Chapter 4 – Interchange Modifications

The Greenville metropolitan area is served by one major US Interstate, I-85, and two US Interstate spurs, I-185 and I-385. Within the area analyzed for this study, I-85 and I-385 are the major freeway systems and carry approximately 89,300 and 33,500 vehicles per day, respectively. Each facility has one interchange with Woodruff Road, and several other interchanges along these facilities are very close to the Woodruff Road corridor to directly affect traffic operations.

I-85 is a 668-mile US Interstate running from Montgomery, AL to Petersburg, VA. The freeway traverses five states between its termini — Alabama, Georgia, South Carolina, North Carolina, and Virginia. I-385 is a 42-mile US Interstate running from Greenville, SC to Clinton, SC. The facility is a spur of I-85, intended to provide a connection between I-85 and I-26.

Each interchange in the study area was analyzed during the course of this project to determine whether potential upgrades, both near and long term, would provide congestion relief and increased safety. Each location was analyzed based on feasibility and cost effectiveness. Recommendations are included at the end of this chapter for several of the interchanges in the study area. In addition, upgrades to existing freeway overpasses and construction of new freeway overpasses were examined to enhance cross access mobility.

The following sections provide insight on typical interchange configurations, design standards, existing conditions and problem areas at local interchanges, and recommendations for future improvements.

Typical Interchange Designs

The following interchange configurations are the most common types found in the United States. While other variations exist, these are the configurations most likely to be found in a typical freeway setting. When determining the optimal configuration for a freeway interchange, it is important to consider many factors, including projected traffic volumes, land availability, and projected area growth.

Freeway-to-Surface-Street Connections

Freeway-to-surface-street interchanges are intended to provide access to and from the freeway without interrupting its flow, usually by grade separating one of the facilities and providing directional ramps between the freeway and the surface street. A complete interchange between a freeway and a surface street requires four ramps to provide full movements between the two facilities.

The following configurations are the most common freeway-to-surface-street interchanges found in the study area and the United States.

A **diamond** interchange is the most basic four-ramp interchange configuration. This layout provides basic entrance and exit movements between the freeway system and the crossing facility. This configuration is effective when traffic volumes are not particularly high or when there are no special constraints governing the construction of the interchange. This configuration does not handle large volumes of traffic or large left-turning volumes well, often causing congestion on the ramps and freeway spillback. For higher traffic volumes on ramps and surface streets, traffic signals need to be installed to accommodate demand. The I-385 interchanges at Woodruff Road and Roper Mountain Road are diamond interchanges.

Diamond interchange configuration

An alternative to the diamond is a **partial cloverleaf** interchange, which also utilizes the four-ramp configuration. With two entrance and exit ramps, the partial cloverleaf is functionally equivalent to the diamond; however, the ramps can be configured to accommodate either adjacent property or heavy turning movements. The connection of the ramps from the freeway to the surface street still requires some form of traffic control, whether signed or signalized. As traffic volumes rise, congestion can occur on the ramps and the surface street.

Partial cloverleaf interchange

Full cloverleaf interchanges remove the need for traffic control by providing separate ramps for left-turning and right-turning movements. Traffic that would turn left at a stop-controlled intersection can simply use a loop ramp that merges with the desired direction of travel. The result is reduced delay for entering and exiting traffic. The first interchange constructed in the United States was a full cloverleaf between Routes 4 and 25 in New Jersey in 1929. The I-85 interchange at Laurens Road is a full cloverleaf interchange.

The most significant disadvantage of the cloverleaf interchange is weaving, in which traffic merging left and traffic merging right must cross paths to reach the desired travel lane. This situation becomes increasingly dangerous when volumes become higher than about 1,000 vehicles per hour. At these conditions, interference increases quickly and speeds drop on both the ramps and mainlines, increasing the likelihood of congestion.

Cloverleaf interchange configuration

The **single point urban interchange (SPUI)** is a relatively new interchange treatment that merges the principles of a diamond interchange and a typical intersection to form a configuration that can handle greater capacities with less right-of-way needs. The first SPUI was constructed in Clearwater, Florida in 1974, and today there are more than 60 in place nationwide. The I-85 interchange at SC 14 is a single point urban interchange.

