Figure D.12). The area immediately surrounding the railroad at this point has shrubs and other vegetation.

A.7.4 Law Lane

Law Lane is currently a two-lane, two-way road. Between Fee Lane and slightly east of Jordan Avenue, there is on-street parking on the south side (Figure D.13), and some on-street parking is on the north side immediately surrounding Jordan Avenue. These parking spots are controlled by IU and are either angle or straight-in parking, which could be converted to parallel parking in the case of any widening or other upgrades of Law Lane. This would allow upgrades without requiring much additional paving and with only some loss of parking capacity. A sidewalk currently runs the length of Law Lane on the northern side of the road.

The intersection of Jordan Avenue and Law Lane is signalized, with no turning lanes. Jordan Avenue is a two-way, two-lane road with a bike lane. To the south of Law Lane on Jordan Avenue, there is an overpass over the railroad.

East of the parking near Jordan Avenue, there is no on-street parking. There is a narrow grassy strip with a few small trees separating the sidewalk from the road. About halfway between Jordan Avenue and Union Street, there is a pedestrian crossing (Figure D.15) of the railroad to the south of Law Lane, with no markings on Law Lane itself of the pedestrian crossing's presence (Figure D.14).

The intersection of Law Lane and Union Street is currently a three-way stop (Figure D.16), with a grade crossing of the railroad on Union Street to the south of Law Lane (Figure D.17). This grade crossing has blinking lights, but no gates, Gates and other safety measures should be placed in the case of any upgrades to Law Lane and the existing intersection.

A.7.5 Proposed Parking Lot

The location of the proposed parking lot north of Law Lane is currently an open grassy field with various kinds of trees (Figure D.18). Some of these trees would need to be cleared; however, a number of the trees may be able to be preserved through grassy islands within the parking lot.

A.7.6 Proposed Law Lane Connector

The southern edge of a parking lot (Figure D.19) and a shared-use path in fair condition (Figure D.20) is currently on the location of the proposed Law Lane connector. The path has a light pole adjacent to it, a small fenced off area about halfway between Union Street and 10th Street, and trees and other vegetation to the south bordering the railroad.

A.7.7 Law Lane Extension West

To the west of Fee Lane is a parking lot controlled by IU. The grade of the parking lot is a few feet higher than Law Lane and Fee Lane (Figure D.21), so some excavation would be needed for a westward extension of Law Lane. In addition, an east-west strip of trees is located in the center of the parking lot (Figure D.22). Some of these trees would have to be removed in order to extend Law Lane. However, additional trees could be placed to compensate for this in the context of landscaping around the new road construction.

A.7.8 13th Street

13th Street is currently a two-lane, two way road with no center lines and a somewhat narrow right-of-way (Figure D.23). On the south side of the road is a Works Progress Administration (WPA) sidewalk. The City of Bloomington has expressed the desire to preserve these sidewalks, which would require any widening of 13th Street to occur on the north side of the existing right-of-way. Currently, 13th Street west of Walnut Grove is mainly abutted on the north by open fields, and the small amount of existing construction is not near the road such that it would affect widening.

Appendix B - Codes and Regulations

B.1 Introduction

Throughout the 10th Street Extension and Modernization Study for the City of Bloomington, Indiana, Urban Engineering must design in accordance with several codes and regulations. Urban Engineering's proposed sustainable development and side-path options will be in accordance with the American Association of State Highway and Transportation Officials (AASHTO) bicycle guide (FHWA, 1999). The AASHTO bicycle path guide provides standards for designing side paths. Urban Engineering's proposed road design must be in accordance with the Indiana Department of Transportation (INDOT) guidelines and specifications (INDOT, 2006). INDOT provides standards and specifications for the design and construction of roads. Finally, Urban Engineering's proposed modernization must be in compliance with the Manual for Uniform Traffic Control Device (MUTCD) Standards (MUTCD, 2003) published by the Federal Highway Administration (FHWA). The MUTCD provides guidance on selecting the appropriate signage, and guidance for determining the appropriate locations of the signs. This appendix provides a brief overview of the codes and regulations that are relevant for the 10th Street Extension and Modernization.

B.2 Indiana Department of Transportation Specification 2006 (INDOT, 2006)

Any entity, or individual, involved with transportation projects funded by the Federal Highway Administration (FHWA) located within the state of Indiana, must comply with the Indiana Department of Transportation standards and specifications code book (INDOT, 2006). The code is published to provide minimum standards for engineers, contractors, and material suppliers by controlling the design, construction, quality, efficiency, and integrity of transportation projects throughout Indiana. Urban Engineering will use the code as a minimum standard to ensure that the design work submitted is in compliance with all state regulations. There are nine sections in the standards and specifications code manual, which start with 100 and end at 900. Urban Engineering will use the sections that are applicable to the design of roadway extensions, sidepaths, road realignments, and increased turning radii.

B.2.1 Section 200 - Earthwork

Section 200 provides standards and specifications for earthwork operations. The width, depth, moisture content, and compaction of the sub-grade are discussed in this section. The items listed are essential in providing a secure foundation for the roads and side-paths. These specifications will help prevent sub-grade failures, which will therefore help prevent pavement failures.

B.2.2 Section 300 - Bases

Section 300 provides standards and specifications for road and side-path bases. The base, typically placed on top of the sub-grade, will provide a better foundation for the road than just the subgrade. INDOT specifies the depth and the size of aggregate that must be used as a base. Information in section 300 also includes compaction and drainage information. Compaction is important in sub-bases to ensure that the base does not separate, and drainage is necessary to redirect water away from underneath the roadway. Proper drainage will aid in preventing any freezing and thawing problems that could occur in the winter.

B.2.3 Section 400 – Bituminous Pavements

Section 400 outlines the construction requirements for preparation, implementation and maintenance of asphalt pavements in design. The specifications educate entities on procedures of control measures, design conditions and limitations of bituminous materials. This code provides sections on various asphalt mixes and the stipulations that must be followed to employ such mixes. Improperly designed asphalt mixes can result in major complications apparent by poor road conditions.

B.2.4 Section 500 – Rigid Pavements

Section 500 identifies standards and specifications for concrete pavements. This section contains necessary instruction and information on design, construction and methodology of concrete placement. The code specifies materials, design relationships and equipment for installing safe, long-lasting concrete structures. Poorly designed concrete mixes may result in dismal sidewalk and structural conditions.

B.2.5 Section 600 – Incidental Construction

Section 600 provides standards for incidental construction such as guardrails, sidewalks, curb ramps, steps, and handrails in INDOT projects. The specifications given apply to the design of new sidewalks and curb ramps along road construction and intersection widening. According to the specifications, placement of curb ramps has priority over drainage structures and signal, light, and utility poles. This may require specifying the movement of existing utility poles if a curb ramp is necessary according to ADA standards.

B.2.6 Section 800 – Traffic Control Devices and Lighting

Section 800 provides standards for the placement of traffic control devices and lighting. The specifications will apply to any signage or pavement markings placed on new or existing road construction. According to the specifications, all signs, sign structures, and pavement traffic markings must be placed according to the MUTCD.

B.3 Manual on Uniform Traffic Control Devices (MUTCD)

The Manual on Uniform Traffic Control Devices (MUTCD) (FHWA, 2003) is put together by the Federal Highway Administration (FHWA) and is intended for the use of designers and planners for controlling traffic with signs, signals, and road markings. We will be using this code in order to comply with the City of Bloomington's regulations and in order to be consistent with the rest of the city's appearance.

Several parts of the MUTCD will be used in determining the placement of these signs, signals, and road markings. The following is a list of the parts of the MUTCD that will pertain to this project.

Part 2: Signs
Part 3: Markings
Part 6: Temporary Traffic Control
Part 7: Traffic Controls for School Areas
Part 8: Traffic Controls for Highway-Rail Grade Crossings
Part 9: Traffic Control for Bicycle Facilities

These parts will influence the signage and signaling of the project, as well as the maintenance of traffic during the construction phases. The scope of the project lies in the heart of the Indiana University campus, thus the need for a safe pedestrian crossing that will cross a proposed roadway is of importance because of the heavy pedestrian and vehicular traffic. Much of this challenge will come from the limited amount of options from the code.

B.4 AASTHO Guide for the Development of Bicycle Facilities

The AASHTO Guide for the Development of Bicycle Facilities (AASHTO, 1999), commonly referred to as the bike guide, was written by the American Association of State Highway and Transportation Officials to aid engineers, architects, and planners in the design of bicycle trails and paths. The purpose of the bike guide is to help designers choose the proper type of path to use for each project and to make the path as safe and usable as possible.

The bike guide provides guidance and important design features such as stopping sight distance, vertical and horizontal curve alignments, and maximum grades. In addition, the guide provides information on signage and pavement markings. However, the bike guide does not just provide technical assistance to its user; it also provides ideas for aesthetics and gives the reader the logic and theory behind the stopping sight distances and other items. Urban Engineering will implement the regulations and guidelines outlined in the bike guide to design a shared use path with adequate safety for pedestrians in the corridor. The challenge will be to fit the project into the existing layout and aesthetics of the City of Bloomington while providing adequate safety for all users.

Appendix C - Design Options

C.1.0 10th Street Overview

Currently 10th street is experiencing traffic overcrowding due to the limited number of east west corridors (Figure C.1). Sections C.1.1 to C.1.6 are a list of possible alternatives to alleviate the over-crowding issues. The combination of options which best meet the Metropolitan Planning Organization's requests will be selected using a decision matrix, which is discussed in Appendix R.

Figure C.1: Image of the east-west corridors

C.1.1 Widening and Realignment

This option focuses on widening 10th Street from Dunn Street to Union Street (Figure C.2). Due to the limited right-of-way, the road widening will require some realigning. The realignment will help alleviate the problems associated with the narrow right-of-way. The widening shall upgrade 10th Street into a two-way 4 lane corridor. The advantages of this option are that movement for transit would be improved, and widening and realigning 10th Street would be a very feasible option. The disadvantages of this option are that more of the area would be paved, which would require some tree removal. This also might interfere with any historical landmarks along 10th Street that may need to be removed and then replaced.

Figure C.2: Proposed widening and realignment of 10th Street.

C.1.2 Sidepaths

A new sidepath, or bike path, is proposed for bicyclists along 10th Street. The sidepath will run parallel to 10th street and provide a place for bikers to commute safely. (Figure C.3.) The advantages of this option are that pedestrian and bicycle safety would be increased, and the implementation of a sidepath would be a feasible option. The disadvantages of this option are that the implementation of a sidepath would make more of the area paved, so the aesthetically pleasing grassy areas along 10th Street could potentially be lost; this could certainly be replaced, though.

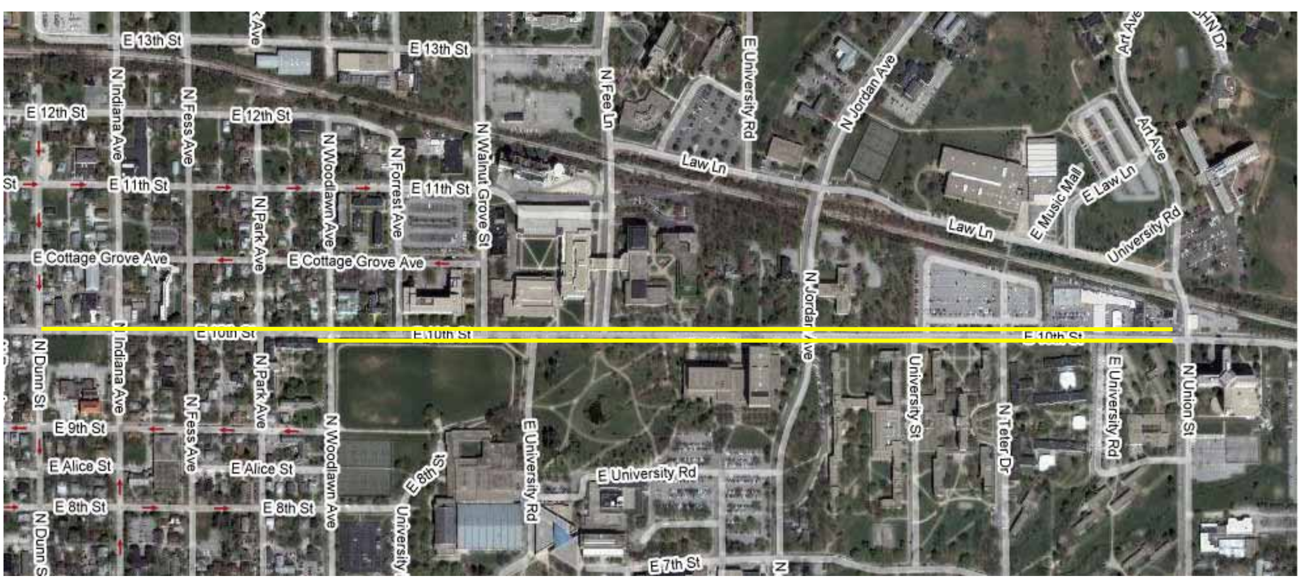


Figure C.3: Proposed side path along 10th Street.

C.1.3 Temporary Bus Parking Stalls

Temporary bus parking stalls will be used to allow the buses to park outside the travel lane while the passengers load and unload. The stalls will be located at bus stops on the right side of the road. The stalls will eliminate the wait time commuters experience during passenger loading and unloading (Figure C.4). The advantages of this option are that the extremely feasible implementation of temporary bus parking stalls would be beneficial to transit with a minimum impact on the historic preservation and green characteristics of the area.

Figure C.4: Proposed design for temporary bus parking stall along 10th Street.

C.1.4 One Way Pair Corridor

This option focuses on converting 10th Street into a pair of one way corridors to be used in conjunction with Law Lane. 10th Street will serve as a one way east bound corridor extending from Woodlawn Avenue to Union Street (Figure C5). The advantages of this option are that a one way corridor would maintain present levels of pedestrian and bicycle safety and the transit in the area would be marginally improved, but the disadvantages of this option are that this option is not feasible for public transportation routes or in relation to green engineering and historical preservation.

Figure C.5: Proposed one way pair of Law Lane and 10th Street.

C.1.5 Intersection Improvements

This option includes increasing the turning radii at key intersections (Figure C.6). The proposed increased turning radii will help larger vehicles, such as public transportation vehicles, navigate more efficiently. The larger intersections will also increase safety. In addition to increasing turning radii, some intersections would be upgraded to have left turn lanes. The advantages of improving intersections would be evident in pedestrian and bicycle safety with improved signals and crosswalks. Additionally, this option would be good for transit and would not have a negative impact on green engineering or the historic preservation of the area.

Figure C.6: Proposed intersection improvements.

C.1.6 Do Nothing

The "do nothing" option would include minimal improvements to key intersections. Improvements would include improved signals and updated crosswalks. The installation of "smart" traffic signals at intersections located on 10th Street would allow traffic to flow more efficiently. The "smart" signals, or traffic-adaptive system, would use modern technology to monitor traffic flow. The traffic-adaptive system uses video or pavement sensors to digitize information and send it to a computer that makes instantaneous decisions on how long traffic lights should stay red and green. In other words, the system adapts to the traffic flow. The advantages of this option would be that it would not impact the historic preservation or green characteristics of the area. The disadvantages of this option would be that no major improvements have been made to transit or to pedestrian and bicycle safety.

C.2.0 Overview of Law Lane Rehabilitation from Fee Lane to Union Street

Revisions to Law Lane (Figure C.7) are proposed to provide more east-west corridor alternatives from which travelers can choose and can be located later in Appendix C. The combination of options which best meet the MPO's requests will be selected using a decision matrix, which is discussed in Appendix R. The options proposed can be used individually or in conjunction with each other.

Figure C.7: View of Law Lane from Fee Lane to Union Street.

C.2.1 Widening and Realignment with Parking Lot

This option focuses on widening Law Lane (Figure C.8). The widening may require road realignments due to the narrow right-of-way and adjacent railroad. The proposed widening will maintain two lanes of traffic, but will increase the lane widths. The widening will help increase the traffic safety and efficiency of the corridor. The advantages of this option are that movement for transit would be improved on Law Lane. The disadvantages of this option are that more of the area would be paved, which would require some trees to be removed. This also might interfere with any historical landmarks along Law Lane that may need to be removed and then replaced.

Figure C.8: Proposed widening and realignment of Law Lane.

C.2.2 Sidepath

A new sidepath is proposed to run parallel with Law Lane (Figure C.9). The sidepath will provide a place for bikers to commute a safe distance from vehicular traffic. The advantages of this option are that pedestrian and bicycle safety would be increased with the implementation of a sidepath. The disadvantages of this option are that the implementation of a sidepath would make more of the area paved, which would not be good for the historic preservation of the area or with respect to green engineering.

Figure C.9: Proposed sidepath along Law Lane.

C.2.3 Crosswalk Improvements

A modernized crosswalk is proposed for Law Lane located directly across from the recreational center (Figure C.10). The crosswalk will provide a safe place for recreational patrons to cross Law

Lane. The crosswalk will consist of flashing lights, rumble strips, and other signage that will caution motorists of pedestrian traffic. The advantages of improving the crosswalk across Law Lane would be an increase in pedestrian and bicyclist safety as well as a minimal impact on the historic preservation or the green characteristics of the area. The disadvantages of this option would be the small impact it would have on improving transit in the area.

Figure C.10: Proposed crosswalk across Law Lane.

C.2.4 Intersection Improvements

This option includes increasing the turning radii at key intersections. The proposed increased turning radii will help larger vehicles, such as public transportation vehicles, navigate more efficiently. The larger intersections will also increase safety (Figure C.11). In addition to increasing turning radii, some intersections would be upgraded to have left turn lanes. The advantages of improving intersections would be evident in pedestrian and bicycle safety with improved signals and crosswalks. Additionally, this option would be good for transit and would not have a negative impact on green engineering or the historic preservation of the area.

Figure C.11: Proposed locations of increased radii along Law Lane.

C.3.0 Overview of Roadway Improvements from Dunn Avenue to Fee Lane

Fee Lane and 10th Street are very congested corridors (Figure C.12). The two streets cause problems that impact the adjacent corridors, creating the need for alternatives to alleviate congestion. The lack of viable options to these roadways that can provide equal amenities is a concern. Within this section are options which will best meet the MPO's requests. These options will be evaluated in a decision matrix and discussed later in Appendix R.

Figure C.12: View of corridor from Dunn Avenue to Fee Lane.

C.3.1 Law Lane Extension

One way to alleviate traffic congestion on Fee Lane is to divert traffic onto another north/south roadway that is of similar capacity. Two options are available. One option would be the extension of Law Lane northwest to the intersection of 13th Street and N. Walnut Grove Street (Figure C.13). Another option would be to extend Law Lane parallel to the railway to N. Walnut Grove Street (Figure C.14). The advantages of this option would be improved traffic flow and marginal improvement in pedestrian and bicycle safety with only a minimal impact on green engineering. N. Walnut Grove Street is currently in adequate condition to handle the increased traffic load from Law Lane.

Figure C.13: Proposed extension of Law Lane to 13th Street.

Figure C.14: Proposed extension of Law Lane from Fee Lane to N. Walnut Grove Street.

C.3.2 Adjoining Roads

With the extension of Law Lane to the proposed roadways, it will be necessary to construct new roadways and/or repair existing ones to facilitate the additional traffic. The connection of N. Woodlawn Avenue between 12th Street and 13th Street (Figure C.15) would serve as a means to provide a much needed through route and accessibility for emergency and transportation vehicles. Another option would be to extend the Law Lane railway parallel extension from N. Walnut Grove Street over the railway to 12th Street (Figure C.16). The advantages of this option would be an improvement in transit, but this option would not be very feasible. Also, this option would have an adverse affect on green engineering and historic preservation.

Figure C.15: Purpose connection of N. Woodlawn Avenue between 12th Street and 13th Street.

Figure C.16: Purposed extension of the Law Lane railway parallel extension from N. Walnut Grove Street over the railway to 12th Street.

C.3.3 Relocation of Fire Station

This option would move the fire station at Woodlawn Avenue to a location north of the railway. A fire station on 3rd Street serves the 10th through 14th Street area in a partnership with the Woodlawn Avenue station. The Woodlawn Avenue station also services the areas north of the railway, so moving the fire station north of the railway would decrease the response time to locations in that area. The advantages of relocating the fire station would be an improved response time. The disadvantages of this option would be a negative impact on green engineering and historic preservation, and this option may not be feasible do to monetary constraints.

C.4.0 Overview of Railway Options

The underpass of the railway near the east end of 10th Street (Figure C.17) is a major concern for the Bloomington MPO. 10th Street makes a sharp s-curve under the railway through a narrow underpass, which causes traffic to back-up during the heavy traffic periods of the day. Within this section are the options which will best meet the MPO's requests to alleviate the traffic and improve the flow of automobiles on 10th Street. These options will be evaluated in a decision matrix and discussed later in Appendix R.

Figure C.17: Image of the existing railroad underpass.

C.4.1 Law Lane Extension

This option would include extending Law Lane east from Union Street to 10th Street (Figure C.18). Extending Law Lane east would give traffic the option of bypassing the 10th Street underpass to get to the SR 45/46 Bypass by taking a number of streets north to Law Lane (Figure C.19). Making Law Lane run all the way to the SR 45/46 Bypass would help alleviate the traffic on 10th Street. The advantages of the Law Lane extension would be an improvement in transit and it is an option that is feasible. The disadvantages of the Law Lane extension would be that it provides no improvements to pedestrian and bicycle safety and it adds pavement to the area which is poor from the green engineering aspect.

Figure C.18: Proposed extension of Law Lane from Union Street to 10th Street

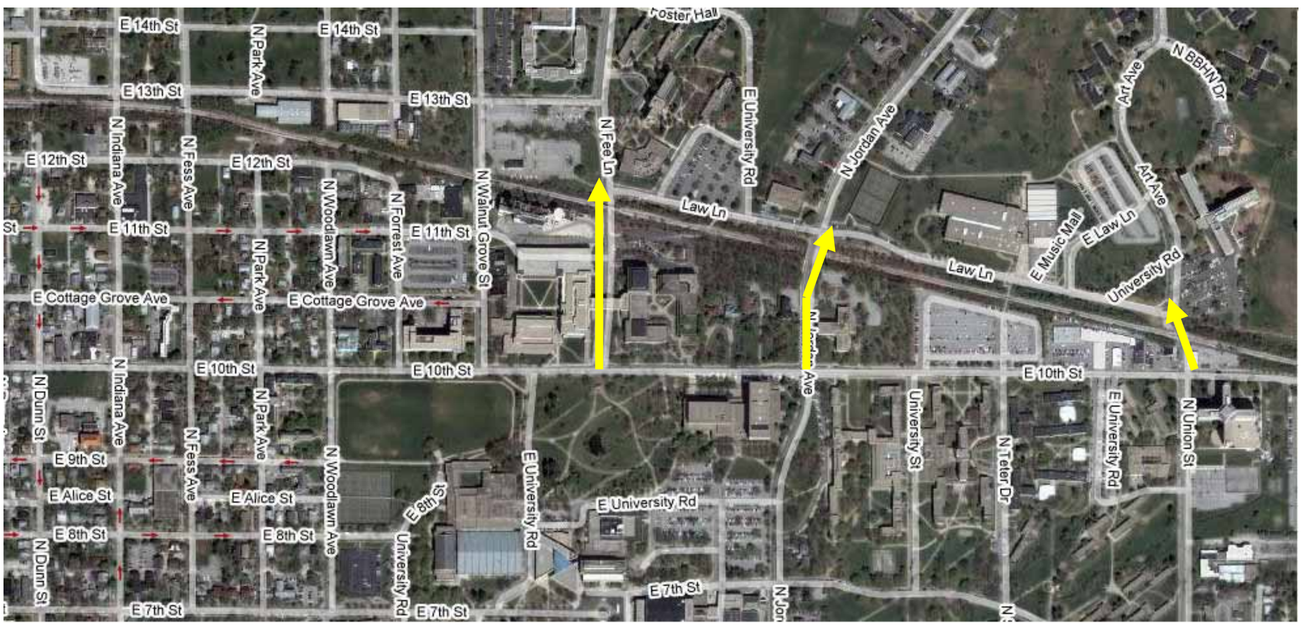


Figure C.19: View of the North-South streets that drivers can take from 10th Street to Law Lane to by pass the underpass to the east.

C.4.2 Railroad Underpass Renovation

This option would include a renovation of the existing railroad underpass over 10th Street. The existing railroad underpass is narrow, has too low of a clearance for articulated buses, and has sustained some structural damage over its lifetime due to vehicles not making the tight turn (Figure C.17). The new underpass would include a realignment of 10th Street to decrease the deflection angle under the railway (Figure C.20). In addition, the roadway would be lowered and the open space between abutments would be increased to allow articulated buses to utilize this underpass. The advantages of rehabilitating the railroad underpass would be that traffic could flow smoother as it got to the underpass and it would not have any adverse affects to green engineering. The disadvantages of a railroad underpass would be some changes with respect to historic preservation.

Figure C.20: Proposed realignment of the 10th Street underpass.

C.4.3 At-Grade Crossing

This option would include shutting down the existing railroad overpass and placing an at-grade crossing to the west of the existing overpass (Figure C.21). An at-grade crossing would make it possible for articulated buses to use 10th Street to get to the 45/46 Bypass. This option has disadvantages with respect to flow of transit, pedestrian and bicyclist safety, and feasibility since the railroad companies prefer to consolidate crossings instead of add crossings.

Figure C.21: Proposed at-grade crossing to replace the underpass.

D.1.0 Photographic Survey Overview

Urban Engineering has catalogued a photographic survey of the 10th Street corridor to serve as visual reference for engineers and planners as the project progresses. Included in the survey are aerial photographs of the corridor and close-up photographs of significant features around the 10th Street corridor. Note: All aerial photos and maps were obtained from Google.

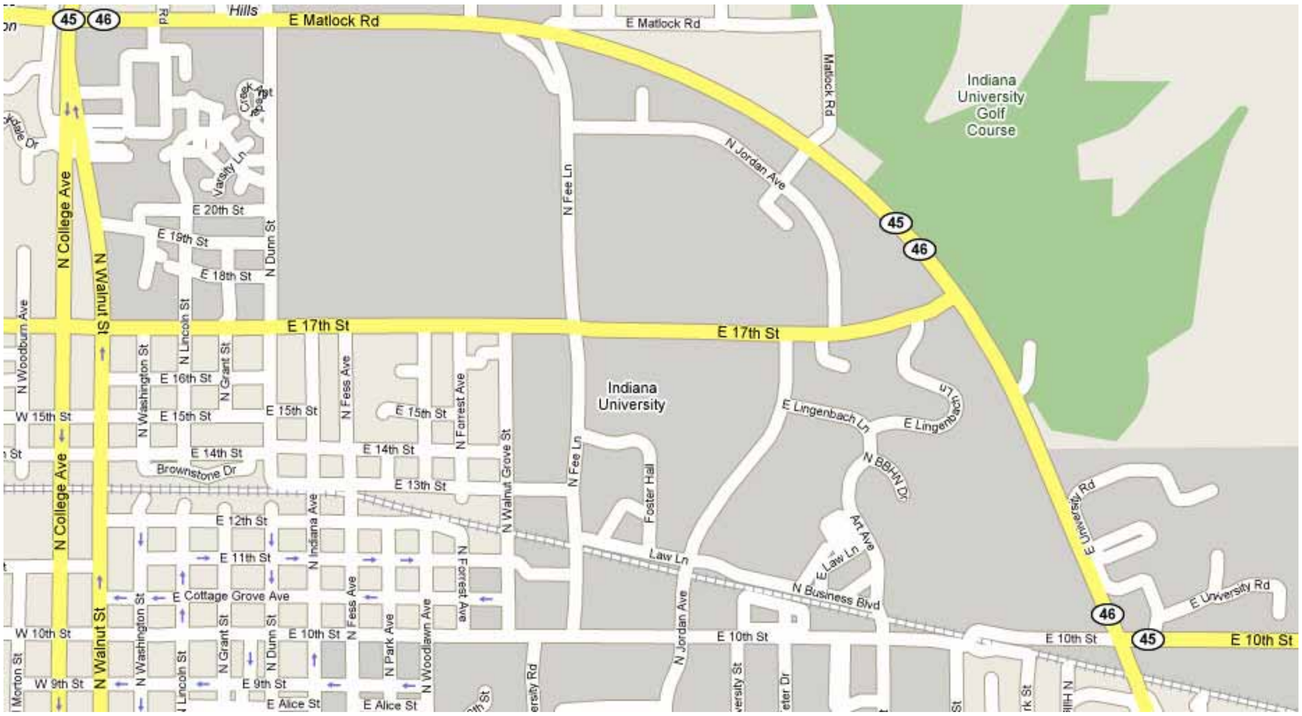


Figure D.1: Image of 10th Street corridor.

Figure D.2: Aerial photograph of the corridor from North Fee Lane to Union Street.

Figure D.3: Aerial photograph of the corridor from Union Street to 45/46 Bypass.

Figure D.4: Aerial photograph of the corridor from North Fess Avenue to North Fee Lane.

Figure D.5: Businesses along 10th Street west of Union Street, looking westward.

Figure D.6: 10th Street just east of Fee Lane, looking westward.

Figure D.7: Underpass at the bottleneck of 10th Street.

Figure D.8: Looking westward along 10th Street immediately west of Woodlawn Avenue.

Figure D.9: Intersection of 10th Street and Woodlawn Avenue.

Figure D.10: Bloomington Transit bus making the turn from 10th Street onto Woodlawn Avenue.

Figure D.11: Looking north on Woodlawn Avenue.

Figure D.12: Railroad track just north of Woodlawn Avenue, note existing cuts into rock.

Figure D.13: Law Lane east of Fee Lane, note on-street parking on the right.

Figure D.14: Looking west on Law Lane at area of pedestrian crossing.

Figure D.15: Pedestrian crossing of railroad.

Figure D.16: Law Lane and Union Street intersection looking westward.

Figure D.17: Union Street at-grade railroad crossing, note the lack of signals.

Figure D.18: Current state at location north of Law Lane and west of Union Street.

Figure D.19: Existing edge of parking lot located northeast of Union Street & Law Lane intersection.

Figure D.20: Existing shared use path and light pole for path lighting.

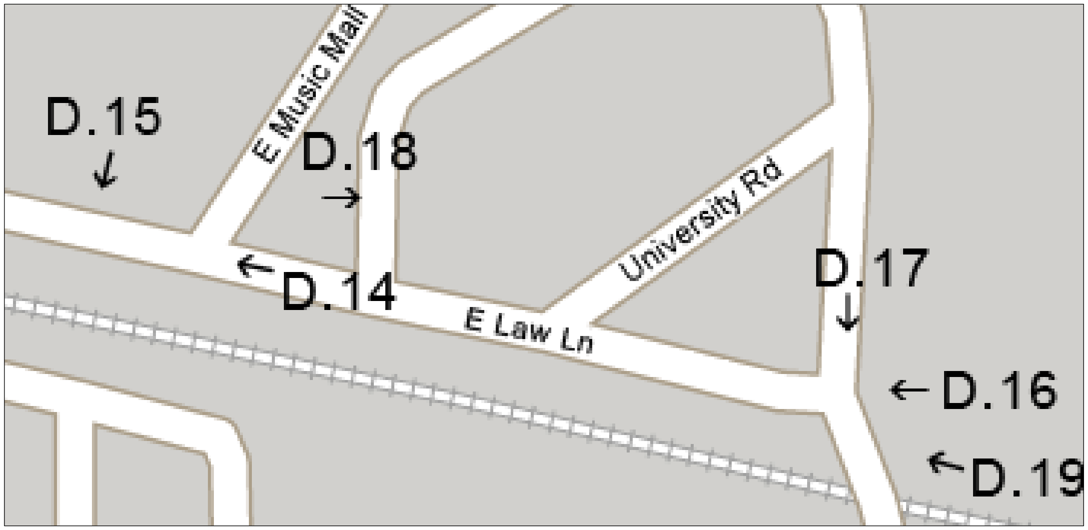
Figure D.21: Law Lane and Fee Lane intersection.

