



Study of Connectors

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Executive Summary

The City of Bluffdale is one of the fastest growing cities in the state of Utah and faces a constant demand for updated infrastructure. The City has begun a project to connect the Mountain View Corridor to I-15 via Porter Rockwell Blvd. This will help increase business, accessibility, and development in Bluffdale. However, once this project is completed a group of businesses that use Pony Express Rd will have severely limited access to the arterial road 14600 S. As such, we at BCCM Consulting have been tasked to come up with a cost-effective solution that would allow sufficient access to the businesses by designing a road between Pony Express Road and Porter Rockwell Blvd.

The Bluffdale City Engineers have specified three promising options for potential connector roads. In order to select the ideal location of the road a full transit study was needed during the morning and evening peak hours at the two roads. The three possible sites for a connector road as indicated by Bluffdale City as well as other promising sites needed to be mapped and the potential connector designs drawn up and compared.

Also, a basic geometric design of the roadways and specifications of utilities were required. From there BCCM Consulting will make recommendations and propose a connector road to the City of Bluffdale Engineering. In addition to the recommended design, alternate designs will also be discussed and a poster will be prepared to sum up the conclusions.

Introduction

Background

Porter Rockwell Boulevard is being expanded to connect Mountain View Corridor to I-15 at the 14600 South (SR140) interchange. When that project is completed Porter Rockwell Blvd will become a minor arterial road. Pony Express is the west frontage road of I-15 in Bluffdale. After completion of the project the changes made to the Porter Rockwell Blvd and 14600 S will limit access to the frontage roads.

Specifically, Pony Express Rd will be limited to a ride-in/ride-out access which means that there will be no way to make left turns onto Pony Express Rd from 14600 S and left turns onto 14600 S from Pony Express Rd. This will help reduce traffic and accidents and speed up the travel time for traffic using Porter Rockwell and 14600 S but several businesses that are located on the frontage road will have reduced access to 14600 S. Most of their

customers currently come from I-15 and turn left from 14600 S onto Pony Express. With the new changes this could prove costly and troublesome to the businesses. There are also many cement trucks and semi-trucks that use the frontage road that will not have access once it

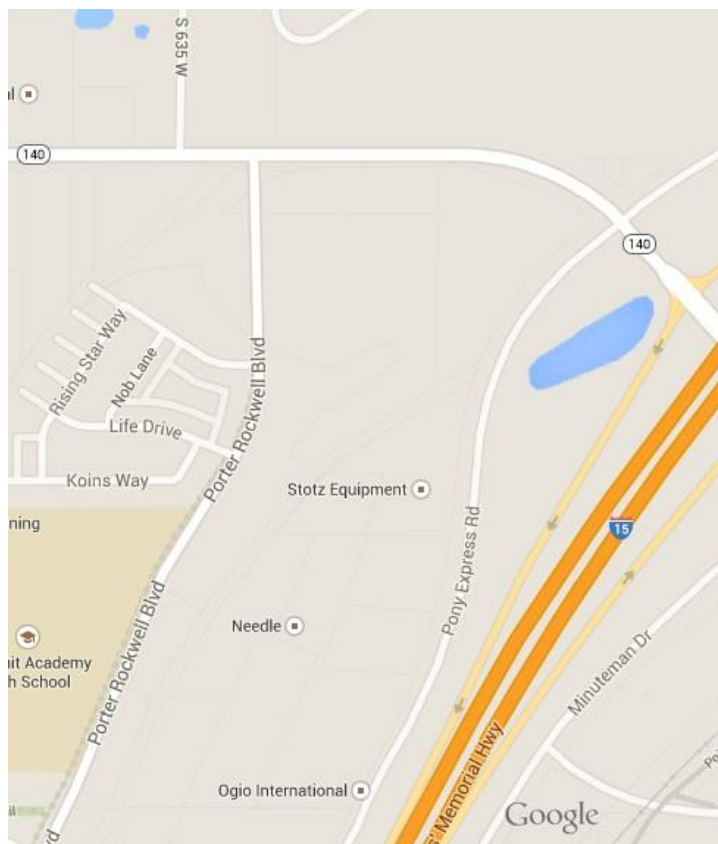


Figure 1: Map of the Area

becomes a ride-in/ride-out access road. The proposed connector road would solve both of these problems as well as help ease local traffic.

