IMPROVING PEDESTRIAN SAFETY

A Research Paper submitted to the Department of Engineering Systems and Environment
In Partial Fulfillment of the Requirements for the Degree
Bachelor of Science in Civil Engineering

With Aimée Barnes

By

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On my honor as a University student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments.

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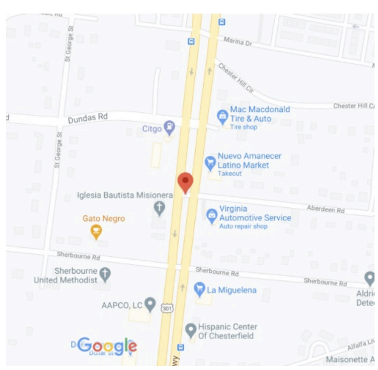
Project Problem Statement:

Pedestrian safety is a growing concern, and it is more important than ever on a corridor just south of Richmond, VA, on Jefferson Davis highway. A particular segment, between Merriewood and Marina Drive, has been particularly highlighted for the need for pedestrian safety improvement pedestrian infrastructure. The team must explore options to improve pedestrian safety along this specific corridor. Solutions may include geometric alterations to the roadway, adjusted pedestrian traffic patterns, an app to coordinate autonomic vehicles, or a plethora of other methods. Beyond a technical standpoint, the team must evaluate the socio-economic aspects of the community. Solutions that work long term and support the needs of the community are of the uppermost importance for this project.

Because the students were tasked with finding a solution that could be implemented today as well as a solution for the future, the project was separated into subcategories. The civil engineering students took the lead on the design for today, while the systems engineers began research on what might be implemented in the future. All the same, students still met up weekly on Mondays to ensure the team was on the same page. Following this split organization of our project, aside from the scope which was developed collectively, the report will consist of only work from the civil students.

Due to restrictions to student lab access, the civil students faced a challenge when accessing AutoCad files provided by Timmons Group. Still the team was able to use both engineering judgement as well as analysis techniques to justify and complete a design. This final report includes a well-developed scope, CPM schedule, conceptual design, a CAD schematic design, right of way, traffic signal warrant, crosswalk implementation, water analysis, and profile/section views.

Scope:



Route 301, south of Richmond, exemplifies characteristics of poor pedestrian safety. High traffic speeds, volumes, wide crossing widths, and the general lack of pedestrian infrastructure has led to 2 pedestrian fatalities in the past year and infrastructure failures. Our project will serve to enhance the safety and connectivity of the community without jeopardizing the local history, culture, and lifestyle in the area. The sociocu ature of the project will require our team to know both the residential and commercial u vell as the demographics of the surrounding community.

Transportation and land development design skills will be used to avoid increasing vehicular traffic in the area while optimizing safety through design changes. Using programs such as Civil 3D, AutoCAD, ArcGIS, and Bluebeam will allow the team to propose a complete road design. The project team notes that Covid19 may cause significant restrictions concerning site visits and communication with outside sources.

The growth in technology with regards to automated vehicles will soon offer new opportunities and challenges regarding pedestrian safety. Given the intended longevity of our design, the project will consider how transportation systems and pedestrian infrastructure may be influenced by future and technology, including but not limited to pedestrian detection systems, smart signals, signage, and connected vehicle frameworks. Investigation regarding adjacent development and current comprehensive plans will aid in the understanding of the future potential.

Semester 1

Schedule:

To ensure the project moved at a steady pace throughout the semester, a CPM schedule was developed (Appendix 1). Fall semester consisted of Research, Determination of goals, meetings and coordination, a site visit, conceptual design, and schematic design. The research was continuous throughout the semester. Shared goals were determined along with systems group members using a systems framework. Main goals consisted of minimizing pedestrian incidents, optimizing the level of service, and minimizing the effects of social and political forces on safety improvements. Concerning meetings and coordination, the team met to discuss the progress of the project on Monday evenings. Students met with Professor Smith on Friday when available, and with Timmons group on Wednesday morning when in need of assistance. The team made a crucial site visit, late October. After both driving and walking the site, a conceptual design was put together and presented to Timmons group.

