Reconstruction of I-94 and I-69 Interchange

Andrew Dobbs

Follow this and additional works at: http://scholarworks.wmich.edu/honors_theses
Part of the Civil and Environmental Engineering Commons

Recommended Citation
Andrew Dobbs, having been admitted to the Carl and Winifred Lee Honors College in the fall of 2008, successfully completed the Lee Honors College Thesis on April 17, 2012.

The title of the thesis is:

*Reconstruction of I-94 and I-69 Interchange*

---

Dr. Valerian Kwigizile, Civil and Construction Engineering

Dr. Pingbo Tang, Civil and Construction Engineering

Professor John Polasek, Civil and Construction Engineering
Reconstruction of I-94 and I-69 Interchange

Port Huron, Michigan

Gregg Aukeman, Andrew Dobbs, Adam Mueller, Manuel Torreira
Acknowledgements

Jeff Chenault: Sponsor (Parsons Brinckerhoff)

Laurie Langlois: Sponsor (Parsons Brinckerhoff)

Dr. Valerian Kwizile: Faculty Advisor (Western Michigan University)

John Polasek: Professor (Western Michigan University)
Background and Description

In recent years, Michigan has emphasized the modernization of its interstate highway system in order to bring it up to current federal and state standards. I-94 to the south and I-69 to the west have been reconstructed to meet current standards. This project focuses on the reconstruction of the interchange of I-94 and I-69. This interchange consists of six bridges. In the middle of the interchange is Michigan Road, a local road that passes over the interchange and constricts the elevation of the freeway. Figure 1 shows the aerial view of the current interchange.

Many problems exist within the interchange because it does not meet current Michigan Department of Transportation (MDOT) standards. There have been flooding issues in the past because the current interchange was not designed for the 100 year storm. Because of the vast wetlands in and around the interchange, the infiltration of storm water is insufficient. Also, the current ramp configuration does not meet the desired design speed of 60 mph; moreover, in some locations the existing alignment only reaches a 40 mph design speed (according to current standards).

Another objective of the project is to redesign ramps so that traffic will enter the roadway from a more traditional location, the right hand side of the interstate. Entrances and exits from the right hand side are consistent with drivers’ expectations. This is a key component to meeting current standards. Currently, the ramp from I-94 east to I-69 west enters the mainline on the left. The proposed design will address this deficiency by adjusting this ramp to travel over westbound I-69 and enter on the right.

![Figure 1 (Google Maps, 2012)](image-url)
Scope of Work
Most of the problems with the interchange are on the west side of Michigan Road. Our team met with the client, Parsons Brinckerhoff, and decided that we should restrict our design work to the west half only. In addition, the time frame in which we had to complete our design was minimal. We felt that our client deserved our best work, and this could only be done if our design area was reasonable. Furthermore, Michigan Road serves as a tie in point with which to join the proposed roadways to the east side of the interchange.

![Existing Diagram](image)

**Figure 2**

We first created three alignment alternatives based solely on horizontal curve calculations. We evaluated the advantages and disadvantages of each alternative according to our constraints and design criteria. Our recommendation was taken to our advisor and client who both agreed. In order to make sure our horizontal alignment was satisfactory, we determined superelevation transitions using MDOT standards.

With the horizontal alignment complete, our next step was to design the vertical alignment of the mainlines and ramps. We used Microsoft Excel first in designing our vertical curves to make sure we understood the criteria and formulas. After completion of the basic vertical alignment, we finalized the vertical curves by using professional software: Microstation and GeoPak.
What remained were many details that had to be clarified in order to provide a cost estimate. We assumed a pavement thickness, calculated earthwork, and determined the area of wetlands impacted. With these figures, we concluded with a cost estimate of the construction of our design.

**Constraints**
The interchange lies on several acres of dense wooded wetlands, and this has been known to cause flooding on the highway. Due to this serious issue, the proposed interchange and drainage design must account for the 100 year storm. This requires raising the elevation of I-94 and in turn raising the over passing roads to meet the minimum 16’-3” underclearance requirement (MDOT, 2012). In addition, the Michigan Department of Environmental Quality (MDEQ) requires a restoration or creation of two acres of wetlands for each acre disturbed (MDEQ, 2012).

The interchange is located in a suburban area, so the surrounding neighborhoods and local roads restrict the design of the reconstructed interchange. This results in a very narrow right-of-way. In addition, the proposed design must tie into three different points both horizontally and vertically; these points occur at Range Road, Griswold Road, and Michigan Road. For vertical alignment, the proposed design must match both the existing elevations and grades.

**Horizontal Alignment**
The first step in our design was to consider the horizontal alignment. When a vehicle moves in a circular path, it undergoes centripetal acceleration. Vehicles withstand this acceleration through superelevation (e) or “banking” of the roadway. Also, the side friction (f) between tires and pavement surface affect a vehicle’s ability to sustain this acceleration. Using these two variables, we can determine minimum acceptable radii for different design speeds using basic mechanics.

\[
R_{min} = \frac{V^2}{15(0.01e_{max} + f_{max})}
\]

(AASHTO, 2004)

The maximum allowable superelevation is set by MDOT as 7% (MDOT, 2012). The side friction factor is a function of the design speed of the roadway.
Figure 3 clearly demonstrates that the friction factor decreases as the design speed increases. Side friction factors were determined for design speeds from 30 to 75 mph using Figure 3 and placed in the minimum radius equation.

![Figure 3 (AASHTO, 2004)](image_url)

<table>
<thead>
<tr>
<th>Friction Factor</th>
<th>0.09</th>
<th>0.10</th>
<th>0.11</th>
<th>0.12</th>
<th>0.13</th>
<th>0.14</th>
<th>0.15</th>
<th>0.16</th>
<th>0.18</th>
<th>0.20</th>
</tr>
</thead>
<tbody>
<tr>
<td>Design Speed (mph)</td>
<td>75</td>
<td>70</td>
<td>65</td>
<td>60</td>
<td>55</td>
<td>50</td>
<td>45</td>
<td>40</td>
<td>35</td>
<td>30</td>
</tr>
<tr>
<td>Superelevation (%)</td>
<td>7</td>
<td>7</td>
<td>7</td>
<td>7</td>
<td>7</td>
<td>7</td>
<td>7</td>
<td>7</td>
<td>7</td>
<td>7</td>
</tr>
<tr>
<td>Radius (ft)</td>
<td>2344</td>
<td>1922</td>
<td>1565</td>
<td>1263</td>
<td>1008</td>
<td>794</td>
<td>614</td>
<td>464</td>
<td>327</td>
<td>222</td>
</tr>
</tbody>
</table>

Table 1

To confirm the accuracy of our calculations, we compared our minimum radii with MDOT standards (Table 2). They were found to be exactly equal. Knowing the minimum radius corresponding to each design speed enabled us to begin designing our alternatives within the boundaries of the right-of-way.
In creating alternative 1, our main objective was to make all the design speeds as high as possible. We were able to achieve 65 mph on all the ramps while maintaining 70 mph on the mainlines. This resulted in several drawbacks however.

The design speed of Ramp A was increased from 55 mph to 65 mph. This entailed a large increase in the radius, causing Ramp A to be extremely close to the right-of-way. Even though it doesn’t actually cross the boundary, it must be noted that there is likely to be disruption of land outside the right-of-way due to the shoulder and ditch.

The design speed of Ramp D was significantly improved in this alignment; it was increased from 40 mph to 65 mph. Eastbound I-94 now had to be shifted slightly to the right (east) to provide enough space for Ramp D to have the required clearances over westbound I-94. This creates a dilemma downstream on I-94. The westbound and eastbound roadways continually grow farther apart, and where eastbound I-69 crosses over I-94, the span of the bridge is considerably long.
The design of Ramps B and F had fewer constraints. We had plenty of space to adjust their positioning and tried to place them in the most efficient way. We designed them such that their roadway lengths would be minimized.

Some other problems that exist in alignment 1 are the sharp skew angles of the bridges and the weaving of traffic. The sharp skew angles of the bridges will increase the cost of the bridges because the length of the span of the bridges will be greater. Since eastbound I-94 is only a two lane freeway and has both an exit on the left hand side (Ramp D) and an exit on the right hand side (Ramp B) within a quarter mile of each other, traffic will be weaving in and out of lanes trying to get to their exit.

Alignment Alternative 2
Our goal when designing alternative 2 was to modify alternative 1 to increase feasibility and constructability. As mentioned above, alternative 1 solved the main problems but introduced more difficulties. We attempted to remove these difficulties in alternative 2.

The 65 mph design speed of Ramp D in alignment 1 was desirable but brought on more problems than it was worth. We were able to fix these problems while still maximizing the design speed. The left hand exit of Ramp D from eastbound I-94 was a safety issue that needed to be addressed. We resolved this
issue by keeping the existing horizontal alignment of I-94 and having Ramp D exit on the right hand side. The right hand exit caused our design speed to be only 60 mph. The new curve introduced a problem with the entrance onto westbound I-69. This was solved by moving westbound I-69 south towards eastbound I-69. The proximity of eastbound I-69 to westbound I-69 reduced the bridge span of Ramp D, which will reduce the cost of the bridge.

The right-of-way problem in alignment 1 would have made the construction of Ramp A nearly impossible. To account for this, we determined a minimum distance between the ramp and the right-of-way that was needed in order for the entire roadway to stay within the right-of-way. This minimum distance was fixed, and we then found the highest design speed that would not result in a higher distance. The design speed was found to be 60 mph.

We also increased the design speed of Ramp F to 70 mph. This of course increased the radius of the curve and the length of the ramp. We felt that the increase in speed outweighed the cost of the extra length of the ramp.

In order to correct the weaving problem in alignment 1, we combined ramps B and D into a single exit off eastbound I-94. This increases the roadway length but drastically improves safety. The one problem that alignment 2 was not able to solve is the severe skew angles.

Figure 5

alignment Alternative 2
Alignment Alternative 3
The one problem that alignments 1 and 2 have in common is the severe skew angles of the bridges. Naturally, in our next alternative we made an effort to solve the skew problem. This would effectively decrease bridge span lengths and reduce cost. To achieve this we had to relocate many of the mainlines and ramps.

Ramp B and Ramp D both exit together as they did in alignment 2 but their divergence is very different. Ramp D does not separate from Ramp B until much further downstream in order to produce an almost perpendicular angle of Ramp D over eastbound I-69. Ramp D then bridges over both bounds of I-94 and westbound I-69 in one short bridge that is also nearly perpendicular. In order to make this work, the radius of Ramp D had to be small. The greatest design speed we could obtain was 40 mph, no improvement upon the existing design speed.

To keep the span of Ramp D over I-94 and westbound I-69 short, westbound I-69 had to be moved as close as possible to I-94, and the two bounds of I-94 had to be very closely spaced. This decreased the design speeds of the mainlines. All of I-69 is 65 mph and all of I-94 is 60 mph.

In conclusion, alternative 3 may be the least expensive option due to the bridges, but not the most favorable.
Analysis of Alternatives
Following the design of the three alternatives, a meeting was held with our advisor. Upon showing our first alignment, our advisor liked the fact that the design speeds were so high but did not like the safety hazard that presented itself with the left hand exit of ramp D from eastbound I-94. Alignment 2 was much more pleasing to him because of the right hand exit for ramp D from eastbound 1-94. The lower design speeds were not a major concern because our design still met our clients’ requests. Our advisor immediately disliked alignment 3 because ramp D had such a low design speed. He explained that this did not improve the interchange at all. With the recommendations of our advisor, we then took the three proposals to our client.

The client was very pleased with the variety of the three alternatives we offered to them. We first showed them alignment 3 and explained that we were trying to think outside of the norm but relayed our advisor’s opinion that this alignment would not be the best option. They liked the perpendicular angles of the bridges but realized this alignment didn’t solve any of the constraints. Alignments 1 and 2 were shown to them at the same time because of their similarities. We highlighted the high design speeds of alignment 1 but also pointed out the difficulties that it created. We pointed out how those difficulties were solved in alignment 2 but the design speeds had to be reduced slightly. The higher design speeds of alignment 1 were lucrative to our clients, but with our persuasion and advice, they decided that alignment 2 was the best option. Adjourning the meeting, we only focused on alignment 2 for the rest of our design.