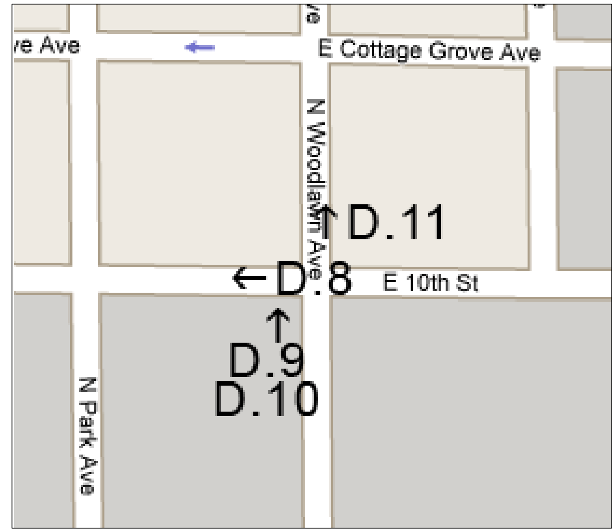
Figure D.22: Existing parking lot west of Fee Lane viewed from the west.

Figure D.23: Current state of 13th Street, note WPA sidewalk on left.

D.1.1 Photo Orientation Guide

The following maps provided are to help visualize where the photograph was taken relative to the project area. The location of the photo is represented by the figure number and the direction of the photo is represented by the arrow shown. Figure D.24 represents the entire project area and the pictures that were taken throughout it. Figure D.24a and Figure D.24b are closer views of certain areas of the project area where multiple photos were taken. All of the figures are placed on the page with the same north orientation.





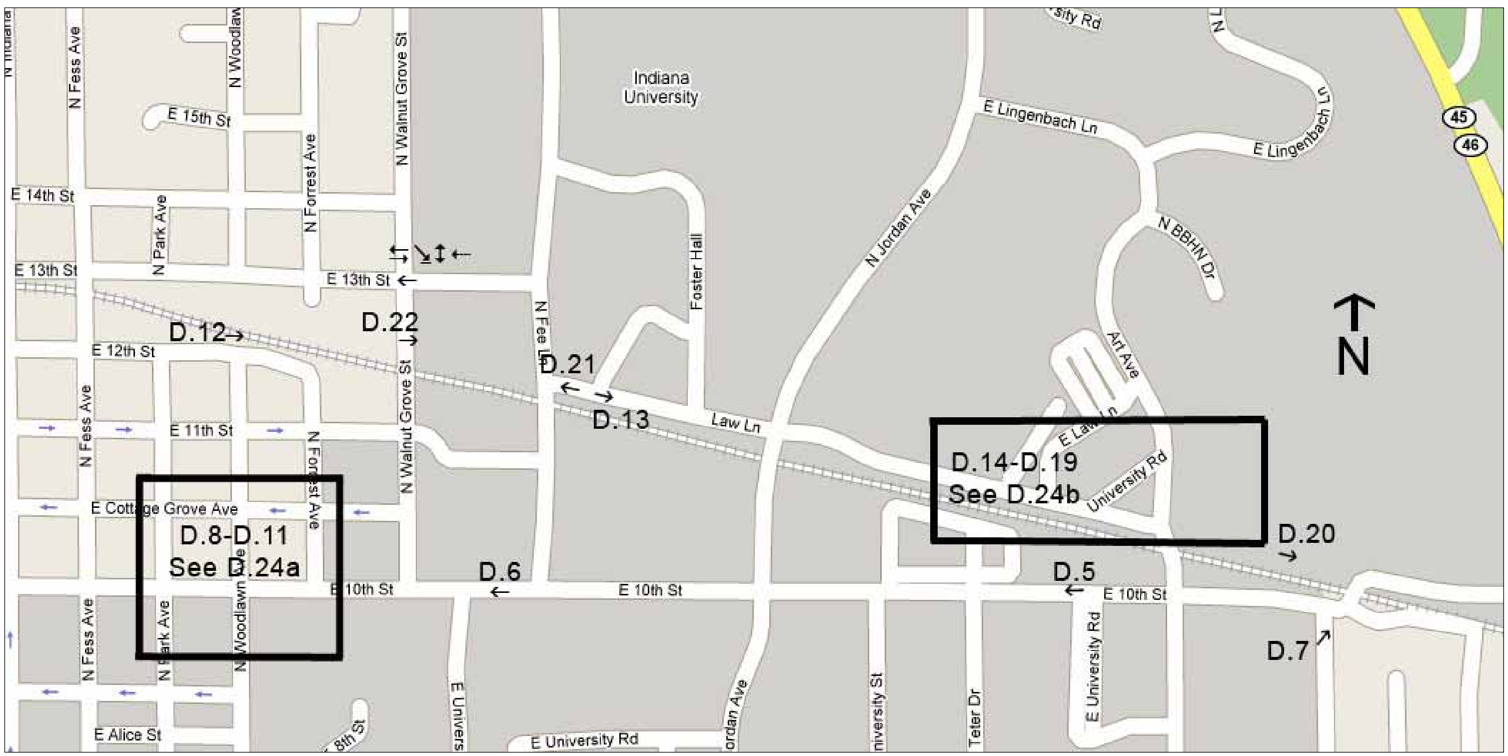


Figure D.24 (bottom): Map showing location and direction of photographs. **Figure D.24a (top right):** Inset of 10th and Woodlawn intersection. **Figure D.24b (top left):** Inset of eastern end of Law Lane.

Appendix E - Intersections

E .1 Intersection Improvement Overview

Improvements are being proposed to several intersections throughout the 10th Street corridor in Bloomington, Indiana. Crosswalks, increased intersection radii, intersection realignments, and turn lanes are among the major design improvements outlined in this appendix. Pedestrian safety at intersections is a priority; therefore, Urban Engineering would like to incorporate safety features into the intersection designs by upgrading crosswalks and verifying adequate sight distance between vehicles and pedestrians. The crosswalks and curb ramps were designed using Manual on Uniform Traffic Control Devices (MUTCD) Section 3B.17 (MUTCD, 2007) and the Indiana Department of Transportation (INDOT) Standard Drawings Section 600 (INDOT, 2007). All curb ramps will meet the design standards on INDOT Standard Drawing No.E 604-SWCR-02, which provides details about tactile warning strips, maximum curb ramp slopes, and minimum curb ramp widths. Intersection radii were designed to provide easier maneuverability for public transport, emergency, and other large vehicles. At intersections where increasing turning radii was warranted, Urban Engineering implemented a fifty-two feet turning radius, which exceeds the fifty feet that is recommend on Figure 20, Chapter 3 of the Transit Cooperative Research Program's (TCRP) Report 19 (TCRP, 1996). Turn lanes were included at key intersections to improve the level of service and increase safety. INDOT Design Manual Section 46-4.02 (INDOT, 2007) was used to design the turn lane taper, width, and storage length of the turn lanes.

E.2 10th Street and Woodlawn Avenue

The intersection improvements at 10th Street and Woodlawn Avenue are critical for public transportation vehicles. Current conditions (Figure E.1) make it difficult for public transportation vehicles traveling north on Woodlawn Avenue to turn east onto 10th Street. To alleviate this problem, Urban Engineering would like to increase the curb radii on the northeast and southeast corner from thirty-five feet to a turning radius of fifty-two feet (Figure E.2). In addition to increasing the turning radii, a left and right turn lane will be added to westbound 10th Street. Increasing the turning radii and adding the turn lanes will require the removal of some trees and an acquisition of a small portion of parcel number 013-90750-00. Monroe County GIS does not identify the owner of this property.

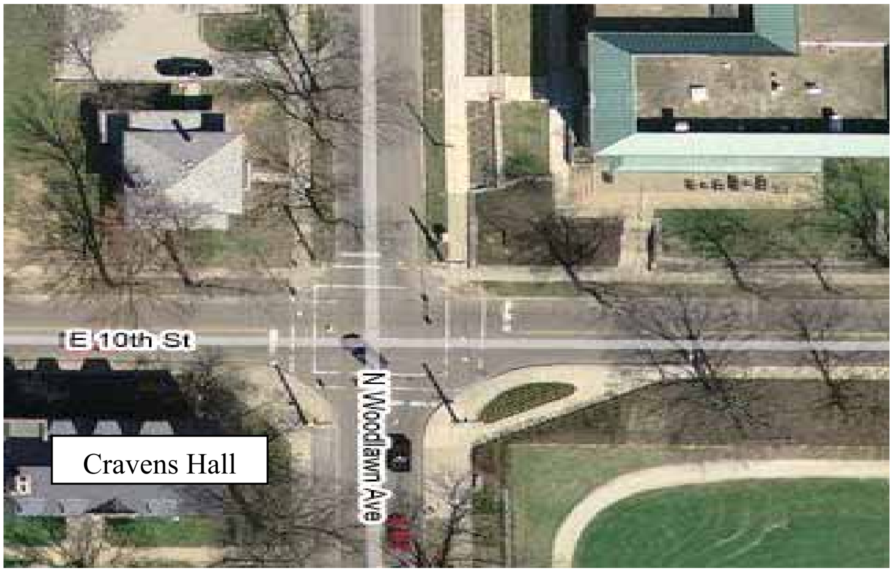


Figure E.1: Image of the existing intersection of 10th Street and Woodlawn Avenue. (Adapted from Google Maps, 2007)

The existing sidewalk to the north of 10th Street will be replaced following the intersection improvements at 10th Street and Woodlawn Avenue. (Figure E.2) The existing sidewalk to the south of 10th Street will be replaced by a ten foot shared use path discussed in Appendix L. The intersection of 10th Street and Woodlawn Avenue will be signalized, Appendix J, to facilitate traffic flow through the intersection.

Pedestrian crosswalks will be upgraded to include four, six-feet-wide crosswalks, with six-inch solid white lines that lead to INDOT Standard Type D curb ramps (INDOT Standard Drawing No.E 604-SWCR-06). Indiana University's Cravens Hall (Figure E.1) is a permanent fixture on the southwest corner of the intersection that obstructs the view between drivers and pedestrians using crosswalks. The removal of Craven's Hall is not an option; therefore, pedestrian crossing signs will be posted to caution east and westbound 10th Street motorists of pedestrian presence.

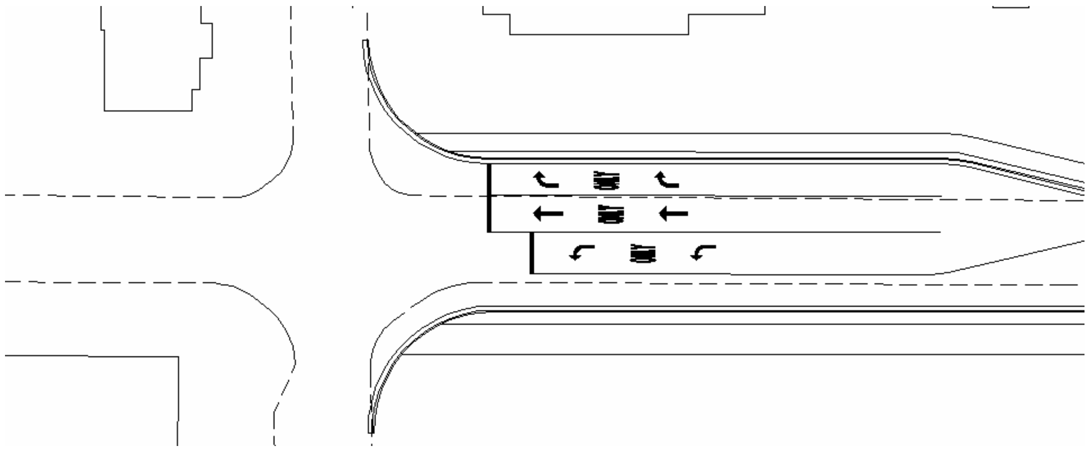


Figure E.2: Image of the proposed intersection improvements at 10th Street and Woodlawn Avenue.

E.3 10th Street and Walnut Grove

Upon reviewing the intersection of 10th Street and Walnut Grove Street (Figure E.3), Urban Engineering recommend that a left turn lane be added to the eastbound 10th Street and a right turn lane be added to westbound 10th Street at the intersection (Figure E.4). The added turning lanes should allow traffic to proceed through the intersection even when a motorist is trying to make a turn onto Walnut Grove Street. In addition to the changes on 10th Street, a left and right turn lane will be added to Walnut Grove Street so motorists can more easily make turns onto 10th Street. The intersection will be upgraded to include signals (Appendix J) to facilitate the turning movements that will be taking place at the intersection. Urban Engineering would like to improve the pedestrian crossings at this intersection using a six-feet-wide crosswalk across Walnut Grove Street with six-inch solid white lines, leading to existing curb ramps.

Figure E.3: Image of the existing intersection of 10th Street and Walnut Grove Street. (Adapted from Google Maps. 2007)

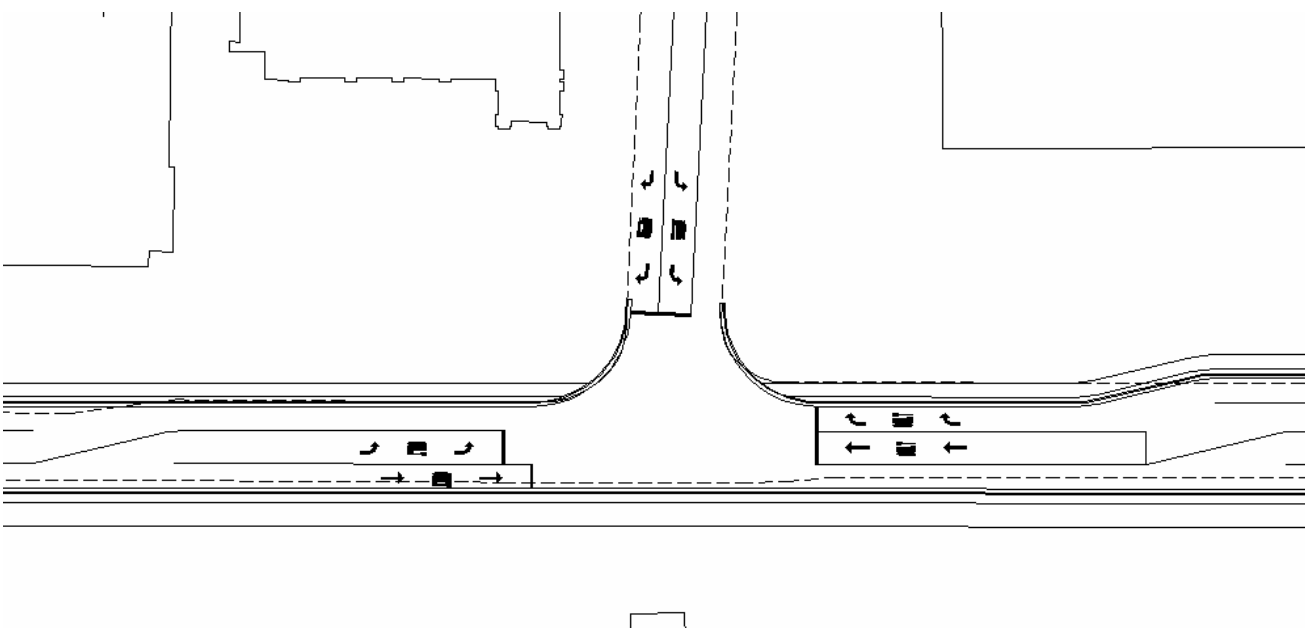


Figure E.4: View of the updates to the intersection of 10th Street and Walnut Grove Street.

E.4 10th Street and Fee Lane

The intersection of 10th Street and Fee Lane currently has existing turn lanes that meet vehicular traffic demands (Figure E.5). Existing pedestrian crosswalks meet INDOT Standards. Urban Engineering proposes that the existing crosswalks get repainted during construction of the other intersections along 10th Street.

Figure E.5: View of the existing intersection of 10th Street and Fee Lane. (Adapted from Google Maps, 2007)

E.5 10th Street and Jordan Avenue

The intersection of 10th Street and Jordan Avenue currently has existing turn lanes that meet vehicular traffic demands (Figure E.6). Existing pedestrian crosswalks meet INDOT Standards. Urban Engineering proposes that the existing crosswalks get repainted during the construction of the other intersections along 10th Street.

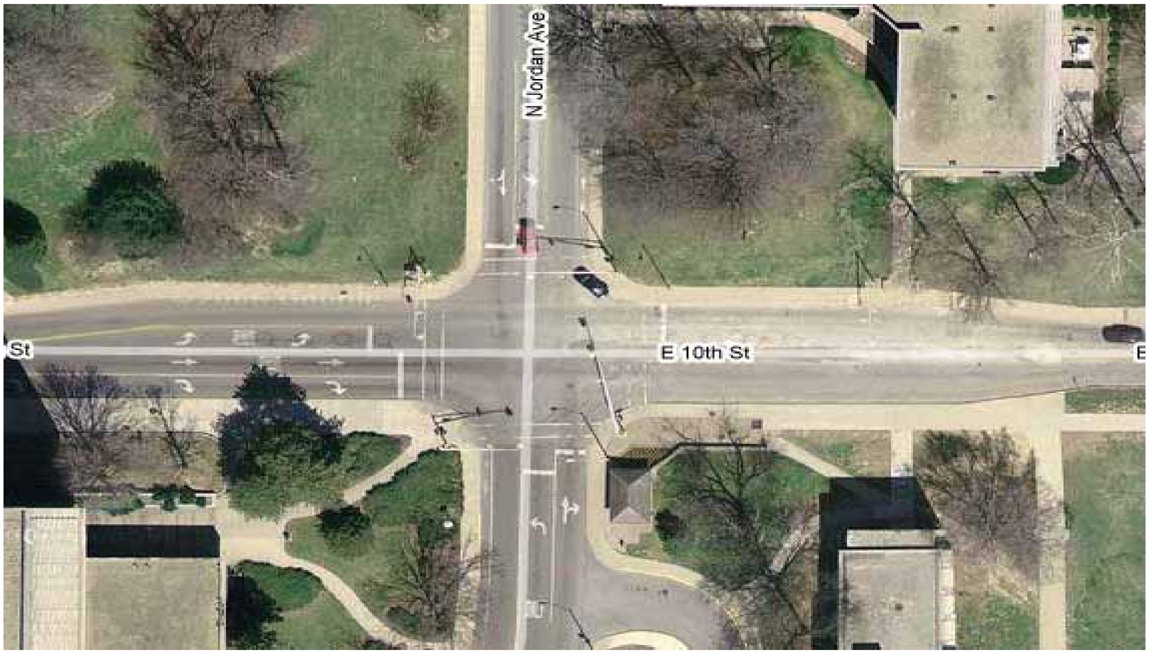


Figure E.6: View of the existing intersection of 10th Street and Jordan Avenue. (Adapted from Google Maps, 2007)

E.6 10th Street and Union Street

The existing intersection of 10th Street and Union Street requires several modifications (Figure E.7). Urban Engineering has proposed increasing the southeast and southwest intersection radii to fifty-two feet (Figure E.8). The increased intersection radii will assist maneuverability for public transport vehicles, but will require an acquisition of a small portion of parcel 013-65000-00. Monroe County GIS does not identify the owner's name. The southeast corner of the intersection will also require the removal of a few trees and the relocation of a pole.

Figure E.7: Image of the existing intersection of 10th Street and Union Street. (Adapted from Google Maps, 2007)

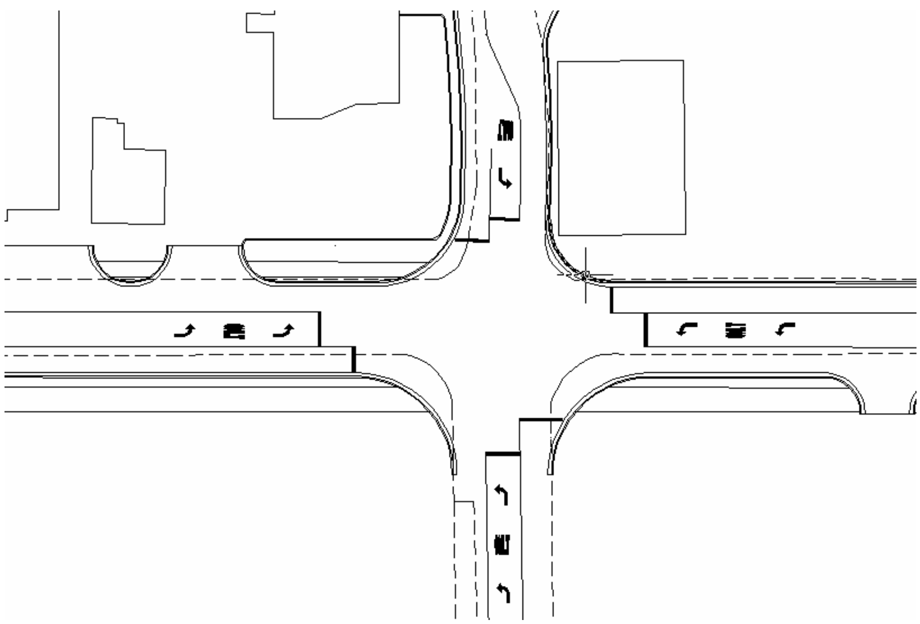


Figure E.8: Image of the proposed intersection of 10th Street and Union Street.

Due to the likelihood of traffic congestion resulting from an at-grade railroad crossing located one-hundred and seventy feet north of the 10th Street-Union Street intersection, Urban Engineering has added a left turn lane paired with a right turn/straight through lane for vehicles traveling south on Union Street (Figure E.8). 10th Street will be updated with east and westbound left turn lanes. The intersection will be controlled by electronic signals as discussed in Appendix J. The turn lane taper is one-hundred feet which will provide space for vehicles to decelerate in the travel lane. A storage length of one-hundred feet was determined using INDOT Design Manual Section 46-4.02 (INDOT, 2007). An acquisition of a small portion of the property on the northwest corner will be required for this improvement. Mr. George Huntington, Jr. is the respective owner of parcel number 013-41730-00. The existing sidewalk to the north of 10th Street will be relocated following the intersection improvements at 10th Street and Union Avenue (Figure E.8). The existing sidewalk to the south of 10th Street will be replaced by a ten-foot shared use path discussed in Appendix L.

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Urban Engineering also upgraded the crosswalk conditions by including six-feet-wide crosswalks across 10th Street and Jordan Avenue. The crosswalks should be marked with six-inch solid white lines and would have Type D curb ramps (INDOT Standard Drawing No.E 604-SWCR-06).

E.7 Law Lane and Union Street

After the Law Lane extension, Appendix F, the intersection of Law Lane and Union Street will experience an increase in east-west traffic flow. The current intersection is at a skewed angle that will make it difficult for vehicles traveling on west Law Lane to make southbound turns onto Union Street (Figure E.9). To make this intersection more usable, Urban Engineering proposes realigning Union Street to intersect Law Lane in a more perpendicular alignment (Figure E.10). Realigning Union Street will eliminate the severe turn from Law Lane onto Union Street. Urban Engineering proposes implementing a turning radius of fifty-two feet for all four corners of the intersection. This will be sufficient for the buses that are used by IU and the City of Bloomington.

Figure E.9: Image of the existing intersection of Law Lane and Union Street. (Adapted from Google Maps, 2007)

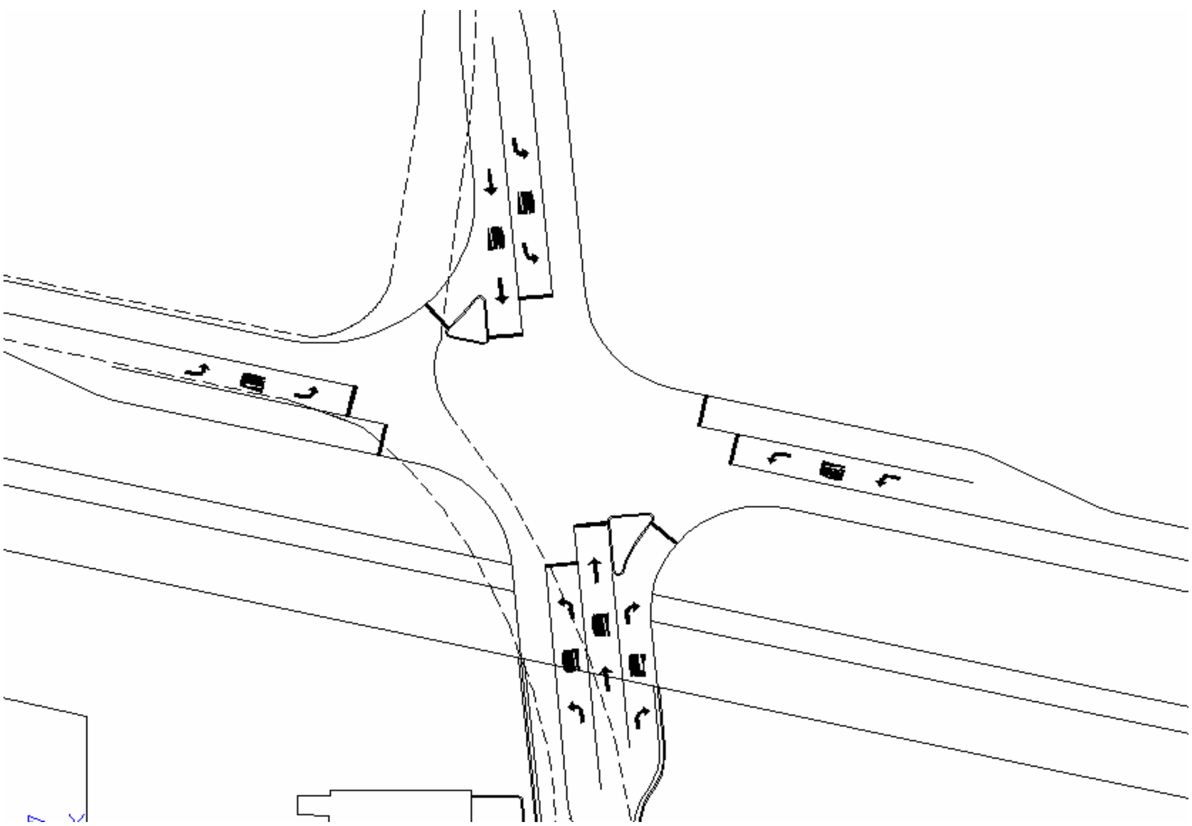


Figure E.10: Image of the proposed intersection at Law Lane and Union Street.

To make these improvements, right-of-way will need to be purchased from parcel number 013-71370-00, which is west of the intersection and owned by IU. Part of this parcel will be converted from parking to roadway during the Law Lane extension east. In addition to losing parking space, several trees will need to be removed near the proposed intersection to account for stopping sight distances. The existing sidewalk that parallels with western edge of Union Street will be relocated and realigned parallel to the new alignment of Union Street. The sidewalk to the north of Law Lane will be replaced following the intersection improvements.

A primary concern for the intersection of Law Lane and Union Street is the railway at-grade crossing. Urban Engineering proposes widening Union Street northbound to allow for left and right turn lanes to be used in coordination with a center lane (Figure E.10). The additional lanes should allow traffic to move to its designated turn lane instead of backing up into the railroad crossing, which occurs in the existing one lane configuration. The right turn lanes on north and southbound Union Street will be controlled by a yield sign. In addition to the Union Street turn lanes, Urban Engineering proposes adding a left turn lane to east and westbound 10th Street. The intersection will be signalized to facilitate flow through the intersection (Appendix J).

Crosswalks will be added to the intersection to increase safety for pedestrians while crossing the intersection. The crosswalks will be six-feet-wide, with six-inch wide solid white lines. Each of the four crosswalks will lead to INDOT Standard Type D curb ramps (INDOT Standard Drawing No.E 604-SWCR-06). The east-west running southern crosswalk will be paired with the shared use path that will run to the north of and parallel to the railway (Figure E.10).

E.8 Law Lane and Jordan Avenue

The intersection of Law Lane and Jordan Avenue is different from other intersections along Law Lane due to on-street parking that borders both sides of Law Lane (Figure E.11). Currently, Law Lane has a horizontal curve through its intersection with Jordan Avenue. Urban Engineering would like to realign and straighten Law Lane through the intersection with Jordan Avenue (Figure E.12). Straightening Law Lane will require the removal of the existing on-street parking to the south of

Law Lane. The parking to the north of Law Lane will be left in place. In order to straighten Law Lane, some right-of-way will need to be purchased from parcel number 013-77250-00 and 013-71350-00. Monroe County GIS does not identify the owners of the properties. During the realignment of Law Lane at its intersection with Jordan Avenue, several trees will be removed. In addition to the removal of trees, two light poles will need to be relocated.

Figure E.11: Image of the existing intersection of Law Lane and Jordan Avenue. (Adapted from Google Maps, 2007)

At the intersection, left turn lanes will be added to east and westbound Law Lane. These left turn lanes will allow motorists to make a left turn onto Jordan Avenue without halting other traffic that is trying to progress through the intersection. (The intersection will be controlled by electronic signals as discussed in Appendix J). Also, pedestrian crosswalks will be added to this intersection. The pedestrian crosswalks will be six-feet-wide, with six-inch wide solid white lines. Each of the four crosswalks will lead to INDOT Standard Type D curb ramps (INDOT Standard Drawing No.E 604-SWCR-06).

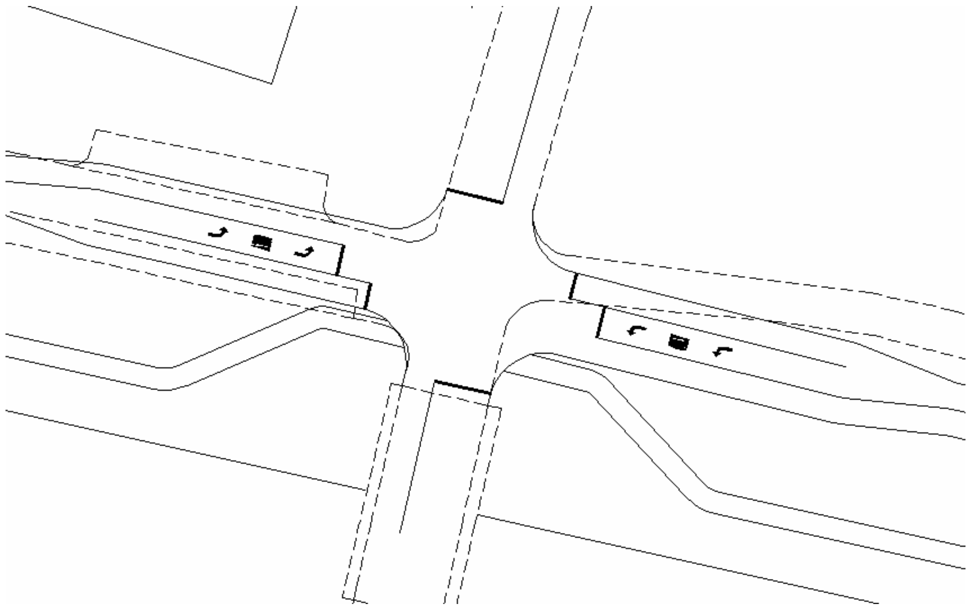


Figure E.12: Image of the proposed intersection at Law Lane and Jordan Avenue.