The SPUI configuration resembles a diamond interchange from afar. The main difference occurs at the junction of the entrance and exit ramps with the surface street. Where a diamond interchange would have two separate intersections to move traffic, the SPUI utilizes one intersection. In this regard, the configuration operates as a normal at-grade intersection with opposing left turns moving concurrently. All movements can be handled with a three-phase traffic signal:

1. Through traffic, surface street
2. Left-turning exit traffic
3. Left-turning entrance traffic

The major advantages of the single point urban interchange configuration are its compact layout (requiring little right-of-way) and its ability to move left turns concurrently (increasing capacity). The disadvantages of this configuration include:

- Unfamiliar to drivers
- Multi-lane ramps and surface streets lead to large areas of pavement
- Larger overpasses and bridge structures can be very expensive
- Not pedestrian and bicycle friendly

Single point urban interchange configuration

Freeway-to-Freeway Connections

Freeway-to-freeway interchanges are intended to provide access between the intersecting facilities without interrupting flow on the mainline of the freeways. This is usually accomplished through a series of directional ramps and multiple grade separations. A freeway ending at another freeway requires four ramps, and two freeways crossing one another require eight ramps to create a complete interchange. The following configurations are the most common freeway-to-freeway connections found in the study area and the United States.

Northbound I-85 at Old Sulphur Springs Road

The **four-level-stack** interchange is the most common freeway-to-freeway interchange. Each freeway has a direct connection to the other roadway, with no looping or weaving required. The directional ramps cross one another in a four-level deck that can be seen for up to a mile in the approaching directions. With proper design speeds, drivers might not feel the need to decelerate when utilizing the ramps. The disadvantages of this configuration include the large footprint necessary, the high cost of construction, and local opposition.

Full cloverleaf interchanges are also very effective at handling freeway-to-freeway connections. Unlike the stack interchange, the cloverleaf only requires two levels to accommodate all eight movements. However, as with the freeway-to-surface-street full cloverleaf connection, weaving is a consideration and can cause congestion and safety-related problems. To counter the effects of weaving, a collector-distributor system may be used.

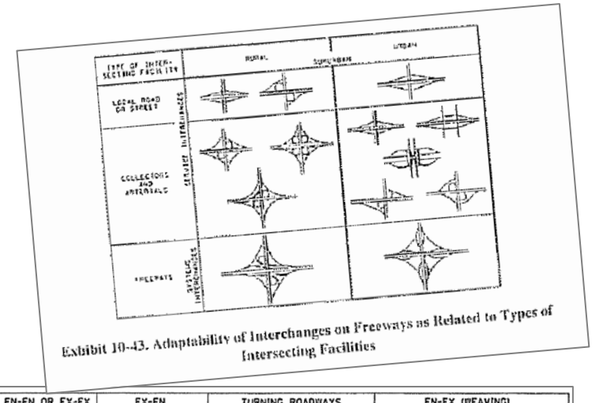
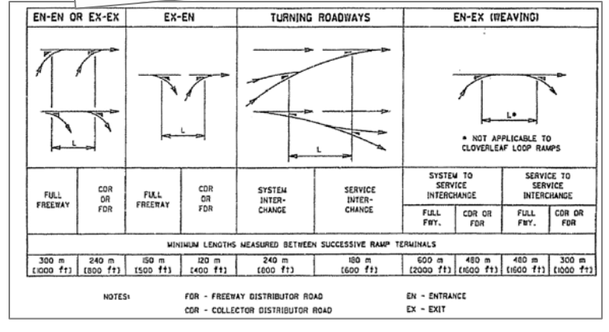


Exhibit 10-43. Adaptability of Interchanges on Freeways as Related to Types of Intersecting Facilities

Design Standards

Freeway design and operation is governed by the Federal Highway Administration (FHWA), and standards for both freeway and interchange design are provided by the American Association of State Highway and Transportation Officials (AASHTO). Published policies on design practices can be found in the AASHTO *Policy on Geometric Design of Highways and Streets*, 2004. The manual provides guidance and standards for many topics including interchange warrants, interchange designs, signing and marking, ramp design speeds, minimum ramp spacing, and minimum acceleration and deceleration distances on ramps. The tables and figures to the right are taken from the design manual and are commonly used to design the components of an interchange.