Other Horizontal Considerations
In order to complete our horizontal design, we had to establish lane and shoulder widths and design all entrance and exit ramps. These criteria are all set by MDOT standards. Figure 7 states that all freeway lanes should be at least 12 feet. MDOT provides guidelines on ramp lane widths; 3.07.02E of the Michigan Road Design Manual states that “single lane ramp widths are normally 16 feet 0 inches.” (MDOT, 2012) Figure 8 dictates shoulder requirements for mainlines and ramps. Ramp shoulders are straightforward; 6 feet on the left and 8 feet on the right. Determination of mainline shoulders involves the amount of traffic on the freeway. At the request of the client, we used 8 foot shoulders for the median and 12 foot shoulders for the outside.

In summary:

<table>
<thead>
<tr>
<th></th>
<th>Lane Width (ft)</th>
<th>Left Shoulder Width (ft)</th>
<th>Right Shoulder Width (ft)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mainlines</td>
<td>12</td>
<td>8</td>
<td>12</td>
</tr>
<tr>
<td>Ramps</td>
<td>16</td>
<td>6</td>
<td>8</td>
</tr>
</tbody>
</table>

Table 3
Figures 8-11 present standards regarding minimum lengths for parallel entrance and exit ramps. Taper lengths should be at least 300 feet for entrance and exit ramps. For entrance ramps, the parallel section is given on the diagram (Figure 9) as $L_{\text{gap}}$. For a mainline design speed of 70 mph, $L_{\text{gap}}$ is 360 feet (Figure 8).
For exit ramps, a calculation is needed. $L_d$ is 360 feet assuming a grade between -3% and 3% (Figure 12). Therefore, the parallel section is:

$$360 - 150 = 210 \text{ feet}$$

In summary:

<table>
<thead>
<tr>
<th></th>
<th>Taper Length (ft)</th>
<th>Parallel Length (ft)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Entrance Ramps</td>
<td>300</td>
<td>360</td>
</tr>
<tr>
<td>Exit Ramps</td>
<td>300</td>
<td>210</td>
</tr>
</tbody>
</table>

Table 4
CASE I

Figure 9 (MDOT, 2012)

MINIMUM ENGLISH LENGTHS FOR PARALLEL ENTRANCE RAMPS

<table>
<thead>
<tr>
<th>RAMP DESIGN SPEED (MPH)</th>
<th>PERCENT GRADE OF THROUGH ROADWAY</th>
<th>LA (FT)</th>
<th>Lc (FT)</th>
<th>Lb (FT)</th>
<th>Lc (FT)</th>
<th>Ld (FT)</th>
<th>Le (FT)</th>
</tr>
</thead>
<tbody>
<tr>
<td>20</td>
<td>-3 TO LESS THAN -5</td>
<td>978</td>
<td>912</td>
<td>660</td>
<td>556</td>
<td>450</td>
<td></td>
</tr>
<tr>
<td></td>
<td>BETWEEN -3 AND -3</td>
<td>1630</td>
<td>1530</td>
<td>1100</td>
<td>910</td>
<td>450</td>
<td></td>
</tr>
<tr>
<td></td>
<td>+3 TO LESS THAN +5</td>
<td>2528</td>
<td>2280</td>
<td>1540</td>
<td>1094</td>
<td>608</td>
<td></td>
</tr>
<tr>
<td>25</td>
<td>-3 TO LESS THAN -5</td>
<td>946</td>
<td>852</td>
<td>612</td>
<td>500</td>
<td>450</td>
<td></td>
</tr>
<tr>
<td></td>
<td>BETWEEN -3 AND +3</td>
<td>1500</td>
<td>1420</td>
<td>1020</td>
<td>780</td>
<td>450</td>
<td></td>
</tr>
<tr>
<td></td>
<td>+3 TO LESS THAN +5</td>
<td>2320</td>
<td>2201</td>
<td>1419</td>
<td>1092</td>
<td>608</td>
<td></td>
</tr>
<tr>
<td>30</td>
<td>-3 TO LESS THAN -5</td>
<td>946</td>
<td>852</td>
<td>612</td>
<td>500</td>
<td>450</td>
<td></td>
</tr>
<tr>
<td></td>
<td>BETWEEN -3 AND +3</td>
<td>1510</td>
<td>1350</td>
<td>910</td>
<td>670</td>
<td>450</td>
<td></td>
</tr>
<tr>
<td></td>
<td>+3 TO LESS THAN +5</td>
<td>2492</td>
<td>2160</td>
<td>1385</td>
<td>972</td>
<td>608</td>
<td></td>
</tr>
<tr>
<td>35</td>
<td>-3 TO LESS THAN -5</td>
<td>952</td>
<td>738</td>
<td>550</td>
<td>500</td>
<td>450</td>
<td></td>
</tr>
<tr>
<td></td>
<td>BETWEEN -3 AND +3</td>
<td>1420</td>
<td>1230</td>
<td>800</td>
<td>550</td>
<td>450</td>
<td></td>
</tr>
<tr>
<td></td>
<td>+3 TO LESS THAN +5</td>
<td>2450</td>
<td>2030</td>
<td>1200</td>
<td>798</td>
<td>450</td>
<td></td>
</tr>
<tr>
<td>40</td>
<td>-3 TO LESS THAN -5</td>
<td>696</td>
<td>600</td>
<td>550</td>
<td>500</td>
<td>450</td>
<td></td>
</tr>
<tr>
<td></td>
<td>BETWEEN -3 AND +3</td>
<td>1360</td>
<td>1000</td>
<td>550</td>
<td>500</td>
<td>450</td>
<td></td>
</tr>
<tr>
<td></td>
<td>+3 TO LESS THAN +5</td>
<td>2088</td>
<td>1700</td>
<td>425</td>
<td>725</td>
<td>608</td>
<td></td>
</tr>
<tr>
<td>45</td>
<td>-3 TO LESS THAN -5</td>
<td>650</td>
<td>600</td>
<td>550</td>
<td>500</td>
<td>450</td>
<td></td>
</tr>
<tr>
<td></td>
<td>BETWEEN -3 AND +3</td>
<td>1040</td>
<td>820</td>
<td>550</td>
<td>500</td>
<td>450</td>
<td></td>
</tr>
<tr>
<td></td>
<td>+3 TO LESS THAN +5</td>
<td>1924</td>
<td>1435</td>
<td>425</td>
<td>725</td>
<td>608</td>
<td></td>
</tr>
<tr>
<td>50</td>
<td>-3 TO LESS THAN -5</td>
<td>650</td>
<td>600</td>
<td>550</td>
<td>500</td>
<td>450</td>
<td></td>
</tr>
<tr>
<td></td>
<td>BETWEEN -3 AND +3</td>
<td>1360</td>
<td>1000</td>
<td>550</td>
<td>500</td>
<td>450</td>
<td></td>
</tr>
<tr>
<td></td>
<td>+3 TO LESS THAN +5</td>
<td>2088</td>
<td>1700</td>
<td>425</td>
<td>725</td>
<td>608</td>
<td></td>
</tr>
<tr>
<td>55</td>
<td>-3 TO LESS THAN -5</td>
<td>650</td>
<td>600</td>
<td>550</td>
<td>500</td>
<td>450</td>
<td></td>
</tr>
<tr>
<td></td>
<td>BETWEEN -3 AND +3</td>
<td>1360</td>
<td>1000</td>
<td>550</td>
<td>500</td>
<td>450</td>
<td></td>
</tr>
<tr>
<td></td>
<td>+3 TO LESS THAN +5</td>
<td>1360</td>
<td>1000</td>
<td>550</td>
<td>500</td>
<td>450</td>
<td></td>
</tr>
<tr>
<td>60</td>
<td>-3 TO LESS THAN -5</td>
<td>650</td>
<td>600</td>
<td>550</td>
<td>500</td>
<td>450</td>
<td></td>
</tr>
<tr>
<td></td>
<td>BETWEEN -3 AND +3</td>
<td>1360</td>
<td>1000</td>
<td>550</td>
<td>500</td>
<td>450</td>
<td></td>
</tr>
<tr>
<td></td>
<td>+3 TO LESS THAN +5</td>
<td>1360</td>
<td>1000</td>
<td>550</td>
<td>500</td>
<td>450</td>
<td></td>
</tr>
<tr>
<td>65</td>
<td>-3 TO LESS THAN -5</td>
<td>650</td>
<td>600</td>
<td>550</td>
<td>500</td>
<td>450</td>
<td></td>
</tr>
<tr>
<td></td>
<td>BETWEEN -3 AND +3</td>
<td>1360</td>
<td>1000</td>
<td>550</td>
<td>500</td>
<td>450</td>
<td></td>
</tr>
<tr>
<td></td>
<td>+3 TO LESS THAN +5</td>
<td>1360</td>
<td>1000</td>
<td>550</td>
<td>500</td>
<td>450</td>
<td></td>
</tr>
<tr>
<td>70</td>
<td>-3 TO LESS THAN -5</td>
<td>650</td>
<td>600</td>
<td>550</td>
<td>500</td>
<td>450</td>
<td></td>
</tr>
<tr>
<td></td>
<td>BETWEEN -3 AND +3</td>
<td>1360</td>
<td>1000</td>
<td>550</td>
<td>500</td>
<td>450</td>
<td></td>
</tr>
<tr>
<td></td>
<td>+3 TO LESS THAN +5</td>
<td>1360</td>
<td>1000</td>
<td>550</td>
<td>500</td>
<td>450</td>
<td></td>
</tr>
<tr>
<td>75</td>
<td>-3 TO LESS THAN -5</td>
<td>650</td>
<td>600</td>
<td>550</td>
<td>500</td>
<td>450</td>
<td></td>
</tr>
<tr>
<td></td>
<td>BETWEEN -3 AND +3</td>
<td>1360</td>
<td>1000</td>
<td>550</td>
<td>500</td>
<td>450</td>
<td></td>
</tr>
<tr>
<td></td>
<td>+3 TO LESS THAN +5</td>
<td>1360</td>
<td>1000</td>
<td>550</td>
<td>500</td>
<td>450</td>
<td></td>
</tr>
</tbody>
</table>

Figure 10 (MDOT, 2012)
### Minimum English Lengths for Parallel Exit Ramps

<table>
<thead>
<tr>
<th>Ramp Design Speed (MPH)</th>
<th>Percent Grade of Through Roadway</th>
<th>TAPER=30:1 Delta=15°15'</th>
<th>TAPER=40:1 Delta=15°45'</th>
<th>TAPER=50:1 Delta=17°26'</th>
<th>TAPER=50:1 Delta=17°26'</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>ROADWAY DESIGN SPEED = 75 MPH</td>
<td>ROADWAY DESIGN SPEED = 70 MPH</td>
<td>ROADWAY DESIGN SPEED = 60 MPH</td>
<td>ROADWAY DESIGN SPEED = 55 MPH</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0 = 23' Ld min = 350'</td>
<td>0 = 23' Ld min = 350'</td>
<td>0 = 24' Ld min = 300'</td>
<td>0 = 24' Ld min = 300'</td>
</tr>
</tbody>
</table>


#### Notes:
- Ld (ft) = Length of deceleration distance
- Ld min = Minimum length

**Figure 11 (MDOT, 2012)**

**Figure 12 (MDOT, 2012)**
Figure 13 verifies that we met the above requirements and represents a final horizontal design.