Timeline

In January we met with Matt Chadwick of Bluffdale City Engineers, presented a project schedule shown in figure 2 and discussed the City of Bluffdale's plans and expectations. The Bluffdale Engineering Department had already done some preliminary research and had three rough locations for potential connector road. They requested us to perform more extensive research and studies to determine the best location to place the road. The city also wanted our potential road sites mapped and our recommendations on which ones would yield the greatest benefit at the lowest cost. They accepted our project timeline and gave us all of the maps and data they had of the area.

Tasks	January				February				March				April	
	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8	Week 9	Week 10	Week 11	Week 12	Week 13	Week 14
Project Management Plan														
Data Collection														
Research														
Data Entry														
Prelim AutoCad														
50% Report														
Geometric Design														
Final AutoCAD														
Final Report														
Poster														
Presentation														

Figure 2: Project Timeline

The bulk of the research was completed early on in the project to leave the majority of the time for analyzing data and designing road connectors. Several potential designs were created but only the most effective are presented here.

Data Collection and Analysis

Traffic Counts

In order to accurately create connector roads, designs, traffic counts, site mapping, and data analysis had to be completed. Morning and evening peak hour traffic counts were completed for both Porter Rockwell Blvd and Pony Express Rd. Based on the nature and usage of the two streets, the counts focused on passenger cars, heavy trucks, and RV's. The data collected from the peak hour counts revealed that the most frequent type of vehicle to travel both roads were passenger cars. On Porter Rockwell there were occasional semi-trucks that were counted and there appeared to be more in the afternoon than the morning. On Pony Express there were many cement trucks that were counted in the semi-truck/large vehicle category. There is a Jack B. Parsons cement and materials plant down by the end of the frontage road and the cement trucks all use the frontage road to get to I-15. There was a steady flow back and forth of cement trucks in the morning and a large flow back to the plant at the end of the day. There were also semi-trucks that used Pony Express Rd but the majority of the heavy vehicles were cement trucks.

After completing the traffic counts it was apparent that the connector road will require enough space to allow large vehicles enough maneuvering room to drive safely and quickly. The design vehicle for the connector is a WB-62 Semi-truck as this would be the largest vehicle to use the road. It was also apparent that many of the passenger vehicles that used Pony Express Rd during the peak hours were doing so to gain quicker access to the freeway. Some passenger cars also appeared to use the road to skip the freeway entirely during rush hour.

Site Visits

Provo Roundabout Connector

In order to get a better idea of how a potential connector road could be designed and constructed, the BCCM team visited sites in Provo and other cities. In Provo, there is a roundabout with a connector road that is very similar to the potential designs in Bluffdale. We travelled on site and examined and documented how the road was constructed, its surroundings, and its feasibility as a template that could be used to design connector roads in Bluffdale.

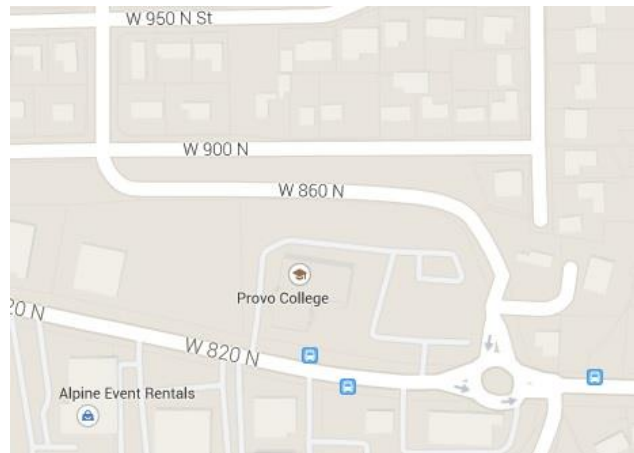


Figure 3: Provo City Connector

Porter Rockwell Blvd is significantly lower in elevation than Pony Express Rd. Depending on where the connector road is placed there can be a lot of potential grading and cut and fill that needs to be done in order to properly construct the road. This Provo City road has been built in similar conditions and it has a fairly steep grade. The road has a fairly steep grade between the two roads it is connecting but evens out on both ends. It is cut into the side of a hill and it is noteworthy that retaining walls were not required to keep the slope stable and the road in place. If a similar design is to be used for the Bluffdale project it would require cutting into the hillside and steep grading. However, depending on the design the Bluffdale connector road could avoid constructing retaining walls for the length of the road which would cut down on cost tremendously.