Study Area Interchanges

Within the study area, there are four freeway-to-surface-street interchanges and one freeway-to-freeway interchange. In addition, one grade separation within the study area that investigated for conversion to full interchange configuration and a new grade-separated crossing of I-85 between Salters Road/Old Sulphur Springs Road and Woodruff Road was analyzed. The following locations were evaluated to determine potential upgrades that might benefit congestion and safety along the Woodruff Road corridor and within the study area.

I-385 at Woodruff Road

The interchange at Woodruff Road and Interstate 385 is a standard four-ramp diamond interchange with signalized intersections at the ramp termini on Woodruff Road. The southbound exit ramp has recently been widened to facilitate larger capacities of traffic from I-385 to Woodruff Road. Average 2006 daily traffic volumes on the ramps are:

- Southbound exit ramp – 12,758 vehicles per day
- Southbound entrance ramp – 5,375 vehicles per day
- Northbound entrance ramp – 5,474 vehicles per day
- Northbound exit ramp – 13,524 vehicles per day

I-385 at Woodruff Road

I-85 at Woodruff Road

The interchange at Woodruff Road and Interstate 85 is a partial cloverleaf configuration with a loop ramp in the southeast quadrant and diagonal ramps in each quadrant. The loop ramp provides access to northbound I-85 from eastbound Woodruff Road. Vehicles traveling westbound on Woodruff Road have a diagonal free flow ramp that provides access to northbound I-85. The ramps feed into a collector-distributor system that carries traffic between the Woodruff/I-85 interchange and I-385/I-85 interchange. The ramp termini at Woodruff Road are signalized intersections. Within the last five years, the ramps have been upgraded to handle larger capacities, primarily from southbound I-85.

This location currently experiences heavy delay in the AM and PM peak periods. Traffic waiting to turn onto the ramps from westbound Woodruff Road experiences heavy queuing, sometimes extending into the next intersection, creating further congestion along the corridor. Average 2006 daily traffic volumes on the ramps are:

- Southbound exit ramp – 10,267 vehicles per day
- Southbound entrance ramp – 7,428 vehicles per day
- Northbound exit ramp – 17,831 vehicles per day

I-85 at Woodruff Road

I-385 at Roper Mountain Road

The Roper Mountain Road and Interstate 385 interchange is a standard four-ramp diamond interchange with a signalized intersection at the ramp termini on Roper Mountain Road. A frontage road intersects Roper Mountain Road approximately 350 feet from the northbound entrance and exit ramps causing continual spillback problems during the peak hour. The interchange is approximately 1 mile from the I-85/I-385 interchange. The section between the two interchanges experiences heavy weaving in peak hours. Average 2005 daily traffic volumes on the ramps are:

- Southbound exit ramp – 5,270 vehicles per day
- Southbound entrance ramp – 9,113 vehicles per day
- Northbound exit ramp – 5,106 vehicles per day
- Northbound entrance ramp – 10,107 vehicles per day

I-385 at Roper Mountain Road

I-85 at Laurens Road

The interchange of Laurens Road and Interstate 85 is an eight-ramp full cloverleaf configuration, with all entering and exit traffic on Laurens Road merging to and from the series of ramps. This merge operation causes a heavy weaving movement at the base of the loop ramps, creating congestion and an unsafe driving environment. Average 2006 daily traffic volumes on the ramps are:

- Southbound exit ramp (Eastbound Laurens) – 4,524 vehicles per day
- Southbound exit ramp (Westbound Laurens) – 3,232 vehicles per day
- Southbound entrance ramp (Eastbound Laurens) – 6,029 vehicles per day
- Southbound entrance ramp (Westbound Laurens) – 3,344 vehicles per day
- Northbound exit ramp (Eastbound Laurens) – 3,900 vehicles per day
- Northbound exit ramp (Westbound Laurens) – 4,130 vehicles per day
- Northbound entrance ramp (Eastbound Laurens) – 2,895 vehicles per day
- Northbound entrance ramp (Westbound Laurens) – 5,370 vehicles per day