Superelevation
As previously mentioned, vehicles withstand centripetal acceleration during a horizontal curve through superelevation (e) or tilting of the roadway. This “banking” of the lanes is what permits vehicles to operate efficiently at realistic design speeds. Various factors have to be taken into consideration when determining a suitable superelevation rate. According to MDOT standards, the rate of superelevation (e %), as well as the transition slope of pavement edges (Δ %), depends on design speeds and radii. Table 2 clearly demonstrates this relationship. These two values were determined for each curve on our alignment and can be seen in Table 5.

The normal crown rate (NC) is defined as 2% (MDOT, 2012). W is the distance from the axis of rotation to the farthest outside edge. This was simplified to be 12 feet for mainline lanes and 16 feet for all ramps. Using these values, we can determine C and L using the equations from MDOT standards below. C is the distance required to transition from normal crown to level, also known as tangent runout. L is the entire distance required to transition from level to the required superelevation, also known as superelevation runoff. MDOT allows a distance of 1/3 L after the point of curvature (PC), to fully transition to the required superelevation (MDOT, 2012). This is graphically represented in the upper left
diagram on Figure 14. If the crown is in the same direction as the superelevation (upper right diagram on Figure 14), the actual transition distance is much less. This applies to ramp A and ramp B. Ramp F needs a full superelevation of 7%, as well as westbound I-94, which it ties into. Therefore, no transition is needed on ramp F, which is why it is excluded from Table 5. In addition, the lower diagram on Figure 14 is for the mainlines, where there are two lanes. In this case, the outside lane controls and has the same C and L equations as the ramps.

\[
D = W \times NC \quad S = W \times e \quad C = \frac{D}{\Delta \%} \times 100 \quad L = \frac{S}{\Delta \%} \times 100
\]

(MDOT, 2012)

In Table 5 all the D, S, C, and L values were calculated for each curve. In addition, the transition distances on each side of the PC were calculated. For ramp A and ramp B, the transition distance was calculated as well.

See Appendix A for drawings of the superelevation transitions. Curve 1 on westbound I-69 does not include a drawing for the PC because this point occurs on the east side of Michigan Road, which is outside the scope of our project.
Storm Water Consideration

In order to design for the 100 year storm, a consultant provided us with information. They conducted a hydrological analysis and determined the required elevations of the ditches to prevent flooding. Then they created a map of these required elevations. For each ditch, they specified how much higher the
shoulder needed to be than the ditch. We added this distance to each ditch elevation. However, since all our superelevation transitions rotate about the centerline of the road, the edge of the road could potentially be below the required elevation. In order to account for this, we determined the change in elevation of the edge of the shoulder due to a 7% superelevation, which is the maximum that occurs in our design. Lane widths are 12 feet and the largest shoulder width that occurs is 12 feet. Ramp lane widths are 16 feet with the right shoulder being 8 feet.

Mainlines: \[0.07 \times (12 + 12) = 1.68 \text{ ft}\]

Ramps: \[0.07 \times (16 + 8) = 1.4 \text{ ft}\]

Therefore, the maximum change in elevation of the edge of the shoulder is 1.68 feet. We conservatively added 2 feet to every point.

Figure 15 shows our calculated required roadway elevations. With the knowledge of these target elevations, we were able to begin vertical alignment.
**Vertical Alignment**

A vertical alignment consists of differing grades connected by vertical curves. These curves are parabolic and can be either a crest or sag (Garber & Hoel, 2009). A crest occurs when the initial grade of the back tangent is greater than the final grade of the forward tangent. A sag occurs when the initial grade of the back tangent is smaller than the final grade of the forward tangent. Figure 16 illustrates this concept.

The equation below is used to determine the elevation of the roadway at a specific point on a vertical curve. $G_1$ is the initial grade and $G_2$ is the final grade (both in decimal form), $L$ is the length of the curve, and $y_{PVC}$ is the elevation at the point of vertical curvature (in feet), which is the beginning of the curve.

$$y = y_{PVC} + G_1x + \frac{(G_2 - G_1)x^2}{2L}$$

(Garber & Hoel, 2009)

The length of the curve is constrained by several criteria: comfort, appearance, drainage, and stopping distance. Since the design speeds are 60 mph or higher, stopping sight distance usually governs, and curves are often designed solely based on this (AASHTO, 2004). The minimum length of a curve can be established by using the equation below. The $K$ factor is determined using only the stopping sight distance criterion and depends on the design speed (Table 6). $A$ is the difference in grades $G_1$ and $G_2$.

$$L = KA$$

(AASHTO, 2004)
K Values for Crest Curves

<table>
<thead>
<tr>
<th>Design Speed (mph)</th>
<th>K</th>
</tr>
</thead>
<tbody>
<tr>
<td>15</td>
<td>3</td>
</tr>
<tr>
<td>20</td>
<td>7</td>
</tr>
<tr>
<td>25</td>
<td>12</td>
</tr>
<tr>
<td>30</td>
<td>19</td>
</tr>
<tr>
<td>35</td>
<td>29</td>
</tr>
<tr>
<td>40</td>
<td>44</td>
</tr>
<tr>
<td>45</td>
<td>61</td>
</tr>
<tr>
<td>50</td>
<td>84</td>
</tr>
<tr>
<td>55</td>
<td>114</td>
</tr>
<tr>
<td>60</td>
<td>151</td>
</tr>
<tr>
<td>65</td>
<td>193</td>
</tr>
<tr>
<td>70</td>
<td>247</td>
</tr>
<tr>
<td>75</td>
<td>312</td>
</tr>
<tr>
<td>80</td>
<td>384</td>
</tr>
</tbody>
</table>

K Values for Sag Curves

<table>
<thead>
<tr>
<th>Design Speed (mph)</th>
<th>K</th>
</tr>
</thead>
<tbody>
<tr>
<td>15</td>
<td>10</td>
</tr>
<tr>
<td>20</td>
<td>17</td>
</tr>
<tr>
<td>25</td>
<td>26</td>
</tr>
<tr>
<td>30</td>
<td>37</td>
</tr>
<tr>
<td>35</td>
<td>49</td>
</tr>
<tr>
<td>40</td>
<td>64</td>
</tr>
<tr>
<td>45</td>
<td>79</td>
</tr>
<tr>
<td>50</td>
<td>96</td>
</tr>
<tr>
<td>55</td>
<td>115</td>
</tr>
<tr>
<td>60</td>
<td>136</td>
</tr>
<tr>
<td>65</td>
<td>157</td>
</tr>
<tr>
<td>70</td>
<td>181</td>
</tr>
<tr>
<td>75</td>
<td>206</td>
</tr>
<tr>
<td>80</td>
<td>231</td>
</tr>
</tbody>
</table>

Table 6 (AASHTO, 2004)

There were three constraints we had to meet when designing vertical curves. We had to match the existing elevations and grades at every tie in point (Range Road, Griswold Road, and Michigan Road), we had to ensure that all bridges cleared underpassing roads by at least 16’3”, and we had to meet all the target elevations for storm water. In addition, MDOT restricts vertical grades between -3% and 3% on mainlines and -5% and 5% on ramps (MDOT, 2012).

We began our vertical alignment by utilizing the parabolic equation in Microsoft Excel. Table 7 is an example of this method. It represents ramp B. Figure 17 is a plot of elevation versus station for ramp B.
<table>
<thead>
<tr>
<th>Station</th>
<th>Elevation</th>
<th>Distance</th>
<th>Curve type</th>
<th>PVC</th>
<th>curve type</th>
</tr>
</thead>
<tbody>
<tr>
<td>0+00.00</td>
<td>645.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0+50.00</td>
<td>643.83</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1+00.00</td>
<td>642.65</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1+50.00</td>
<td>641.48</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2+00.00</td>
<td>640.30</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2+50.00</td>
<td>639.13</td>
<td>510.00</td>
<td>STRAIGHT</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3+00.00</td>
<td>637.95</td>
<td></td>
<td>K</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3+50.00</td>
<td>636.78</td>
<td></td>
<td>Min L</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4+00.00</td>
<td>635.60</td>
<td></td>
<td>CHECK</td>
<td></td>
<td>YES</td>
</tr>
<tr>
<td>4+50.00</td>
<td>634.43</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5+00.00</td>
<td>633.25</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5+10.00</td>
<td>633.02</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5+50.00</td>
<td>632.12</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6+00.00</td>
<td>631.13</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6+50.00</td>
<td>630.27</td>
<td>321.28</td>
<td>SAG</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7+00.00</td>
<td>629.56</td>
<td></td>
<td>K</td>
<td>157</td>
<td></td>
</tr>
<tr>
<td>7+50.00</td>
<td>628.98</td>
<td></td>
<td>Min L</td>
<td>281.72</td>
<td></td>
</tr>
<tr>
<td>8+00.00</td>
<td>628.55</td>
<td></td>
<td>CHECK</td>
<td></td>
<td>YES</td>
</tr>
<tr>
<td>8+31.28</td>
<td>628.35</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8+50.00</td>
<td>628.25</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9+00.00</td>
<td>628.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9+50.00</td>
<td>627.78</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10+00.00</td>
<td>627.60</td>
<td>1268.72</td>
<td>SAG</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10+50.00</td>
<td>627.44</td>
<td></td>
<td>K</td>
<td>157</td>
<td></td>
</tr>
<tr>
<td>11+00.00</td>
<td>627.32</td>
<td></td>
<td>Min L</td>
<td>259.12</td>
<td></td>
</tr>
<tr>
<td>11+50.00</td>
<td>627.24</td>
<td></td>
<td>CHECK</td>
<td></td>
<td>YES</td>
</tr>
<tr>
<td>12+00.00</td>
<td>627.18</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12+50.00</td>
<td>627.16</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>13+00.00</td>
<td>627.17</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>13+50.00</td>
<td>627.22</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>14+00.00</td>
<td>627.29</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>14+50.00</td>
<td>627.40</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>15+00.00</td>
<td>627.54</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>15+50.00</td>
<td>627.71</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>16+00.00</td>
<td>627.92</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>16+50.00</td>
<td>628.16</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>17+00.00</td>
<td>628.43</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Distance</td>
<td>Curve type</td>
<td>CREST</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>----------</td>
<td>------------</td>
<td>-------</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>17+50.00</td>
<td>PVC</td>
<td>631.77</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>18+00.00</td>
<td>g1</td>
<td>1.09</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>18+50.00</td>
<td>g2</td>
<td>-2.50</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>19+00.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>19+50.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>20+00.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>20+50.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>21+00.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>21+50.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>22+00.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>22+50.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>23+00.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>23+50.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>24+00.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>24+50.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>25+00.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>25+50.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>26+00.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>26+50.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>27+00.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>27+50.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>28+00.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>28+50.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>29+00.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>29+50.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>30+00.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>30+50.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>31+00.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>31+50.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>32+00.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>32+50.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>33+00.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>33+50.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>34+00.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>34+50.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>35+00.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>35+50.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>35+99.23</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Under Michigan Road

Table 7
We took our Excel-generated vertical alignments to our faculty advisor. He explained that our process, although technically correct, was not the best way. He introduced Microstation and Geopak and gave us some helpful guidelines on how to use the software. With his help and the client’s instruction, we were able to generate all vertical alignments on Microstation while still meeting the constraints. This also allowed us to take into account the existing ground profile so we could minimize earthwork. Our process consisted of designing the ground level roadways first, which included eastbound and westbound I-94 and westbound I-69. Next, we designed the roadways that overpass the ground level roadways. These are eastbound I-69 and ramp D. As previously mentioned, these had to conform to the MDOT clearance standard of 16’3”. We assumed a conservative bridge thickness of 84”. Therefore, the road to road clearance is 23’3”. See Appendix B for proposed vertical alignment profiles.

**Pavement Assumptions**

Rigid pavements will be used for the entire interchange because, when properly designed and constructed, they have long service lives and usually are less expensive to maintain than flexible pavements. According to the MDOT Pavement Design and Selection Manual, the thickness for concrete (rigid) pavements in highways normally ranges from 6-13 inches (MDOT, 2012).