Proposed Connector Sites

The Bluffdale City Engineers' proposed sites for a connector road and several other potential sites were visited and examined by the BCCM team. This was done to better orient the team to the area, determine the feasibility of each of the three main options for connector sites, and search for other possible sites. Starting from the northernmost site, the proposed site for our

design option 2 had a significantly larger elevation change from top to bottom than was originally assumed from pictures and would definitely take excavation work to grade a potential road and deliver a smooth ride. Based on the roads that are currently there, it would make the most sense to follow the hillside between Porter Rockwell Blvd and Pony Express Rd and connect the road where there is already a three-way intersection that connects an under construction subdivision to Porter Rockwell.

Initial observations found that our design option 1 had the gentlest slope from top to bottom and would also provide the least amount of impact to the area. If placed between the storage units to the north and the subdivision to the south it would be a straight shot road that would require minimal grading. In addition to the connector road a four way intersection could be made where the connector meets Pony Express Rd that would also get rid of a fork in the road that Bluffdale City is concerned with. . One of the concerns with the current layout of Pony Express Rd is that the fork in the road creates a potential danger zone where vehicles approaching from the south from Lehi don't stop and wait for the merging traffic from the lower road in the fork. Traffic heading northbound from the left side of the fork are the only vehicles required to stop at this intersection as it is presently constituted. Of this traffic, most vehicles are cement trucks that are travelling to and from the Parson's cement plant to the south. When they arrive at the intersection, they are required to stop and then immediately accelerate as fast as possible to match the road speed. The traffic approaching the intersection from the right side of the fork does not have a stop sign and this poses a safety threat to the vehicles using the left road of the fork. Local residents also use Pony Express Rd frequently to get to I-15 at 14600 S and also to access restaurants and stores at Thanksgiving Point in Lehi. When a driver is heading northbound on the right side road of the fork and wants to get to the local neighborhoods they have to execute a dangerous, almost 180 degree, turn to get onto the left side road. An intersection would provide a safer way to merge traffic from both of the roads and keep traffic better controlled. If a connector road was built in this location it would solve the connector problem and the fork in the road problem all at once.

Option 3 appeared to be the least feasible of the main design options after the site visit. It is past the fork in the road and therefore would not be able to address that problem and has a steep grade from top to bottom. One of the attractive features of design 1 is that it is close to the

affected business and would be easy to find if it were constructed. Option 3 however is far enough south that it would be more difficult for someone that has just exited the freeway to find and would be just as expensive if not more expensive than option 1 to construct with less benefits. This option was all but ruled out by the site visits. After surveying the area there were not any other potential sites that appeared to offer more benefits than the original three designs.

Preliminary Design Work

In order to better understand the landscape of the area we took the maps provided by Bluffdale City and plotted them in ArcMap. This allowed us to map the topography of the area. The gradation was set to two meters to better illustrate the difference in elevation between Porter Rockwell Blvd and Pony Express Rd. It also gave real numbers and data to what we had observed during our onsite visit. From the topographical mapping of the area, it was again apparent that our design option 1 would most likely be the most feasible of the designs. The change in elevation from starting point to finish affects the amount of cut and fill work and therefore the total cost of the project. The less grading the better and option 1 at this point seemed to be the most cost effective of all of the design options.



Figure 4: Elevation Contours of the Area

It had been discussed before the project started whether or not we would need to use Synchro, a traffic program that determines the level of service of a roadway based on the number of lanes, the type of intersection, the volume of traffic, and the type of traffic. Since this road would experience minimal use, it was safe to assume that a two lane, two direction roadway was sufficient for this application. Because of this, a synchro simulation was not needed. We have made the assumption that simple stop-signs and four-way intersections will be used where the connector road meets Porter Rockwell Blvd and Pony Express Rd. The intersections will be designed with enough clearance and width that Bluffdale City can upgrade to a traffic light system in the future if it is deemed necessary but for the initial design of the connector road simplicity is the overall goal. We aim to design a road that will be effective and meet all of the goals and criteria set forth by the city while also being simple and cost-effective.