I-85 at Laurens Road looking eastbound

I-85 at I-385

The Interstate 85 and Interstate 385 interchange is an eight-ramp, four-level-stack configuration, with a mixture of directional and loop ramps connecting the two facilities. Approach and departure ramps onto Interstate 385 have been modified in the past five years to lessen the weaving problem between the two facilities. Vehicles entering or exiting I-85 utilize a series of collector-distributor roads to separate traffic from the mainline and provide appropriate acceleration and deceleration distances between the successive interchanges. Average 2005 daily traffic volumes on the ramps are:

- Southbound I-385 to Northbound/Southbound I-85 – 12,579 vehicles per day
- Northbound I-385 to Northbound I-85 – 9,790 vehicles per day
- Northbound I-385 to Southbound I-85 – 6,061 vehicles per day
- Northbound I-85 to Southbound I-385 – 5,207 vehicles per day
- Northbound/Southbound I-85 to Southbound I-385 – 14,487 vehicles per day
- Southbound I-85 to Southbound I-385 – 8,750 vehicles per day

I-85 at I-385

I-85 at Salters Road/Old Sulphur Springs Road (Overpass Only)

The Salters Road/Old Sulphur Springs Road overpass crosses I-85 approximately 1.2 miles north of the Laurens Road interchange and 1 mile south of the Woodruff Road interchange. The current structure is aging and due for replacement. Salters Road and Old Sulphur Springs Road merge west of the overpass, and the two-lane roadway crosses the overpass and intersects the new Millennium Parkway east of the interstate.

The 2004 average daily traffic along the roadway is 4,100 vehicles. The traffic volumes along this corridor are expected to increase dramatically when the International Center for Automotive Research and the Verdae Development are fully built out. Previous planning efforts ruled out the potential for an interchange at this location due to its proximity to the interchange at Woodruff Road. At the charrette, this location was considered for full replacement as a 4-lane bridge with distinctive gateway architectural features.

Salters Road/Old Sulphur Springs Road Overpass

Recommendations

The I-85 and I-385 interchanges along Woodruff Road are some of the primary sources of congestion along the corridor, distributing large amounts of traffic onto the facility during peak hours. Initial observation indicated the Woodruff Road corridor suffers from too much access to freeway facilities. That is, I-85 and I-385 interchange spacing along Woodruff Road do not meet current federal spacing standards. The current configurations place the interchanges approximately one-half mile apart with eight traffic signals within this distance (four at the interchanges and four at commercial driveways). Traffic from the freeways coupled with traffic from adjacent developments creates an undesirable level of congestion and level of service.

I-85 at Woodruff Road

Congestion at the Woodruff Road and I-85 interchange is the heaviest of any location along the corridor, with queuing occurring on both the surface streets and ramps. In many instances, queuing stacks into the intersection and onto ramps thereby inhibiting movements from all approaches until upstream signals clear. This scenario effectively could be treated using better enforcement efforts through regular patrolling or ITS monitoring with ramp spillback detection.

Near-Term Recommendations (1 to 3 years)

A few cost-effective geometric considerations can potentially reduce congestion in the near term. These potential improvements are illustrated in **Figure 4.1** and include:

- Reconfiguring the northbound diagonal entrance ramp to provide more spacing between the intersection and the entrance to the Shops at Greenridge; Reconfiguration allows for right-in/right-out access at the Shops at Greenridge
- Extending the monolithic concrete island at the southbound entrance ramp to prohibit through movements to the northbound loop ramp at the adjacent intersection to allow southbound left turn phasing to be upgraded to protected-permitted (see inset image)
- Adding right turn lane to existing northbound exit ramp along with an additional auxiliary lane from northbound exit ramp to Carolina Point Parkway intersection.

Figure 4.1 – Proposed near-term improvements at I-85 and Woodruff Road

Long-Term Recommendations (5 to 15 years)

Potential long-term solutions include complete reconstruction of the facility, upgrading it from a partial cloverleaf with two signalized termini to a single point urban interchange. This type of interchange can handle larger capacities of traffic, which are expected as development continues along the corridor. The main cost associated with this improvement would be the reconstruction of the ramps and the large overpass structure over I-85. **Figure 4.2** depicts this potential improvement.

With the completion of one or both of these improvements, coupled with access management and signal timing improvements along the corridor, congestion levels should decrease, creating a safer and more suitable driving environment along Woodruff Road.