Appendix F - Alignments

F.1 10th Street Overview

Urban Engineering redesigned 10th Street with an emphasis on pedestrian safety and increased traffic efficiency. Two different designs are provided for the section of 10th Street from Woodlawn Avenue to Union Street. The first design includes widening 10th Street and adding a center two-way left turn lane. This design is the most effective at alleviating traffic congestion along 10th Street, but widening requires several major modifications to the area. Widening requires a major steamline to be relocated and approximately fifty trees to be removed and replaced. The stakeholders involved with the project opposed the removal of trees because the tree canopy along 10th Street is highly valued; therefore, Urban Engineering provided an alternative design known as the 10th Street Upgrade.

The 10th Street Upgrade maintains the existing right-of-way except at two major intersections where intersections are upgraded. The upgrade dramatically reduces the number of tree replacements and it eliminates the need to relocate the steam line. For the 10th Street Upgrade to be effective, left turns will be limited at designated intersections along 10th Street during peak traveling periods.

The MPO will select the design that best suits the City of Bloomington's needs. Regardless of the design that is chosen, the alignment will be resurfaced with a pavement that was designed by Urban Engineering (Appendix I). In addition, both designs allow for a shared-use side path, located on the south side of 10th Street (Appendix L).

F.1.1 Widening 10th Street from Woodlawn Avenue to Union Street

The decision to widen 10th Street from Woodlawn Avenue to Union Street is an effective solution for alleviating the traffic congestion problems. The existing 10th Street conditions include two 14 feet wide travel lanes, and two recently upgraded intersections at North Fee Lane and Jordan Avenue. Urban Engineering's original design includes widening 10th Street to thirty-eight feet, adding a center two-way left turn lane, and resurfacing the alignment. To achieve the widening, Urban Engineering relocated the centerline four feet to the south of the existing centerline. The proposed edge of pavement is offset nineteen feet from the new centerline on both sides. The widening permits two twelve feet travel lanes and a fourteen feet center two-way left turn lane (Figures N.1 to N.7). The lane widths were determined using the Geometric Design Criteria for Two Lane Urban Arterial Table 53-7 (INDOT Design Guide, 2007). The two-way left turn lane improves the traffic efficiency along the corridor by decreasing the amount of time spent waiting on traffic to make left turns.

Several modifications are required to achieve the widening, which will have an impact on all surroundings. Widening 10th Street requires nine feet of right-of-way to be acquired on the south side of 10th Street and one foot of right-of-way on the north side of 10th Street from Woodlawn Avenue to Union Street. Most of the property on the north and south side of 10th Street belongs to IU; however, there are a few unnamed property owners that will have to relinquish portions of their property to this project. The acquisition of right-of-way does not require demolition of any buildings, but it does require trees to be removed/replaced and utilities to be relocated.

Approximately forty-five trees that are located within ten feet on the south side of 10th Street from Woodlawn Avenue to Union Street, plus approximately five trees located within three feet on the north side of 10th Street, from Woodlawn Avenue to Forrest Avenue, will have to be removed and replaced with younger trees. The younger trees will be offset three feet from the proposed edge of pavement. In addition, a major steamline owned and operated by IU must remain active during the entire project. Widening 10th Street requires approximately two-thousand six-hundred feet of the steamline to be relocated approximately fifteen feet further south of the existing steamline. Finally, street light poles along 10th Street will be relocated to the proposed edge of pavement (Appendix H).

F.1.2 10th Street Upgrade from Woodlawn Avenue to Union Street

The alternative design to widening 10th Street is known as the 10th Street Upgrade. The 10th Street Upgrade design maintains the existing right-of-way from Woodlawn Avenue to Union Street, except at key intersections, and eliminates the major modifications associated with widening 10th Street. The upgrade design includes upgrading key intersections, pavement resurfacing, and limiting left turns during peak periods at intersections that do not currently have left turn lanes. The design does not accommodate traffic needs as well as the widening because it decreases the ability to make left turns at certain intersections; nonetheless, it does improve traffic efficiency from the existing conditions, and it pleases a majority of the stakeholders involved by preserving the aesthetics of the City of Bloomington.

The majority of major intersections along 10th Street have already been modified to help meet the traffic demands; however, intersections at Woodlawn Avenue and Union Street have not been upgraded. For traffic traveling west on 10th Street, Urban Engineering designed a left turn lane onto Woodlawn Avenue and for traffic traveling either direction on 10th Street left turn lanes onto Union Street were designed (Figures N.1 to N.7). The existing travel lanes are approximately fourteen feet. To accommodate for the turn lanes at both intersections, Urban Engineering's design decreases the travel lane to twelve feet and includes fourteen feet turn lanes.

Urban Engineering does not have traffic modeling capabilities; therefore, the AASHTO Green Guide (Geometric Design of Highways and Streets, 2004) was used to determine the storage depth of one-hundred and fifty-feet for each turn lane. The storage depth is based on an estimate of three cars and one bus per traffic signal cycle, multiplied by one and a half for peak periods, and then multiplied by the average car length of twenty feet. Acquisition of property from IU is required to achieve the additional right-of-way at both intersections. No major utilities are impacted by this design, because the acquisition of right-of-way is on the north side of 10th Street. This design requires approximately four trees on the northeast corner of 10th Street and Woodlawn Avenue to be removed and replaced with smaller trees.

Finally, Urban Engineering's 10th Street Upgrade design also includes limiting left turns at intersections along 10th Street during peak travel periods. Left turns will not be allowed while IU classes are in session from the hours of 7 a.m. to 6 p.m. at the following intersections: Forrest Avenue, Walnut Grove, Campbell Street, and Sunrise Drive.

F.1.3 10th Street Design from Union Street to SR 46

Regardless of the design that the client selects from Woodlawn Avenue to Union Street, the section of 10th Street from Union Street to State Road 46 Bypass includes tapering 10th Street east of Union Street, replacing the railroad bridge, realigning the road under the railroad bridge, increasing the vertical clearance under the bridge, and resurfacing the pavement.

Part of the design includes replacing the existing concrete bridge with a pre-fabricated steel bridge (Appendix M). The new steel bridge allows Urban Engineering to provide two significant designs that improves the safety and efficiency of traffic along 10th Street. The existing 10th Street alignment at the underpass has a sharp s-curve that creates maneuverability difficulties for vehicular traffic. Due to the steel bridge's increased span, Urban Engineering decreased the deflection angle of the road under the bridge by creating a new alignment. The realignment decreased the s-curve from approximately a ninety degree angle to a forty-five degree angle (Figure N.16). Next, the steel bridge increases the vertical clearance. The prefabricated steel bridge has shallower girders than the existing concrete bridge, which helps increase the vertical clearance at the underpass. To increase the vertical clearance more, Urban Engineering recommends excavating below the existing elevation to provide a two percent grade that leads up to the underpass. A combination of the two modifications increases the vertical clearance from ten feet five inches to fourteen feet, and allows high profile fire trucks and public transport vehicles to use the underpass. However, new storm drains must be placed to remove storm water run-off that will accumulate under the bridge.

On the north side of the underpass, 10th Street will lead into a roundabout (Appendix M). The roundabout connects traffic from Law Lane Extension East, 10th Street, and potentially 14th Street depending on the City of Bloomington's future transportation plans. This design requires some trees located along the south side of the railroad and some trees located on the north side of the overpass to be removed and replaced with younger trees located in an out of the way place. There are some major utilities in this area that will also need to be relocated. The major utilities in the area include a steamline, fiber optics, power lines, and telephone lines (Appendix H).

F.2 Law Lane Overview

To help alleviate some of the congestion from 10th Street, Urban Engineering implemented several designs to make it easier for commuters to use Law Lane as an alternative east-west route. Urban Engineering designed an extension to the east and improved several intersections along Law Lane. Urban Engineering also designed a shared use side path that extends from Fee Lane to SR 46 (Appendix L). The modifications made to Law Lane improve the traffic efficiency, increase pedestrian safety, and enhances the City of Bloomington's aesthetic appeal.

F.2.1 Law Lane Extension East

Urban Engineering designed a road that extends Law Lane east of Union Street. The extension consists of two-twelve feet travel lanes and leads into a roundabout designed by Urban Engineering (Appendix G). The extension allows 10th Street traffic to access Law Lane on the north side of the railroad overpass (Figures N.12 and N.13). The extension passes through an existing parking lot and it requires acquisition of parcel number 013-71370-00. Approximately fifteen trees located near the existing parking lot have to be removed/replaced and some utilities will have to be relocated. The major utilities to be relocated are fiber-optics, power lines, telephone lines, and a steam line (Appendix H). The extension will be surfaced with a pavement designed by Urban Engineering (Appendix I) along with pavement markings that Urban Engineering provided (Appendix K).

F.2.2 Realigning Law Lane

As noted in Appendix E, Urban Engineering realigned the intersection at Law Lane and Union Street. The new intersection allows the two streets to meet at more of a perpendicular alignment. Urban Engineering also realigned Law Lane immediately east of Jordan Avenue (Figure N.9). The realignment eliminated the parking on the south side of Law Lane and also requires approximately five trees to be removed/replaced. On the west side of Jordan Avenue, Urban Engineering maintained the same alignment and existing twelve feet travel lanes, but the parking on the south side of Law Lane was relinquished to allow space for a 14-fee-wide left turn lane (Figure N.9). Urban Engineering does not have traffic modeling capabilities; therefore, the AASHTO Green Guide (Geometric Design of Highways and Streets, 2004) was used to determine the storage depth of one-hundred and twenty feet. The storage depth is based on an estimate of four cars per traffic signal cycle, multiplied by one and a half for peak periods, and then multiplied by the average car length of twenty feet. Also, a pavement design was provided to be used for resurfacing Law Lane (Appendix I).

Appendix G - Roundabout Design

G.1 Overview

In order to successfully meet the needs of high volume traffic seen throughout the project area, Urban Engineering has elected to incorporate a roundabout that will connect both 10th Street and Law Lane corridors. This urban, single-lane roundabout will be able to accommodate compact vehicles, emergency and public transportation vehicles, and the WB-50 design vehicle.

G.2 Benefits

A roundabout is considered to be the most logical choice for safety, operational improvement, lower overall delays, higher vehicular capacity, community enhancement, and diversion of traffic onto Law Lane. Studies have found that roundabouts contain fewer conflict points in comparison to conventional intersections and allow drivers more time to react to potential conflicts, therefore reducing crash severity and frequency. Bicyclists and pedestrians are involved in a relatively higher proportion of injury accidents at roundabouts as compared to conventional intersections, but accidents can be greatly reduced with proper signage and adequate sight distance for all users. The operational efficiency at roundabouts is greater than that of conventional systems because, at lower speeds, more acceptable gaps are created to merge with circulating traffic. This translates into shorter delays for entering traffic.

G.3 Features

Urban Engineering recommends a large diameter and single-lane use roundabout at the intersection of 10th Street and Law Lane, located just north of the newly renovated 10th Street overpass (Figure G.1). This will provide motorists the ability to concentrate solely on a single lane of roundabout traffic clearly identifiable from the entry points. Roundabout traffic will flow in a counter-clockwise manner and have entry and exit points to each connection. The roundabout shall provide all motor vehicles access to 10th Street and Law Lane corridors.

Figure G.1: Location of roundabout (Adapted from Google Earth, 2007)

The main feature of this roundabout is the introduction of an alternative means to travel along 10th Street west through the campus. Three entry and three exit points will be constructed along the roundabout with accessibility to 10th Street at two points and Law Lane at one. The possibility of an extension to 14th Street on the north will also be available (Figure G.2). The connections to the west and south will be via 10th Street. West bound traffic on 10th Street will utilize the roundabout and be presented with the option of first traveling on Law Lane to continue heading west through the campus. This is a real asset to any motorists wanting to get further north and a key component in alleviating the amount of traffic seen on 10th Street. East-bound Law Lane travelers will be able to access the roundabout and exit onto west-bound 10th Street or west-bound 10th Street. East-bound travelers on 10th Street will be able to access the roundabout and exit on east-bound 10th Street or west-bound Law Lane.

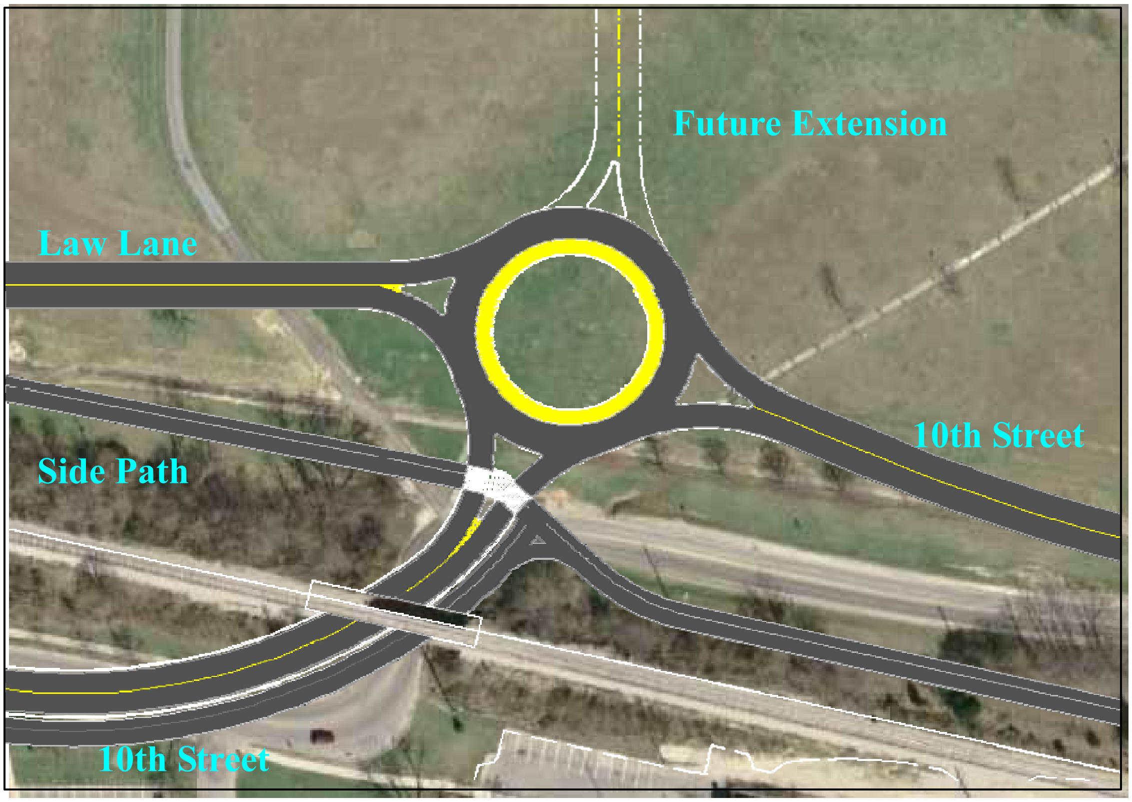


Figure G.2: Future site of roundabout (Adapted from Google Earth, 2007)

The proximity of the railroad track may significantly influence the location and design of the roundabout, and therefore should require a more detailed investigation of some aspects of the design and operation. Urban Engineering suggests that the roundabout be developed far enough north of existing 10th Street so that construction can proceed without affecting traffic flow as discussed in Appendix P**.** Urban Engineering believes that the southernmost point of the roundabout should be no less than 20 feet north of the existing roadway.

Proper signage will be addressed in approaching the roundabout to inform users of the necessary precautions and movements. Yield signs and lines, and roundabout warnings will accompany every entrance into the roundabout. Crosswalks for pedestrians and bicyclists will be denoted by their proper signage for both entering and exiting vehicles. An island will be located in the center of the roundabout to provide adequate deflection for all motor vehicle traffic. Splitter islands will be located between the entry and exit point for each connection in order to provide the proper radii for all vehicles to maneuver (Figure G.3).

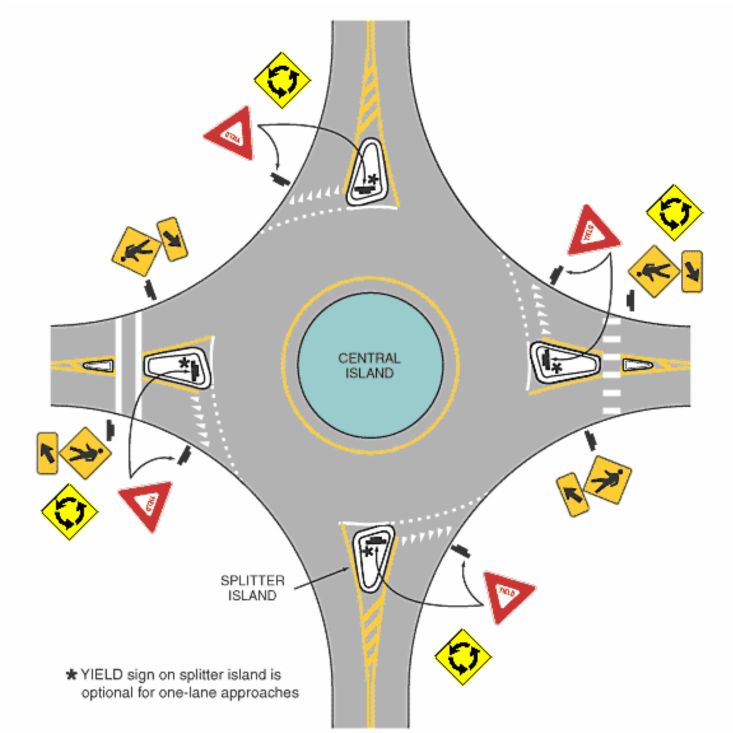


Figure G.3: Proper signage for roundabout (Adapted from MUTCD, 2004)

G.4 Geometric Design

This roundabout will feature geometric elements suitable for appropriate travel and accommodation of larger vehicles by incorporating a suitable roadway width, truck apron, design speed, and adequate sight availability. The dimensions will include a 130-foot inscribed circle, a 14-foot travel lane and an 8 foot truck apron (Figure G.4)

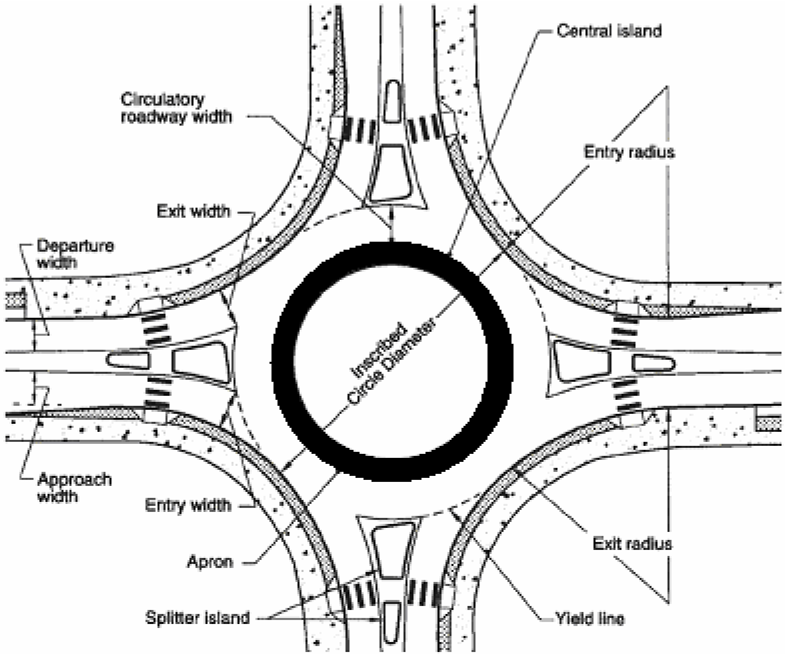


Figure G.4: Geometric elements of modern roundabout (Adapted from FHWA, 2000)

For this single-lane roundabout, the size of the inscribed circle diameter is largely dependent upon the turning requirement of a WB-15 (WB-50) design vehicle, resulting in a required diameter between 100 feet and 130 feet. A central island will be located within the roundabout and its size will play a key role in determining the amount of deflection imposed on the through vehicle's path. Urban Engineering recommends a 130-foot inscribed circle diameter to provide deflection and accommodate for the large articulated buses that the city plans to purchase.

The circulatory roadway width should be designed with a minimum circulatory width 1.0 to 1.2 times the width of the widest entering roadway. This should accommodate the design vehicles by allowing adequate width through each of the turning movements. Therefore, the roadway will maintain a 14-foot travel width (Figure G.5) to coincide with both 10th Street and Law Lane connections, which both connect to the roundabout with 12-foot lanes. The circulatory roadway shall slope 2% away from the central island towards a barrier curb with suitable drainage measures. The roadway pavement design will be developed in the final pavement design in Appendix I.

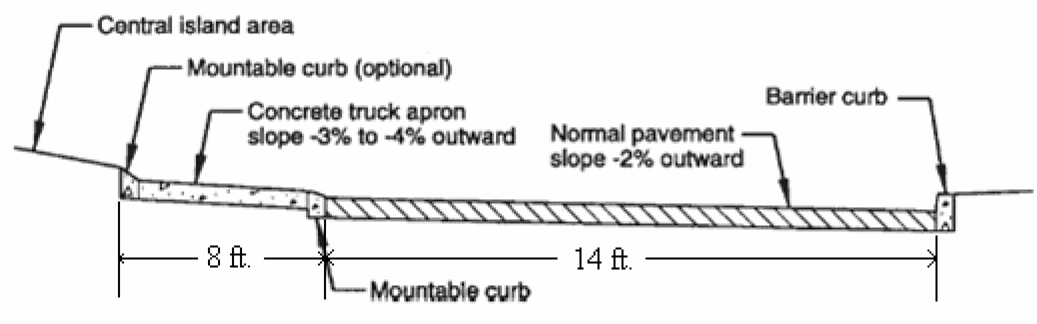


Figure G.5: Typical circulatory roadway section with truck apron (Adapted from FHWA, 2000)

The truck apron shall be 8 feet wide in order to allow for emergency and maintenance vehicles (Figure G.5). The apron shall be constructed of colored concrete and/or textured paving materials to differentiate it from the roadway surface. The truck apron surface shall have a brush finish and a 3% to 4% cross slope away from the central island to discourage pedestrian use. So that the truck apron is traversable by trucks but discourages vehicle use, it shall have an outer edge raised 1.2 inches above the circulatory roadway surface. A 6-inch mountable curb with a 1:1 slope face shall be installed, Portland grey in color, and no expansion material shall be specified between the circular roadway and the truck apron. Truck apron pavement thickness shall be developed with the final pavement design in Appendix I.

Splitter islands will be located at each connection point to increase entrance and exit radii, provide shelter for pedestrians, assist in controlling speeds, and deter wrong-way movements. Splitter islands can also be used to mount signs. The splitter islands shall have a minimum length of 50 feet to provide sufficient protection for pedestrians and alert approaching drivers to the roundabout geometry. The splitter island on the south side of this roundabout will contain a crossing for a shared-use side path.

Achieving appropriate vehicular speeds through the roundabout is the most critical design objective because it has profound impacts on safety. Every roundabout type has an optimum design speed to minimize crashes. For an urban single-lane roundabout, site category suggests that a 20 mph maximum entry design speed be recommended. The entry speed objectives for this single-lane roundabout are simple due to a lack of conflict between traffic in adjacent lanes. Therefore, the entry radius can be reduced or increased as necessary to produce the desired entry path radius. Provided that sufficient clearance is given for the design vehicle, approaching vehicles can adjust their path accordingly and negotiate the roundabout through the entry geometry. Entry and exit radii at this urban, single-lane roundabout shall be no less than 60 feet. This will allow emergency and transportation vehicles easy maneuverability but not result in excessive entry and exit speeds. Due to the different corridor angles, entry and exit radii will vary accordingly, but should properly allow vehicles to negotiate the roundabout geometry and ensure low speeds at pedestrian crossings.

Stopping sight distance is also a key component in maintaining adequate safety for all users of the roundabout. Stopping sight distance is the distance along the roadway for a driver to brake to a complete stop when perceiving and reacting to an object. Stopping sight distance shall be provided when entering and exiting the roundabout. Design values suggest that the stopping sight distance for a 30 mph roadway entering the roundabout is about 198 feet (FHWA, 2000). The intersection sight distance should is approximately 190 feet considering a conflicting approach speed of 20 mph for vehicles entering the roundabout. Keeping sight distance to a minimum at the intersection is beneficial to decrease vehicles speeds and increase safety of the intersection for all users. Landscaping in the central island can be effective in restricting sight distance to minimum requirements.

G.5 Pedestrian and Bicycle Crossing

A shared-use side path will be located to the south of the roundabout. The side path will cross 10th Street and the splitter island connecting on the south side of the roundabout (Figure G.2). The crossing will be 10 feet, the same width as the side path. The crossing should be located one vehicle-length (7.5 m [25 ft]) away from the entrance yield line. The splitter island width at the crosswalk should be a minimum of 6 feet to accommodate bicyclists. The pedestrian refuge at the splitter island should remain at street level, eliminating the need for a ramp. Americans with Disabilities Act Accessibility Guidelines (ADA, 2006) recommends that a detectable warning surface be applied to the surface of the refuge within the splitter island to alert shared-use path users that they are in a hazardous vehicle area. The warning surface should prompt them to be careful and alert in crossing the

Appendix H - Utility Locations

Because the 10th Street Extension and Modernization project area is located within the Indiana University (IU) campus and surrounded by existing infrastructure, there is a wide variety of utilities (Figures H.1-H.3). These utilities are controlled by various parties, including IU, AT&T, Vectren, Duke Energy, Smithville Telephone Company, and Level 3 Communications (Kaden, 2007).

The client has a choice between two alignment options in the 10th Street corridor between Woodlawn Avenue and Union Street. IU recently constructed a new steam line on the south side of 10th Street. This steam line is located underneath the sidewalk. If the 10th Street widening option is chosen, this steam line will either have to be relocated or a new cap which can support a road must be constructed. IU has stated that, if 10th Street is to be widened, the steam line should be relocated to allow for servicing without road closures (Kaden, 2007). If the steam line is relocated, it should be relocated south of its current location.

In addition to the steam line, there are several other utility lines along 10th Street (Figure H.4) which must be maintained. These include electric, water, stormwater, fiber optic and telephone communications, and natural gas lines. There are also light poles on the north side of Law Lane and in various locations on either side of 10th Street (Indiana University Engineering Services, 2007).

There are existing electrical lines controlled by Duke Energy running on both the northern and southern sides of the railroad line. There are overhead lines on both sides of the railroad, and an underground line to the south of the railroad. Along this line there is also a telephone line controlled by Smithville Telephone Company. This electrical and communications line will affect the reconstruction of the railroad overpass and the realignment of 10th Street in the vicinity of and underneath the overpass (Indiana University Engineering Services 2007).

At the location of the eastern Law Lane extension, there is a steam line, a condensate line, and a fiber optic line, all of which are controlled by IU (Figure H.5). These utility lines will affect any road construction in the area (Indiana University Engineering Services 2007).

Before any road realignment, widening, or new road construction, representatives from all utilities must be notified, and all work must be coordinated with these utilities to ensure no damage to utility-owned property or disruptions of service. Indiana University Engineering Services has a map of all utilities within the project area.

Figure H.1: Water lines located on the project site, map provided by client.

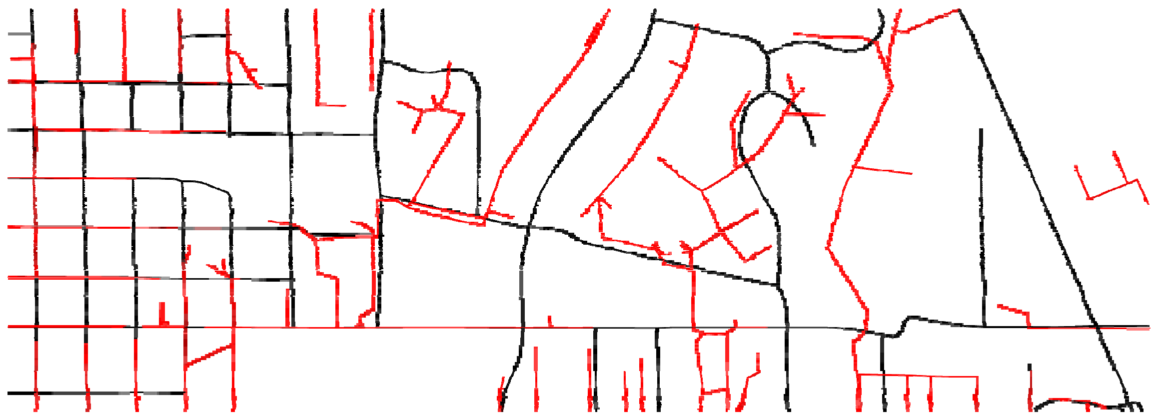


Figure H.2: Sewer lines located on the project site, map provided by client.

Figure H.3: Stormwater lines located on the project site, map provided by client.

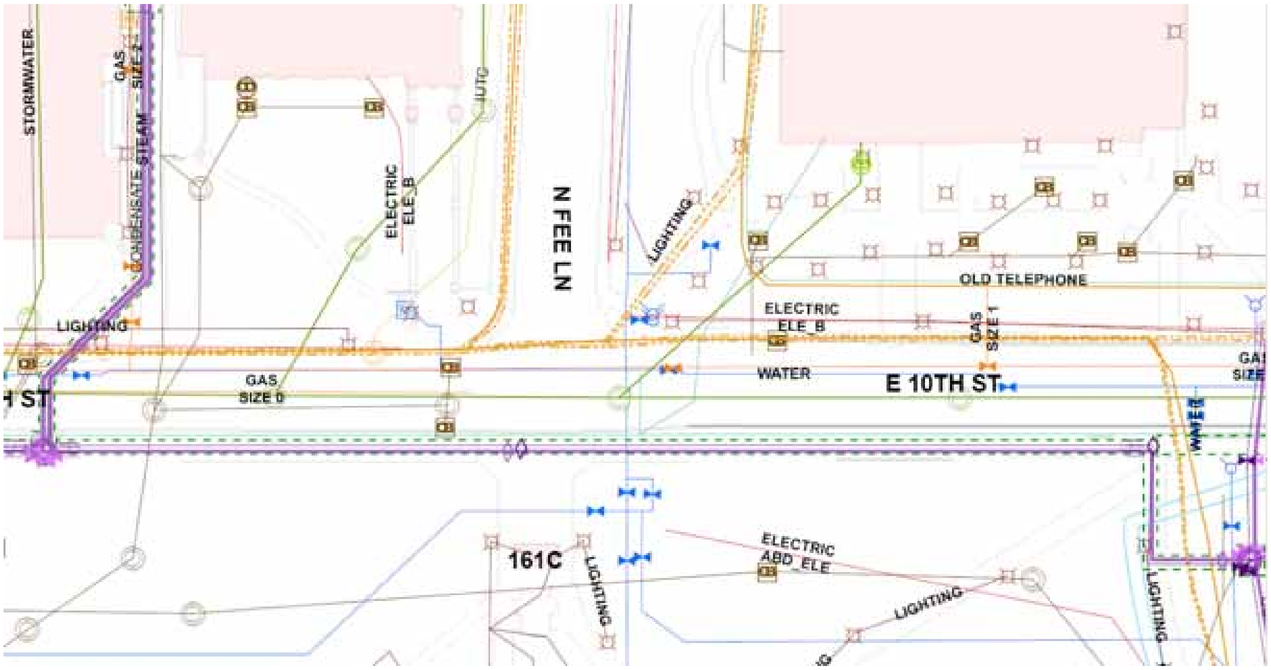


Figure H.4: Utilities in the location of the 10th Street-Fee Lane intersection. The thick purple line to the south of 10th Street represents the steam line (Indiana University Engineering Services, 2007).

Figure H.5: Utilities in the location of the Law Lane extension. The purple line is a steam line, orange lines are communications lines, and blue lines are water, stormwater, and condensate lines (Indiana University Engineering Services, 2007).