Design Options

After the preliminary design work was complete we analyzed in depth each of the design site possibilities. We plotted a potential connector road and designed roadways that would be the most effective for each site. This process included utilizing AutoCAD to draw in new roads and intersections where there previously weren't before. We also calculated the minimum required turning radius for a WB-62 Semi-truck and used that in our intersection design. The CAD drawings were then placed in ArcGIS to further illustrate elevation differences. The road itself was designed as a two lane, two direction road with ample shoulder width to allow for cars to pull over and large vehicles to make maneuvers more safely. Costs on all design options were estimated as well. While designing the roads, Bluffdale City's main goals were kept in mind. We needed to design a road that would give greater access to the businesses on Pony Express, alleviate the fork in the road problem, and do as much as possible to ease traffic and congestion for a local school and the neighborhood.

Design Option 1

Site

Our primary design is the second site is just south of a storage facility at the south end of the business park and just north of a subdivision of houses. In between the store and the subdivision there is a gap of undeveloped land that would be wide enough to fit a connector road. This area also has an elevation change between Pony Express and Porter Rockwell but it gradual and even.



Figure 5: Design Option 1 Site

Design Overview

There are many benefits to constructing a connector road at this location. The most obvious benefit is the minimal amount of cut and fill work necessary to build the road. The terrain has a gradual and even slope from top to bottom and it is a straight shot between the two main roads. As such, the design of the road proved to be simple yet effective. The connector road would intersect Porter Rockwell Blvd and create a three-way intersection. Where it meets Pony Express Rd we propose to lengthen the road that forks off of Pony Express Rd to meet at a four-way intersection where the connector road hits



Figure 6: Design Option 1

Pony Express. The City of Bluffdale had specifically requested that the safety of traffic leaving the cement plant be addressed in any designs that are proposed to them and this four-way stop would resolve that issue. In order to ensure the safety of other vehicles using the intersection, traffic control devices such as “Sharp Turn Ahead” and “Stop Ahead” can be utilized to warn drivers and adequately sized turning radii that can accommodate large trucks and semi’s will need to be incorporated in the final design. This will increase the safety of the road considerably and can be done concurrently with the construction of the connector road. It will also do a better job controlling traffic during peak hours.

Intersections of the Connector

This connector would simply intersect Porter Rockwell Blvd and create a three-way stop. This intersection is simple and straightforward. It would be designed to give semi-trucks enough space to complete a right or left turn. This may develop into a traffic-light intersection as Porter Rockwell becomes a more heavily used road but for the present time it will be controlled with stop signs. A four-way intersection would be constructed where the connector road meets Pony Express Rd. This intersection would replace the fork in the road and would better regulate traffic in the area. The right side fork road would be lengthened to meet at the intersection and would require a sharp turn to connect it.

Design Option 2

Site

Our second recommended design is located at the most northern site for a road. It is just north of the business park on Pony Express Rd and right at the three way intersection of the under-construction subdivision north of the high school on Porter Rockwell Blvd.

Placing a connector road here would give instant and easy business access and tie in with the subdivision that is under construction. It would also be easy for cars just exiting the freeway to find and cut down on driving time.

However the one thing that became readily apparent from the site visit was the large elevation difference between the two roads. And due to a lot of new construction in this immediate area, the elevation grade is very steep.



Figure 7: Design Option 2 Site

Design Overview

By inspection the most feasible method to construct a road would be to follow the steep slope that runs in a southwest direction from the top of Pony Express Blvd. This would considerably cut down on cut and fill expenses and make for an easy construction process as well. The roadway would still have to be cut out of the hillside in much the same manner that the Provo City roundabout connector was done. While a slope stability analysis would



Figure 8: Design Option 2

still be needed to ensure safety of construction and longevity of the road, based off of the Provo City example retaining walls would not be needed if the roadway was cut properly from the slope. For this road the vertical and horizontal curves would need to be calculated to ensure a smooth and pleasant drive.

Intersections of the Connector

This design features a four-way stop where the connector road meets Porter Rockwell Blvd and a three-way intersection where it connects to Pony Express Rd. There is already a three-way intersection at a subdivision on Porter Rockwell and this connector would join the intersection to make it a four-way stop. There is currently no intersection on Pony Express so the connector road would create a three-way intersection with stop signs.