Types of rigid highway pavements:
- Jointed Plain Concrete Pavement (JPCP)
- Jointed Reinforced Concrete Pavement (JRCP)
- Continuously Reinforced Concrete Pavement (CRCP)

(Garber & Hoel, 2009)

Jointed Plain Concrete Pavement (JPCP) will be used for this design. It is the most common type of rigid pavement, and it controls cracking by dividing the pavement into individual slabs. This type of pavement uses contraction joints placed transversely along the width of the pavement. Pavements that are subject to a decrease in temperature will contract if they are free to move. Therefore, contraction joints are placed in order to release some of the tensile stresses induced in the slab. These joints are
typically spaced at 12-50 ft intervals in order to prevent cracking in the middle of the slab. Tie bars and dowel bars may also be used to assist in load transfer wherever slab thickness exceeds 8 inches (Garber & Hoel, 2009).

Directly under the surface course is the base course. According to MDOT standards, the thickness of this layer should not be less than 6 inches and should be extended to 1 to 3 ft outside the edge of the pavement structure (MDOT, 2012). The base course provides additional load distribution and it contributes to frost resistance, as well as drainage by effectively moving water from beneath the pavement and into an underdrain system (AASHTO, 2004).

For the purpose of earthwork computations, we assumed the thickness for the surface course (concrete pavement) to be 12 inches and the base course to have a thickness of 16 inches. The base course will also consist of Open-Graded Drainage Course material.

**Earthwork**

A preliminary estimate of the required amounts of cut and fill for the interchange has been computed using the average end area method. We obtained the proposed and existing elevations for each roadway at 100 feet intervals (each station) using a function on Microstation. Given this information, the assumed pavement thickness of 28 inches, and assumed embankment ratios, cross-sectional areas can be calculated. We assumed a 2:1 embankment, which is the steepest allowable slope, for ramp D and eastbound I-69, as these contain bridges and are at quite high elevations at times. Furthermore, a 4:1 embankment was assumed on all other roadways.

See Figure 18. For a fill calculation, the rectangular area underneath the roadway is:

\[ A_1 = (\text{Lanes} + \text{Shoulders}) \times (\text{Proposed} - \text{Existing} - \text{Pavement}) \]

And the area of one of the triangles is:

\[ A_2 = \frac{1}{2} \times \text{Embankment ratio} \times (\text{Proposed} - \text{Existing} - \text{Pavement}) \times (\text{Proposed} - \text{Existing} - \text{Pavement}) \]

So the total area is:

\[ A_1 + 2A_2 = (\text{Lanes} + \text{Shoulders}) \times (\text{Proposed} - \text{Existing} - \text{Pavement}) + \text{Embankment ratio} \times (\text{Proposed} - \text{Existing} - \text{Pavement})^2 \]

Using a similar derivation, the cut calculation is:

\[ (\text{Lanes} + \text{Shoulders}) \times (\text{Existing} - \text{Proposed} + \text{Pavement}) + \text{Embankment ratio} \times (\text{Existing} - \text{Proposed} + \text{Pavement})^2 \]

Volume in cubic yards is calculated by multiplying the above area by the station increment of 100 feet and dividing by 27 ft³/yd³. This was performed in Microsoft Excel for each roadway and total volumes of cut and fill were computed (Table 8).
**EARTHWORK (cyd)**

<table>
<thead>
<tr>
<th>ROADWAY</th>
<th>CUT</th>
<th>FILL</th>
</tr>
</thead>
<tbody>
<tr>
<td>WB94</td>
<td>10,081</td>
<td>3</td>
</tr>
<tr>
<td>EB94</td>
<td>22,700</td>
<td>-</td>
</tr>
<tr>
<td>WB69</td>
<td>134,825</td>
<td>444</td>
</tr>
<tr>
<td>EB69</td>
<td>6,784</td>
<td>141,871</td>
</tr>
<tr>
<td>RAMPA</td>
<td>1,212</td>
<td>88,991</td>
</tr>
<tr>
<td>RAMPB</td>
<td>36,884</td>
<td>14,165</td>
</tr>
<tr>
<td>RAMPD</td>
<td>-</td>
<td>297,638</td>
</tr>
<tr>
<td>RAMPF</td>
<td>2,631</td>
<td>3,926</td>
</tr>
<tr>
<td>TOTAL</td>
<td>215,117</td>
<td>547,038</td>
</tr>
</tbody>
</table>

**TOTAL FILL NEEDED** 331,922

**Table 8**
Note that earthwork was excluded from the calculation on portions of roadways where bridges exist. In addition, due to unknown soil conditions, swell and shrinkage factors were not taken into consideration. See Appendix C for detailed Excel calculations for every station.

**Wetlands Impact**
To determine the acreage of disturbed wetlands, we had to establish slope stake lines for our design. These lines represent where the embankments of the roadways meet the existing ground profile. Everything within these lines is part of the footprint of the proposed interchange. Therefore, any wetlands that fall within the lines will be disturbed.

Using the same embankment ratios as stated in the earthwork section, the following equation was utilized to determine the perpendicular distance from the edge of the shoulder to the slope stake line:

\[
L = \text{Embankment ratio} \times (\text{Proposed} - \text{Existing})
\]

This equation was used for every station, or 100 feet. Then all the points were connected to generate the slope stake lines. Figure 19 shows the slope stake lines in black and the wetlands in blue. Figure 20 shows only the parts of the wetlands that fall within the footprint. Using the area function on AutoCAD, the total area of disturbed wetlands was determined to be 7.7 acres. In accordance with Michigan Department of Environmental Quality (MDEQ) requirements, we will restore twice this amount (MDEQ, 2012), or 15.4 acres. The restored wetlands must be constructed within the same watershed. The client has offered us the use of a wetlands bank in order to achieve this. The wetlands bank is a reserve of wetlands that lies within the watershed.
Cost Estimate
A basic cost estimate is usually done with a square footage estimate while the final estimate is performed by itemizing. Considering the amount of design that we had done, we felt a square footage estimate would not be adequate. We came up with a balance of the two estimate configurations. There are five sections to the cost estimate, and the roadway section is the only section that we itemized. The structure section estimate was done by an outside client, and the other three sections (maintaining traffic, signing, and mobilization) were all calculated by using a percentage of the roadway and structure estimates.

The roadway section of the cost estimate has four subcategories: removal and construction, drainage, safety, and total cost estimate. The following bullets explain how each calculation was performed for each subcategory.

Removal and Construction
- Clearing: The area of disturbance, equal to the 7.7 acres calculated in the wetlands section
- Tree Removal: This was calculated with the use of a table that gave the number of trees per acre by the diameter and basal area (Coder, 1996)
- Curb and Gutter Removal: There are no existing curbs or gutters
- Fence Removal: The length of the right-of-way boundary
- Pavement Removal: We assumed all existing pavement would be removed
- Excavation and Embankment: This was calculated in the earthwork section
- Geotextile: Equal to the area of open graded drainage course
- Open Graded Drainage Course: The area of the fill needed 16” below the pavement (width of the roadway plus width of the shoulders plus a conservative four feet)
- Class 2 Fill for Shoulder: Half of our shoulder volume is class 2 fill
- Underdrain Outlet: Where there is a barrier between the mainlines and ramps, an underdrain structure is needed every 300 feet for proper drainage
- Underdrain Pipe: Where there is a barrier between the mainlines and ramps, an underdrain pipe is needed to connect all of the underdrain structure
- Concrete Shoulder: Half of our shoulder volume is concrete
- Concrete Pavement: The volume of concrete needed for the mainlines and ramps
- Fence Install: The length of the right-of-way boundary
- Turf Establishment: The surface area of the proposed embankments
- Shoulder Corrugations: The length of roadway times two (for both sides of the road)

Drainage
- Culvert Removal: There is only one existing culvert in the interchange
- Culvert End Removal: There are two ends to the one culvert
- Culvert Concrete: The length of the culvert is 50 feet
- Culvert End Section: There are two ends to the new culvert
Safety
- Guardrail Removal: There was no information on existing guardrails so an approximation was made
- Guardrail Install: The length of roadway that has an embankment slope of 2:1 or steeper
- Guardrail Anchor Bridge: The total number of anchors that are needed when the guardrail intersects with a bridge
- Guardrail Approach Terminal: The number of approaches for the guardrail system
- Guardrail Departing Terminal: The number of departing structures in the guardrail system

Total Cost Estimate
- Mobilization: A conservative 5% of the other roadway and construction costs was used
- Staking: 2% of the other roadway and construction costs was used
- Cleanup: 1% of the other roadway and construction costs was used

The total roadway estimate is $10,790,578 and the structures estimate is $14,829,000. The total of these two estimates was used for the estimates of the three other sections. Maintaining traffic was calculated as 8% of the total cost. Signing was estimated to be 1% of the total cost. Mobilization was estimated to be 5% of the total cost. Our client wanted a 10% contingency which totals $2,561,958. The total estimate of the whole interchange is $31,768,277.

Summary
The three main problems with the existing interchange are the 40 mph design speed of Ramp D, the left-hand entrance of Ramp D onto westbound I-69, and the flooding due to the wetlands. We began by calculating minimum radii associated with different design speeds and using this data to design three horizontal alignment alternatives. We selected alternative 2 for further design. Then we designed the entrance and exit ramps. Next, we calculated required superelevation transition lengths to certify that our horizontal alignment met these requirements. We designed vertical alignments for each roadway using three criteria: tie in points, storm water target points, and bridge underclearances. Then we assumed a pavement thickness for the purpose of earthwork calculations. The cut volume was computed as 215,117 cubic yards, and the fill volume was computed as 547,038 cubic yards. In addition, we established slope stake lines so we could determine the area of impacted wetlands. Using MDEQ’s replacement ratio, we calculated a restoration area of 15.4 acres. We concluded with a preliminary cost estimate for construction of the interchange: $31,768,277.
References


Appendix A: Superelevation Transitions

I-69 WB CURVE 1: PT

I-69 WB CURVE 2: PT
I-69 WB CURVE 3: PC

I-69 WB CURVE 3: PT
I-69 EB CURVE 1: PT

I-69 EB CURVE 2: PC
I-94 EB: PC

70ft
80ft
60ft
60ft

LEVEL 2%

2% 2%
I-94 EB: PT

RAMP A: PC
RAMP A: PT

7%

81.8 ft

PT

92.4 ft

2%
RAMP F: 7% everywhere
Appendix B: Vertical Alignment Profiles
## Appendix C: Earthwork Calculations