Appendix I - Material Selection

I.1 Introduction

Urban Engineering has prepared designs for the construction and renovation of certain roadways and side paths on the campus of Indiana University in Bloomington, Indiana. Based upon the recommendation of our client, the Bloomington Metropolitan Planning Organization, and preference of concerned entities, roadways and shared-use side paths are to be completed using hot mix asphalt.

The important elements considered are the soil classifications, traffic projections, functional classifications, and selection and estimation of design input variables. These criteria and particular contributive components are essential elements in determining the proper design for the selection of appropriate pavement layer thicknesses.

This appendix describes the process used in choosing proper pavement designs. The AASHTO Geometric Design for Highways and Streets (2004), INDOT Standards and Specifications (2006), Asphalt Paving Association of Iowa Design Guide (2007), and Massachusetts Highway Department Mass Highway Design Guide (2006) were used to develop a desired pavement for roadways and side paths utilizing asphalt.

I.2 Design of Roadways

The reconstruction of roadways within the project scope can be extremely costly, not just in monetary terms, but aesthetics and resources as well. Given the limited right-of-way present throughout the Indiana University campus, it may be necessary to design a pavement that is less desirable than would be possible if sufficient right-of-way were available or could be acquired economically. Urban Engineering has considered this problem in the development of designs for the reconstruction of 10th Street and construction of the components along Law Lane. Urban Engineering will design the pavement for 12 feet lane widths with 2-foot shoulders on both roadways.

10th Street and Law Lane are considered to be urban arterials, roadways that carry large traffic volumes within and through an urban area (AASHTO, 2004). 10th Street is an urban principal arterial while Law Lane is an urban minor arterial. The distinction of principal versus minor is based on the nature and composition of travel each serves. Each roadway needs to be designed for level-of-service (LOS) class C or better in order to provide acceptable performance for daily vehicular demands (AASHTO, 2004). The City of Bloomington recommends that the design speeds for these roadways remain between 20 and 30 mph for safety of motorists and pedestrians.

The roadways on the campus of Indiana University experience many different forms of transportation such as trucks, cars, buses, emergency vehicles, bicyclists and pedestrians. Urban Engineering wants to ensure that every roadway accommodates each of these modes. Urban Engineering will do this by rehabilitating parts of 10th Street and Law Lane, as well as constructing a suitable roadway connection between the two as discussed in Appendix C and Appendix G.

Urban Engineering has chosen to utilize hot mix asphalt (HMA) in construction on both 10th Street and Law Lane. Hot mix asphalt will create a smooth, durable, water proof substrate that will not sacrifice skid resistance in order to provide the smoothest ride possible while eliminating the need for construction joints. Hot mix asphalt is the primary pavement on roadways in Indiana and is preferred by the City of Bloomington to be consistent with the other roadway pavements currently in place. Hot mix asphalt will be used as the surface course and intermediate course. The base course will also be HMA, while the sub-base will be crushed stone and the sub-grade is sandy gravel (Figure I.1). Each of these sections was chosen based on present soil conditions and recommendations from the City of Bloomington.

Urban Engineering recommends that further soil testing be conducted at the site of the Law Lane extension in order to properly determine the thickness of layers needed beneath the surface layer given the present soil conditions. The soil tests will provide Urban Engineering and the City of Bloomington important information to decide on the class type of courses needed for the equivalent single-axle loads (ESAL) expected to be seen on the roadway to meet a desired road life and minimize maintenance.

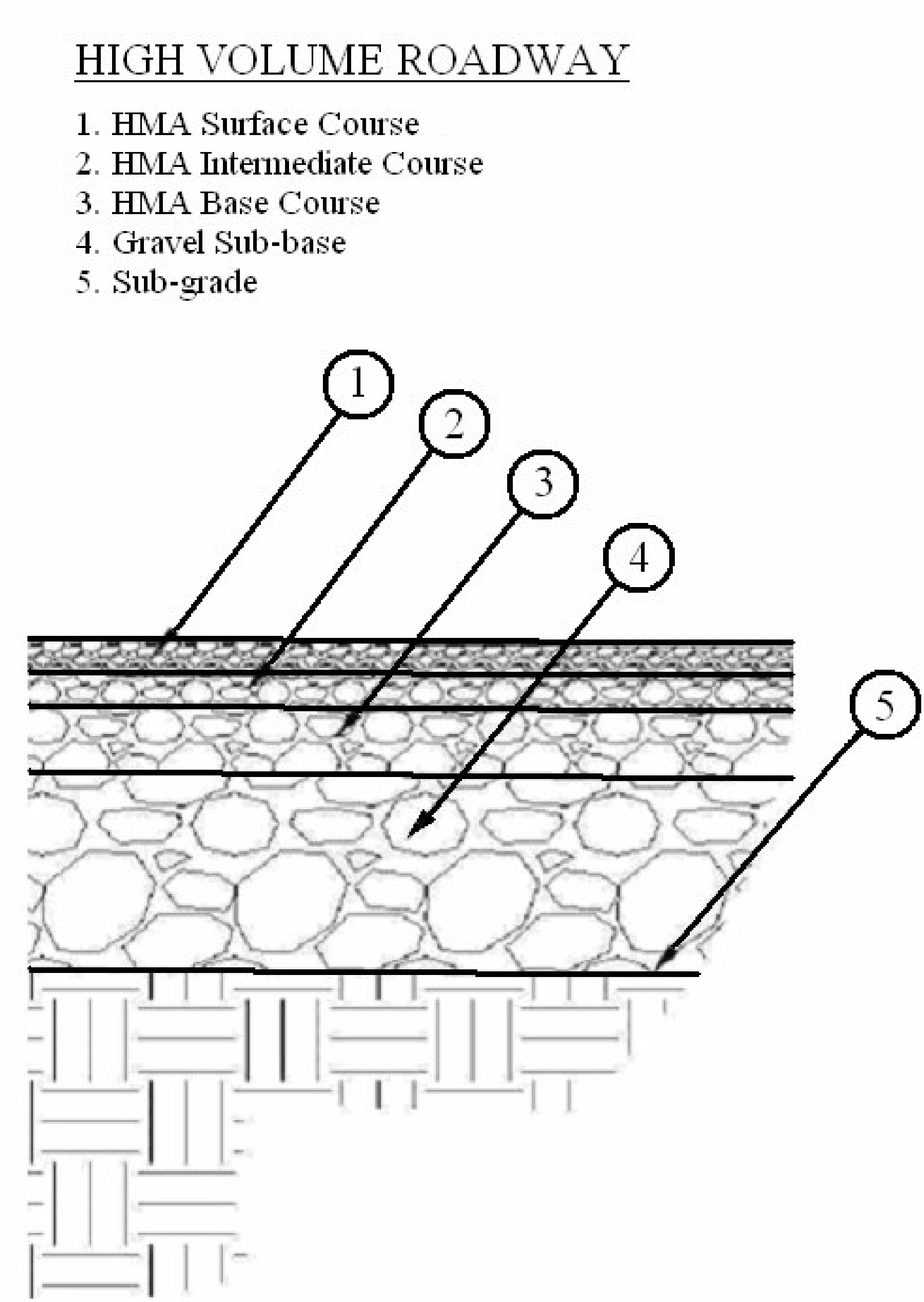


Figure I.1: Pavement course for a flexible roadway (Adapted from MHD, 2006)

The average daily traffic expected on Law Lane after construction of the extension can be expected to be up to 19,350 automobiles with a design period of 15 years. This classifies Law Lane, and consequently 10th Street, which should experience similar amounts, as Traffic Class V arterials. Currently, the sub-grade conditions for 10th Street and Law Lane are moderate to poor. Using the Thickness Design for Arterial Streets (MHD, 2006), California Bearing Ratio (CBR) and asphalt, thickness can be determined. These classifications require reconstruction along 10th Street and newly constructed Law Lane to provide a minimum of 8.0 inches of aggregate gravel sub-base, 3.5 inches of HMA Base, 2 inches of HMA Intermediate Course and 1.5 inches of HMA Surface Course. 1.5 inches will be used for the HMA Surface Course and 2.0 inches will be used for the HMA Intermediate Course, as opposed to MHD recommendations (Table I.1) for constructability. A minimum 12 inch granular base or sub-base will be provided beneath the HMA pavement courses (INDOT, 2006).

Table I.1: Layer Coefficient for Pavements (MHD, 2006)

Highway Type and Pavement Course	Thickness (inches)	Layer Coefficient	SN
HMA Surface Course			
Freeway	1.75	0.44	0.77
Arterial	1.75	0.44	0.77
Collector & Local	1.5	0.44	0.66
Low volume	1.5	0.44	0.66
HMA Intermediate Course			
Freeway	2.00	0.44	0.88
Arterial	1.75	0.44	0.77
Collector & Local	1.75	0.44	0.77
Low volume	2.5	0.34	0.85
HMA Base			
Freeway	4.50	0.34	1.53
Arterial	3.50	0.34	1.19
Collector & Local	3.25	0.34	1.10
Low volume	12" gravel base	0.11	1.32
Sub-base: Stone & Gravel			
Freeway	4" stone	0.14	.56
	8" gravel	0.11	.88
Arterial	4" stone	0.14	.56
	8" gravel	0.11	.88
Collector & Local	12" gravel	0.11	1.32
Total Structural Number			
Freeway	-	-	4.62
Arterial	-	-	4.17
Collector & Local	-	-	3.85
Low Volume			2.83

The pavement structure is characterized by the Structural Number (SN), an abstract number expressing the structural strength required for given combinations of soil support, total traffic expressed in ESAL, terminal serviceability, and regional environmental factors. The SN is converted to layer thickness using a layer coefficient that represents the relative strength of the construction materials in a layer.

Determining the SN for roadways will allow Urban Engineering to determine the sub-base course thickness required for an adequate roadway. SN is determined using a nomograph, given a soil support value, ESALs, regional factor, and terminal serviceability assumed to be 2.5 due to sensitivity to small changes in smoothness of surface pavement.

Once the SN is calculated, it is then possible to determine the sub-base thickness required for an adequate roadway.

$SN = a_1D_1 + a_2D_2 + a_3D_3$ (AASHTO, 2004)
SN = Structural Number (Index indicative of the total pavement thickness required)
Where $a_i = i^{th}$ layer coefficient
$D_i = i^{th}$ layer thickness (inches)

The coefficients are determined by using the Massachusetts Highway Department (MHD, 2006) Mass Highway Pavement Design Guide (Table I.1).

I.3 Law Lane Extension and 10th Street Renovation Design

The support value (S) for the soil where Law Lane will connect to 10th Street will is assumed to be 5.5, a conservative estimate based upon the present soil conditions. Further soil investigation would provide a more accurate value. The daily equivalent 18-kip single-axle load applications, given the implementation of this extension, is expected to be approximately 880 heavy vehicles daily based upon LOS Analysis 20 Year Project for Bloomington’s 13th Street Corridor Study (Bloomington MPO, 2006). The regional factor (R) for Bloomington is 1.0 (Figure I.1). Therefore, the SN for the Law Lane Extension should be 4.0 (Figure I.2)

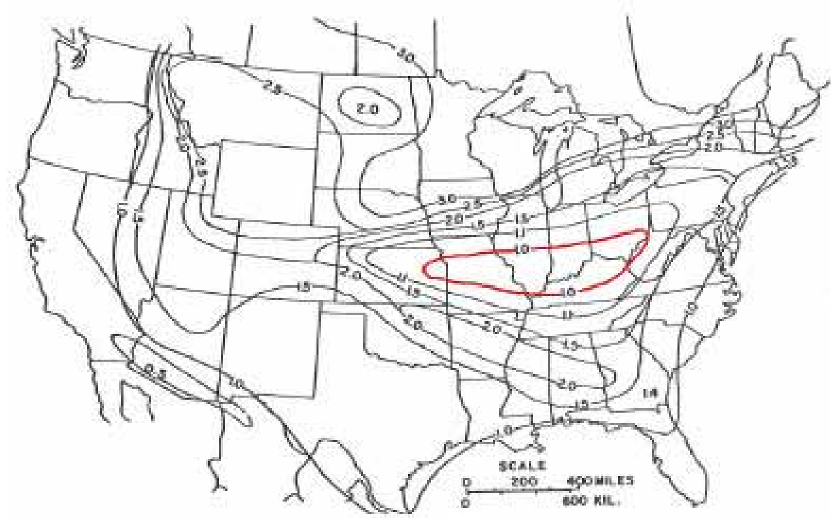


Figure I.1: Diagram showing regional factors for pavement design (Adapted from AASHTO, 1993)

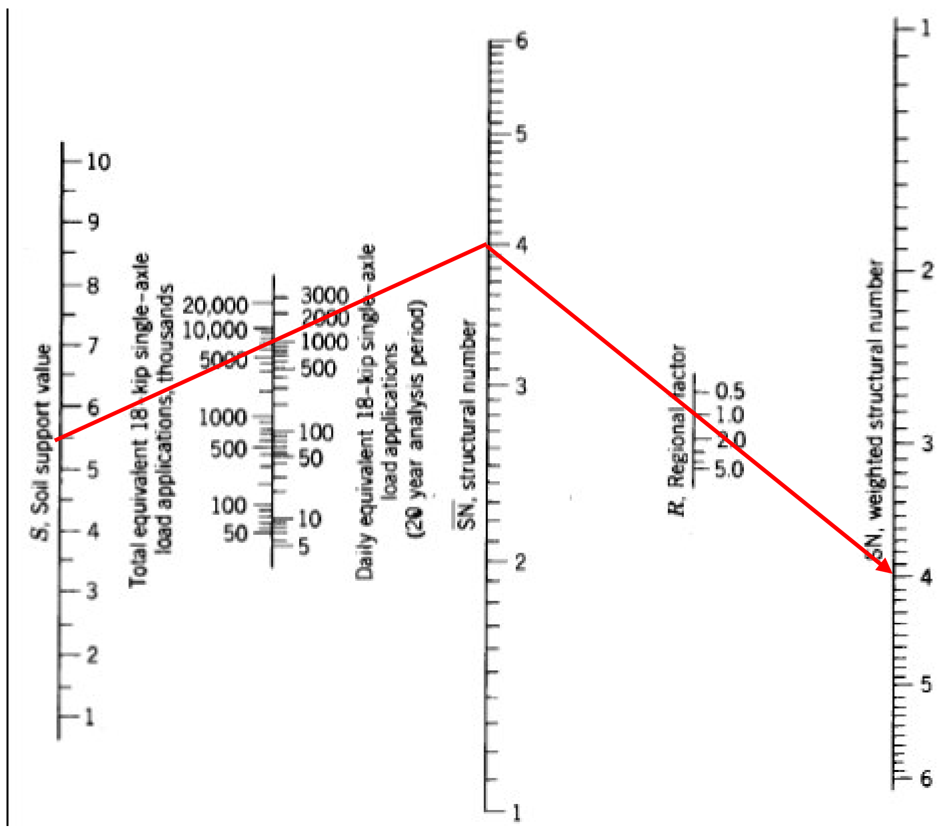


Figure I.2: Structural Number for Law Lane and 10th Street (Adapted from MHD, 2006)

The following calculations were completed to determine Structural Number, making it possible to produce the thickness needed for the crushed stone sub-base.

SN = 4.0

SN = a1*D1 + a2*D2 + a3*D3

Where

a1 = 0.44 (HMA Surface Course) D1= 3.5 inches (HMA surface thickness)

a2 = 0.34 (HMA Base Course) D2 = 3.5 inches (HMA base thickness)

a3 = 0.11 (Sandy gravel sub-base Course) D3 = ? inches (Stone sub-base thickness)

$D3 = (SN – a_1D1 – a_2D2)/a_3$

D3 = 11.54 inches -> 12.0 inches required

I.4 Shared-Use Path Design

Urban Engineering recognizes the requirement for safe, convenient and well-designed bicycle facilities that will encourage bicycle use as a means of transportation. The paved surface of the shared-use side paths will be used by many students and community members throughout the campus. Urban Engineering is committed to designing a side path that provides bicyclists, runners, and pedestrians with the maximum potential for enjoyment and safety.

Urban Engineering has chosen to use hot-mix asphalt pavement as the surface pavement of the shared-use side paths. Hot-mix asphalt will provide a smooth, high-traction, water-resistant surface that will suit all users. Hot-mix asphalt is the preferred surface on many shared-use paths throughout the state of Indiana, and has many distinct advantages over Portland cement concrete pavement. hot-mix asphalt is lower in initial cost, can be more rapidly installed, and eliminates the need for construction joints, which many users find inconvenient. In designing the shared-use paths along 10th Street and Law Lane, Urban Engineering followed the guidelines set forth in the Asphalt Paving Association of Iowa's Asphalt Paving Design Guide (APAI, 2007).

The APAI defines shared-use side paths as traffic class I structures. Class I structures are designed to carry automobiles and maintenance vehicles at low speeds, which is adequate for our design purposes. Considering a traffic class I designation and moderate subgrade conditions, APAI stipulates that the pavement structure include 3 inches of asphalt pavement atop 4 inches of compacted aggregate base (Table I.2).

The compacted aggregate base will be comprised of graded crushed stone. The graded crushed stone base will be compacted after being placed. After the stone is place, the asphalt pavement will be placed and compacted in two separate lifts. The 220 lbs/sq. yd. Intermediate Course HMA will be placed with a depth of 2 inches. The 110 lbs/sq. yd. Surface Wearing Course HMA will then be placed with a depth of 1 inch (Figure I.4). If deemed necessary by a contractor, a tack coat of emulsified asphalt cement may be placed between the Intermediate and Surface Wearing Course HMA layers during construction (APAI, 2007).

Table I.2: Thickness charts for layers of side path (APAI, 2007)

A. For Asphalt Concrete Base Pavements

Design Criteria*			Thickness in Inches Asphalt Concrete	
Traffic Class (ADT)	Subgrade Class	CBR	Surface	Total
I	Good	9	3.0	3.0
	Moderate	6	3.5	3.5
	Poor	3	4.0	4.0

B. For Untreated Aggregate Base Pavements

Design Criteria*			Thickness in Inches		
Traffic Class (ADT)	Subgrade Class	CBR	Untreated Aggregate Base	Hot Mix Asphalt Surface	Total
I	Good	9	4.0	2.5	6.5
	Moderate	6	4.0	3.0	7.0
	Poor	3	6.0	3.0	9.0

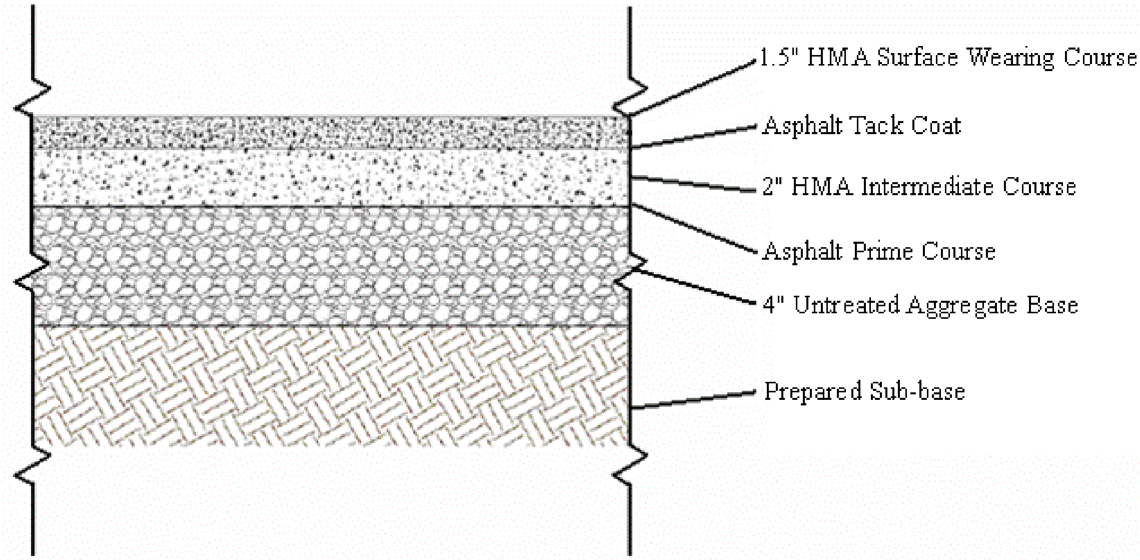


Figure I.4: Pavement layers for new shared-use side paths (Adapted from MHD, 2006)

To ensure structural stability of the shared-use side path, Urban Engineering will use structural number analysis to determine minimum thickness design in addition to APAI requirements. The support value of the soil is assumed to be 5.5, a very conservative estimate. Terminal serviceability is assumed to be 2.0 out of 5 due to sensitivity to small changes in pavement thickness that is experienced on the trail. A maximum of 10 ESAL will be assumed per day over a 15 year service life. The regional factor in Bloomington, IN is 1.0 (Figure I.1). Using these factors, a regionally adjust SN can be determined from the nomograph (Figure I.5). The required structural number is 1.8.

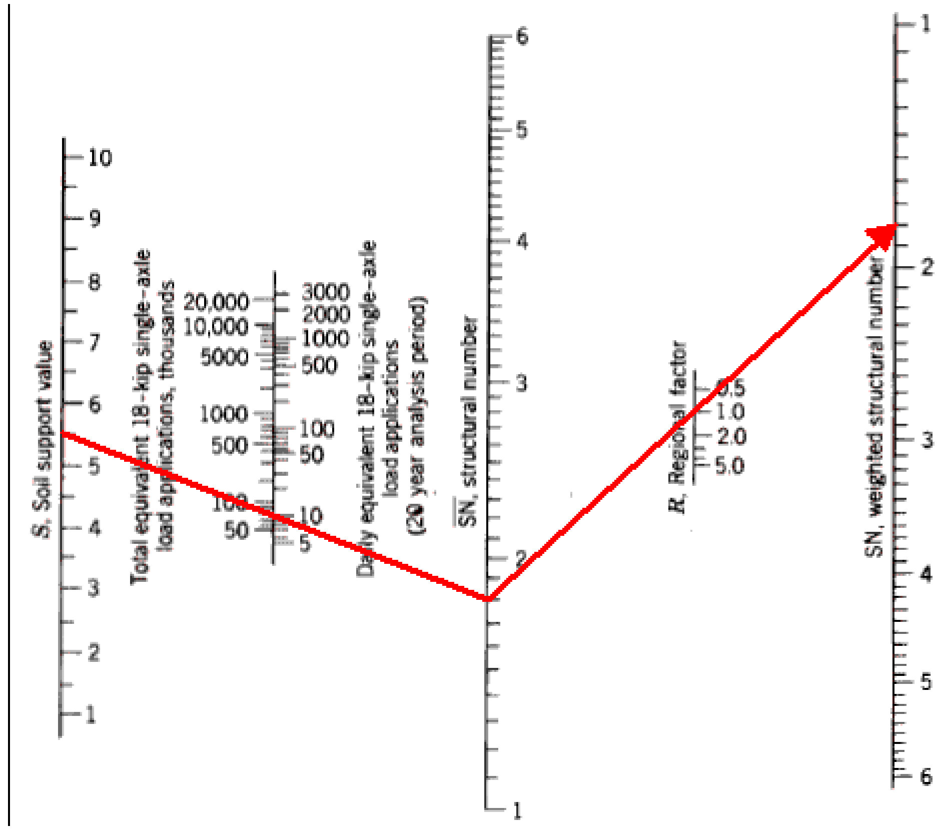


Figure I.5: Nomograph used to estimate SN for shared-use side paths (Adapted from MHD, 2006)

<u>Structural Number Comparison</u>

SN = 1.8

SN = a1*D1 + a2*D2 + a3*D3

Where

a1 = 0.44 (Hot-mix asphalt)	D1= 3.5 inches (HMA thickness)
a2 = 0.14 (Crushed stone base)	D2 = 4 inches (Crushed stone base thickness)
a3 = 0.11 (Sandy gravel subbase)	D3 = 0 inches (Sandy gravel subbase thickness)

SN = a1*D1 + a2*D2 + a3*D3 SN = 1.88

Appendix J - Signs and Signals

J.1 Signs and Signals Overview

Throughout the 10th Street Extension and Modernization project, traffic control devices such as signs and signals may need to be updated and new signs and signals may need to be placed in the course of construction. All signs and signals should conform to the Indiana Department of Transportation (INDOT) design manuals. These design manuals reference the Manual of Uniform Traffic Control Devices (MUTCD) as the basis of their standards for signs and signals (FHWA, 2003).

Proper signage and signaling is important not only to conform to legal standards for road and shared-use facilities, but also to ensure the safety of motorists and pedestrians using facilities within the project area.

INDOT standards state that all signs should be reflectorized (INDOT, 2005). Urban Engineering recommends reflectorized signs be placed throughout the project area to ensure motorist and pedestrian safety, as the corridors are main arterials through the area.

J.2 10th Street

Currently along 10th Street through the project area, there are signalized intersections at Woodlawn Avenue, Fee Lane, Jordan Avenue, Sunrise Drive, and Union Street. Within Urban Engineering's design for the 10th Street alignment, these intersections will remain signalized. In addition, Urban Engineering recommends that signals be placed at Walnut Grove Street, including semiprotected left turns. Proper signals and timing methods should be implemented according to the methods determined by the City of Bloomington.

If the client chooses the 10th Street widening alignment option (a two-way left turn only (TWLTO) lane is constructed along 10th Street), INDOT Standard 75-3.07 mandates that overhead lane control signs be placed at the beginning and the end of the TWLTO lane (INDOT, 2005). In addition, signs should be placed above the two way left turn lane approximately every 1000 feet. Urban Engineering recommends placement of overhead lane control signs at each signalized intersection, since the distance between each signalized intersection on 10th Street is approximately 1000 feet. The proper overhead TWLTO sign is designated as MUTCD Code R3-9a (FHWA, 2003).

J.3 Law Lane

Currently along Law Lane through the project area, the only signalized intersection is at Jordan Avenue. The intersection at Union Street is a three-way stop. After the Law Lane extension is built, Urban Engineering recommends that the Law Lane-Union Street intersection be signalized, including semiprotected left turns. Proper signals and timing methods should be implemented according to the methods determined by the City of Bloomington.

Along the Law Lane Extension, proper signage should be placed to ensure motorist safety. This signage should include speed limit signs (MUTCD R2-1) and advance warning signs for the roundabout (MUTCD W2-6) (FHWA, 2003).

J.4 Roundabout and Sidepaths

Roundabouts are not a common feature in American roadways. Many motorists may not be familiar with a roundabout and can become confused when encountering one. Therefore, it is imperative that proper signage be placed to ensure motorist safety. Proper signage around the roundabout is discussed in Appendix G.

Proper signage for the proposed sidepaths is discussed in Appendix L.

Appendix K - Pavement Markings

K.1 Pavement Marking Overview

The improvements to the 10th Street and Law Lane corridors will require updating existing pavement markings and developing new pavement markings. All the designed pavement markings come from Chapter 76 of the Indiana Department of Transportation (INDOT) Design Manual (INDOT, 2007). The INDOT Design Manual uses standards set out in the Manual of Uniform Traffic Control Devices (MUTCD) for its pavement markings section. Both manuals are very specific in the use and location of pavement markings, as well as the type of and size of the markings that should be used. Marking color and texture is also specified in the manuals. Urban Engineering will make sure that the 10th Street and Law Lane corridors adhere to the specifications set forth in both manuals.

Some areas of the 10th Street and Law Lane corridors will need to be completely repainted after resurfacing and realigning of the roadways are complete, and other areas will just need a repainting of existing markings. Properly laid out pavement markings provide motorists with important information about upcoming intersections and the roadway itself that will help keep them safe. The markings are applied to the roadway with paint that weathers well, and more importantly, is easy to see in the daytime and at night.

Urban Engineering advises that the City of Bloomington utilize thermoplastic paint that meets INDOT (2007) Section 76-3.01 for all its pavement markings. The thermoplastic paint shows up well and is commonly used. White and yellow thermoplastic paint will be use in the corridor, with any words or symbols on the pavement being white in color and normally eight feet high. The message the words are conveying should be read “up” so that the first word of the message is the first word a motorist would see as shown in INDOT (2007) Section 76-2.03(05). Figure K.1 shows typical pavement markings for all the intersections along 10th Street and Law Lane. Yellow thermoplastic paint will be used for centerline markings.

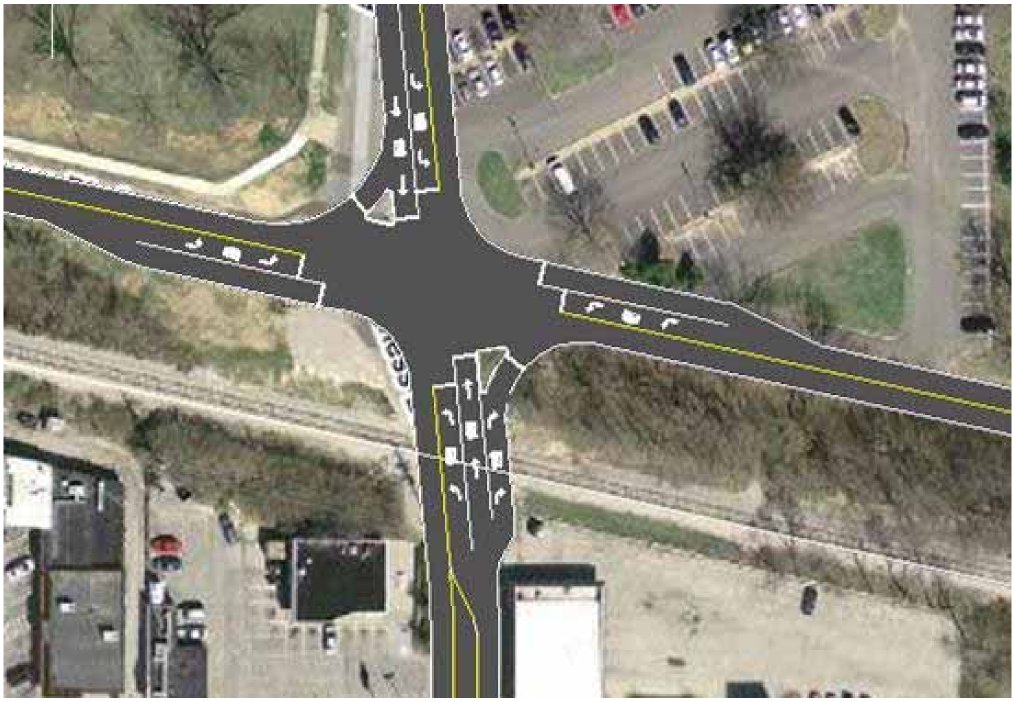


Figure K.1: Image of the pavement markings at the intersection of Law Lane and Union Street

K.2 Mainline Pavement

The mainline 10th Street and Law Lane will both require center and edge lines. The centerline for both 10th Street and Law Lane will need a solid double yellow center line in accordance with INDOT (2007) Section 76-2.01(01). Section 76-2.01(01) also requires that centerlines be placed four inches on either side of the longitudinal joint that runs down the center of the road. This spacing will allow the joint to be sealed without covering the paint. The centerlines should not cross intersections with other roads, but they can continue in front of business or residential drives. INDOT (2007) Section 76-2.02(03) requires that the actual double yellow centerlines be four inch wide solid yellow, reflectorized lines with an eight inch gap between the two lines.

The edge lines of 10th Street and Law Lane should adhere to INDOT (2007) Section 76-2.01(03). Section 76-2.01(03) requires that edge lines be four-inch wide, solid white reflectorized lines. Since 10th Street and Law Lane will both be curbed streets, the edge lines should be approximately four inches from the longitudinal construction joint along the edge of the road. Creating a four-inch gap between the joint and the edge line will allow the joint to be sealed without covering the paint.