Design Option 3

Site

Our third potential design option was the south-most of the three sites. It is also the most undeveloped of the three. It has a steep grade from Pony Express to Porter Rockwell. Because there is relatively little development in this area there would be almost zero impact on current neighborhoods and businesses. This makes it an attractive site in that regard but there were other characteristics of the site that turned us off from this site. Because it is so far south of 14600 S it would not be easy to find for traffic exiting the freeway. It also is beyond where the fork in Pony Express happens and would not be able



Figure 9: Design Option 3 Site

to feasibly address the issue. This site is also very steep take more excavation work then it would be worth to correctly lay a connector road. Because of this we elected not to use design option 3 in our final designs.

Design Overview

After initial designs and calculations, we determined that it would not be feasible to construct a road at this location. While it can be done, there are other sites that would provide more benefits at a lower cost. The road would have to connect on the lower part of the fork which would only complicate the process of re-designing that intersection. There would be a considerable amount of grading that would raise cost and time of construction significantly.

Potential 146000 S U Turn design

Intro

During the initial research and as we continued to work and generate designs we recognized that a U-Turn at the 14600 S and Porter Rockwell Blvd intersection would significantly increase accessibility to Pony Express Rd once it becomes a ride-in/ride-out access. This would be primarily for cars and other smaller passenger vehicles that can make sharper turns. Cement trucks, semi-trucks, and other large vehicles would have to use the connector road but this would create fast access for the majority of traffic that uses Pony Express Rd.

Site

Currently there is a stop sign where northbound Porter Rockwell intersects 14600 S. 14600 S is also currently a two-lane, one-way street but this stands to be changed once the Mountain View Corridor is connected to Porter Rockwell. There is most likely going to be a light system that replaces the stop sign when that project is complete.

Design Overview

We propose that when the intersection is modified and a light system is put in place that Bluffdale City add the lanes and space to allow for U-Turns to be made from the westbound 14600 S road. Vehicles exiting the freeway will not have access to Pony Express Blvd anymore once the intersection is changed. Providing a U-Turn at Porter Rockwell Blvd will allow smaller vehicles to quickly get to Pony Express. This would alleviate the businesses concern of customers' reduced access as well as reduce traffic on Porter Rockwell and Pony Express Rd.

This intersection as it is presently constituted will not be able to meet the traffic demand once the Mountain View Corridor is connected to Porter Rockwell Blvd and will need to be modified regardless of whether a U-Turn is being put in or not and would give the perfect opportunity to construct one while it is being modified.

Road Design

Cross-Section of the Roadway

The connector road needs to be able to allow semi-trucks to safely pass each other and have enough clearance to make turns onto Porter Rockwell Blvd and Pony Express Rd. As such the road was designed with 11' wide lanes and 10' wide shoulders. This will give enough space to do such. The turning radius was also calculated to give our design semi-truck the room required to complete a turn. The road will have a 3 degree slope from the crown to allow for sufficient drainage of rain and other substances. .

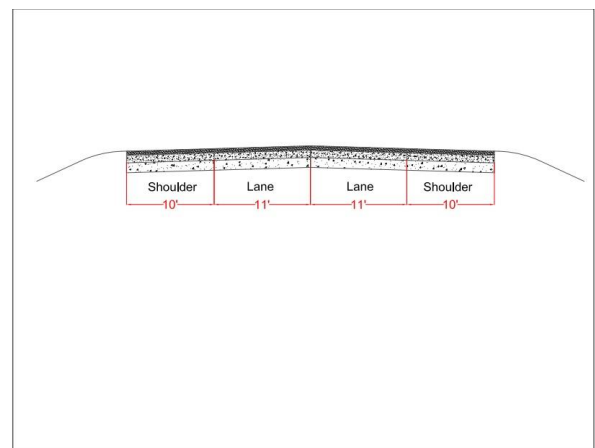


Figure 10: Cross-Section of Connector Road

Pavement Design

The AASHTO 1993 Method was followed to generate a structural number for the connector road that would allow us to create a road that would withstand the expected use and also provide us with dimensions and amounts of material. From our estimations of expected use a structural number of 5.0 was used in the pavement design process. From that number several designs were created and the most cost effective yielded a structural number of 5.01. This particular design consists of a 6 inch asphalt top, a 10 inch well grade aggregate base, and a 13.5 inch coarse aggregate subbase. This allows for a road that is strong and durable enough to withstand the anticipated loadings and usage and be the most financially conservative.