### WB I-94

<table>
<thead>
<tr>
<th>STATION</th>
<th>ELEVATION (Feet)</th>
<th>EXT PROP</th>
<th>CUT (cyd)</th>
<th>FILL (cyd)</th>
<th>LANE WIDTH (ft) = 24</th>
</tr>
</thead>
<tbody>
<tr>
<td>0+00</td>
<td>646.9675</td>
<td>646.7933</td>
<td>520.3608408</td>
<td>0</td>
<td>SHOULDER (ft) = 22</td>
</tr>
<tr>
<td>1+00</td>
<td>644.7676</td>
<td>644.6833</td>
<td>498.4849521</td>
<td>0</td>
<td>PAV. THICKNESS (ft) = 2.33</td>
</tr>
<tr>
<td>2+00</td>
<td>642.3391</td>
<td>642.5733</td>
<td>422.909542</td>
<td>0</td>
<td>STATION INCREMENT (ft) = 100</td>
</tr>
<tr>
<td>3+00</td>
<td>640.1208</td>
<td>640.4633</td>
<td>397.8963066</td>
<td>0</td>
<td>EMBANK Ratio = 4 : 1</td>
</tr>
<tr>
<td>4+00</td>
<td>637.7071</td>
<td>638.3533</td>
<td>329.6066959</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>5+00</td>
<td>635.1946</td>
<td>636.2433</td>
<td>243.3120909</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>6+00</td>
<td>632.7711</td>
<td>634.1333</td>
<td>179.4241968</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>7+00</td>
<td>630.6345</td>
<td>632.0233</td>
<td>174.1374304</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>8+00</td>
<td>628.5719</td>
<td>629.9136</td>
<td>183.5128889</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>9+00</td>
<td>627.0607</td>
<td>628.0457</td>
<td>256.6494239</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>10+00</td>
<td>625.8492</td>
<td>626.3223</td>
<td>299.7171366</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>11+00</td>
<td>624.8549</td>
<td>625.6734</td>
<td>292.0785683</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>12+00</td>
<td>624.2246</td>
<td>625.1691</td>
<td>265.1917239</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>13+00</td>
<td>623.6332</td>
<td>625.0980</td>
<td>159.1479035</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>14+00</td>
<td>623.2466</td>
<td>625.1362</td>
<td>78.5160385</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>15+00</td>
<td>623.0710</td>
<td>625.1743</td>
<td>39.974795</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>16+00</td>
<td>622.8590</td>
<td>625.2125</td>
<td>0</td>
<td>3.441827572</td>
<td></td>
</tr>
<tr>
<td>17+00</td>
<td>622.7283</td>
<td>625.2506</td>
<td>63.44042076</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>18+00</td>
<td>623.3574</td>
<td>625.2888</td>
<td>70.87087019</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>19+00</td>
<td>623.3915</td>
<td>625.3269</td>
<td>70.1419892</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>20+00</td>
<td>623.5065</td>
<td>625.3651</td>
<td>84.21933439</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>21+00</td>
<td>623.6223</td>
<td>625.4032</td>
<td>98.639495</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>22+00</td>
<td>623.7364</td>
<td>625.4414</td>
<td>112.8983128</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>23+00</td>
<td>623.8037</td>
<td>625.4795</td>
<td>118.429384</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>24+00</td>
<td>623.8945</td>
<td>625.5177</td>
<td>128.4566324</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>25+00</td>
<td>624.0055</td>
<td>625.5558</td>
<td>142.4892524</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>26+00</td>
<td>623.9728</td>
<td>625.5940</td>
<td>128.8395143</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>27+00</td>
<td>624.1152</td>
<td>625.6321</td>
<td>148.9710625</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>28+00</td>
<td>624.1984</td>
<td>625.6703</td>
<td>157.756307</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>29+00</td>
<td>624.1618</td>
<td>625.6860</td>
<td>147.5515568</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>30+00</td>
<td>624.0291</td>
<td>625.5404</td>
<td>150.0610687</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>31+00</td>
<td>623.9236</td>
<td>625.2096</td>
<td>194.6850436</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>32+00</td>
<td>623.7069</td>
<td>624.6976</td>
<td>255.4510756</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>33+00</td>
<td>623.5024</td>
<td>624.1276</td>
<td>334.2407825</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>34+00</td>
<td>623.2965</td>
<td>623.5576</td>
<td>416.6642122</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>35+00</td>
<td>623.0079</td>
<td>622.9876</td>
<td>483.0573808</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>36+00</td>
<td>622.6787</td>
<td>622.4176</td>
<td>541.7343356</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>37+00</td>
<td>622.3475</td>
<td>621.8476</td>
<td>601.6206586</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>38+00</td>
<td>621.9493</td>
<td>621.2776</td>
<td>645.749758</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>39+00</td>
<td>621.3721</td>
<td>620.7076</td>
<td>643.8827856</td>
<td>0</td>
<td></td>
</tr>
</tbody>
</table>

Total = 10,080.77 3.44
<table>
<thead>
<tr>
<th>STATION</th>
<th>EXT</th>
<th>PROP</th>
<th>CUT (cyd)</th>
<th>FILL (cyd)</th>
<th>LANE WIDTH (ft)</th>
<th>SHOULDER (ft)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0+00</td>
<td>646.9457</td>
<td>644.5451</td>
<td>1138.523824</td>
<td>0</td>
<td>24</td>
<td>22</td>
</tr>
<tr>
<td>1+00</td>
<td>644.8541</td>
<td>642.1951</td>
<td>1219.781118</td>
<td>0</td>
<td>2.33</td>
<td></td>
</tr>
<tr>
<td>2+00</td>
<td>642.4486</td>
<td>639.8451</td>
<td>1202.161581</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3+00</td>
<td>640.0603</td>
<td>637.4951</td>
<td>1190.055736</td>
<td>0</td>
<td>22</td>
<td></td>
</tr>
<tr>
<td>4+00</td>
<td>637.5638</td>
<td>635.1451</td>
<td>1144.151172</td>
<td>0</td>
<td>2.33</td>
<td></td>
</tr>
<tr>
<td>5+00</td>
<td>635.1363</td>
<td>632.7951</td>
<td>1120.124374</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6+00</td>
<td>632.7619</td>
<td>630.4451</td>
<td>1112.596642</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7+00</td>
<td>630.4704</td>
<td>628.1156</td>
<td>1124.327815</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8+00</td>
<td>628.6076</td>
<td>626.1924</td>
<td>1143.062254</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9+00</td>
<td>627.0000</td>
<td>624.8216</td>
<td>1070.232163</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10+00</td>
<td>625.4200</td>
<td>624.0033</td>
<td>847.231605</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>11+00</td>
<td>624.1245</td>
<td>623.7375</td>
<td>573.096983</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>12+00</td>
<td>623.0599</td>
<td>623.7541</td>
<td>319.0635766</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>13+00</td>
<td>622.3005</td>
<td>623.7707</td>
<td>158.0893701</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>14+00</td>
<td>621.8578</td>
<td>623.7874</td>
<td>71.1990213</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>15+00</td>
<td>621.7427</td>
<td>623.8040</td>
<td>47.44274767</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>16+00</td>
<td>621.6598</td>
<td>623.8206</td>
<td>29.83557162</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>17+00</td>
<td>621.9123</td>
<td>623.8373</td>
<td>72.03806584</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>18+00</td>
<td>622.0017</td>
<td>623.8539</td>
<td>85.40033508</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>19+00</td>
<td>622.1351</td>
<td>623.8706</td>
<td>107.1479708</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>20+00</td>
<td>622.2676</td>
<td>623.8872</td>
<td>129.1459053</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>21+00</td>
<td>622.3318</td>
<td>623.9038</td>
<td>138.29573</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>22+00</td>
<td>622.4136</td>
<td>623.9205</td>
<td>150.9181539</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>23+00</td>
<td>622.4575</td>
<td>623.9371</td>
<td>156.2487991</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>24+00</td>
<td>622.4932</td>
<td>623.9537</td>
<td>159.9914276</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>25+00</td>
<td>622.4991</td>
<td>623.7884</td>
<td>194.0205768</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>26+00</td>
<td>622.6033</td>
<td>623.4184</td>
<td>292.8106043</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>27+00</td>
<td>622.4317</td>
<td>623.0484</td>
<td>336.1201975</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>28+00</td>
<td>622.5680</td>
<td>622.6784</td>
<td>451.9283843</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>29+00</td>
<td>622.5332</td>
<td>622.3084</td>
<td>532.7789553</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>30+00</td>
<td>622.4050</td>
<td>621.9384</td>
<td>593.1682964</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>31+00</td>
<td>622.2506</td>
<td>621.5684</td>
<td>648.4751795</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>32+00</td>
<td>622.0597</td>
<td>621.1984</td>
<td>695.4661551</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>33+00</td>
<td>621.7299</td>
<td>620.8284</td>
<td>706.1441486</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>34+00</td>
<td>621.5228</td>
<td>620.4584</td>
<td>749.9040761</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>35+00</td>
<td>621.1108</td>
<td>620.0884</td>
<td>738.5463635</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>36+00</td>
<td>620.7475</td>
<td>619.7184</td>
<td>740.3546853</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>37+00</td>
<td>620.4152</td>
<td>619.3484</td>
<td>750.5546669</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>38+00</td>
<td>620.0788</td>
<td>618.9784</td>
<td>759.6808583</td>
<td>0</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Total = 22,700.12
<table>
<thead>
<tr>
<th>STATION</th>
<th>ELEVATION (Feet)</th>
<th>CUT (cyd)</th>
<th>FILL (cyd)</th>
<th>LANE WIDTH (ft)</th>
<th>EMBANK Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>0+00</td>
<td>632.7714</td>
<td>632.2730</td>
<td>601.2392</td>
<td>0</td>
<td>22</td>
</tr>
<tr>
<td>1+00</td>
<td>631.9531</td>
<td>631.6128</td>
<td>610.4886</td>
<td>0</td>
<td>100</td>
</tr>
<tr>
<td>2+00</td>
<td>631.6254</td>
<td>630.9525</td>
<td>646.0896</td>
<td>0</td>
<td>2.33</td>
</tr>
<tr>
<td>3+00</td>
<td>631.3808</td>
<td>630.2923</td>
<td>756.4489</td>
<td>0</td>
<td>4 : 1</td>
</tr>
<tr>
<td>4+00</td>
<td>631.0707</td>
<td>629.6320</td>
<td>853.4339</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>5+00</td>
<td>630.8009</td>
<td>628.9718</td>
<td>965.8348</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>6+00</td>
<td>630.5649</td>
<td>628.3115</td>
<td>1093.1193</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>7+00</td>
<td>629.9738</td>
<td>627.6513</td>
<td>1114.3539</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>8+00</td>
<td>629.4974</td>
<td>626.9910</td>
<td>1171.5548</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>9+00</td>
<td>629.0651</td>
<td>626.3308</td>
<td>1243.8325</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>10+00</td>
<td>628.8625</td>
<td>625.6706</td>
<td>1393.6057</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>11+00</td>
<td>628.6446</td>
<td>625.0727</td>
<td>1522.6957</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>12+00</td>
<td>628.5233</td>
<td>624.8779</td>
<td>1548.1583</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>13+00</td>
<td>628.1100</td>
<td>625.0452</td>
<td>1351.3836</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>14+00</td>
<td>627.6553</td>
<td>625.2423</td>
<td>1142.3797</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>15+00</td>
<td>627.4444</td>
<td>625.4394</td>
<td>1017.9510</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>16+00</td>
<td>626.9786</td>
<td>625.6364</td>
<td>826.3438</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>17+00</td>
<td>626.8495</td>
<td>625.8335</td>
<td>736.8205</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>18+00</td>
<td>626.5909</td>
<td>626.0306</td>
<td>617.0355</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>19+00</td>
<td>626.2000</td>
<td>626.2277</td>
<td>471.5634</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>20+00</td>
<td>625.9849</td>
<td>626.4247</td>
<td>375.7200</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>21+00</td>
<td>626.0292</td>
<td>626.6218</td>
<td>341.4605</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>22+00</td>
<td>626.2354</td>
<td>626.8189</td>
<td>343.4814</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>23+00</td>
<td>626.5803</td>
<td>627.0159</td>
<td>376.6714</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>24+00</td>
<td>627.4458</td>
<td>627.2130</td>
<td>534.7492</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>25+00</td>
<td>628.2253</td>
<td>627.4101</td>
<td>683.2799</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>26+00</td>
<td>629.1793</td>
<td>627.6072</td>
<td>891.3352</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>27+00</td>
<td>630.3318</td>
<td>627.8042</td>
<td>1178.2132</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>28+00</td>
<td>631.9497</td>
<td>628.0013</td>
<td>1654.8164</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>29+00</td>
<td>633.8388</td>
<td>628.1984</td>
<td>2300.4200</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>30+00</td>
<td>635.8985</td>
<td>628.3955</td>
<td>3109.2042</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>31+00</td>
<td>637.8327</td>
<td>628.5925</td>
<td>3956.1823</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>32+00</td>
<td>639.7855</td>
<td>628.7863</td>
<td>4904.8974</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>33+00</td>
<td>641.6538</td>
<td>628.8558</td>
<td>5969.890</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>34+00</td>
<td>643.5068</td>
<td>628.7400</td>
<td>7245.4260</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>35+00</td>
<td>644.7711</td>
<td>628.4391</td>
<td>8341.4222</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>36+00</td>
<td>645.6115</td>
<td>627.9793</td>
<td>9307.0541</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>37+00</td>
<td>645.8723</td>
<td>627.4993</td>
<td>9879.6307</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>38+00</td>
<td>646.1920</td>
<td>627.0193</td>
<td>1051.9830</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>39+00</td>
<td>623.8711</td>
<td>626.5393</td>
<td>0</td>
<td>58.71262742</td>
<td></td>
</tr>
<tr>
<td>40+00</td>
<td>621.7893</td>
<td>626.0593</td>
<td>0</td>
<td>385.516214</td>
<td></td>
</tr>
<tr>
<td>41+00</td>
<td>625.8972</td>
<td>625.5793</td>
<td>555.8255</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>42+00</td>
<td>643.0224</td>
<td>625.0993</td>
<td>9529.9566</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>43+00</td>
<td>641.1781</td>
<td>624.6193</td>
<td>8506.2553</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>44+00</td>
<td>639.0242</td>
<td>624.1393</td>
<td>7325.5877</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>45+00</td>
<td>636.5430</td>
<td>623.6593</td>
<td>6023.0220</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>46+00</td>
<td>633.6470</td>
<td>623.1793</td>
<td>4608.5679</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>47+00</td>
<td>630.6293</td>
<td>622.6993</td>
<td>3309.1013</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>48+00</td>
<td>627.4214</td>
<td>622.2193</td>
<td>2125.0407</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>49+00</td>
<td>624.6360</td>
<td>621.7393</td>
<td>1296.2760</td>
<td>0</td>
<td></td>
</tr>
</tbody>
</table>