K.3 Turn Lanes

Turning lanes at the intersections along 10th Street and Law Lane will have a minimum downstream taper of fifty feet in accordance with INDOT (2007) Section 76-2.01(06). The turn lanes will have a solid yellow reflectorized line for the tapered line, and a solid white reflectorized lane separating the turn lane from the travel lane. Both line types should be four inches wide as specified INDOT Section 76-2.02(03). Turn lanes should be marked with INDOT Standard Drawing No. E808-MKPM-02 which is a turn arrow, and where applicable with INDOT Standard Drawing No. E 808-MKPM-02 with the word ONLY where a lane is left or right turn only. The instances where the word ONLY should be used are discussed in INDOT Section 76-2.03(05), which states that when a movement that would normally be legal is prohibited, a turn arrow must be accompanied by the word ONLY.

K.4 Intersection Markings

INDOT (2007) Section 76-2.03(01) specifies stop lines at intersections. The stop lines should be solid white, reflectorized lines that are twenty-four inches wide. The line shall extend across all approach lanes all the way to the center lines. To ensure pedestrian safety, the stop lines should be placed four feet before all crosswalks.

Crosswalks at intersections shall be solid white, reflectorized lines that are not less than six inches wide. The space between the lines should not be less than six feet and should encompass all curb ramps.

Any special markings such as the word STOP or turning arrows at an intersection should be approximately twenty feet from the spot where traffic stops.

K.5 Railroad Crossings

The railroad crossing marking should be not less than fifty feet from the railway according to INDOT (2007) Section 76-2.05(01). The railroad markings should follow the specifications displayed in INDOT Standard Drawing No. E 808-MKPM-07.

Appendix L - Sidepaths

L.1 Shared Use Path Overview

Urban Engineering recognizes the requirement for safe, convenient and well-designed bicycle and pedestrian facilities that will encourage bicycle use as a means of transportation. The intent of this shared use path implementation is to provide a suitable environment for bicyclists and pedestrians to travel on while being consistent with the community's long range transportation plan. The project scope contains many roadways that have little or no bicycle plan in place. The aim of Urban Engineering's plan is to develop a bicycle pathway design for the City of Bloomington to enhance facilities throughout the Indiana University (IU) campus.

Many factors, such as user skill level, barriers, accessibility, aesthetics, personal safety, maintenance, pavement quality, truck and bus traffic, traffic volumes and speeds, intersection conditions, cost, and ordinances, should be considered in determining the appropriate bicycle facility. 10th Street, the main focus of the project, is classified as an urban arterial, meaning it is a principal avenue carrying high volumes of traffic including commercial vehicles. Taking into account lane width, number of lanes and speed limits, Urban Engineering considered the type of user that could be expected and the level of access and mobility to bicyclists that could be afforded throughout the corridor. In choosing the best facility, Urban Engineering decided that a shared use path will be the most beneficial alternative. Given the right-of-way that these corridors provide and the utilities currently in place, it will be very difficult to widen the roadways to provide roadway bicycle paths. A shared use path offers opportunities not provided by the roadway. Shared use paths appealed to this project for many reasons, including the ability to provide recreational opportunities and enhanced safety through separation from motor vehicle traffic. A shared use path will also serve as a direct commute route to jobs and school on a college campus that experiences heavy volumes of motor vehicles and pedestrians. Shared use paths also offer many benefits and security to pedestrians, joggers, dog walkers and skaters.

The American Association of Highway and Transportation Officials Guide for the Development of Bicycle Facilities (AASHTO, 1999) was used in the design of all aspects of the shared use paths here discussed.

L.2 Shared Use Path Design

The shared use paths on 10th Street and Law Lane should be thought of as a complimentary system to the roadway network. Planning considerations for design of the shared use paths must meet designated standards and specifications. Bicyclists require at least forty inches of essential operating space based solely on their profile. Therefore, a minimum spacing of four feet is assumed for any facility designed exclusively for bicyclists. However, for safety and convenience, especially in areas experiencing heavy volumes of motor vehicle or pedestrian traffic, a more comfortable operating space of five feet is more desirable (AASHTO, 1999). Given that 10th Street and Law Lane experience pedestrian, bicycle, and motor vehicle traffic, Urban Engineering has decided to provide the side path with five feet of bicycle operating space in addition to five feet of space that is available to pedestrians for a total of ten feet as is the recommended width for two-directional shared use paths. As seen in Figure 17 of the AASHTO (1999) Bike Guide (Figure L.1), the ten feet of pavement will have a cross slope of two percent and be bordered on both sides by a minimum of two feet of grassy area with a maximum grade of 1:6. There is an additional one to four feet of clear area between the edge of the graded area and any obstacles. As the path goes under the overpass, there will be a spacing of three to six feet between the edge of the trail and the shear wall so that wall will not be a hazard to bicyclists and pedestrians on the path. The six feet of spacing between obstacles will also be used in other areas where trees or other obstacles such as poles are around. The minimum clearance for bicyclists is eight feet, so the fourteen feet of clearance that the overpass will have is sufficient.

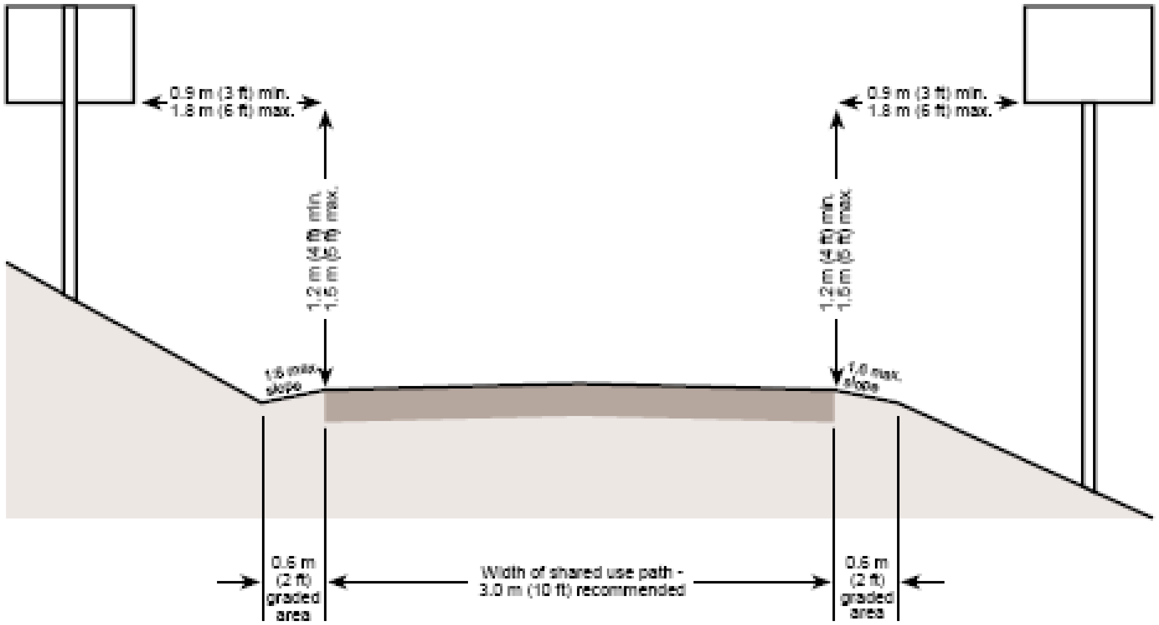


Figure L.1: Cross Section of the shared use path. (Adapted from Figure 17, AASHTO 1999)

L.2.1 Horizontal Alignment Design

When bicyclists make turns, they must lean into the turn to perform the maneuver safely. AASHTO uses, a 15º to 20º lean angle during the design of the horizontal alignments. Using a design speed of 20 mph, a 15º lean angle, and Table 1 of the AASHTO Bike Guide, the minimum radius for a curve is one hundred feet.

Table L.1: Table 1 of the AASHTO Bike Guide

Table 1. Desirable Minimum Radii for Paved Shared Use Paths Based on 15° Lean Angle

Design Speed (V)		Minimum Radius (R)	
km/h	(mph)	m	(ft)
20	(12)	12	(36)
30	(20)	27	(100)
40	(25)	47	(156)
50	(30)	74	(225)

Vertical curves on a shared use path are important for bicyclists because they need proper distance to see any obstructions after a crest curve and because an improperly designed shared-use path can leave a bicyclist or pedestrian on a roller-coaster type trip. The lengths of vertical curves are determined from the stopping sight distance and the algebraic differences in grade when a positive and negative grade meet. Stopping sight distance is determined from the equation:

$$S = \frac{V^2}{30(f +/- G)} + 3.67 * V$$

Where
S=Stopping Sight Distance
V=Velocity
f=Coefficient of Friction (0.25)
G=Grade

Using a design velocity of 20 mph and our grade of 2%:

$$S = \frac{20^2}{30(0.25 + 0.02)} + 3.67 * 20$$
$$S = 131.37 ft$$
$$S = 132 ft$$

The minimum length of a crest vertical curve is determined from Table 3 of the AASHTO (1999) Bike Guide (Table L.2). Stopping sight distance and the algebraic difference in grade are required. Using the stopping sight distance of one hundred thirty-two feet from above, the algebraic difference necessary to need a vertical curve is four percent. No where along the 10th Street or Law Lane shared use paths is there a difference of greater than four percent, so vertical curves will not be needed.

Table L.2: Table 3 from the AASHTO Bike Guide.

Table 3. English Units. Minimum Length of Crest Vertical Curve (L) Based on Stopping Sight Distance

A	S = Stopping Sight Distance (ft)														
(%)	20	40	60	80	100	120	140	160	180	200	220	240	260	280	300
2												30	70	110	150
3								20	60	100	140	180	220	260	300
4						15	55	95	135	175	215	256	300	348	400
5					20	60	100	140	180	222	269	320	376	436	500
6				10	50	90	130	171	216	267	323	384	451	523	600
7				31	71	111	152	199	252	311	376	448	526	610	700
8			8	48	88	128	174	228	288	356	430	512	601	697	800
9			20	60	100	144	196	256	324	400	484	576	676	784	900
10			30	70	111	160	218	284	360	444	538	640	751	871	1000
11			38	78	122	176	240	313	396	489	592	704	826	958	1100
12		5	45	85	133	192	261	341	432	533	645	768	901	1045	1200
13		11	51	92	144	208	283	370	468	578	699	832	976	1132	1300
14		16	56	100	156	224	305	398	504	622	753	896	1052	1220	1400
15		20	60	107	167	240	327	427	540	667	807	960	1127	1307	1500
16		24	64	114	178	256	348	455	576	711	860	1024	1202	1394	1600
17		27	68	121	189	272	370	484	612	756	914	1088	1277	1481	1700
18		30	72	128	200	288	392	512	648	800	968	1152	1352	1568	1800
19		33	76	135	211	304	414	540	684	844	1022	1216	1427	1655	1900
20		35	80	142	222	320	436	569	720	889	1076	1280	1502	1742	2000
21		37	84	149	233	336	457	597	756	933	1129	1344	1577	1829	2100
22		39	88	156	244	352	479	626	792	978	1183	1408	1652	1916	2200
23		41	92	164	256	368	501	654	828	1022	1237	1472	1728	2004	2300
24	3	43	96	171	267	384	523	683	864	1067	1291	1536	1803	2091	2400
25	4	44	100	177	278	400	544	711	900	1111	1344	1600	1878	2178	2500

when $S > L$ $\quad L = 2S - \dfrac{900}{A}$

when $S < L$ $\quad L = \dfrac{AS^2}{900}$

Height of cyclist's eye – 4 1/2 ft
Height of object – 0 ft

Shaded area represents S = L

L – Minimum Length of Vertical Curve (ft)
A – Algebraic Grade Difference (%)
S – Stopping Sight Distance (ft)

Minimum Length of Vertical Curve – 3 ft.

L.3 10th Street Shared Use Path

The 10th Street shared use path will run parallel to and south of 10th Street (Figure L.2). The shared used path will be located between an existing tree line and a rock wall that borders the nearby field. The location of these obstacles will require three to six feet of open space on both sides of the path to ensure safety to those using the shared use path. A typical cross section for the shared use path along 10th Street can be seen in Figure L.3.

Figure L.2: Topographic view of the 10th Street shared use path. (Adapted from Google Maps, 2007)

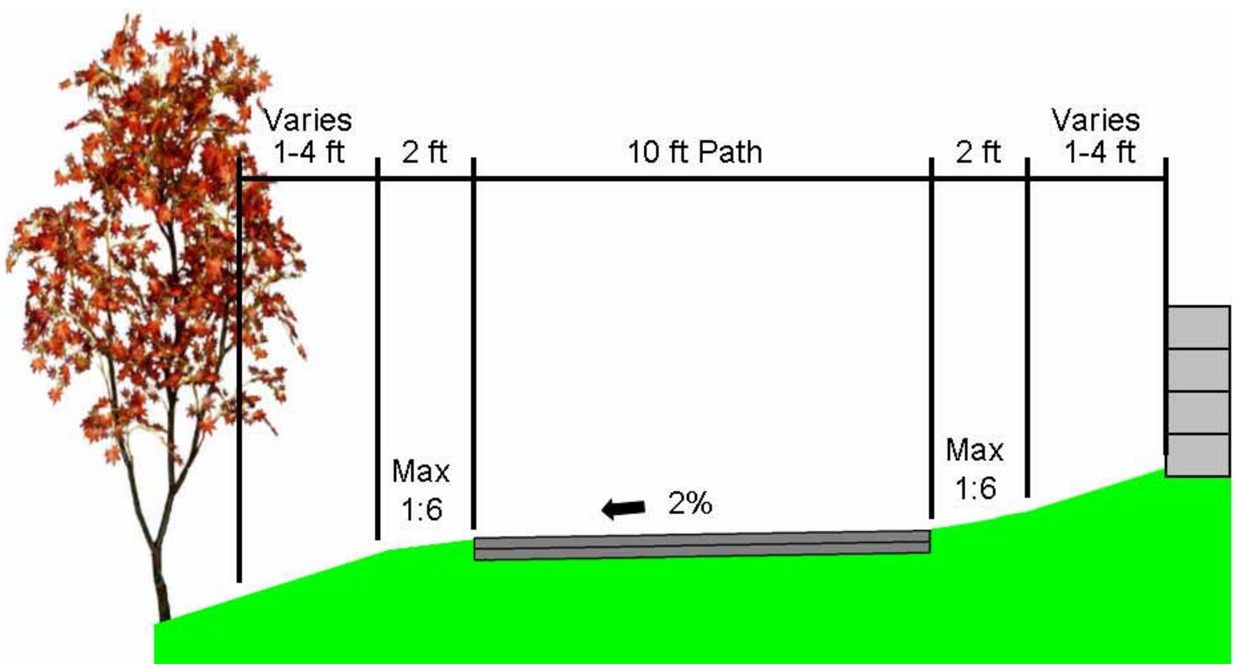


Figure L.3.: A typical layout for the shared use path along 10th Street.

As the shared use path heads east from Woodlawn Avenue to Union Street, it will cross Jordan Avenue, Campbell Street, Sunrise Drive, Union Street, and Jefferson Street (Figure L.2). Shared use paths present complications at intersections because motorists and bicyclists are often unaware of each other. To keep both parties safe, Urban Engineering recommends that adjacent path crossings (Figure L.4) be used to provide bicyclists and motorists easiest recognition of each other.

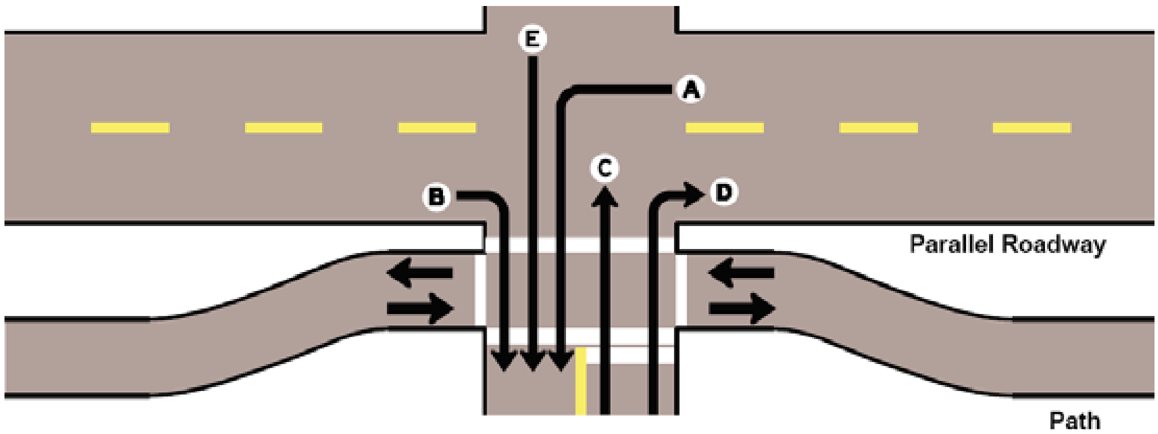


Figure L.4: Example of Adjacent Path Crossing (AASHTO, 1999).

Adjacent Path Crossings experience potential conflicts from several different motorist movements (A through E). Turning movement Type A may require prohibiting permissive left turns for heavy volume roadways or heavy use path crossings. Turning movement B may require an intersection with greatly reduced turning radii to reduce speeds of motor vehicles. Movements C and D incite prohibition of right-turns-on-red and a stop bar in advance of the path crossing. Turning movement E may require an all-red signaling phase to allow time for path users to cross the intersection. Both sides of the shared use path intersection will have American with Disabilities Act (ADA) approved tactile strips to warn bicyclists and pedestrians with sight problems that they have reached an intersection.

Considering the amount of traffic likely to be seen at intersections along the pathways and intended use of the path, the design speed should be suitable to provide bicyclists and pedestrians the most security possible. The intersections of the shared use path and roads will be marked along each route as described in Section L.6. Bicyclists will come to a stop sign at each intersection. Motorists will be alerted to an upcoming intersection with a shared use path with a signals and signage as described in Section L.6.

L.4 Law Lane Shared Use Path

The shared use path along Law Lane (Figure L.5) will be to the south of Law Lane running parallel to the railway in a joint effort with the Indiana Railroad Company who will allow the shared use path to be built on its right-of-way. As the shared use path heads east from Fee Lane, it will cross Jordan Avenue, Union Street, and 10th Street. To ensure pedestrian and bicyclists safety, Urban Engineering recommends that adjacent path crossings (Figure L.4) be used to provide bicyclists and motorists easiest recognition of each other.

Figure L.5: Topographic view of the Law Lane shared use path. (Adapted from Google Maps, 2007)

The Law Lane shared use path will be marked with signage and pavement markings like the 10th Street path and both sides of the shared use path intersection will have ADA approved tactile strips to warn bicyclists and pedestrians with sight problems that they have reached an intersection.

L.5 Combining the Shared Use Paths

The Law Lane and 10th Street shared use paths will be joined together south of the roundabout (Figure L.6). Joining the two paths will require pavement markings and signage and signals to signal users that they need to be more alert to other users on the trail as described in Section L.6.

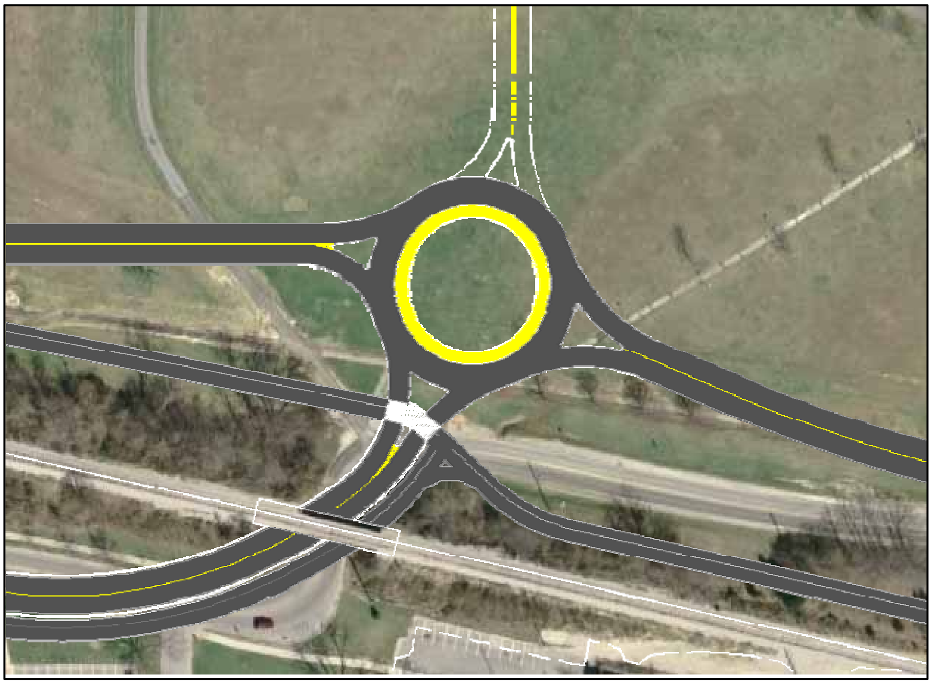


Figure L.6: View of the 10th Street and Law Lane shared use paths joining south of the round-about. (Adapted from Google Maps, 2007)

L.6 Shared Use Path Pavement Markings and Signage

Pavement markings and signage are as important to shared use paths as they are to roadways. The AASHTO (1999) Bike Guide refers to Section 9B of the Manual on Uniform Traffic Control Devices (MUTCD, 2007) for guidance on the placement, size, and usage of both markings and signage for shared use paths.

Pavement markings should be used to alert bicyclists of intersections of a shared use path and a road. Like roadways, shared use paths should be marked with four inch white reflectorized edge lines and four inch yellow reflectorized center lines. Lines should be reflectorized to better show up at night and in the early morning when the path will be used.

At intersections with roads, shared use paths should alert bicyclists that they need to come to a complete stop and look for oncoming traffic. Stop signs and stop bar markings should be placed at the intersection. Stop signs should be twelve inches to twenty-four inches wide and placed at least four feet before the crosswalk line. Stop signs and other route marking, and street name signs should be three to six feet from the edge of the path as shown in Figure 17 of the AASHTO (1999) Bike Guide (Figure L.1). Also, the bottom of the sign should be at a height of four or five feet from the top of the path.

Care should be taken to give motorists warning of the intersection of shared use paths and roads. A bicycle crossing sign should be placed along the road in advance of the actually crossing in a spot where it can be seen by motorists. Guidance on the advance distance from the sign to the intersection comes from the MUTCD Table 2C-4 (MUTCD, 2007). The MUTCD gives no recommendations for advance distance for the design speeds of 30 mph for the roadways and 20 mph for the shared use path other than the signs for each intersection will depend on the site conditions and obstructions along the roadway such as trees and other signs. The signs should be placed fifty-five feet before the intersections in a location that makes them easy to see without entering the clear zone along both sides of the shared use path.

M.1 Overpass Construction Overview

The railroad overpass on 10th Street is a large contributor to the congestion that occurs along 10th Street. Currently, the overpass has narrow travel lanes and a sharp S-curve that run underneath it which makes it difficult for passenger cars to use and impossible for some emergency and public transport vehicles to use. The S-curve causes traffic to slow down in order to make the turn without striking the support piers. The structure itself has been hit so many times that the support piers have deteriorated (Figure M.1). The City of Bloomington and Indiana University (IU) cannot purchase articulated buses because articulated buses cannot pass below the low clearance at the overpass.

Figure M.1: View of the current condition of the overpass on 10th Street.

To rectify these problems, Urban Engineering recommends increasing the radius of 10th Street as it goes under the railroad to meet the improved standards as shown in Appendix F, Section 1.2**.** In addition to increasing the radius, Urban Engineering proposes a complete replacement of the overpass structure. Replacing the overpass presents a challenge because the railway operates approximately four trains daily and the railroad company has expressed concern about any lengthy shutdown.

The replacement of the overpass will require that the Law Lane extension and roundabout to the north of the overpass be already completed. 10th Street will be closed from Union Street to the roundabout throughout construction of the overpass. While vehicular traffic can be rerouted through the Law Lane extension and the new roundabout, maintaining the capability for railroad traffic requires more planning and coordination. To accomplish this task, the removal of the existing structure and the assembly of the new structure will require that the work be completed over several weekends.

Urban Engineering proposes that the new structure be a prefabricated steel unit that is designed to serve the railway and all its future needs. The steel structure will allow the existing middle pier of the overpass to be completely removed, which will aid in the realignment of 10th Street and allow the curve radius under the overpass to be increased. The basis for the construction phasing in this appendix comes from the Federal Highway Administration's Prefabricated Bridge Elements and Systems webpage (FHWA, 2006). Actual implementation of this plan will require the review and planning by professional engineers.

Construction phasing will be critical for the success of the overpass replacement, because it will impact the length of shutdown and the subsequent loss of time and money to the local businesses and the railroad company. In order to minimize shutdown and maximize efficiency, construction will take place over several forty-eight to seventy-two hour periods when railroad traffic is the lightest.

M.2 Phase One: Pier Construction and Overpass Reinforcing

The first phase of the overpass construction will involve the construction of the piers (Figure M.2). The piers will need to be designed to accommodate the weight of the trains that use it daily and also the weight of the structure itself. The construction crews will need to drill to bedrock so that the piers have sufficient strength to support the calculated loads they will experience. Upon reaching bedrock, construction crews will build formwork and place reinforcing steel in the holes to give the piers strength. Once the reinforcing steel and formwork are in place, concrete can be placed and allowed to cure.

While the piers are being built, the overpass can simultaneously be reinforced with temporary supports (Figure M.3). The temporary supports will be necessary for the structure because phase three of construction will involve the removal of the earth behind both ends of the existing abutments (Figure M.4) to allow for the installation of temporary railroad tracks at both ends of the overpass. The removal of the earthen support on both ends of the overpass would leave the structure weak, thus the installation of the temporary supports is necessary. Like the piers, the temporary supports will need to be designed to support the load of the trains and the overpass structure.

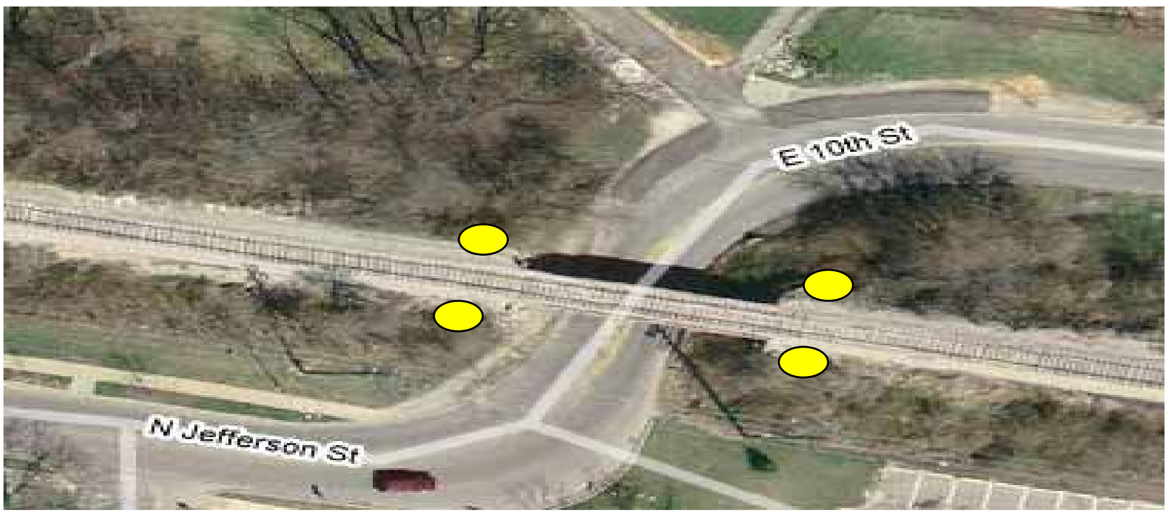


Figure M.2: Image of the piers that would be constructed during phase one of the overpass construction. (Adapted from Google Maps, 2007)

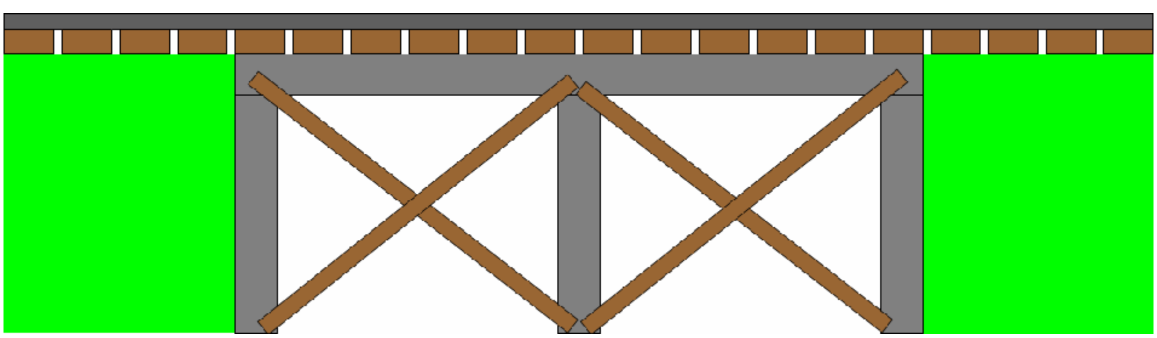


Figure M.3: Image of the temporary overpass supports that would be constructed during phase one of the overpass construction.

M.3 Phase Two: Temporary Overpass End Rail

Removing the entire overpass and installing the new prefabricated structure all at one time will require the shutdown of the railway. To avoid this, Urban Engineering proposes the lengthening of the overpass be done before the major deconstruction of the overpass. Lengthening the overpass will require that the bridge be shut down for as long as needed. During the shutdown, crews will remove the rail from one existing abutment back to where the prefabricated structure will join the existing rail (Figure M.4). Then the ground where the rail used to be will be excavated down to roughly the level it needs to be at for the future elevation of 10th Street. Once the excavation is complete, temporary tracks and supports will be installed so that the railway can be used throughout the following week (Figure M.5). This process will then be repeated for the other end of the overpass the following week during that shutdown (Figure M.6).

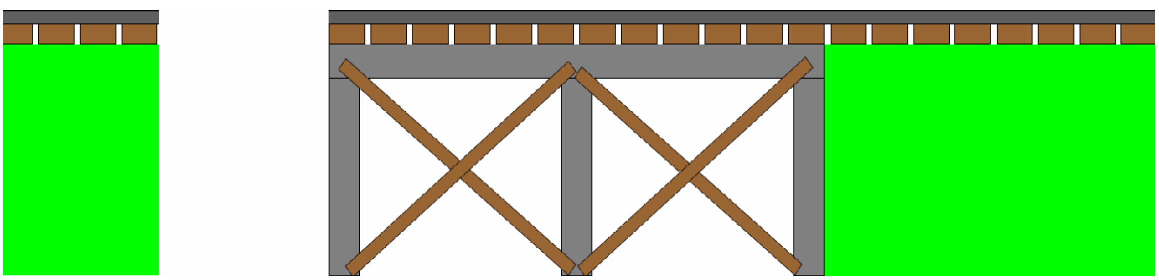


Figure M.4: Image of the overpass after the existing rail and earth embankment have been removed.

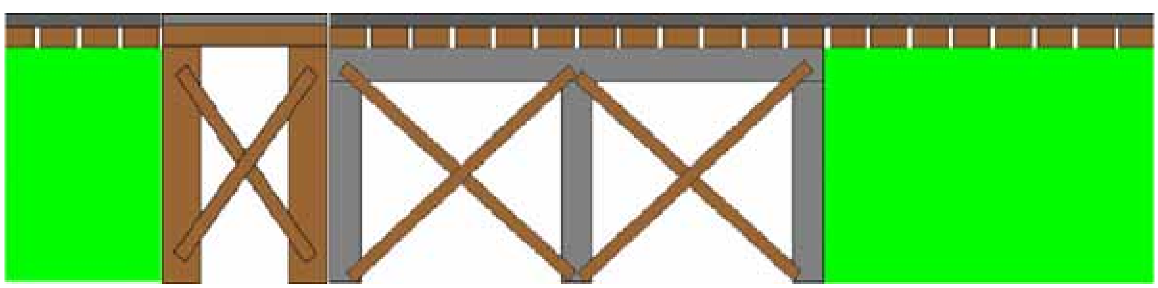


Figure M.5: Image of the overpass after the temporary supports and temporary rail have been installed on one side.