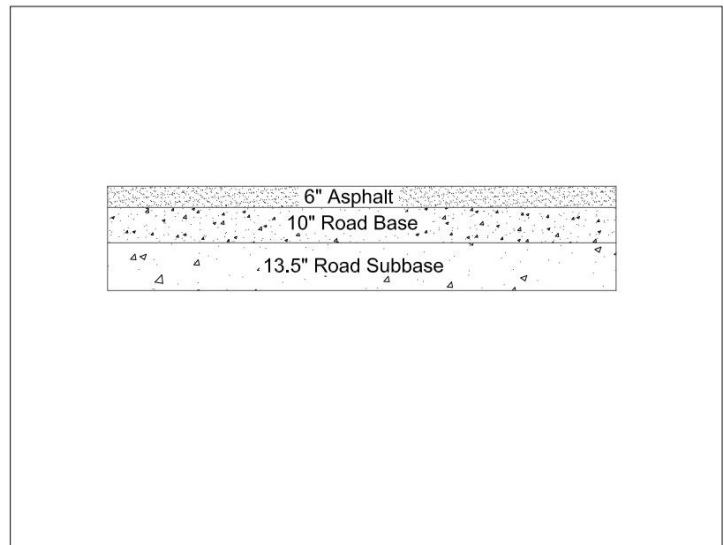


Figure 11: Pavement Design of Connector Road

Cost Analysis

Once the pavement design and road designs were completed the costs of each design option were calculated. These numbers are to be used as a comparison between designs more than they are exact figures on what it will take to build each design. Using 2005 data and adjusting for inflation we estimated a cost per ton of each material to be used in the road construction. The cost per foot per inch of depth of each material was calculated and adding in the width of the road the cost per foot per substance was determined. Each design option's cost was calculated and grading costs were added in as well.

Cost	Paving	Grading	Total
Option 1	\$ 311,192.33	\$ 214,200.00	\$ 525,392.33
Option 2	\$ 388,990.41	\$ 267,750.00	\$ 656,740.41

Figure 12: Cost Estimates

Recommendations and Conclusion

From our study of possible locations of connector roads we recommend design option 1 as the most feasible and beneficial design. Design option 1 has the lowest cost of all considered designs and also addresses multiple problems in the area. It will connect Porter Rockwell Blvd and Pony Express Blvd and eliminate the dangerous fork in the road on Pony Express. It will also have minimal impact on the area as it is currently constituted. In addition to the lower cost of the project it will be easy to construct as well. The terrain it would be constructed on is evenly graded and has a straight path between Porter Rockwell and Pony Express.

We also feel that it would benefit the city to make provisions for a U-Turn lane on 14600 S in order to better serve the businesses on Pony Express and to also alleviate passenger car traffic in the area.

This project has included a full site and traffic study, data analysis, plotting and mapping the data, generating road designs, and cost and feasibility assessments. We hope that this will be of benefit to the City of Bluffdale as it decides where to place a connector road between Pony Express Blvd and Porter Rockwell Blvd. We would like to thank you for selecting BCCM Consultants to design your connector road and for the opportunity to help better the City of Bluffdale.

Appendix

Due to the amount of pictures and data an appendix is provided to display further pictures and data. It is organized by section.

Appendix A. Provo Site Visit



Figure 13: Hillside of the Provo City Connector



Figure 14: Detail of the Provo City Connector Road



Figure 15: Detail of the Provo City Connector Intersection

Appendix B. Peak Hour Traffic Counts

Morning Peak Count

NB Porter Rockwell			SB Porter Rockwell		
Passenger Car	Trucks	RV	Passenger Car	Trucks	RV
6			12		
7			5	1	
5			3		
2	1		4		
7			3		
4			2		
6			2		
3			4		
3			3		
5			6		
12			3		
3			6		
63	1	0	53	1	0

NB Pony Express			SB Pony Express		
Passenger Car	Trucks	RV	Passenger Car	Trucks	RV
21			7	1	
16	1		6	3	
19			8	2	
11			6		
10	1		19	1	
7	3		10	2	
10	5		5	1	
13	1		5	1	
10	1		3		
9	2		5		
9	1		5	4	
135	15	0	79	15	0