Total = 134,824.69 444.23
<table>
<thead>
<tr>
<th>STATION</th>
<th>EXT</th>
<th>PROP</th>
<th>ELEVATION (Feet)</th>
<th>CUT (cyd)</th>
<th>FILL (cyd)</th>
<th>LANE WIDTH (ft)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>0+00</td>
<td>632.4649</td>
<td>632.4176</td>
<td>489.5510874</td>
<td>0</td>
<td>SHOULDER (ft)</td>
<td>22</td>
<td></td>
</tr>
<tr>
<td>1+00</td>
<td>631.5683</td>
<td>631.9876</td>
<td>380.3689916</td>
<td>0</td>
<td>PAV. THICKNESS (ft)</td>
<td>2.33</td>
<td></td>
</tr>
<tr>
<td>2+00</td>
<td>631.0969</td>
<td>631.5576</td>
<td>370.9931694</td>
<td>0</td>
<td>STATION INCREMENT (ft)</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>3+00</td>
<td>630.6842</td>
<td>631.1276</td>
<td>374.9049087</td>
<td>0</td>
<td>EMBANK Ratio</td>
<td>4 : 1</td>
<td></td>
</tr>
<tr>
<td>4+00</td>
<td>630.2393</td>
<td>630.6976</td>
<td>371.5353087</td>
<td>0</td>
<td>EMBANK Ratio</td>
<td>2 : 1</td>
<td></td>
</tr>
<tr>
<td>5+00</td>
<td>629.9937</td>
<td>630.2676</td>
<td>413.699985</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6+00</td>
<td>629.8671</td>
<td>629.8376</td>
<td>485.2676251</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7+00</td>
<td>629.5499</td>
<td>629.4076</td>
<td>512.5710183</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8+00</td>
<td>629.2561</td>
<td>628.9776</td>
<td>546.0408399</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9+00</td>
<td>628.9450</td>
<td>628.5476</td>
<td>575.7087092</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10+00</td>
<td>628.7174</td>
<td>628.1176</td>
<td>627.1748813</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11+00</td>
<td>628.3381</td>
<td>627.6876</td>
<td>640.2569584</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12+00</td>
<td>627.8301</td>
<td>627.2576</td>
<td>620.162325</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>13+00</td>
<td>625.8706</td>
<td>627.0377</td>
<td>218.8412373</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>14+00</td>
<td>624.0428</td>
<td>627.2720</td>
<td>164.5191667</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>15+00</td>
<td>623.4247</td>
<td>627.9608</td>
<td>447.1703356</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>16+00</td>
<td>622.5205</td>
<td>629.1042</td>
<td>787.1049383</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>17+00</td>
<td>621.3429</td>
<td>630.7021</td>
<td>1301.08462</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>18+00</td>
<td>618.4424</td>
<td>632.7546</td>
<td>2218.308642</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>19+00</td>
<td>617.7325</td>
<td>635.1828</td>
<td>2799.438272</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>20+00</td>
<td>619.4479</td>
<td>637.6495</td>
<td>2938.567901</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>21+00</td>
<td>621.1586</td>
<td>640.0697</td>
<td>3478.790123</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>22+00</td>
<td>621.1937</td>
<td>642.3125</td>
<td>3997.845679</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>23+00</td>
<td>620.7724</td>
<td>644.3701</td>
<td>4391.549383</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>24+00</td>
<td>620.1948</td>
<td>646.2425</td>
<td>4779.179012</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>25+00</td>
<td>619.7888</td>
<td>647.9297</td>
<td>5105.623457</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>26+00</td>
<td>619.5281</td>
<td>649.4318</td>
<td>5475.271605</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>27+00</td>
<td>618.8489</td>
<td>650.7487</td>
<td>5660.012346</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>28+00</td>
<td>618.9830</td>
<td>651.8804</td>
<td>5960.604938</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>29+00</td>
<td>618.0056</td>
<td>653.5882</td>
<td>6157.271605</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>30+00</td>
<td>617.9666</td>
<td>654.1643</td>
<td>6271.179012</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>31+00</td>
<td>618.2563</td>
<td>654.5553</td>
<td>6289.938272</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>32+00</td>
<td>618.4640</td>
<td>654.7610</td>
<td>6289.567901</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>33+00</td>
<td>618.5429</td>
<td>654.7816</td>
<td>6278.771605</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>34+00</td>
<td>618.6545</td>
<td>654.6170</td>
<td>6227.623457</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>35+00</td>
<td>633.8298</td>
<td>654.2672</td>
<td>3352.604938</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>36+00</td>
<td>663.7836</td>
<td>653.7322</td>
<td>3426.604938</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>37+00</td>
<td>637.0624</td>
<td>653.0121</td>
<td>3997.845679</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>38+00</td>
<td>637.0624</td>
<td>653.0121</td>
<td>4391.549383</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>39+00</td>
<td>616.9668</td>
<td>652.1067</td>
<td>4779.179012</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>40+00</td>
<td>617.1551</td>
<td>651.0162</td>
<td>5105.623457</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>41+00</td>
<td>616.9945</td>
<td>649.7405</td>
<td>5475.271605</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>42+00</td>
<td>617.3944</td>
<td>648.2796</td>
<td>5660.012346</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>43+00</td>
<td>617.1564</td>
<td>646.6335</td>
<td>5960.604938</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>44+00</td>
<td>617.6282</td>
<td>644.8022</td>
<td>6157.271605</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>45+00</td>
<td>616.4287</td>
<td>642.7858</td>
<td>6278.771605</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>46+00</td>
<td>616.0038</td>
<td>640.5841</td>
<td>6227.623457</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>47+00</td>
<td>615.5890</td>
<td>638.1973</td>
<td>3426.604938</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>48+00</td>
<td>618.0487</td>
<td>635.6253</td>
<td>2709.914074</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>49+00</td>
<td>619.9699</td>
<td>632.8681</td>
<td>1878.198519</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>50+00</td>
<td>620.1678</td>
<td>629.9290</td>
<td>1320.50963</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>51+00</td>
<td>619.9957</td>
<td>626.9290</td>
<td>817.718519</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>52+00</td>
<td>619.7860</td>
<td>623.9290</td>
<td>321.7185185</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>53+00</td>
<td>619.4825</td>
<td>620.9290</td>
<td>156.9158521</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| Total = | 6,783.99 | 141,870.72 |  |

No fill needed for bridge over WB and EB I-94
## RAMP A

<table>
<thead>
<tr>
<th>STATION</th>
<th>ELEVATION (Feet)</th>
<th>CREL PROP</th>
<th>CUT (cyd)</th>
<th>FILL (cyd)</th>
<th>LANE WIDTH (ft) = 16</th>
</tr>
</thead>
<tbody>
<tr>
<td>0+00</td>
<td>626.8884</td>
<td>630.0000</td>
<td>0</td>
<td>95.44739266</td>
<td></td>
</tr>
<tr>
<td>1+00</td>
<td>626.5714</td>
<td>632.3841</td>
<td>0</td>
<td>565.9443319</td>
<td></td>
</tr>
<tr>
<td>2+00</td>
<td>626.3735</td>
<td>634.4574</td>
<td>0</td>
<td>1128.863215</td>
<td></td>
</tr>
<tr>
<td>3+00</td>
<td>626.1387</td>
<td>636.2081</td>
<td>0</td>
<td>1746.181148</td>
<td></td>
</tr>
<tr>
<td>4+00</td>
<td>626.1026</td>
<td>637.6363</td>
<td>0</td>
<td>2276.288841</td>
<td></td>
</tr>
<tr>
<td>5+00</td>
<td>626.1983</td>
<td>638.7418</td>
<td>0</td>
<td>2678.87042</td>
<td></td>
</tr>
<tr>
<td>6+00</td>
<td>623.7928</td>
<td>639.5248</td>
<td>0</td>
<td>4148.359533</td>
<td></td>
</tr>
<tr>
<td>7+00</td>
<td>620.9918</td>
<td>639.9852</td>
<td>0</td>
<td>5963.086242</td>
<td></td>
</tr>
<tr>
<td>8+00</td>
<td>619.3553</td>
<td>640.1231</td>
<td>0</td>
<td>7082.786093</td>
<td></td>
</tr>
<tr>
<td>9+00</td>
<td>617.8775</td>
<td>639.9383</td>
<td>0</td>
<td>7957.465794</td>
<td></td>
</tr>
<tr>
<td>10+00</td>
<td>617.4121</td>
<td>639.4310</td>
<td>0</td>
<td>7928.344963</td>
<td></td>
</tr>
<tr>
<td>11+00</td>
<td>617.8908</td>
<td>638.6010</td>
<td>0</td>
<td>7044.973755</td>
<td></td>
</tr>
<tr>
<td>12+00</td>
<td>617.1991</td>
<td>637.4653</td>
<td>0</td>
<td>6756.803065</td>
<td></td>
</tr>
<tr>
<td>13+00</td>
<td>617.0776</td>
<td>636.2554</td>
<td>0</td>
<td>6075.104552</td>
<td></td>
</tr>
<tr>
<td>14+00</td>
<td>617.0342</td>
<td>635.0455</td>
<td>0</td>
<td>5383.457612</td>
<td></td>
</tr>
<tr>
<td>15+00</td>
<td>616.7089</td>
<td>633.8357</td>
<td>0</td>
<td>4885.8912</td>
<td></td>
</tr>
<tr>
<td>16+00</td>
<td>616.2649</td>
<td>632.6258</td>
<td>0</td>
<td>4473.768542</td>
<td></td>
</tr>
<tr>
<td>17+00</td>
<td>616.5230</td>
<td>631.4159</td>
<td>0</td>
<td>3732.436516</td>
<td></td>
</tr>
<tr>
<td>18+00</td>
<td>615.1962</td>
<td>630.2061</td>
<td>0</td>
<td>3789.179147</td>
<td></td>
</tr>
<tr>
<td>19+00</td>
<td>616.7306</td>
<td>628.9962</td>
<td>0</td>
<td>2565.065498</td>
<td></td>
</tr>
<tr>
<td>20+00</td>
<td>618.5459</td>
<td>627.7863</td>
<td>0</td>
<td>1474.230666</td>
<td></td>
</tr>
<tr>
<td>21+00</td>
<td>618.9746</td>
<td>626.5764</td>
<td>0</td>
<td>996.5961632</td>
<td></td>
</tr>
<tr>
<td>22+00</td>
<td>621.4171</td>
<td>625.5156</td>
<td>0</td>
<td>242.2898276</td>
<td></td>
</tr>
<tr>
<td>23+00</td>
<td>623.7444</td>
<td>625.0497</td>
<td>129.8830005</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>24+00</td>
<td>624.7046</td>
<td>625.2089</td>
<td>252.7868583</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>25+00</td>
<td>625.6807</td>
<td>625.9931</td>
<td>285.0543932</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>26+00</td>
<td>627.1512</td>
<td>627.4023</td>
<td>295.5917875</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>27+00</td>
<td>628.9049</td>
<td>629.4364</td>
<td>248.3051313</td>
<td>0</td>
<td></td>
</tr>
</tbody>
</table>