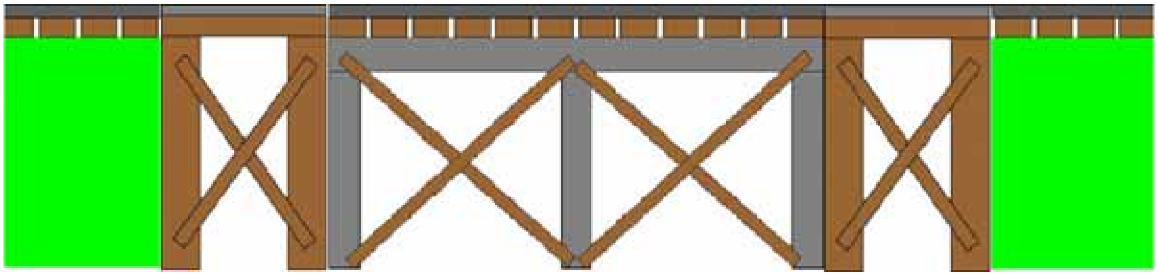


Figure M.6: Image of the overpass after temporary supports have been installed on both ends of the overpass.

M.4 Phase Three: Prefabricated Structure Construction

The prefabricated overpass will most likely not be able to be transported to the site in one piece, so Urban Engineering proposes that the overpass be assembled on-site in the field to the north of the overpass (Figure M.7). Assembling the overpass in the field during the week will allow the structure to be hoisted into place by a team of cranes after the bridge has been demolished. Utilizing the south field will not be an option because of the power lines that run parallel to the railway on the southern border. The north field, which is owned by IU, will require the traffic on Law Lane to be stopped while the structure was being moved over Law Lane. To avoid causing major traffic congestion on Law Lane, Urban Engineering advises that the placement of the structure take place during hours that experience the lightest amount of traffic.

Figure M.7: Image of the location north of 10th Street where the prefabricated structure would be assembled. (Adapted from Google Maps, 2007)

M.5 Phase Four: Overpass Removal and New Structure Placement

Demolishing the overpass and installing the new structure is the most crucial part of the construction process because it might cause the railroad to be shut down for more than forty-eight hours. The existing overpass will need to be completely out of the way before the new structure can be put in place. To remove the overpass, construction crews will first need to remove the temporary rail (Figure M.8) and supports that were put in place during phase two of construction. Also, they will need to break down the temporary supports that had been placed under the overpass in phase one (Figure M.2). Once all the temporary supports have been removed, the demolition of the overpass can begin. The means of demolition will have to take into account the power lines to the south of the overpass, and should ultimately be decided upon by licensed engineers.

As soon as the overpass is removed, the new structure can be picked by a team of two cranes and moved into place. The new structure will then need to be anchored to the piers from phase one (Figure M.9). Upon successful inspection of the new structure, the new overpass can be opened to railroad traffic (Figure M.10). The construction of 10th Street under the overpass could then take place as discussed in Appendix P.

Figure M.8: Image of where the overpass would be removed during phase four of construction. (Adapted from Google Maps, 2007)

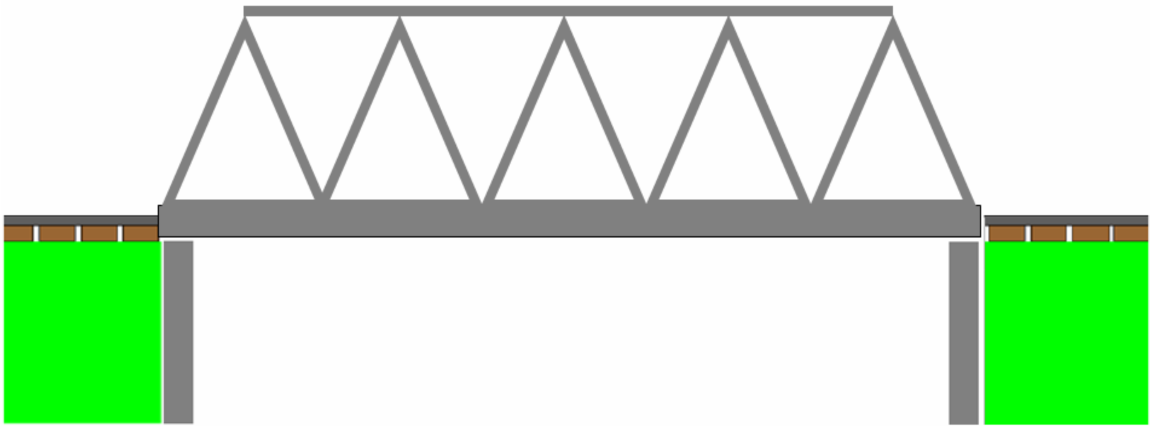


Figure M.9: View of what the final overpass could look like after final construction

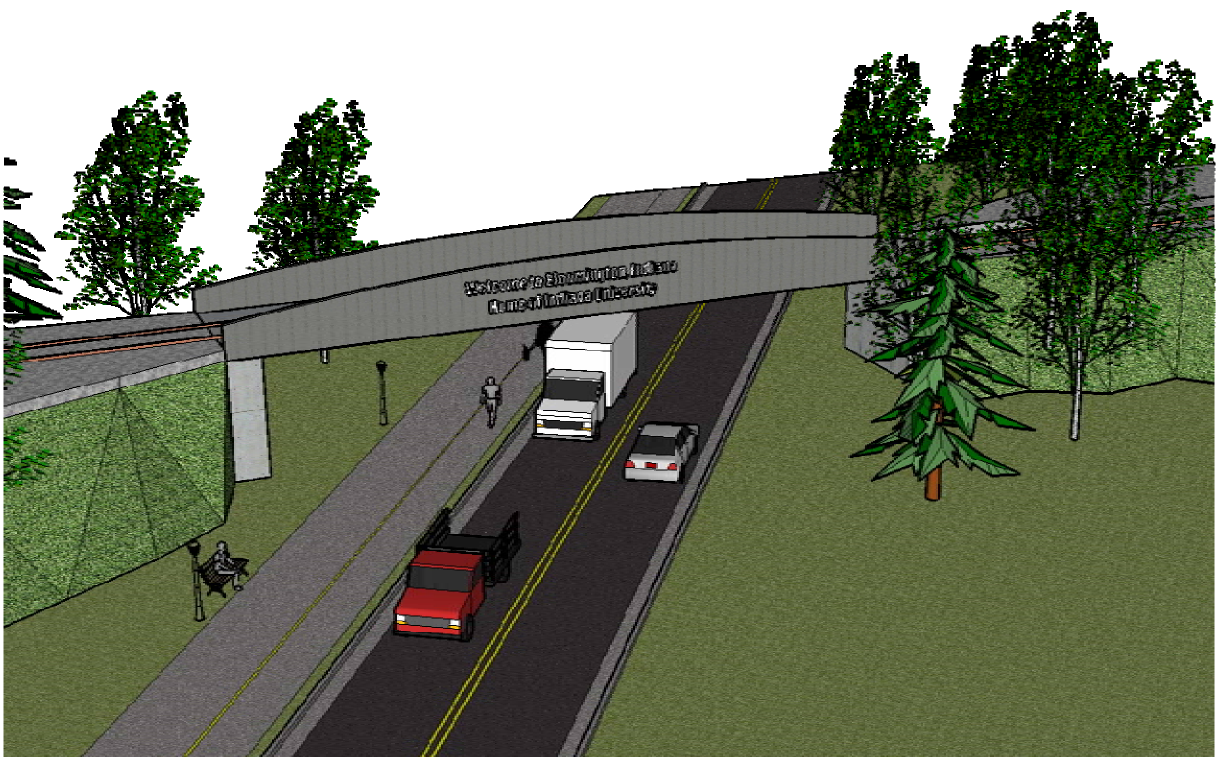
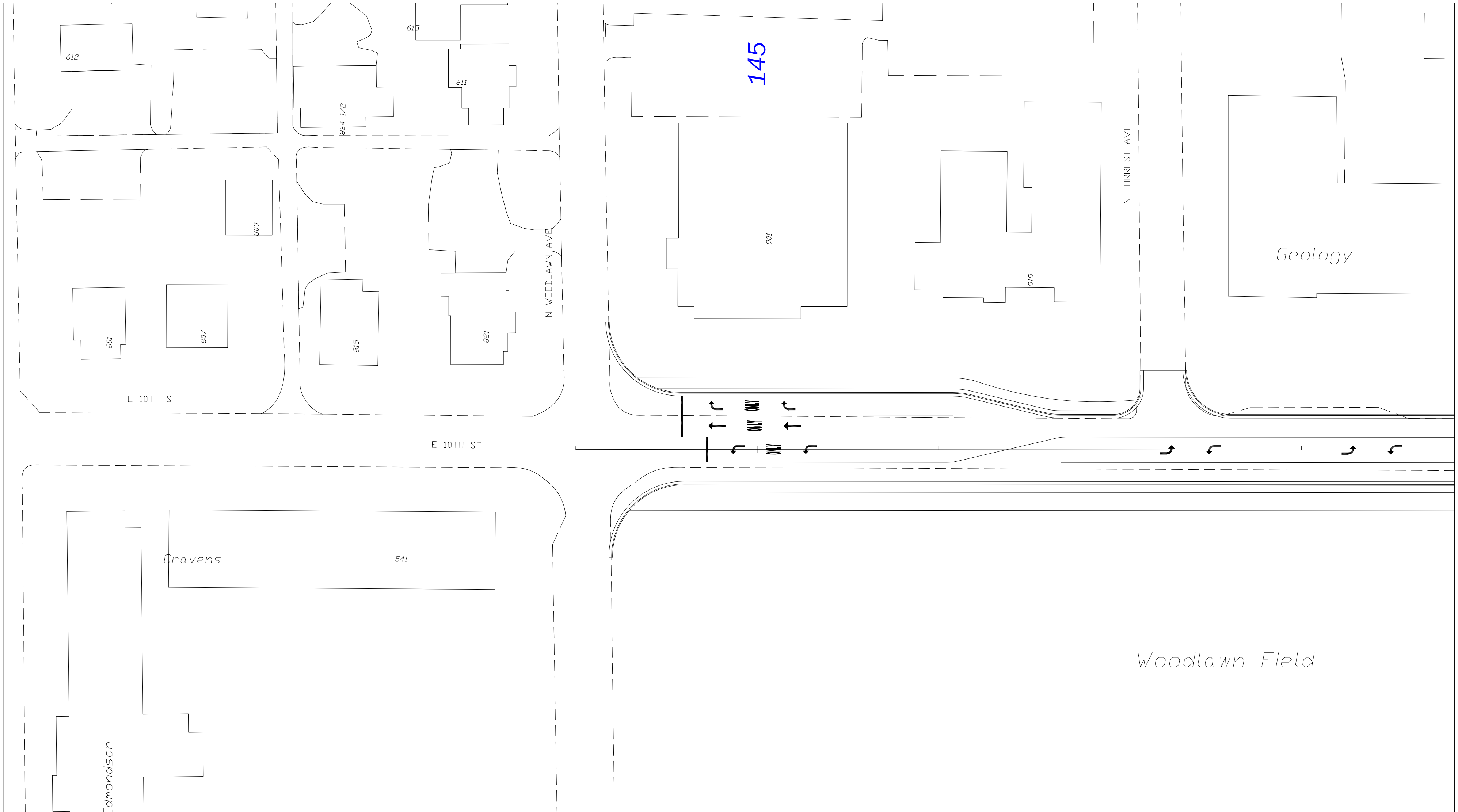
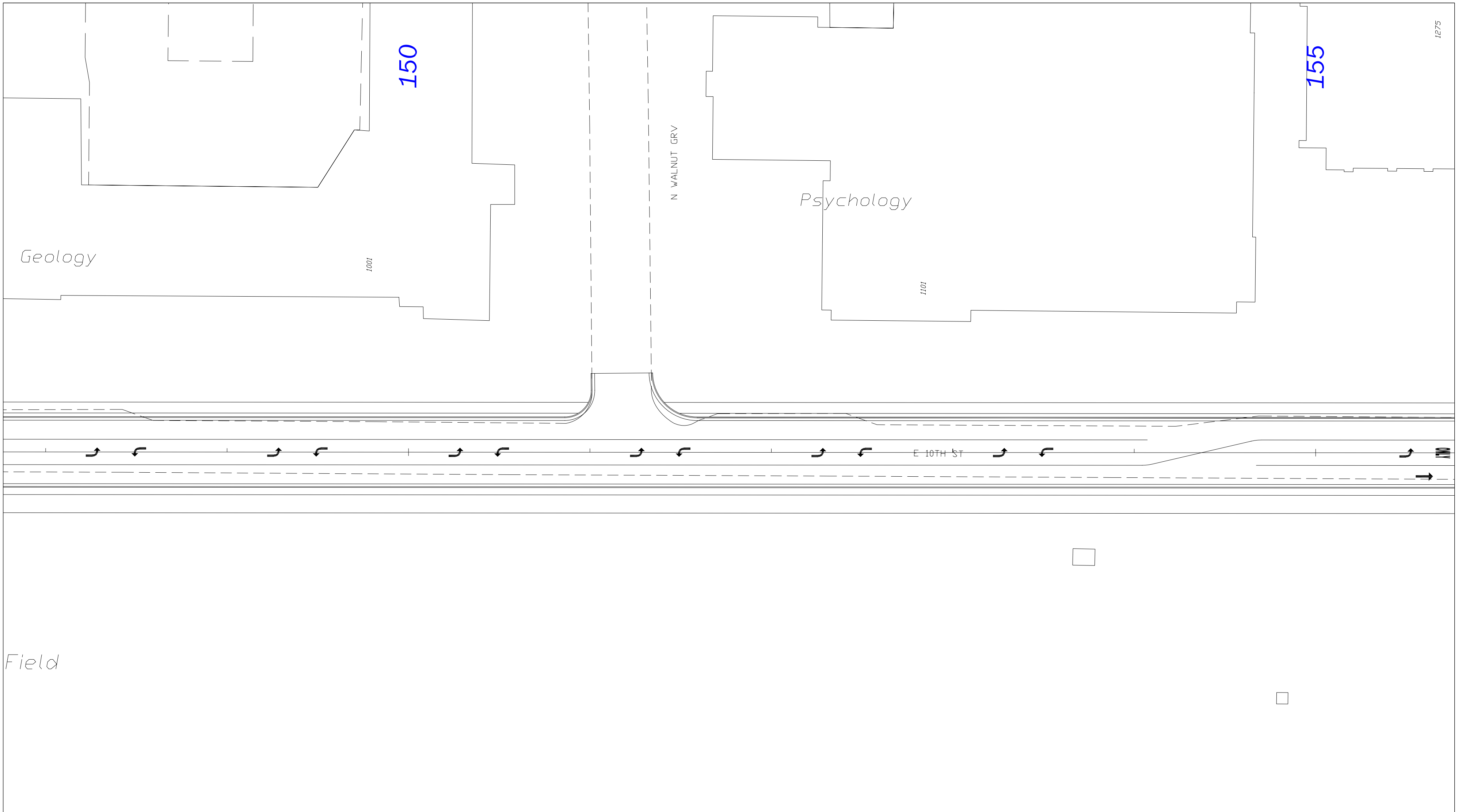


Figure M.10: A 3D rendering of the overpass after construction is completed.



10th Street Alignment - Widening	Designed By: TMS	Drawn By: TMS	Horizontal Scale: 1" = 50'
	Checked By: RDA	Checked By: RDA	Vertical Scale: N/A
STA 144 to STA 148	Date: 01/20/07	Date: 03/28/07	Figure: N.1

Appendix N



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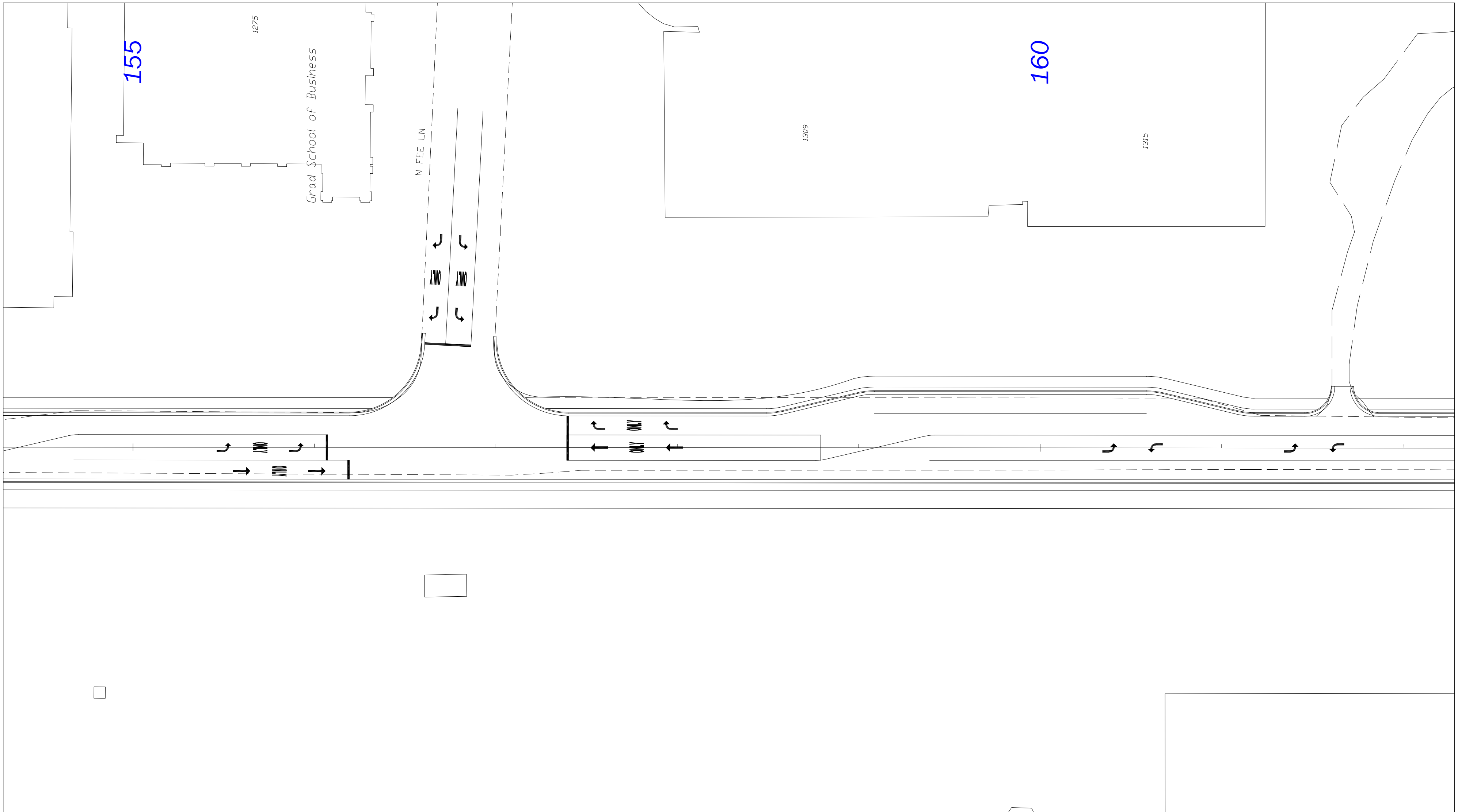
Appendix N



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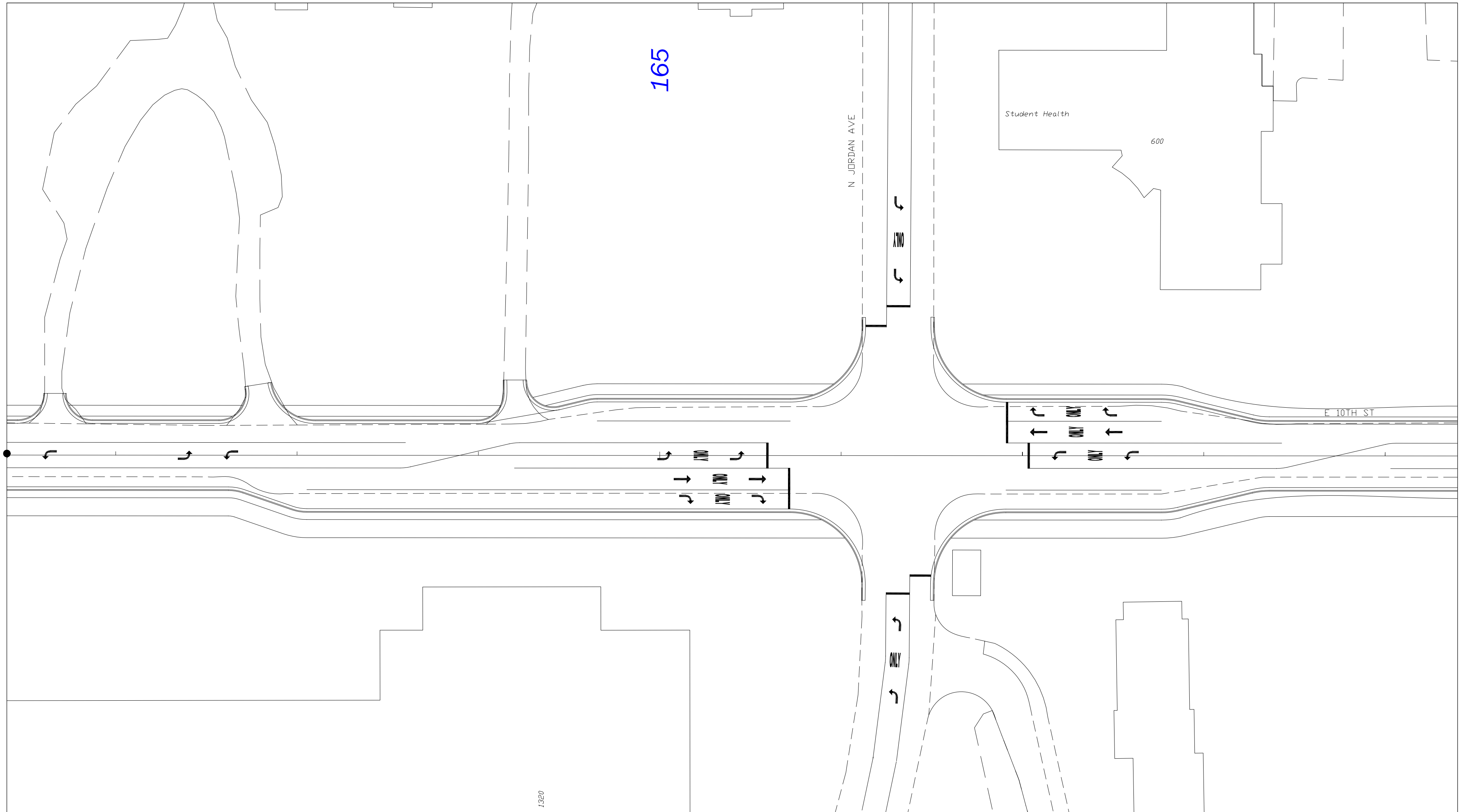
Appendix N



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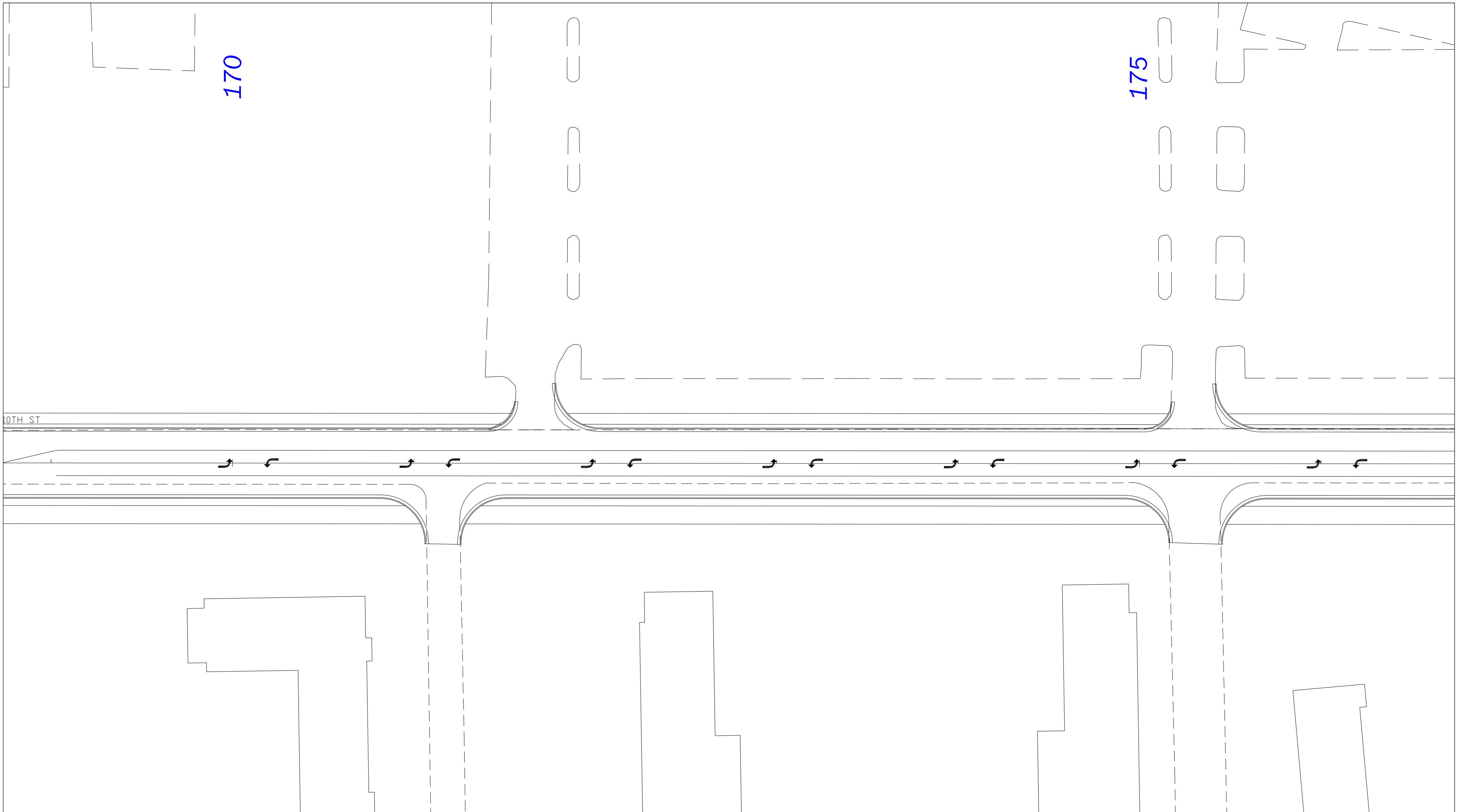

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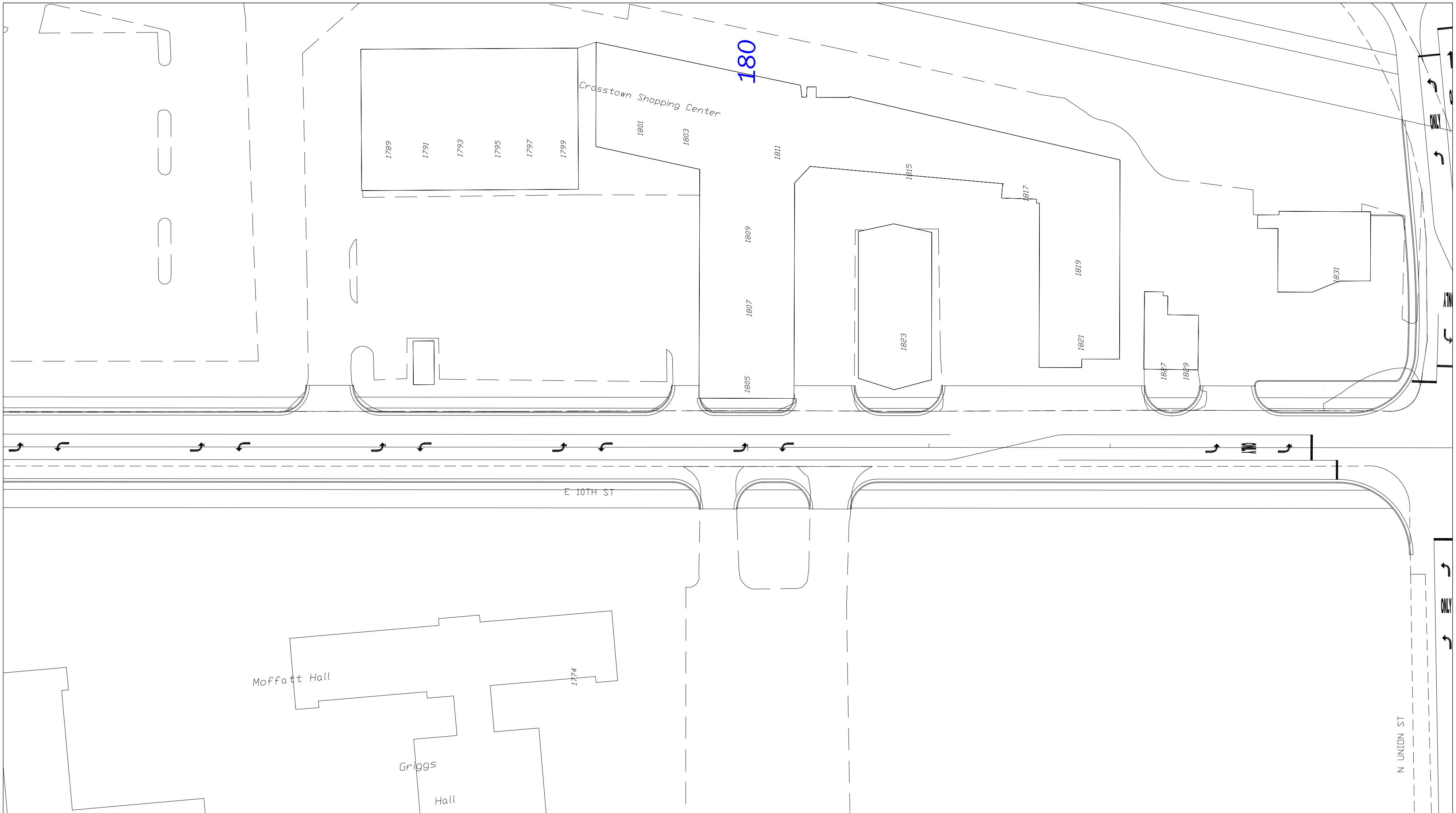
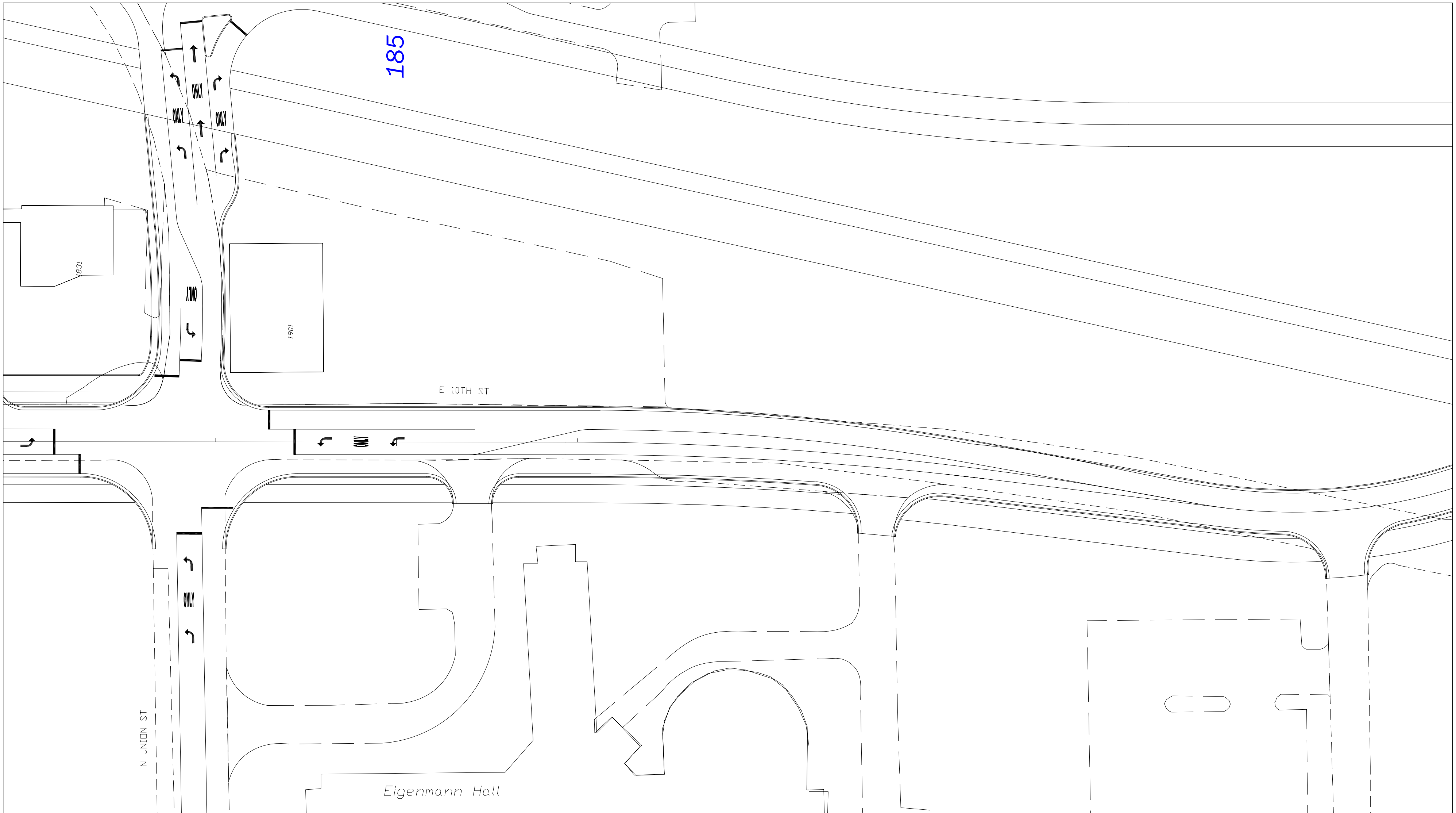
STA 169 to STA 176	Checked By: RDA	Checked By: RDA	Vertical Scale: N/A
	Date: 01/20/07	Date: 03/28/07	Figure: N.5