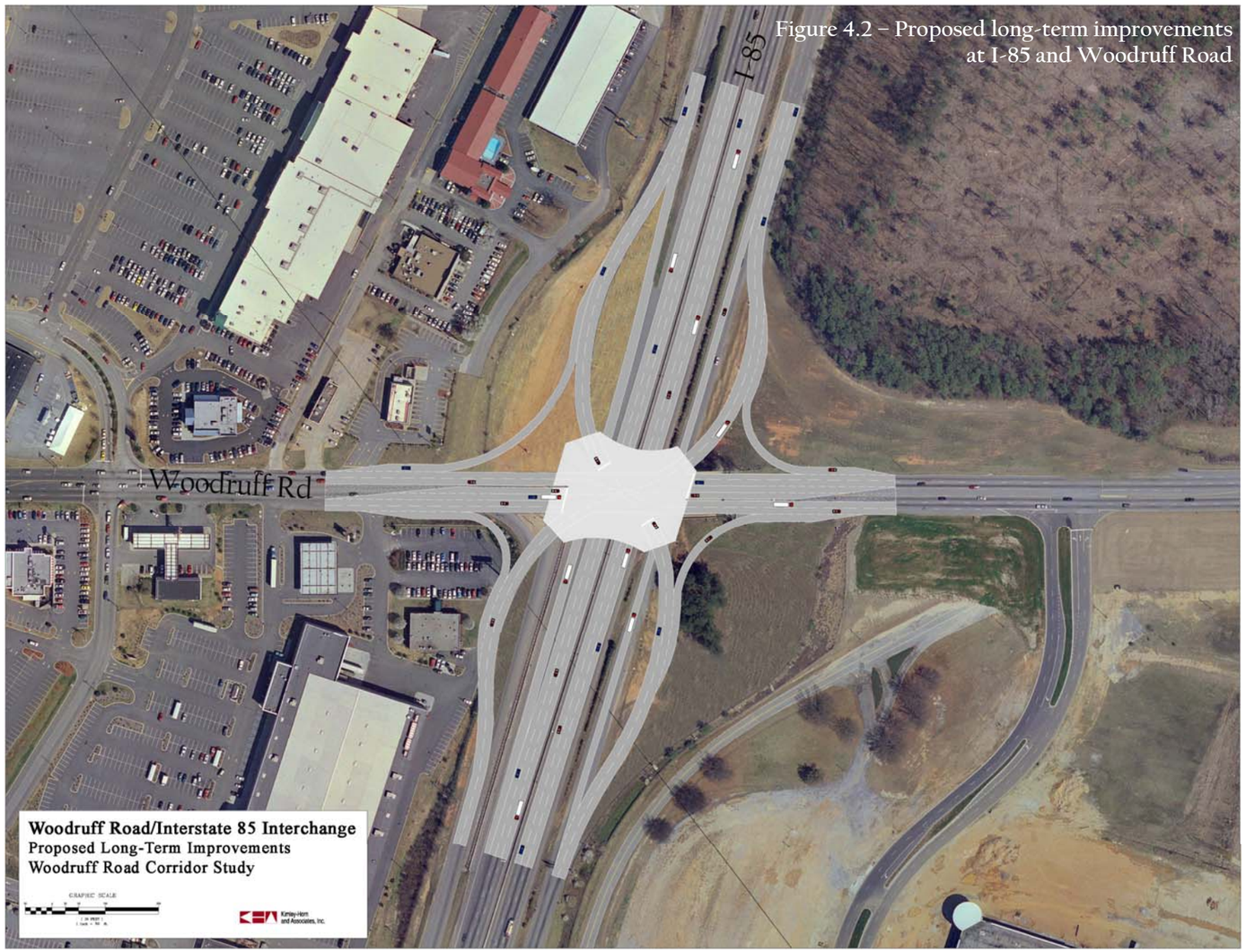
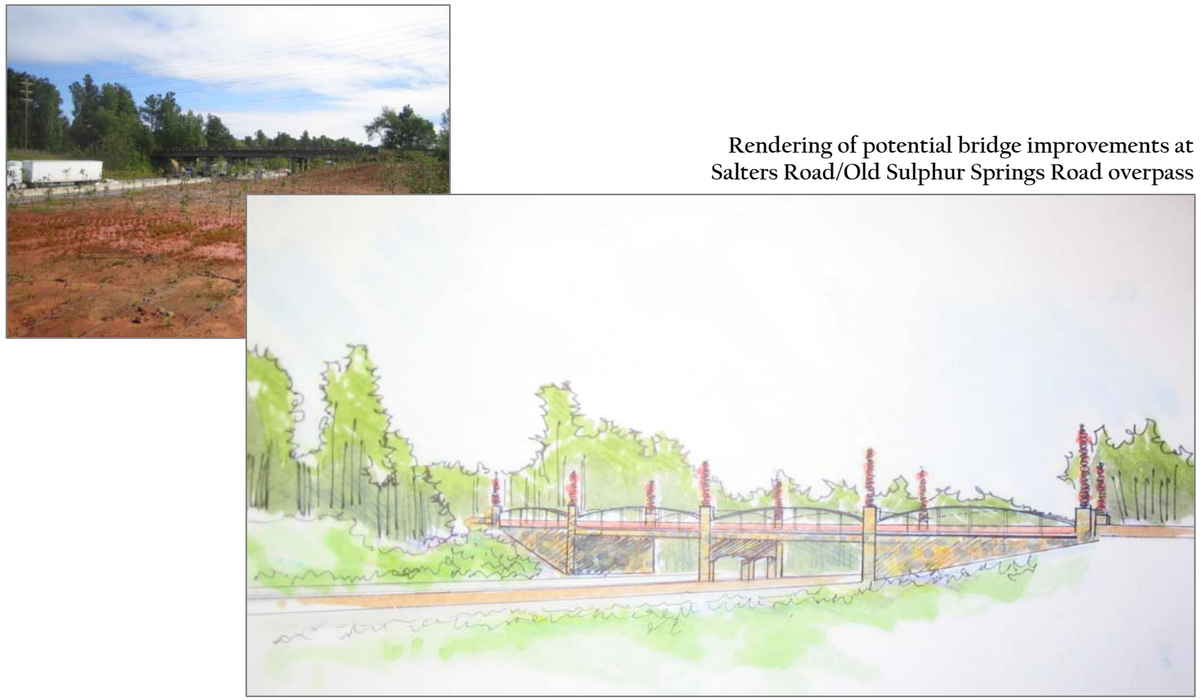