Total = 1,211.62  88,991.43
<table>
<thead>
<tr>
<th>STATION</th>
<th>EXT PROP</th>
<th>CUT (cyd)</th>
<th>FILL (cyd)</th>
<th>LANE WIDTH (ft) = 16</th>
</tr>
</thead>
<tbody>
<tr>
<td>0+00</td>
<td>633.7151</td>
<td>645.0000</td>
<td>0</td>
<td>2181.737715</td>
</tr>
<tr>
<td>1+00</td>
<td>631.2743</td>
<td>642.6500</td>
<td>0</td>
<td>2216.031777</td>
</tr>
<tr>
<td>2+00</td>
<td>628.4745</td>
<td>640.3000</td>
<td>0</td>
<td>2389.518193</td>
</tr>
<tr>
<td>2+00</td>
<td>626.6652</td>
<td>637.9500</td>
<td>0</td>
<td>2572.854649</td>
</tr>
<tr>
<td>3+00</td>
<td>625.1323</td>
<td>635.6000</td>
<td>0</td>
<td>2251.028213</td>
</tr>
<tr>
<td>4+00</td>
<td>624.1743</td>
<td>633.4320</td>
<td>0</td>
<td>1479.697833</td>
</tr>
<tr>
<td>5+00</td>
<td>625.2545</td>
<td>631.8094</td>
<td>0</td>
<td>733.0870388</td>
</tr>
<tr>
<td>6+00</td>
<td>627.4010</td>
<td>630.7421</td>
<td>0</td>
<td>127.019906</td>
</tr>
<tr>
<td>7+00</td>
<td>630.1763</td>
<td>629.9317</td>
<td>384.8924485</td>
<td>0</td>
</tr>
<tr>
<td>8+00</td>
<td>633.0744</td>
<td>629.1217</td>
<td>1283.843927</td>
<td>0</td>
</tr>
<tr>
<td>9+00</td>
<td>635.5231</td>
<td>628.6107</td>
<td>1582.868912</td>
<td>0</td>
</tr>
<tr>
<td>10+00</td>
<td>635.7615</td>
<td>628.6552</td>
<td>2368.947074</td>
<td>0</td>
</tr>
<tr>
<td>11+00</td>
<td>641.4936</td>
<td>629.2553</td>
<td>4764.737007</td>
<td>0</td>
</tr>
<tr>
<td>12+00</td>
<td>646.9628</td>
<td>630.4109</td>
<td>7382.093156</td>
<td>0</td>
</tr>
<tr>
<td>13+00</td>
<td>650.8931</td>
<td>631.7586</td>
<td>9212.986934</td>
<td>0</td>
</tr>
<tr>
<td>14+00</td>
<td>648.9513</td>
<td>632.8594</td>
<td>7076.718124</td>
<td>0</td>
</tr>
<tr>
<td>15+00</td>
<td>636.1894</td>
<td>633.7102</td>
<td>877.844105</td>
<td>0</td>
</tr>
<tr>
<td>16+00</td>
<td>633.5503</td>
<td>634.3110</td>
<td>211.3766756</td>
<td>0</td>
</tr>
<tr>
<td>17+00</td>
<td>636.4818</td>
<td>634.6618</td>
<td>147.8544856</td>
<td>0</td>
</tr>
<tr>
<td>18+00</td>
<td>632.0807</td>
<td>634.7625</td>
<td>40.51746693</td>
<td>0</td>
</tr>
<tr>
<td>19+00</td>
<td>631.2677</td>
<td>634.6133</td>
<td>127.6545749</td>
<td>0</td>
</tr>
<tr>
<td>20+00</td>
<td>631.4925</td>
<td>634.2141</td>
<td>45.37408895</td>
<td>0</td>
</tr>
<tr>
<td>21+00</td>
<td>632.3135</td>
<td>635.5649</td>
<td>137.5567369</td>
<td>0</td>
</tr>
<tr>
<td>22+00</td>
<td>633.6791</td>
<td>632.6657</td>
<td>537.7944297</td>
<td>0</td>
</tr>
<tr>
<td>23+00</td>
<td>631.8914</td>
<td>631.5165</td>
<td>409.5744857</td>
<td>0</td>
</tr>
<tr>
<td>24+00</td>
<td>629.1268</td>
<td>630.1173</td>
<td>175.9177979</td>
<td>0</td>
</tr>
<tr>
<td>25+00</td>
<td>626.6478</td>
<td>628.4681</td>
<td>60.90301039</td>
<td>0</td>
</tr>
<tr>
<td>26+00</td>
<td>624.5637</td>
<td>626.5689</td>
<td>38.05439236</td>
<td>0</td>
</tr>
<tr>
<td>27+00</td>
<td>622.5780</td>
<td>624.4197</td>
<td>58.20671607</td>
<td>0</td>
</tr>
<tr>
<td>28+00</td>
<td>621.0059</td>
<td>622.0217</td>
<td>172.109542</td>
<td>0</td>
</tr>
</tbody>
</table>

Total = 36,884.28 14,164.52
<table>
<thead>
<tr>
<th>STATION</th>
<th>ELEVATION (Feet)</th>
<th>EXT PROP</th>
<th>CUT (cyd)</th>
<th>FILL (cyd)</th>
<th>LANE WIDTH (ft) = 16</th>
</tr>
</thead>
<tbody>
<tr>
<td>0+00</td>
<td>628.3693</td>
<td>632.0000</td>
<td>0</td>
<td>156.6197057</td>
<td>14</td>
</tr>
<tr>
<td>1+00</td>
<td>627.2906</td>
<td>631.4049</td>
<td>0</td>
<td>221.3803131</td>
<td>2.33</td>
</tr>
<tr>
<td>2+00</td>
<td>626.4588</td>
<td>631.1958</td>
<td>0</td>
<td>309.8712107</td>
<td>100</td>
</tr>
<tr>
<td>3+00</td>
<td>625.7331</td>
<td>631.6118</td>
<td>0</td>
<td>487.0379615</td>
<td>2 : 1</td>
</tr>
<tr>
<td>4+00</td>
<td>625.4792</td>
<td>632.6527</td>
<td>0</td>
<td>711.3312101</td>
<td></td>
</tr>
<tr>
<td>5+00</td>
<td>624.8062</td>
<td>634.3186</td>
<td>0</td>
<td>1179.444431</td>
<td></td>
</tr>
<tr>
<td>6+00</td>
<td>624.4093</td>
<td>636.6095</td>
<td>0</td>
<td>1817.467095</td>
<td></td>
</tr>
<tr>
<td>7+00</td>
<td>624.2969</td>
<td>639.5254</td>
<td>0</td>
<td>2664.539432</td>
<td></td>
</tr>
<tr>
<td>8+00</td>
<td>623.8912</td>
<td>642.7970</td>
<td>0</td>
<td>3875.804825</td>
<td></td>
</tr>
<tr>
<td>9+00</td>
<td>623.3517</td>
<td>646.0701</td>
<td>0</td>
<td>5343.162541</td>
<td></td>
</tr>
<tr>
<td>10+00</td>
<td>623.6085</td>
<td>649.3432</td>
<td>0</td>
<td>6656.625643</td>
<td></td>
</tr>
<tr>
<td>11+00</td>
<td>623.2829</td>
<td>652.6163</td>
<td>0</td>
<td>8400.034074</td>
<td></td>
</tr>
<tr>
<td>12+00</td>
<td>622.3922</td>
<td>655.8894</td>
<td>0</td>
<td>10656.62656</td>
<td></td>
</tr>
<tr>
<td>13+00</td>
<td>622.1904</td>
<td>659.1626</td>
<td>0</td>
<td>12736.54877</td>
<td></td>
</tr>
<tr>
<td>14+00</td>
<td>621.9120</td>
<td>662.4146</td>
<td>0</td>
<td>15032.82902</td>
<td></td>
</tr>
<tr>
<td>15+00</td>
<td>622.0934</td>
<td>665.4099</td>
<td>0</td>
<td>16995.31444</td>
<td></td>
</tr>
<tr>
<td>16+00</td>
<td>623.5526</td>
<td>668.0827</td>
<td>0</td>
<td>17877.91568</td>
<td></td>
</tr>
<tr>
<td>17+00</td>
<td>625.4169</td>
<td>670.4328</td>
<td>0</td>
<td>18237.33331</td>
<td></td>
</tr>
<tr>
<td>18+00</td>
<td>624.8039</td>
<td>672.4604</td>
<td>0</td>
<td>20252.12546</td>
<td></td>
</tr>
<tr>
<td>19+00</td>
<td>630.6438</td>
<td>674.1654</td>
<td>0</td>
<td>4881.572346</td>
<td></td>
</tr>
<tr>
<td>20+00</td>
<td>638.5693</td>
<td>675.5478</td>
<td>0</td>
<td>4106.093827</td>
<td></td>
</tr>
<tr>
<td>21+00</td>
<td>628.3115</td>
<td>676.6077</td>
<td>0</td>
<td>5447.450864</td>
<td></td>
</tr>
<tr>
<td>22+00</td>
<td>619.3696</td>
<td>677.3449</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>23+00</td>
<td>617.9480</td>
<td>677.7596</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>24+00</td>
<td>617.9480</td>
<td>677.8517</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>25+00</td>
<td>636.3412</td>
<td>677.6212</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>26+00</td>
<td>631.4561</td>
<td>677.0681</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>27+00</td>
<td>618.4082</td>
<td>676.1924</td>
<td>0</td>
<td>28937.49344</td>
<td></td>
</tr>
<tr>
<td>28+00</td>
<td>618.2529</td>
<td>674.9942</td>
<td>0</td>
<td>27972.93583</td>
<td></td>
</tr>
<tr>
<td>29+00</td>
<td>617.0418</td>
<td>673.4734</td>
<td>0</td>
<td>27689.60338</td>
<td></td>
</tr>
<tr>
<td>30+00</td>
<td>617.6215</td>
<td>671.6300</td>
<td>0</td>
<td>25521.85444</td>
<td></td>
</tr>
<tr>
<td>31+00</td>
<td>618.3229</td>
<td>669.4640</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>32+00</td>
<td>617.6772</td>
<td>666.9755</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>33+00</td>
<td>622.4088</td>
<td>664.1643</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>34+00</td>
<td>620.9494</td>
<td>661.0306</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>35+00</td>
<td>620.0629</td>
<td>657.6609</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>36+00</td>
<td>616.3503</td>
<td>654.2798</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>37+00</td>
<td>616.7199</td>
<td>650.8986</td>
<td>0</td>
<td>11050.42873</td>
<td></td>
</tr>
<tr>
<td>38+00</td>
<td>621.4482</td>
<td>647.5174</td>
<td>0</td>
<td>6810.587899</td>
<td></td>
</tr>
<tr>
<td>39+00</td>
<td>626.9270</td>
<td>644.1362</td>
<td>0</td>
<td>3292.069697</td>
<td></td>
</tr>
<tr>
<td>40+00</td>
<td>625.8852</td>
<td>641.0290</td>
<td>0</td>
<td>2639.000416</td>
<td></td>
</tr>
<tr>
<td>41+00</td>
<td>624.8476</td>
<td>638.5456</td>
<td>0</td>
<td>2219.449248</td>
<td></td>
</tr>
<tr>
<td>42+00</td>
<td>624.9220</td>
<td>636.6872</td>
<td>0</td>
<td>1706.948954</td>
<td></td>
</tr>
<tr>
<td>43+00</td>
<td>626.2890</td>
<td>635.4538</td>
<td>0</td>
<td>1104.74768</td>
<td></td>
</tr>
<tr>
<td>44+00</td>
<td>628.7941</td>
<td>634.8455</td>
<td>0</td>
<td>515.5186647</td>
<td></td>
</tr>
<tr>
<td>45+00</td>
<td>631.4132</td>
<td>634.8420</td>
<td>0</td>
<td>130.6077572</td>
<td></td>
</tr>
</tbody>
</table>