Appendix N



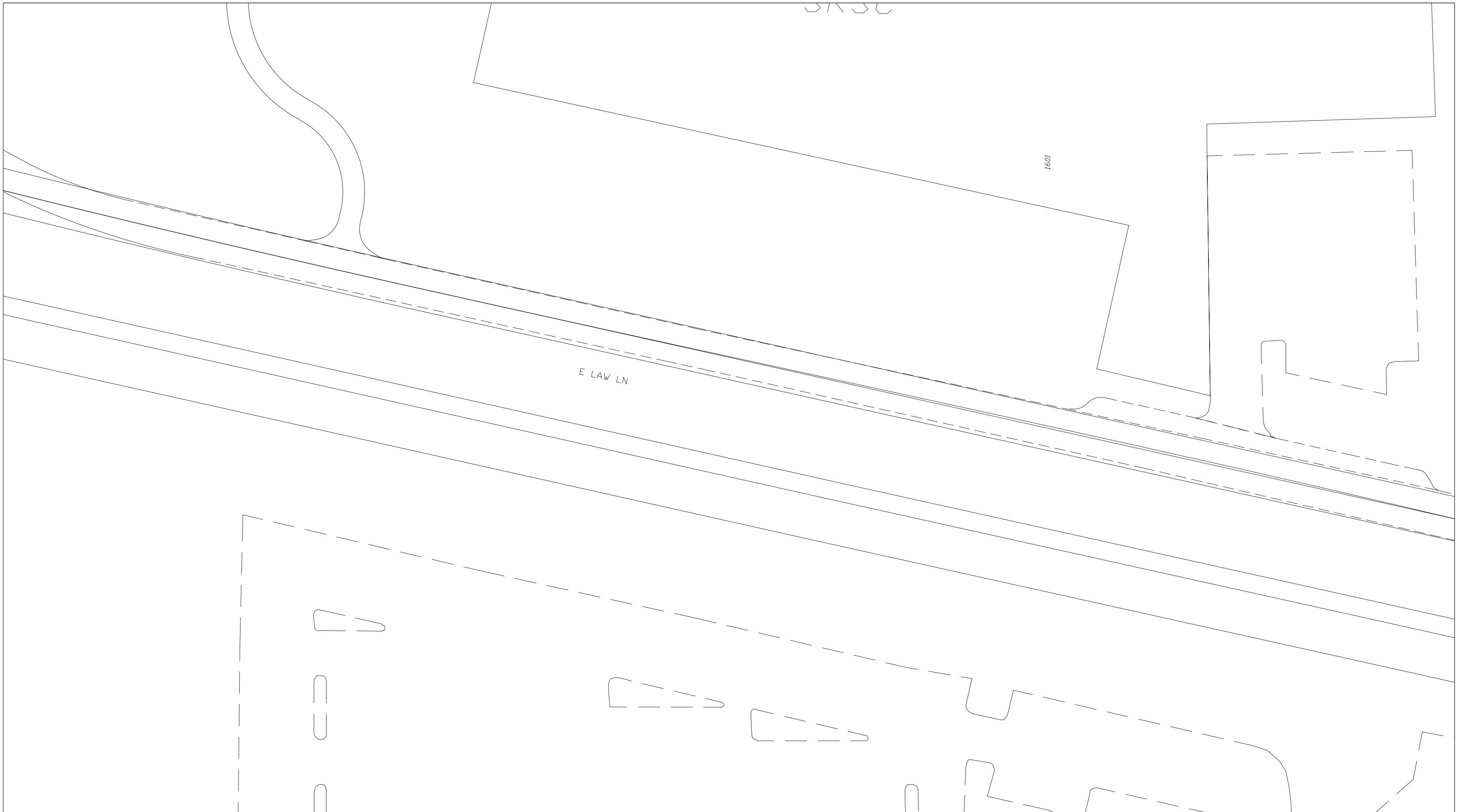
URBAN ENGINEERING	10th Street Alignment - Widening	Designed By: TMS	Drawn By: TMS	Horizontal Scale: 1" = 50'
		Checked By: RDA	Checked By: RDA	Vertical Scale: N/A
	STA 176 to STA 183	Date: 01/20/07	Date: 03/28/07	Figure: N.6



10th Street Alignment - Widening	Designed By: TMS	Drawn By: TMS	Horizontal Scale: 1" = 50'
	Checked By: RDA	Checked By: RDA	Vertical Scale: N/A
STA 183 to STA 186	Date: 01/20/07	Date: 03/28/07	Figure: N.7

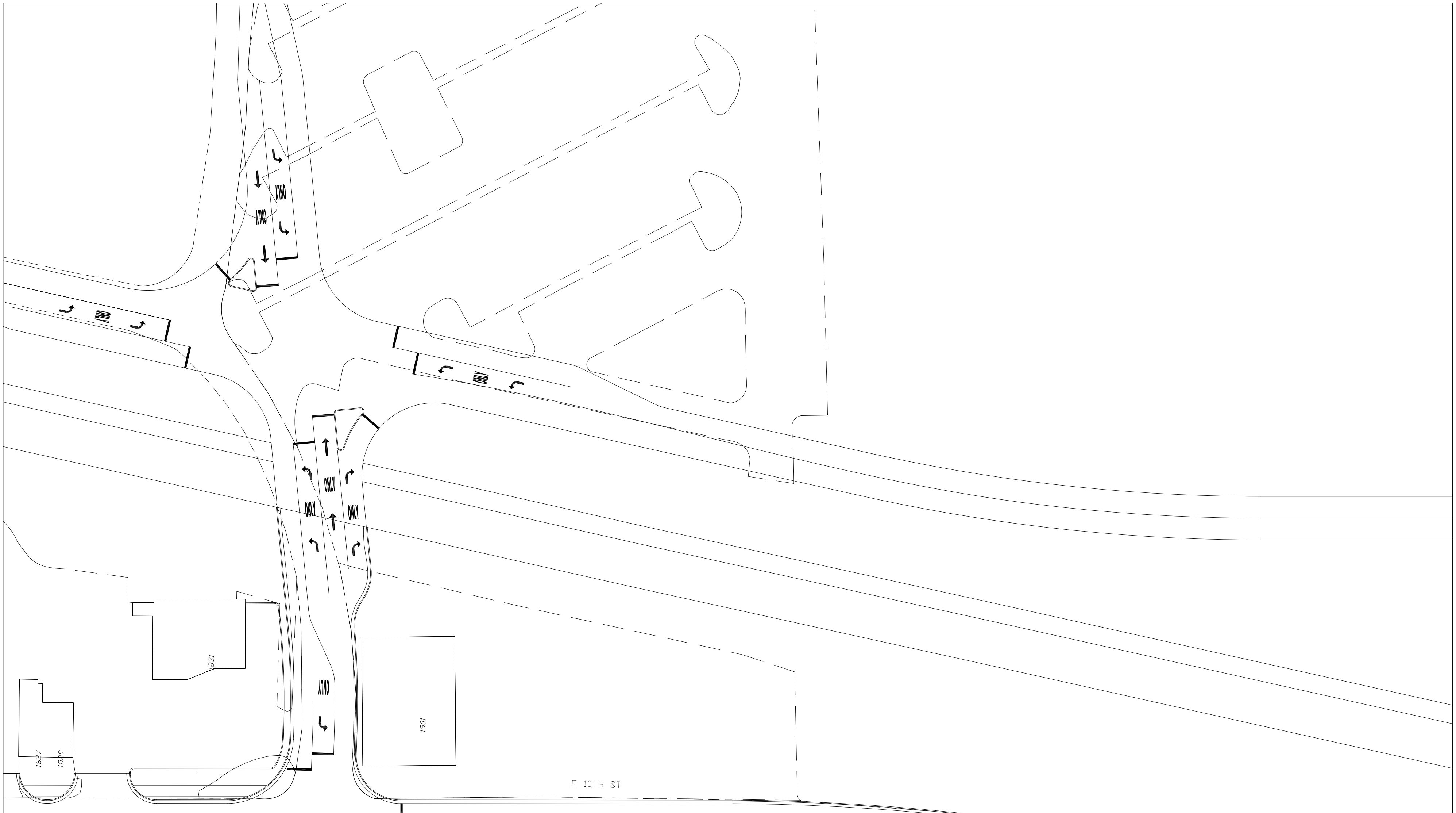
Law Lane Alignment	Designed By: TMS	Drawn By: TMS	Horizontal Scale: 1" = 50'
Law Lane	Checked By: RDA	Checked By: RDA	Vertical Scale: N/A
	Date: 01/20/07	Date: 03/28/07	Figure: N.8

URBAN ENGINEERING	Law Lane Alignment	Designed By: TMS	Drawn By: TMS	Horizontal Scale: 1" = 50'
		Checked By: RDA	Checked By: RDA	Vertical Scale: N/A
	Law Lane	Date: 01/20/07	Date: 03/28/07	Figure: N.9

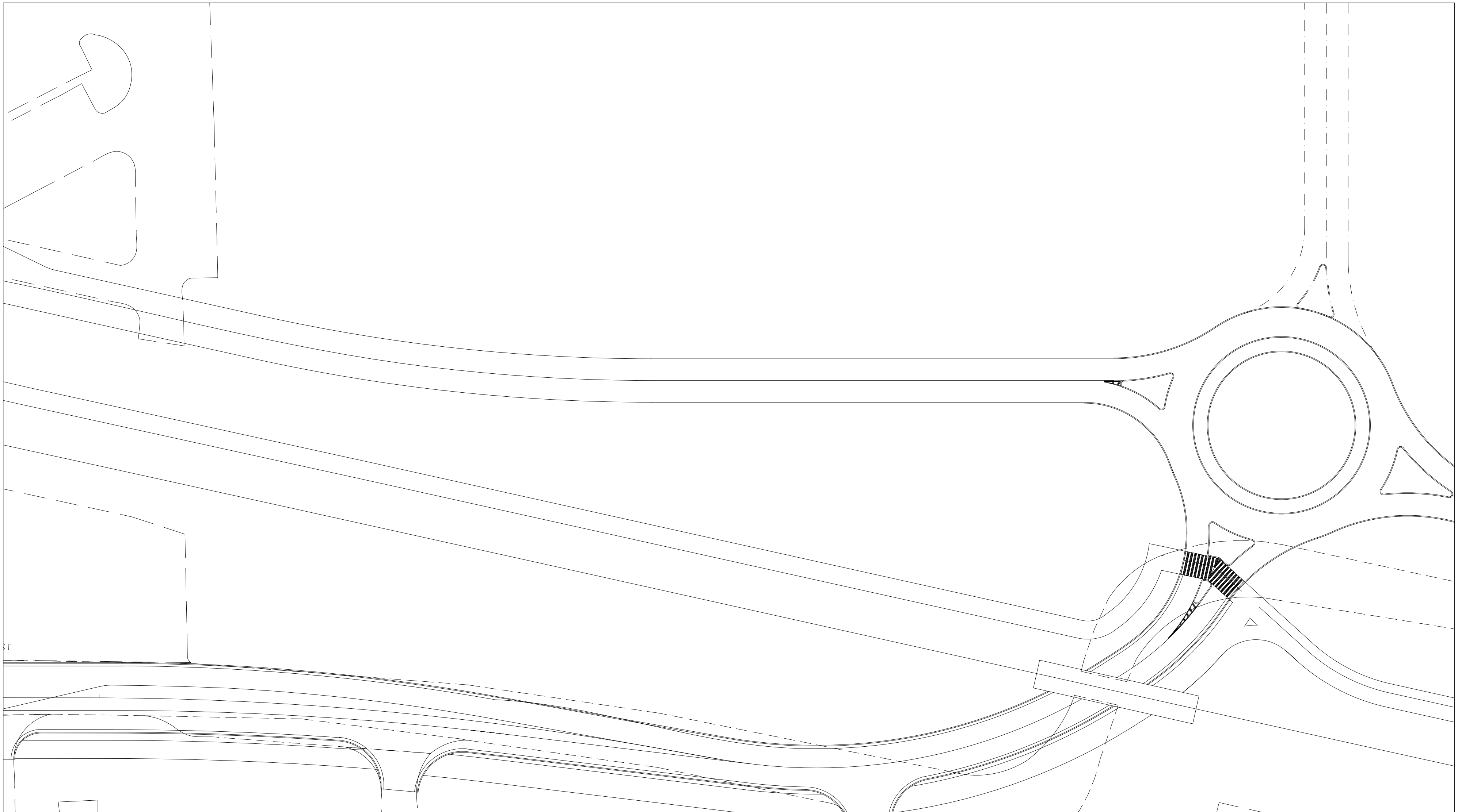


Law Lane Alignment	Designed By: TMS	Drawn By: TMS	Horizontal Scale: 1" = 50'
Law Lane	Checked By: RDA	Checked By: RDA	Vertical Scale: N/A
	Date: 01/20/07	Date: 03/28/07	Figure: N.10

Law Lane Alignment	Designed By: TMS	Drawn By: TMS	Horizontal Scale: 1" = 50'
Law Lane	Checked By: RDA	Checked By: RDA	Vertical Scale: N/A
	Date: 01/20/07	Date: 03/28/07	Figure: N.11

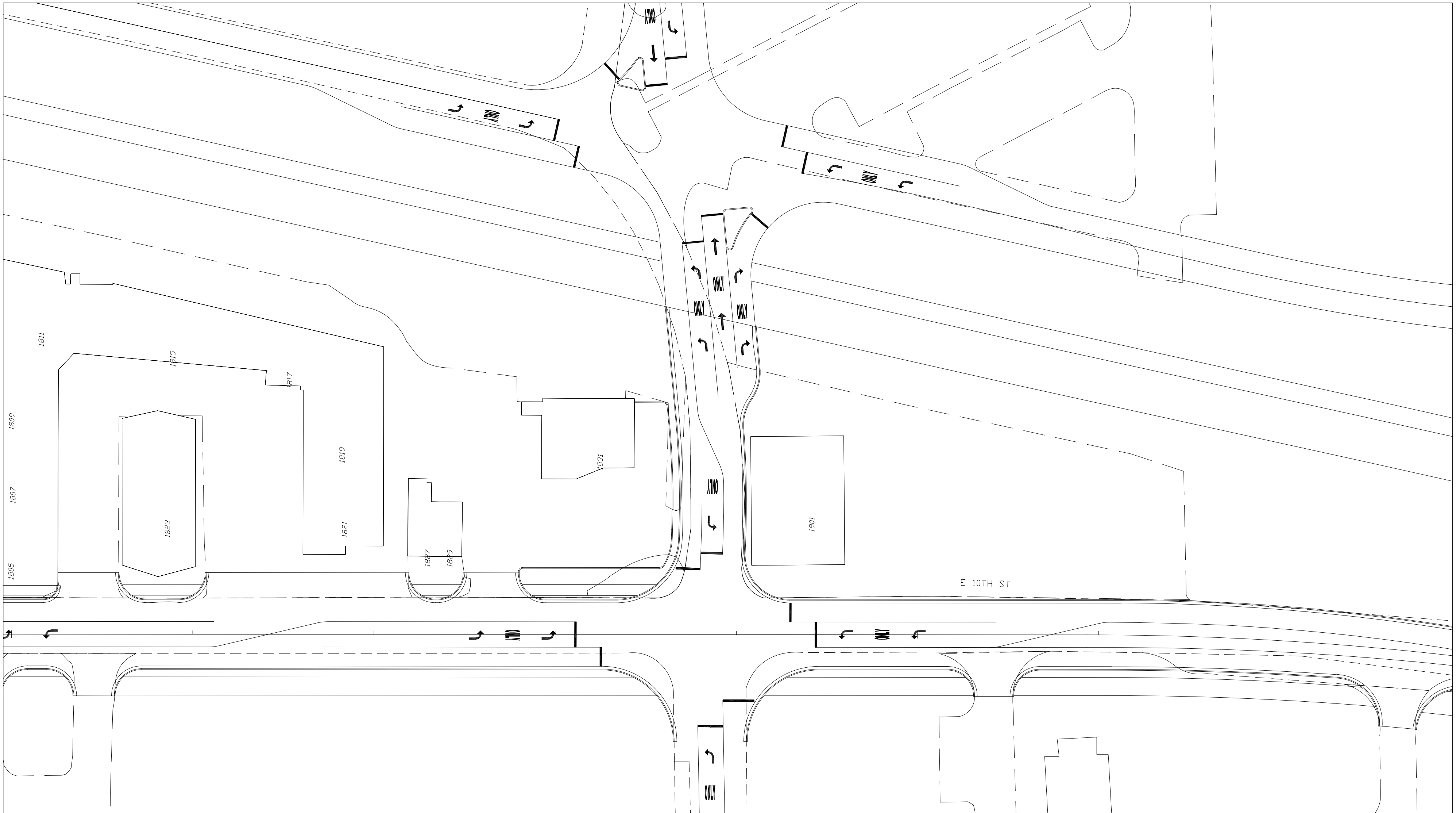


Law Lane Alignment	Designed By: TMS	Drawn By: TMS	Horizontal Scale: 1" = 50'
Law Lane Extension	Checked By: RDA	Checked By: RDA	Vertical Scale: N/A
	Date: 01/20/07	Date: 03/28/07	Figure: N.12

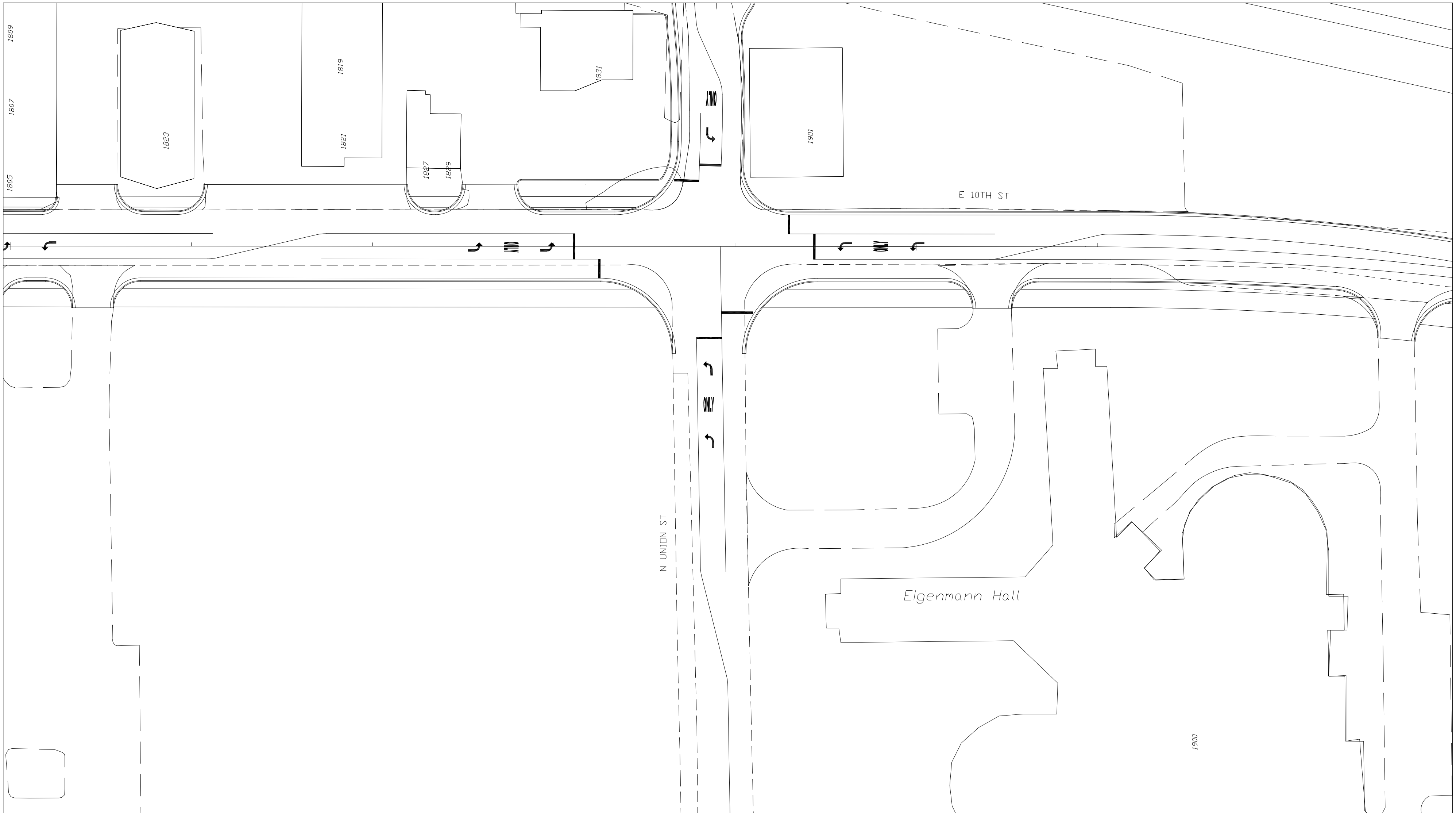


URBAN ENGINEERING	Law Lane Alignment	Designed By: TMS	Drawn By: TMS	Horizontal Scale: 1" = 50'
		Checked By: RDA	Checked By: RDA	Vertical Scale: N/A
	Law Lane Extension	Date: 01/20/07	Date: 03/28/07	Figure: N.13

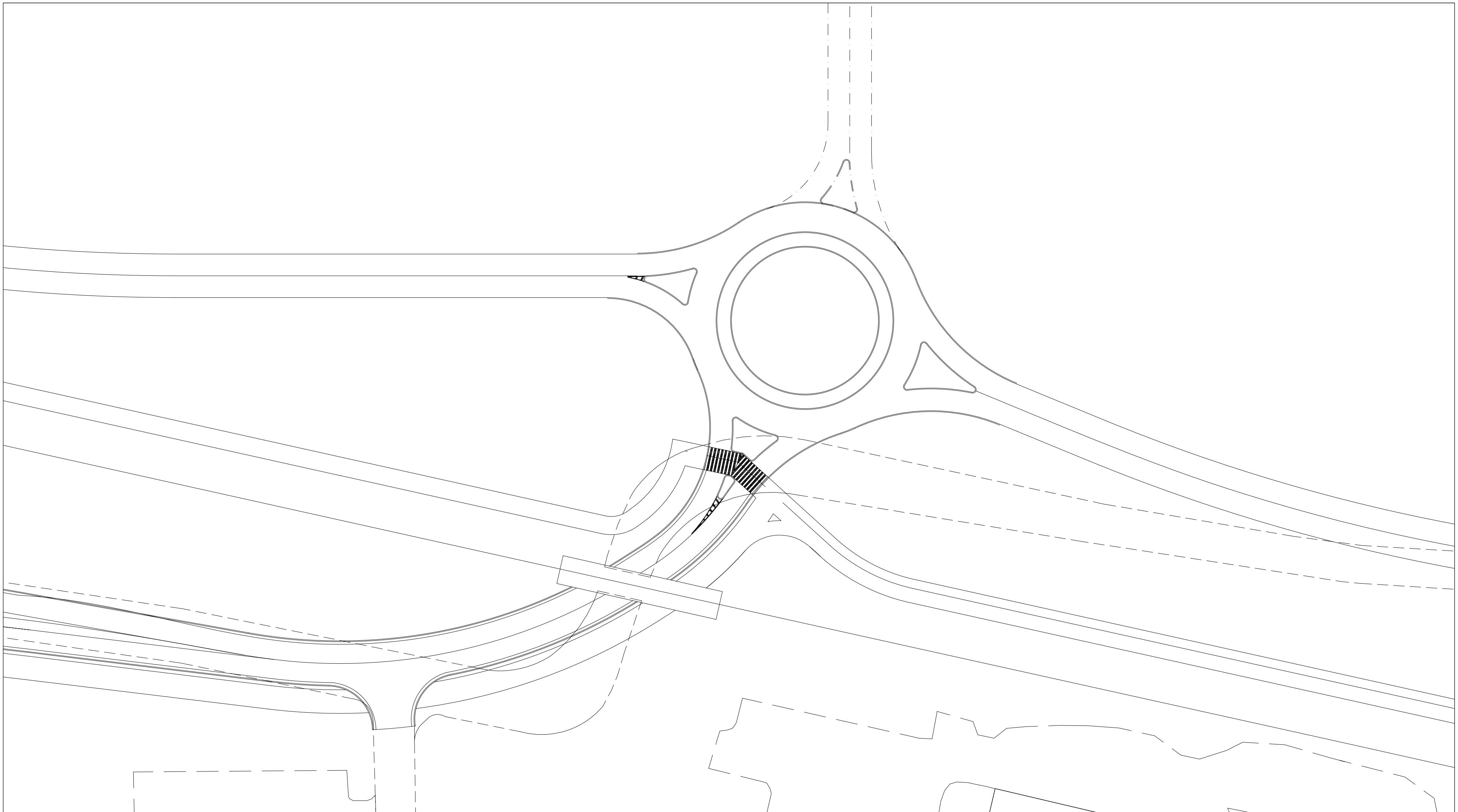
URBAN ENGINEERING	Union Street Alignment	Designed By: TMS	Drawn By: TMS	Horizontal Scale: 1" = 50'
	North of Law Lane	Checked By: RDA	Checked By: RDA	Vertical Scale: N/A
		Date: 01/20/07	Date: 03/28/07	Figure: N.14



Union Street Alignment	Designed By: TMS	Drawn By: TMS	Horizontal Scale: 1" = 50'
Law Lane to 10th Street	Checked By: RDA	Checked By: RDA	Vertical Scale: N/A
	Date: 01/20/07	Date: 03/28/07	Figure: N.15



Union Street Alignment	Designed By: TMS	Drawn By: TMS	Horizontal Scale: 1" = 50'
	Checked By: RDA	Checked By: RDA	Vertical Scale: N/A
South of 10th Street	Date: 01/20/07	Date: 03/28/07	Figure: N.16

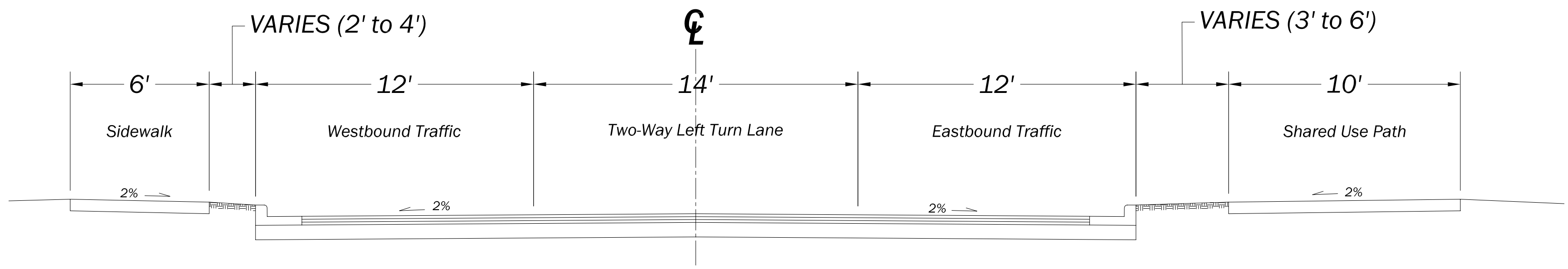


10th Street Alignment	Designed By: TMS	Drawn By: TMS	Horizontal Scale: 1" = 50'
Roundabout	Checked By: RDA	Checked By: RDA	Vertical Scale: N/A
	Date: 01/20/07	Date: 03/28/07	Figure: N.17

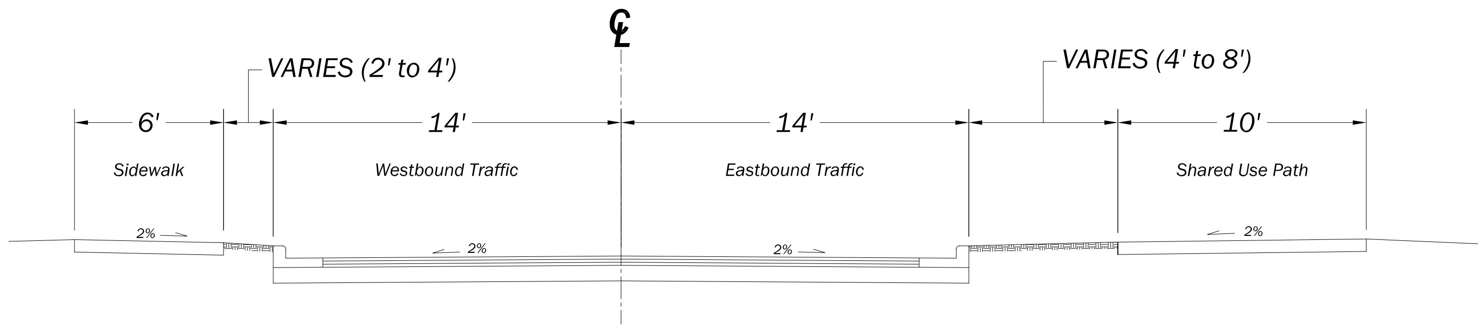
URBAN ENGINEERING

10th Street Alignment	Designed By: TMS	Drawn By: TMS	Horizontal Scale: 1" = 50'
	Checked By: RDA	Checked By: RDA	Vertical Scale: N/A
Roundabout	Date: 01/20/07	Date: 03/28/07	Figure: N.18

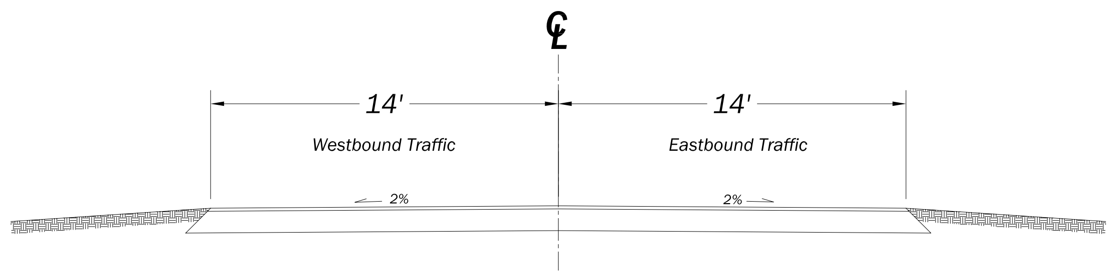
Appendix O - Cross Sections



10th Street Widening

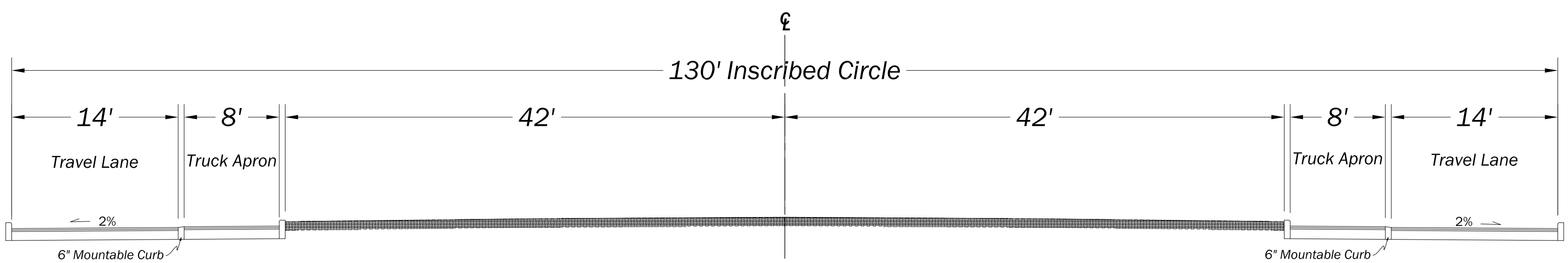


10th Street Upgrade



Law Lane Extension

UE URBAN ENGINEERING	Typical Cross Sections	Designed By: TMS	Drawn By: TMS	Horizontal Scale: N/A
		Checked By: RAR	Checked By: RAR	Vertical Scale: N/A
	Road Alignments	Date: 02/24/07	Date: 02/28/07	Figure: O.1



Roundabout

Typical Cross Sections	Designed By: TMS	Drawn By: TMS	Horizontal Scale: 1" = 10'
Roundabout	Checked By: RAR	Checked By: RAR	Vertical Scale: N/A
	Date: 02/24/07	Date: 02/28/07	Figure: O.2

Appendix P - Construction Phasing

P.1 Construction Phasing

Since there were several designs proposed for different locations within the project, Urban Engineering divided the construction into three phases in order to minimize the impact on the community. Due to the project's close proximity to IU campus, Urban Engineering recommends that the majority of the construction take place during the summer months. Performing the construction when IU classes are not in session will be beneficial, because the traffic demand on 10th Street and the surrounding corridors will be dramatically reduced.