Figure 4.2 – Proposed long-term improvements at I-85 and Woodruff Road

I-85 at Salters Road/Old Sulphur Springs Road (Overpass Only)

South of the Woodruff Road and I-85 interchange, the overpass at Salters Road and Old Sulphur Springs Road is in need of upgrades to carry increased traffic volumes generated by the International Center for Automotive Research and the Verdae Development. The rendering to the right depicts potential upgrades to the overpass as it is rehabilitated.



Rendering of potential bridge improvements at Salters Road/Old Sulphur Springs Road overpass

Alternative Cross Access between Salters Road/ Old Sulphur Springs Road and Woodruff Road (Overpass Only)

An alternative cross access point could be created north of the Salters Road overpass, allowing for a parallel route from the Verdae Development to the proposed developments at The Point. Based on planning level analysis conducted at the design charrette, an overpass at this location would provide necessary cross access but would be difficult to implement due to its potential impact to current development plans. As shown in the rendering below, construction of this overpass would require considerable approach distances due to elevation differences between the east and west sides of I-85.

Profile view rendering of proposed new grade separation at I-85

I-85 at Laurens Road

Further south of the aforementioned overpasses, the interchange of Laurens Road and I-85 and its related weaving problem create safety risk to drivers as well as moderate congestion during peak hours. The acceleration and deceleration lanes shared by the loop ramps onto I-85 do not provide adequate room for merging traffic to and from Laurens Road. This short weave distance combined with the speed of vehicles entering and exiting has contributed to many crashes at this location.

Near-Term Recommendations (1 to 3 years)

A potential near-term solution would remove one set of opposing loop ramps, eliminating the weave problem altogether. The diagonal ramps in each quadrant would remain, and the two remaining loop ramps would have to be altered to handle left-turning traffic from their respective directions. The left-turn movement would require some paving in the median to provide a left-turn acceleration lane for traffic to merge with through traffic. This operation would also require a two-phase signal to provide a protected turning movement. Through traffic on the opposing side would be allowed to operate continuously while the turning movements were operating. **Figure 4.3** provides a conceptual rendering of the proposed improvements.