Total = 297,638.37
<table>
<thead>
<tr>
<th>STATION</th>
<th>EXT</th>
<th>PROP</th>
<th>CUT (cyd)</th>
<th>FILL (cyd)</th>
<th>LANE WIDTH (ft)</th>
<th>SHOULDER (ft)</th>
<th>PAV. THICKNESS (ft)</th>
<th>STATION INCREMENT (ft)</th>
<th>EMBANK Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>0+00</td>
<td>619.3361</td>
<td>619.3494</td>
<td>337.5230321</td>
<td>0</td>
<td>16</td>
<td>14</td>
<td>2.33</td>
<td>100</td>
<td>4 : 1</td>
</tr>
<tr>
<td>1+00</td>
<td>618.9365</td>
<td>619.8817</td>
<td>182.789133</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2+00</td>
<td>618.7625</td>
<td>620.4140</td>
<td>82.6466177</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3+00</td>
<td>618.9690</td>
<td>620.9463</td>
<td>41.43718125</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4+00</td>
<td>619.3065</td>
<td>621.4787</td>
<td>18.28835483</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5+00</td>
<td>620.0456</td>
<td>622.0110</td>
<td>42.88703612</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6+00</td>
<td>621.2069</td>
<td>622.5433</td>
<td>125.4944603</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7+00</td>
<td>620.6568</td>
<td>623.0756</td>
<td>0</td>
<td>9.604511868</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8+00</td>
<td>618.3390</td>
<td>623.6079</td>
<td>0</td>
<td>453.841506</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9+00</td>
<td>617.1906</td>
<td>624.1402</td>
<td>0</td>
<td>828.6210065</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10+00</td>
<td>618.0579</td>
<td>624.6725</td>
<td>0</td>
<td>747.2406559</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11+00</td>
<td>617.8992</td>
<td>625.2048</td>
<td>0</td>
<td>918.7471971</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12+00</td>
<td>620.0729</td>
<td>625.7245</td>
<td>0</td>
<td>531.820647</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>13+00</td>
<td>621.0181</td>
<td>625.9531</td>
<td>0</td>
<td>389.3506584</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>14+00</td>
<td>623.0472</td>
<td>625.7768</td>
<td>0</td>
<td>46.35595957</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>15+00</td>
<td>628.3275</td>
<td>625.3095</td>
<td>1018.841014</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>16+00</td>
<td>625.7777</td>
<td>624.8295</td>
<td>524.1475706</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>17+00</td>
<td>623.8707</td>
<td>624.3495</td>
<td>257.0117613</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total =</td>
<td></td>
<td></td>
<td>2,631.06</td>
<td>3,925.58</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
# Appendix D: Cost Estimate Tables

## Removal and Construction

<table>
<thead>
<tr>
<th>Pay Item Code</th>
<th>Item Description</th>
<th>Unit</th>
<th>Quantity</th>
<th>Unit Price</th>
<th>Ext. Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>2010001</td>
<td>Clearing</td>
<td>Acre</td>
<td>7.7</td>
<td>$7,875.00</td>
<td>$60,638</td>
</tr>
<tr>
<td>2020004</td>
<td>Tree, Rem, 6 inch to 18 inch</td>
<td>Ea</td>
<td>102</td>
<td>$231.00</td>
<td>$23,562</td>
</tr>
<tr>
<td>2040006</td>
<td>Curb and Gutter, Rem</td>
<td>Ft</td>
<td>0</td>
<td>$9.02</td>
<td>-</td>
</tr>
<tr>
<td>2040009</td>
<td>Fence, Rem</td>
<td>Ft</td>
<td>1414</td>
<td>$1.24</td>
<td>$1,752</td>
</tr>
<tr>
<td>2040111</td>
<td>Pavt, Rem</td>
<td>Syd</td>
<td>58159</td>
<td>$5.81</td>
<td>$337,676</td>
</tr>
<tr>
<td>2050006</td>
<td>Excavation, Earth</td>
<td>Cyd</td>
<td>215117</td>
<td>$3.57</td>
<td>$767,968</td>
</tr>
<tr>
<td>2050010</td>
<td>Embankment, CIP</td>
<td>Cyd</td>
<td>331922</td>
<td>$3.68</td>
<td>$1,219,813</td>
</tr>
<tr>
<td>3030020</td>
<td>Geotextile Separator</td>
<td>Syd</td>
<td>145994</td>
<td>$3.15</td>
<td>$459,881</td>
</tr>
<tr>
<td>3037011</td>
<td>Open-Graded Dr Cse, 16 inch, Modified</td>
<td>Syd</td>
<td>145994</td>
<td>$19.25</td>
<td>$2,810,385</td>
</tr>
<tr>
<td>3077011</td>
<td>Shoulder, Cl II, 11 inch</td>
<td>Syd</td>
<td>30304</td>
<td>$13.65</td>
<td>$413,650</td>
</tr>
<tr>
<td>4040113</td>
<td>Underdrain, Outlet Ending, 6 inch</td>
<td>Ea</td>
<td>8</td>
<td>$115.50</td>
<td>$924</td>
</tr>
<tr>
<td>4040043</td>
<td>Underdrain, Pipe, Open-Graded, 6 inch</td>
<td>Ft</td>
<td>1860</td>
<td>$4.20</td>
<td>$7,812</td>
</tr>
<tr>
<td>6020224</td>
<td>Shoulder, Nonreinf Conc, High Performance</td>
<td>Syd</td>
<td>30304</td>
<td>$35.00</td>
<td>$1,060,640</td>
</tr>
<tr>
<td>6027011</td>
<td>Conc Pavt, Nonreinf, 11 inch High Performance</td>
<td>Syd</td>
<td>71660</td>
<td>$27.50</td>
<td>$1,970,650</td>
</tr>
<tr>
<td>8080002</td>
<td>Fence, Woven Wire with Steel Post</td>
<td>Ft</td>
<td>14142</td>
<td>$2.73</td>
<td>$38,608</td>
</tr>
<tr>
<td>8167011</td>
<td>Turf Establishment, Performance</td>
<td>Syd</td>
<td>106972</td>
<td>$4.20</td>
<td>$449,282</td>
</tr>
<tr>
<td>8220001</td>
<td>Shoulder Corrugations, Ground or Cut, Conc</td>
<td>Ft</td>
<td>61770</td>
<td>$0.68</td>
<td>$42,158</td>
</tr>
<tr>
<td></td>
<td><strong>Total Estimate Cost</strong></td>
<td></td>
<td></td>
<td>$9,681,168</td>
<td></td>
</tr>
</tbody>
</table>

## Drainage

<table>
<thead>
<tr>
<th>Pay Item Code</th>
<th>Item Description</th>
<th>Unit</th>
<th>Quantity</th>
<th>Unit Price</th>
<th>Ext. Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Culv, Rem</td>
<td>Ea</td>
<td>1</td>
<td>$903.00</td>
<td>$903</td>
</tr>
<tr>
<td></td>
<td>Culv End, Rem</td>
<td>Ea</td>
<td>2</td>
<td>$247.00</td>
<td>494</td>
</tr>
<tr>
<td></td>
<td>Culv, Conc</td>
<td>Ft</td>
<td>50</td>
<td>$210.00</td>
<td>10,500</td>
</tr>
<tr>
<td></td>
<td>Culv, End Sect</td>
<td>Ea</td>
<td>2</td>
<td>$577.50</td>
<td>1,155</td>
</tr>
<tr>
<td></td>
<td><strong>Total Estimate Cost</strong></td>
<td></td>
<td></td>
<td>$13,052</td>
<td></td>
</tr>
</tbody>
</table>

## Safety

<table>
<thead>
<tr>
<th>Pay Item Code</th>
<th>Item Description</th>
<th>Unit</th>
<th>Quantity</th>
<th>Unit Price</th>
<th>Ext. Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>2040008</td>
<td>Guardrail, Rem</td>
<td>Ft</td>
<td>15000</td>
<td>$2.00</td>
<td>30,000</td>
</tr>
<tr>
<td>8070002</td>
<td>Guardrail, Type T</td>
<td>Ft</td>
<td>16790.0</td>
<td>$20.00</td>
<td>335,800</td>
</tr>
<tr>
<td>8070023</td>
<td>Guardrail Anch, Bridge Det T2</td>
<td>Ft</td>
<td>8</td>
<td>$1,500.00</td>
<td>12,000</td>
</tr>
<tr>
<td>8070043</td>
<td>Guardrail Approach Terminal, Type T</td>
<td>Ea</td>
<td>4</td>
<td>$2,520.00</td>
<td>10,800</td>
</tr>
<tr>
<td>8070051</td>
<td>Guardrail Departing Terminal, Type T</td>
<td>Ea</td>
<td>4</td>
<td>$638.10</td>
<td>2,552</td>
</tr>
<tr>
<td></td>
<td><strong>Total Estimate Cost</strong></td>
<td></td>
<td></td>
<td>$390,432</td>
<td></td>
</tr>
</tbody>
</table>

## Total Estimate Cost

<table>
<thead>
<tr>
<th>Pay Item Code</th>
<th>Item Description</th>
<th>Unit</th>
<th>Quantity</th>
<th>Unit Price</th>
<th>Ext. Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>1000001</td>
<td>Mobilization, Max.</td>
<td>LS</td>
<td>1</td>
<td>5%</td>
<td>$504,233</td>
</tr>
<tr>
<td>1040001</td>
<td>Contractor Staking</td>
<td>LS</td>
<td>1</td>
<td>2%</td>
<td>$201,693</td>
</tr>
<tr>
<td>2090001</td>
<td>Project Cleanup</td>
<td>LS</td>
<td>1</td>
<td>1%</td>
<td>$100,847</td>
</tr>
<tr>
<td></td>
<td><strong>Total Estimate Cost</strong></td>
<td></td>
<td></td>
<td>$10,084,652</td>
<td></td>
</tr>
</tbody>
</table>

61
<table>
<thead>
<tr>
<th>Roadway</th>
<th>Total</th>
<th>$10,790,578</th>
</tr>
</thead>
<tbody>
<tr>
<td>Structures</td>
<td></td>
<td></td>
</tr>
<tr>
<td>S29 of 77111 - Ramp D over WB 69</td>
<td>$2,977,000</td>
<td></td>
</tr>
<tr>
<td>S23 of 77111 - Ramp D over I-94</td>
<td>$5,286,000</td>
<td></td>
</tr>
<tr>
<td>S15 of 77111 - EB I-69 over I-94</td>
<td>$6,566,000</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>$14,829,000</td>
<td></td>
</tr>
<tr>
<td>Maintaining Traffic</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Assumption - 8% of $25,619,578</td>
<td>$2,049,566</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>$2,049,566</td>
<td></td>
</tr>
<tr>
<td>Signing</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Assumption - 1% of $25,619,578</td>
<td>$256,196</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>$256,196</td>
<td></td>
</tr>
<tr>
<td>Mobilization</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Assumption - 5% of $25,619,578</td>
<td>$1,280,979</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>$1,280,979</td>
<td></td>
</tr>
<tr>
<td>Total Estimate Cost</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10% Contingency of $2,561,958</td>
<td>$31,768,277</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>$31,768,277</td>
<td></td>
</tr>
</tbody>
</table>