P.2 Phase One

Phase one prepares for the increased traffic that will be placed on Law Lane as a result of temporarily closing 10th Street for construction in phase two. Phase one includes building the roundabout north of the railroad underpass (Appendix G), building the Law Lane extension (Appendix F), making intersection improvements along Law Lane (Appendix E), and realigning Law Lane (Appendix F). Before construction can begin, utilities will have to be located, and some will have to be relocated (Appendix H). Once the utilities have been located and relocated if necessary, the roundabout and Law Lane extension construction can begin without impacting traffic on 10th Street or Law Lane. Concurrently, while the roundabout and Law Lane Extension are being built, construction on Law Lane can begin. The intersections along Law Lane including Union Street, Jordan Avenue, and Fee Lane will be upgraded first. It is important to upgrade the intersections because traffic from 10th Street will be redirected onto Law Lane in phase two. After the intersection improvements are complete, Union Street and Law Lane should be realigned.

Next, the sidepath that runs parallel to Law Lane should be started and completed during this phase (Appendix L). It is imperative to have a safe place for pedestrians to commute on Law Lane before 10th Street is closed for construction. Finally, resurfacing the pavement on "Old" Law Lane, paving the Law Lane Extension, installing signals (Appendix J), installing traffic signs, placing pavement markings (Appendix K), re-sodding the outer construction perimeter, and planting new trees to replace the trees that were removed during construction will conclude phase one and commence phase two.

P.3 Phase Two

Now that Law Lane has been upgraded, the Law Lane extension can be opened to traffic and 10th Street can be closed to thru traffic. 10th Street will be closed east of Union Street to the north side of the underpass at the roundabout (Figure P.1). The 10th Street closure will allow construction crews to remove the old railroad bridge and replace it with the new bridge (Appendix M). While 10th Street is closed, crews can also realign the section of 10th Street under the railroad bridge (Appendix F).

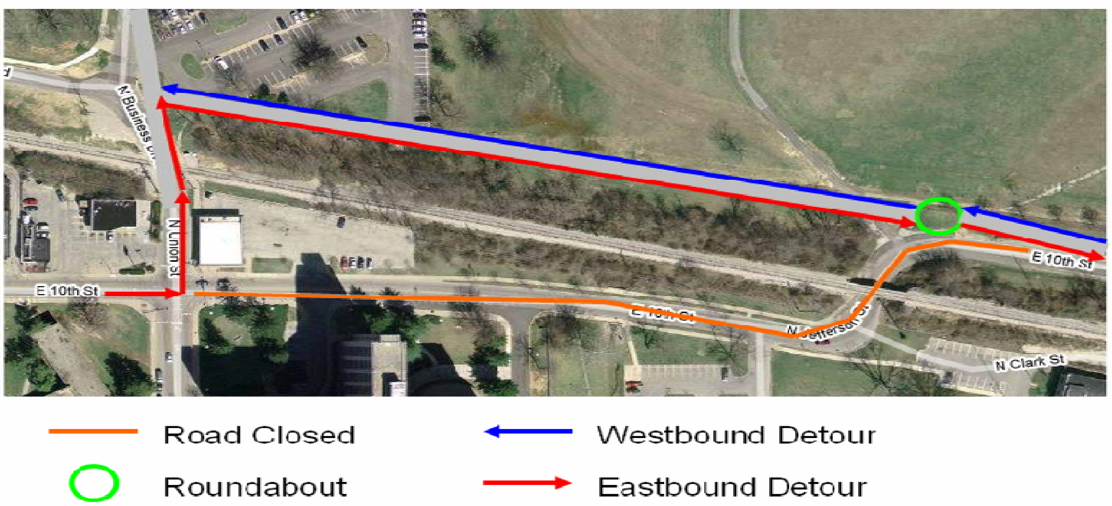


Figure P.1: Phase Two detour route. (Adapted from Google Maps, 2006)

Traffic traveling east bound on 10th Street will be diverted north onto Union Street. At the Law Lane Extension, traffic can access the roundabout and reconnect to 10th Street on the north side of the railroad underpass. Traffic traveling westbound on 10th Street will access 10th Street as normal from SR 46 and will be detoured at the roundabout onto Law Lane Extension. At the Union Street and Law Lane intersection, westbound traffic will have the option to access 10th Street by turning south on Union Street, or traffic can continue traveling west on Law Lane (Figure P.1).

Next, the section of 10th Street from Union Street to the roundabout will be resurfaced, traffic signs will be installed, and respective pavement markings will be placed (Appendix K). After these tasks have been completed, 10th Street from Union Street to the roundabout can be reopened for public use.

P.4 Phase Three

Regardless of the design that the City of Bloomington chooses, construction along 10th Street from Woodlawn Avenue to Union Street will occur during this phase (Appendix F). If the client decides to pursue the 10th Street widening design, the steam line utility relocation should take place early in phase one so that construction crews will not interfere with the construction along 10th Street.

10th Street will not be closed to thru traffic because the construction along 10th Street can be performed at night and/or in segments without closing down large sections of 10th Street. Furthermore, 10th Street traffic will have the ability to access Law Lane as an alternative east-west route. Construction crews will resurface 10th Street, pave new sections of 10th Street, place pavement markings (Appendix K), install signals (Appendix J), and install appropriate signs. Construction of the shared use sidepath along 10th Street can be executed next (Appendix L). Finally, crews can replace any trees that were removed during the construction process, re-sod the construction zone, and re-open all lanes on 10th Street to public traffic.

Appendix Q - Cost Estimate

Q.1 Introduction

Urban Engineering has estimated the cost of construction for the proposed designs. These costs are based on the Indiana Department of Transportation (INDOT) Unit Price Averages (INDOT, 2007), and the Federal Highway Administration (FHWA, 2007). The estimate includes major utility relocations, construction, materials, overhead, and profit.

Q.2 Cost Estimates

The estimates provided in Table Q.1 through Q.7 list unit prices, INDOT unit price item numbers, and material quantities for each design option within the project. Since the total final cost depends on which design options the client decides to implement, the estimate is cataloged into the individual options within the project.

If the client decides to pursue the 10th Street widening along with the additional designs, the estimated cost is 12.5 million dollars. The steam line utility relocation accounts for 5.2 million of the 12.5 million dollars. However, if the client decides to maintain the existing right-of-way along 10th Street and pursue the additional options that have been provided, the estimated cost is 6.6 million dollars.

Table Q.1: Cost estimate for 10th Street Widening option

	Item #	$/unit	Unit	Quantity	Cost
Light Standard, Remove	202-01502	$ 298	EA	10	$ 2,980
Relocate Steam Line		2000	LF	2600	5200000
Tree, 18 in., Remove	202-02255	471	EA	50	23550
Curb, Concrete, Remove	202-02279	7	LF	7960	55720
Sidewalk, Concrete, Remove	202-52710	10	SYS	613	6133
Traffic Signal Equipment, Remove	202-96632	2556	EA	19	48564
Excavation, Common	203-02000	25	CYS	2948	73704
Subgrade Treatment, Type IIIA	207-08267	4	SYS	4422	17689
Milling Asphalt, Removal	306-08039	4	SYS	12382	49529
QC/QA-HMA, 2, 70, Surface, 9.5mm	401-07327	64	TON	2773	177455
QC/QA-HMA, 2, 70, Intermediate, 12.5 mm	401-07378	31	TON	2773	85955
Compact Crushed Aggregate	303-04489	24	TON	945	22686
Curb Ramp, Concrete, E	604-07899	80	SYS	378	30222
Curb and Gutter, Concrete	605-06140	19	LFT	7960	151240
Sodding	621-06574	4	SYS	4422	17689
Plant, Decid Tree, Single Stem, Over 3.5 in.	622-05652	648	EA	50	32400
Signal Support Foundation, 3FT X 3FT X 8FT	805-01816	1,499	EA	20	29980
Traffic Signal Head, 3 Face, 12 in Red	805-78205	714	EA	19	13566
Traffic Signal Head, 5 Face, 12 in Red	805-78230	1,032	EA	16	16512
Signal Strain Pole, Steel, 36 Ft	805-81060	4,240	EA	20	84800
Light Pole	807-04654	2490	EA	20	49800
Line, Thermoplastic, Dotted, Yel-low, 4 in.	808-01045	1	LFT	7960	7960
Line, Thermoplastic, Solid, White, 4 in.	808-06703	2	LFT	7960	15920
Line, Thermoplastic, Solid, Yellow, 4 in.	808-75245	1	LFT	7960	7960
Transverse Markings, Epoxy, Stop Line, 2	808-74805	11	LFT	464	5104
Total Cost					**$ 6,227,000**

Table Q.2: Cost estimate for 10th Street Upgrade option

	Item #	$/unit	Unit	Quantity	Cost
Light Standard, Remove	202-01502	$ 298	EA	6	$ 1,788
Tree, 18 in., Remove	202-02255	471	EA	4	1884
Curb, Concrete, Remove	202-02279	7	LF	270	1890
Sidewalk, Concrete, Remove	202-52710	10	SYS	133	1333
Traffic Signal Equipment, Remove	202-96632	2556	EA	8	20448
Excavation, Common	203-02000	25	CYS	167	4167
Milling Asphalt, Removal	306-08039	4	SYS	12382	49529
QC/QA-HMA, 2, 70, Surface, 9.5mm	401-07327	64	TON	2043	130756
Sidewalk, Concrete	604-06070	39	SYS	133	5200
Curb Ramp, Concrete, E	604-07899	80	SYS	111	8889
Curb and Gutter, Concrete	605-06140	19	LFT	270	5130
Sodding	621-06574	4	SYS	667	2667
Plant, Decid Tree, Single Stem, Over 3.5 in.	622-05652	648	EA	4	2592
Signal Support Foundation, 3FT X 3FT X 8FT	805-01816	1,499	EA	8	11992
Traffic Signal Head, 3 Face, 12 in Red	805-78205	714	EA	8	5712
Traffic Signal Head, 5 Face, 12 in Red	805-78230	1,032	EA	5	5160
Signal Strain Pole, Steel, 36 Ft	805-81060	4,240	EA	8	33920
Light Pole	807-04654	2490	EA	6	14940
Line, Thermoplastic, Dotted, Yellow, 4 in.	808-01045	1	LFT	7960	7960
Line, Thermoplastic, Solid, White, 4 in.	808-06703	2	LFT	7960	15920
Line, Thermoplastic, Solid, Yellow, 4 in.	808-75245	1	LFT	7960	7960
Transverse Markings, Epoxy, Stop Line, 2	808-74805	11	LFT	464	5104
Total Cost					**$345,000**

Table Q.3: Cost estimate for construction on 10th Street from Union Street to SR 46

	Item #	$/unit	Unit	Quantity	Cpst
Tree, 18 in., Remove	202-02255	$ 471	EA	20	$ 9420
Sidewalk, Concrete, Remove	202-52710	10	SYS	44	444
Excavation, Common	203-02000	25	CYS	1000	25000
Milling Asphalt, Removal	306-08039	4	SYS	6344	25374
QC/QA-HMA, 2, 70, Surface, 9.5mm	401-07327	64	TON	1047	66988
Curb Ramp, Concrete, E	604-07899	80	SYS	44	3556
Curb and Gutter, Concrete	605-06140	19	LFT	2600	49400
Sodding	621-06574	4	SYS	1980	7920
Plant, Decid Tree, Single Stem, Over 3.5 in.	622-05652	648	EA	20	12960
Line, Thermoplastic, Solid, White, 4 in.	808-06703	2	LFT	1782	3564
Line, Thermoplastic, Solid, Yellow, 4 in.	808-75245	1	LFT	1782	1782
Transverse Markings, Epoxy, Stop Line, 2	808-74805	11	LFT	26	286
Total Cost					**$ 207,000**

Table Q.4: Cost estimate for bridge replacement

	Item #	$/unit	Unit	Quantity	Cost
Excavation	203-02000	$ 25	CYS	1200	$ 30,000
Concrete work	FHWA Source		LS	1	115000
Prefabricated Steel Bridge	FHWA Source		LS	1	4250000
Temporary Bridge Steel Sections	FHWA Source		LS	1	525000
Removal of Existing Bridge	FHWA Source		LS	1	275000
Track Replacement	FHWA Source	450	LF	100	45000
Total Cost					**$ 5,240,000**

Table Q.5: Cost Estimate for all Law Lane construction, including eastward extension

	Item #	$/unit	Unit	Quantity	Cost
Light Standard, Remove	202-01502	$ 298	EA	2	$ 596
Tree, 18 in., Remove	202-02255	471	EA	15	7065
Traffic Signal Equipment, Remove	202-96632	2556	EA	4	10224
Excavation, Common	203-02000	25	CYS	2756	68889
Subgrade Treatment, Type IIIA	207-08267	4	SYS	4133	16533
Milling Asphalt, Removal	306-08039	4	SYS	7152	28608
QC/QA-HMA, 2, 70, Surface, 9.5mm	401-07327	64	TON	1862	119173
QC/QA-HMA, 2, 70, Intermediate, 12.5 mm	401-07378	31	TON	682	21142
Compact Crushed Aggregate	303-04489	24	TON	884	21204
Curb Ramp, Concrete, E	604-07899	80	SYS	222	17778
Sodding	621-06574	4	SYS	2008	8033
Plant, Decid Tree, Single Stem, Over 3.5 in.	622-05652	648	EA	15	9720
Signal Support Foundation, 3FT X 3FT X 8FT	805-01816	1,499	EA	12	17988
Traffic Signal Head, 3 Face, 12 in Red	805-78205	714	EA	11	7854
Traffic Signal Head, 5 Face, 12 in Red	805-78230	1,032	EA	6	6192
Signal Strain Pole, Steel, 36 Ft	805-81060	4,240	EA	12	50880
Light Pole	807-04654	2490	EA	4	9960
Line, Thermoplastic, Solid, White, 4 in.	808-06703	2	LFT	7230	14460
Line, Thermoplastic, Solid, Yellow, 4 in.	808-75245	1	LFT	7230	7230
Transverse Markings, Epoxy, Stop Line, 2	808-74805	11	LFT	262	2882
Total Cost					**$ 446,000**

Table Q.6: Cost Estimate for roundabout construction

	Item #	$/unit	Unit	Quantity	Cost
Excavation, Common	203-02000	$ 25	CYS	553	$ 13823
Subgrade Treatment, Type IIIA	207-08267	4	SYS	829	3318
QC/QA-HMA, 2, 70, Surface, 9.5mm	401-07327	64	TON	125	8000
QC/QA-HMA, 2, 70, Intermediate, 12.5 mm	401-07378	31	TON	125	3875
Compact Crushed Aggregate	303-04489	24	TON	709	17019
Line, Thermoplastic, Solid, White, 4 in.	808-06703	2	LFT	320	641
Transverse Markings, Thermoplastic, Yield	805-01828	80	Each	4	320
Transverse Markings, Thermoplastic, Round	805-01829	80	Each	4	320
Total Cost					**$ 47000**

Table Q.7: Cost estimates for sidepath construction

Item #		$/unit	Unit	Quantity	$
Description	203-02000	$ 25	CYS	202	$ 5,043
Excavation, Common	401-07327	58	TON	2996	173753
QC/QA-HMA, 2, 70, SURFACE, 9.5 mm	401-07356	41	TON	2996	122825
QC/QA-HMA, 2, 64, INTERME-DIATE, 9.5 mm	808-06703	1	LFT	16340	16340
Line, Thermoplastic, Solid, White, 4 IN.	808-75245	3	LFT	8170	24510
Line, Thermoplastic, Solid, Yel-low, 4IN.	808-75297	6	LFT	280	1680
Transverse Markings, Thermo-plastic, Stop Sign	802-99058	131	SFT	50	6550
Total					**$ 351,000**

Appendix R - Assessment of Options

R.1 Overview

The purpose of this appendix to itemize the criteria that Urban Engineering used to make project recommendations. Due to the complexity of our project, we have decided to divide the project into four separate areas when assessing our options. We, along with the help of Bloomington Metropolitan Planning Organization (MPO), have chosen five criteria on which to base our assessment. They are transit, pedestrian/bicycle safety, feasibility, green engineering, and historical preservation. The thresholds for some of the criteria are unique due to the difference in the existing conditions. These differences are indicated as needed.

R.2 Transit

The transit criterion is based on how many vehicles per day (VPD) it can accommodate a designated level of service (LOS). The vehicles per day are based on the Bloomington MPO 2030 Long Range Transportation Plan's projected daily vehicular demand. The level of service is based on the INDOT Design Manual document for a two-lane urban arterial. This is a criterion that had two unique thresholds—one quantitatively and the other qualitatively.

Table R.1 shows the criteria used for the 10th Street, the Law Lane Rehabilitation, and the Underpass options. The criteria are based on quantitative amounts that were based by the daily vehicular demand. Note: In the event that two criterion overlap (ex: 14,000 VPD and LOS = A), the smaller rating will govern.

Table R.1 - Transit Criteria
10th Street, Law Lane Rehabilitation, and Underpass Criteria

Rating	Criterion
3	>20,000 VPD plus a LOS ≥ C
2	20,000 VPD plus a LOS ≤ D to 15,000 VPD plus a LOS ≥ C
1	<15,000 VPD plus a LOS ≤ D

Table R.2 shows the criteria used for the Roadway Rehabilitation from Dunn Ave. to Fee Lane. The criteria are based on qualitative results that we believe will be the result of the changes made.

Table R.2 - Transit Criteria Roadway Rehabilitation from Dunn Ave. to Fee Lane	
Rating	Criterion
3	Improvement that impact all vehicles
2	Improvement that impact emergency vehicles
1	No improvements for any vehicles

R.3 Pedestrian/Bicycle Safety

The pedestrian/bicycle safety is also one of the criteria that have two unique thresholds. In this case, both are qualitative; but the current conditions of the areas are very different in terms of the daily traffic demand.

Table R.3 shows the criteria used for the 10th Street and the Law Lane Rehabilitation options. These are two of the four areas that experience high traffic demand along with a lot of pedestrian and bicycle activity, so a more defined threshold was used to rate these two options.

Table R.3 - Pedestrian/Bicycle Safety Criteria 10th Street and Law Lane Rehabilitation	
Rating	Criterion
3	Physical barrier between bike lane and traffic lane
2	Pavement marking separation between bike lane and traffic lane
1	No visible separation between traffic and bike lane

Table R.4 shows the criteria used for the Roadway Rehabilitation from Dunn Ave. to Fee Lane and the Underpass options. These areas are different than the previous two areas in the fact that they have limited pedestrian and bicycle use.

Table R.4 - Pedestrian/Bicycle Safety Criteria Roadway Rehabilitation from Dunn Ave. to Fee Lane and Underpass	
Rating	Criterion
3	Safety improvement for both pedestrian and bicycle
2	Safety improvement for either pedestrian or bicycle
1	No improvements in safety for any pedestrian or bicycle

R.4 Feasibility

Feasibility is a criterion that is hard to assign a quantitative value. The cost of a project can usually fall under this criterion, but Urban Engineering has not been given any limitations on the cost. A lower cost would help to initiate a "go-ahead" to start construction, but we believe that all of our options are within a reasonable range of each other. With that being said, we have decided to base this criterion on the number of stakeholders that may have any influence on an option along with how well it follows Bloomington's Long Range Transportation Plan (LRTP). The stakeholders that we have considered are the City of Bloomington, Indiana University, Indiana Railroad, Bloomington Public Transit, Indiana University Transit, Bloomington Fire Department, and the Citizens Advisory Committee. This is not an exhausted list, but we believe these stakeholders will influence the project's outcome the most. Additionally, an option may or may not comply with the LRTP since we had virtually no limit when brainstorming our design options.

We were able to use the same thresholds for all four areas. Table R.5 shows the criteria used for all of the options in the four areas within the scope of the project.

Table R.5 - Feasibility Criteria

Rating	Criterion
3	<3 stakeholders and compliance with LRTP
2	3, 4, or 5 stakeholders and moderate compliance with LRTP
1	>5 stakeholders and little or no compliance with LRTP

R.5 Green Engineering

The criterion of green engineering was also hard to establish a quantitative threshold. Instead, a qualitative rating was given to each of the four areas. These were determined by factors such as how much right-of-way we will be obtaining to widen a road, or how much we will change the natural habitat of the current condition by choosing a certain option. Trees, in particular, are highly valued in the city of Bloomington; therefore, if an option is going to require the removal of many trees it will rate very low. Table R.6 shows the thresholds used for all four areas.

Table R.6 - Green Engineering Criteria

Rating	Criterion
3	Habitat left as is, for the most part
2	Some removal of vegetation –or– slight increase in construction materials (ex: HMA, concrete, etc.)
1	Replacing significant amounts of natural habitat

R.6 Historic Preservation

The city of Bloomington also values its historical landmarks. These range from historical buildings to the WPA sidewalks located in various areas of the project scope. Again, this criterion was based on qualitative thresholds. The same philosophy that was used in green engineering was also used for this criterion. For instance, an option that requires the removal of a landmark could potentially rate very low. Table R.7 shows the thresholds used for all four areas.

Table R.7 - Historical Preservation Criteria

Rating	Criterion
3	Preserve all historical landmarks
2	Removal with replacement of historical landmarks
1	Removal without replacement of historical landmarks

R.7 Design Option Recommendations

The following information in this section presents the recommendations of each of the four areas within the project scope. These recommendations are based on the decision matrix that corresponds to each of the four areas. In some cases, more than one option was recommended to achieve optimal results. Urban Engineering would like to emphasize that combining all of the recommended options from each of the four areas will result in the most optimal result. Combining these options together would create one large project that upon completion could alleviate much of the traffic congestion that 10th Street currently experiences.

It should also be noted that each of these four recommendations could stand alone as separate projects if desired. For instance, if the City of Bloomington decides to follow through with only the underpass option recommendation and none of the others, it will certainly work.

R.7.1 10th Street Recommendation

Urban Engineering recommends realigning and widening 10th Street, including a side-path to run parallel to 10th Street, installing bus storage lanes, and improving intersections. The recommendations provided are based on the decision matrix and the criteria mentioned previously. The options proposed meet the criteria fairly well. The intersection improvements scored a three for each criterion. The sidepath and bus stalls both meet the criteria well, and each option had a total score of

11.8. The sidepath would have scored higher, but it did not meet the transit criteria because it adds very little to the transit system. Widen and realign scored in the middle range; indicating it matched most of the criteria as well. After careful analysis, Urban Engineering chose not to recommend the one-way pair corridor and the do nothing option. The options were not recommended because they did not meet the criteria well. See Table R.8 for the decision matrix.

TABLE R.8		**10th Street Options**					
		C.1.1	C.1.2	C.1.3	C.1.4	C.1.5	C.1.6
Criteria	**Importance Weight**	**Widen and Realign**	**Existing condition plus Side-path**	**Existing condition plus Tem-porary Bus stalls**	**One way corridor paired with Law Lane**	**Intersection Improve-ments**	**Do Nothing**
Transit	2	3	1	2	2	3	1
Pedestrian/Bicycle Safety	2	2	3	2	2	3	1
Feasibility	1	3	3	3	1	3	1
Green Engineering	0.2	2	2	2	1	3	3
Historic Preservation	0.2	2	2	2	2	3	3
Total Score		13.8	11.8	11.8	9.6	16.2	6.2

R.7.2 Law Lane Recommendation

Urban Engineering recommends improving the intersections along Law Lane. The improvements include increasing intersection radii and improving pedestrian crosswalks at intersections along Law Lane. The recommendations provided are based on the given criteria and the decision matrix. The intersection improvements option met the criteria extremely well, because it scored a perfect three for each of the criteria. See Table R.9 for the decision matrix. The sidepath option did not meet the criteria well; therefore, it was not recommended. The "widening and realign with parking lot" and "cross walk improvement" options, met the criteria fairly well. However, the two options are not being recommended because Law Lane was recently rehabilitated, and Urban Engineering does not foresee any changes needing to made to the current condition of Law Lane.

TABLE R.9		Law Lane Rehabilitation Options			
		C.2.1	C.2.2	C.2.3	C.2.4
Criteria	**Impor-tance Weight**	**Widen and Realign with parking lot**	**Existing condition plus Side-path**	**Existing condition plus Cross walk improvements**	**Intersection improvements**
Transit	2	3	1	1	3
Pedestrian/Bicycle Safety	2	2	3	3	3
Feasibility	1	1	1	2	3
Green Engineering	0.2	1	2	3	3
Historic Preservation	0.2	2	2	3	3
Total Score		11.6	9.8	11.2	16.2

R.7.3 Roadway Rehabilitation from Dunn Ave. to Fee Lane Recommendation

Urban Engineering recommends an extension of Law Lane to the west. This is determined by decision matrix shown below in Table R.10. This extension would allow traffic to continue to continue westbound until reaching Walnut Grove Street. This street was recently renovated to accommodate for large amounts of vehicular traffic going northbound and southbound. The one way corridor with 10th Street also scored very high, but considering the low score that it scored in the 10th Street options, we felt that it would not be as efficient as anticipated due to the number of stakeholders opposed to the this option. Urban Engineering does not recommend connecting 12th Street and 13th Street via Woodlawn Ave. because of the limited right-of-way available as well as the strong opposition from Indiana University. The relocation of the fire station is also not recommended at this time due to the ineffectiveness it has for this project. Urban Engineering believes that its current location provides sufficient fire coverage to the area.

TABLE R.10		Roadway Rehabilitation from Dunn Ave. to Fee Lane Options			
		C.3.1	C.3.2	C.3.3	C.3.4
Criteria	**Impor-tance Weight**	**Law Lane Ex-tension - West**	**Adjoining roads (Connection of Wood-lawn between 12th & 13th Streets**	**Relocation of Fire Station**	**One way cor-ridor with 10th Street**
Transit	2	3	2	2	2
Pedestrian/Bicycle Safety	2	2	2	1	3
Feasibility	1	2	1	1	1
Green Engineering	0.2	2	1	1	2
Historic Preservation	0.2	1	1	1	2
Total Score		12.6	9.4	7.4	11.8

R.7.4 Underpass Recommendation

Urban Engineering recommends an extension of Law Lane to the east as well as the replacement of the current railroad bridge over 10th Street. The extension of Law Lane to the east would allow traffic coming from SR 45/46 to avoid 10th Street by traveling north along Law Lane all the way to Fee Lane, or even Walnut Grove Street, if desired. It would also be able to serve as a detour route during the replacement of the recommended railroad bridge rehabilitation. The railroad underpass rehabilitation would involve a weekend construction operation that eventually would result in a wider and more efficient underpass. The underpass rehabilitation would also allow for pedestrians and bicyclists to pass safely through with designated sidewalks and/or lanes. Urban Engineering does not recommend creating an at-grade crossing in this location because of strong railroad opposition as well as ineffectiveness transit and pedestrian/bicycle safety ratings because of rail traffic. A complete score of the options is shown below in Table R.11.

TABLE R.11		**Underpass Rehabilitation Options**		
		C.4.1	C.4.2	C.4.3
Criteria	**Importance Weight**	**Law Lane Extension - West**	**Adjoining Roads (Connection of Woodlawn between 12th & 13th Streets)**	**Relocation of Fire Station**
Transit	2	3	3	1
Pedestrian/Bicycle Safety	2	1	3	1
Feasibility	1	3	2	1
Green Engineering	0.2	1	3	2
Historic Preservation	0.2	2	1	1
Total Score		11.6	14.8	5.6

R.8 Other Options Considered

Urban Engineering also looked at the "do nothing" option for each of the areas. This was to determine if leaving 10th Street and the surrounding area in its current condition would be more effective than an option considered. It was determined at the start of the option assessment that this option would be least effective than all of the recommended options that we considered.