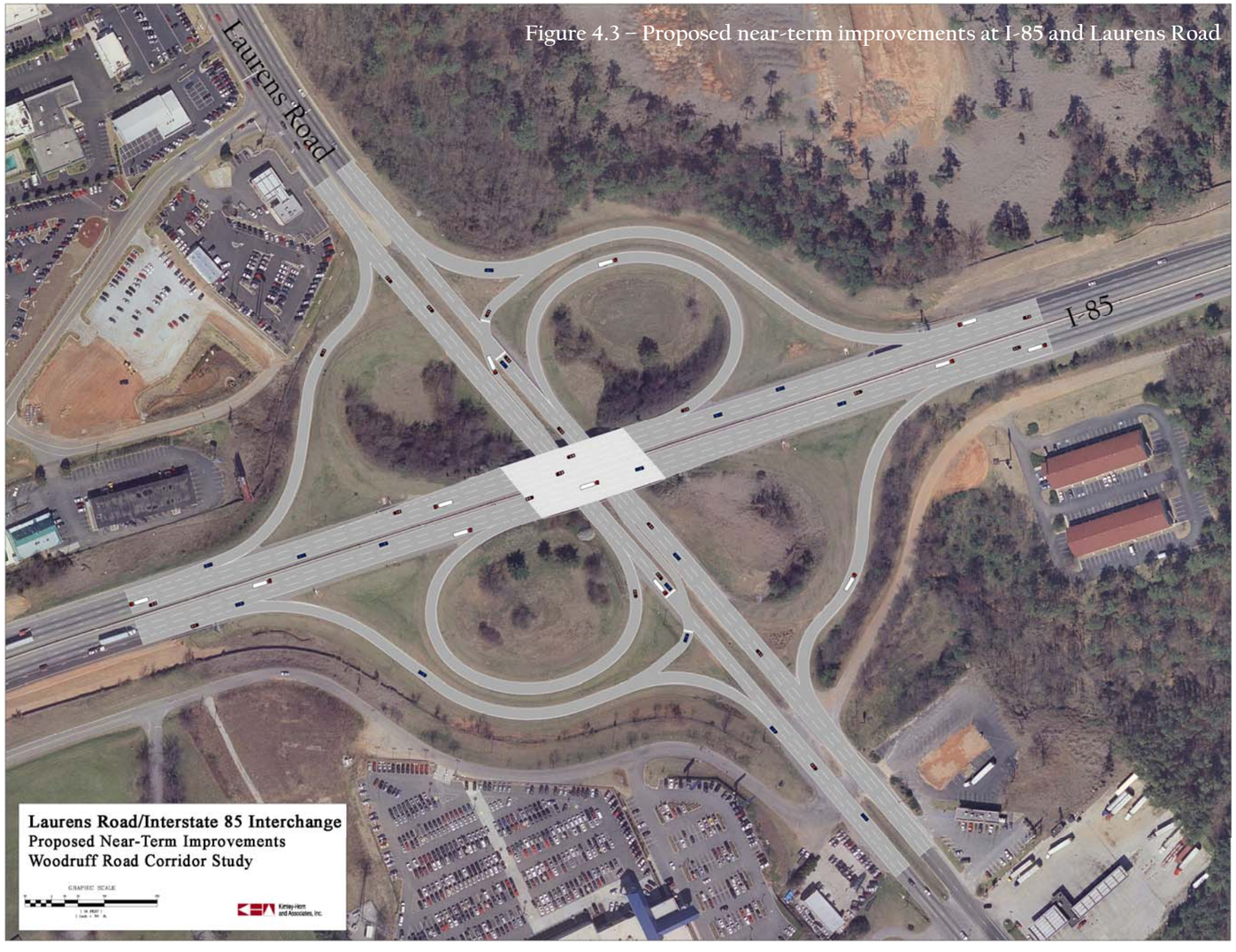


Figure 4.3 – Proposed near-term improvements at I-85 and Laurens Road

Long-Term Recommendations (5 to 15 years)

Potential long-term solutions include converting the cloverleaf facility into a single point urban interchange. Because the traffic on I-85 currently travels above the movements on Laurens Road, the turning movement operation of the SPUI would operate under the overpass at a new signal. This potential improvement would require complete reconstruction of the ramps and replacement of the bridge structure to allow additional vertical clearance to accommodate the new signal. **Figure 4.4** provides a conceptual rendering of the proposed improvements.