Evening Peak Count

NB Porter Rockwell			SB Porter Rockwell		
Passenger Car	Trucks	RV	Passenger Car	Trucks	RV
32			23	2	
29	1		24	1	
41	1		19	1	
23			15		
20	2		9	2	
12			8		
12			5		
9	1		7		
11			11	1	
13			5		
4			13		
7			5		
213	5	0	144	7	0

NB Pony Express			SB Pony Express		
Passenger Car	Trucks	RV	Passenger Car	Trucks	RV
7	1		9	1	
10	1		8	3	
5			10	4	
7	2		9	3	
12			7	3	
12			11		
11	1		10	3	
10	1		11	1	
20			15		
15			18	2	
20			17		
23			13		
152	6	0	138	20	0

Appendix C. Design Option 1



Figure 16: Lower Site View of Design 1



Figure 17: Intersection of Design 1 Connector and Pony Express Rd



Figure 18: Intersection of Design 1 and Porter Rockwell Blvd

Appendix D. Design Option 2



Figure 19: Upper Site View of Design 2



Figure 20: Alternate View of Design 2



Figure 21: Intersection of Design 2 and Porter Rockwell Blvd



Figure 22: Intersection of Design 2 and Pony Express Rd

Appendix E. U Turn design



Figure 23: U-Turn Design at 14600 S and Porter Rockwell Blvd Intersection



Figure 24: 14600 S and Pony Express Intersection



Figure 25: Full U-Turn Design

Appendix F. Pavement Design

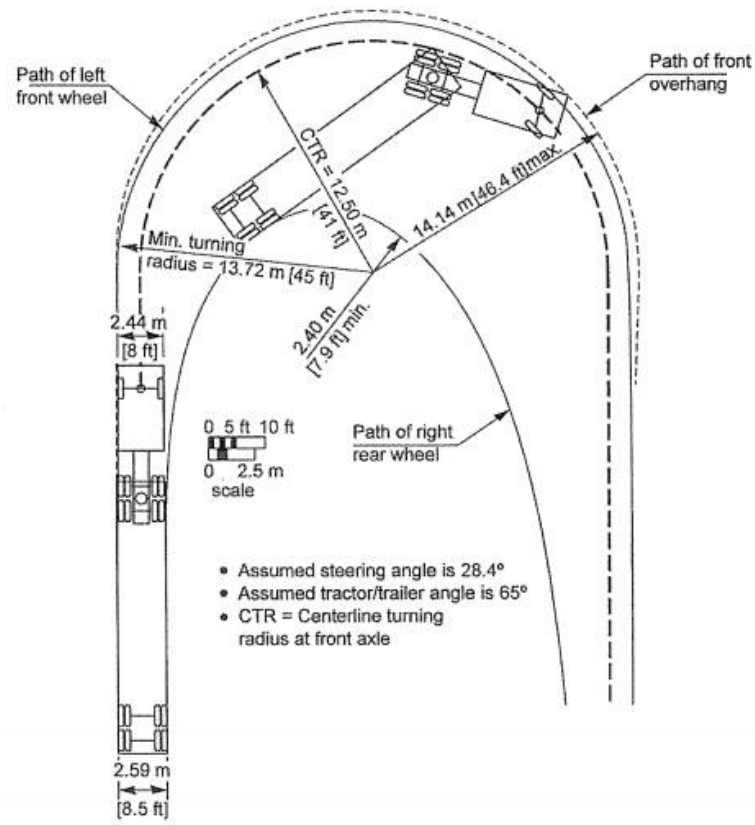


Figure 26: Minimum Turning Radius for a Semi-Truck

Appendix G. Cost Estimate Data

Asphalt Concrete Depth (in)	Base Compacted dense aggregate, well graded Depth (in)	Course Aggregate Depth (in)	Overall Depth of Pavement	SN	Added Grading per Foot @ \$3/yd
4	14	17	35	5.02	236.25
6	10	13.5	29.5	5.01	178.5
8	7	9	24	5.02	120.75

Figure 27: Pavement Design Variations

Material	Depth (in)	Cost per Foot	Option 1 @1500 ft	Option 2 @ 1200 ft
Asphalt Concrete	6	\$ 189.30	\$ 283,951.99	\$ 227,161.59
Base Compacted dense aggregate, well graded	10	\$ 41.27	\$ 61,909.87	\$ 49,527.89
Course Aggregate	13.5	\$ 28.75	\$ 43,128.56	\$ 34,502.85

Figure 28: Cost of Materials