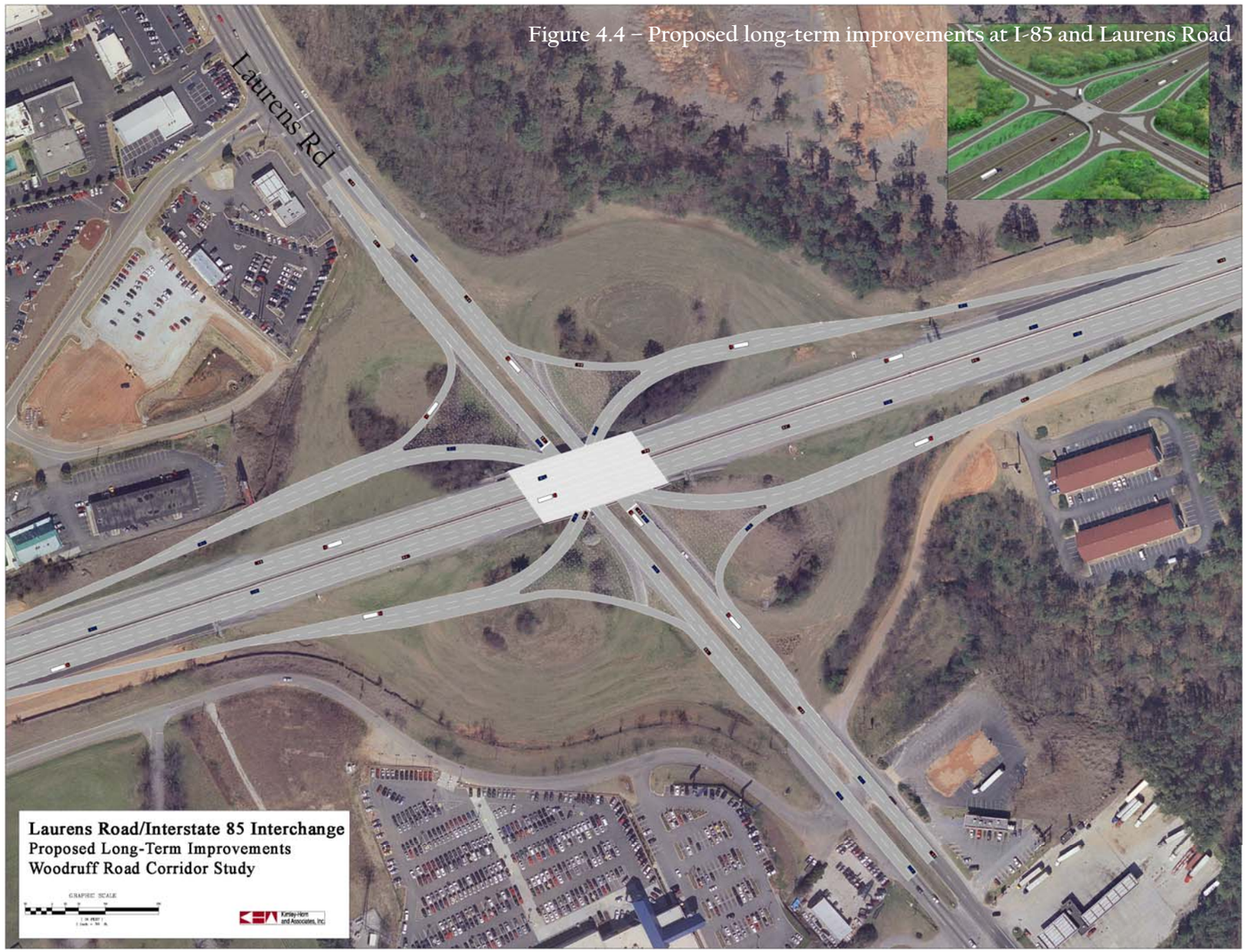


Figure 4.4 – Proposed long-term improvements at I-85 and Laurens Road