During the second Semester of the project, the civil students met with Timmons Group and Professor Smith when available on a biweekly basis. The University of Virginia Heighten Covid lab restrictions second semester causing both Civil and Systems Students to Alter plans. Due to the inability to regularly access Civil 3D, civil students placed an emphasis on 6 main categories: Right of way acquisition, Traffic Signal warrant, Water analysis, Marina Drive crossing, and cross sectional analysis.

<u>Conceptual design:</u>

The presentation of the conceptual design was well done and received beneficial feedback from Timmons group. The presentation was in a PowerPoint format, with the road segment divided by street intersections. Blue beam was used to create notes on google satellite images. Figure 1 illustrates the beginning of the road segment, at the intersection of Dundas Road and Jefferson Davis Highway (the project was later extended to reach Marina Drive). The team proposes a crosswalk at the already signalized Dundas intersection. Spanning the entirety of the proposed segment is the sidewalk as well as curb and gutter. Figure 1 alludes to what would be landscaping in the final stages of the project. Landscaping would be included along the wide grass medians to discourage pedestrians from jaywalking.

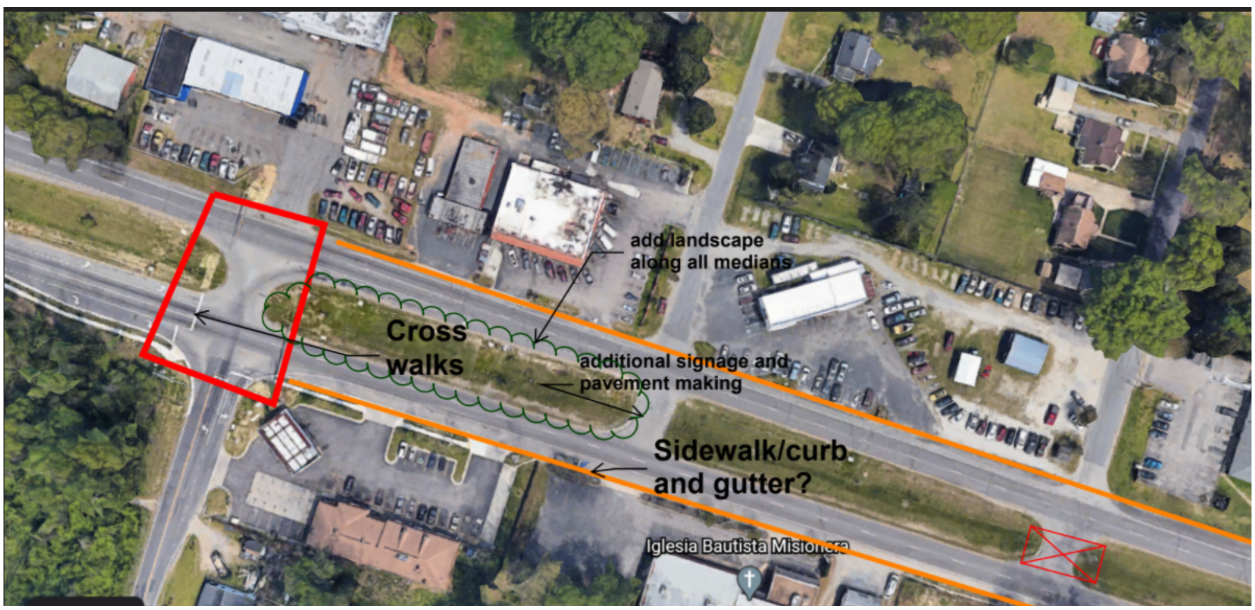


Figure 1) Intersection of Dundas Rd and Jefferson Davis Highway

Figure 2 shows the intersection of Swineford and Jefferson Davis Highway. Before this intersection, it is also indicated where the team proposes to close off the median entrance into Sherbourne road. The team decided to remove this turn due to its redundancy. Aberdeen road connects to the same neighborhood as Sherbourne which can be more clearly seen in figure 3. The team proposes this block to create a more continuous sidewalk as well as minimize potential conflict points. The new proposed signalized intersection was largely based on the team's site visit. The large size, poor site clearance, and near bus stops were some of the observed conditions that the group believed warranted a signal. To further evaluate the need for a signal, the civil students put together a traffic signal warrant, detailed later in the report.

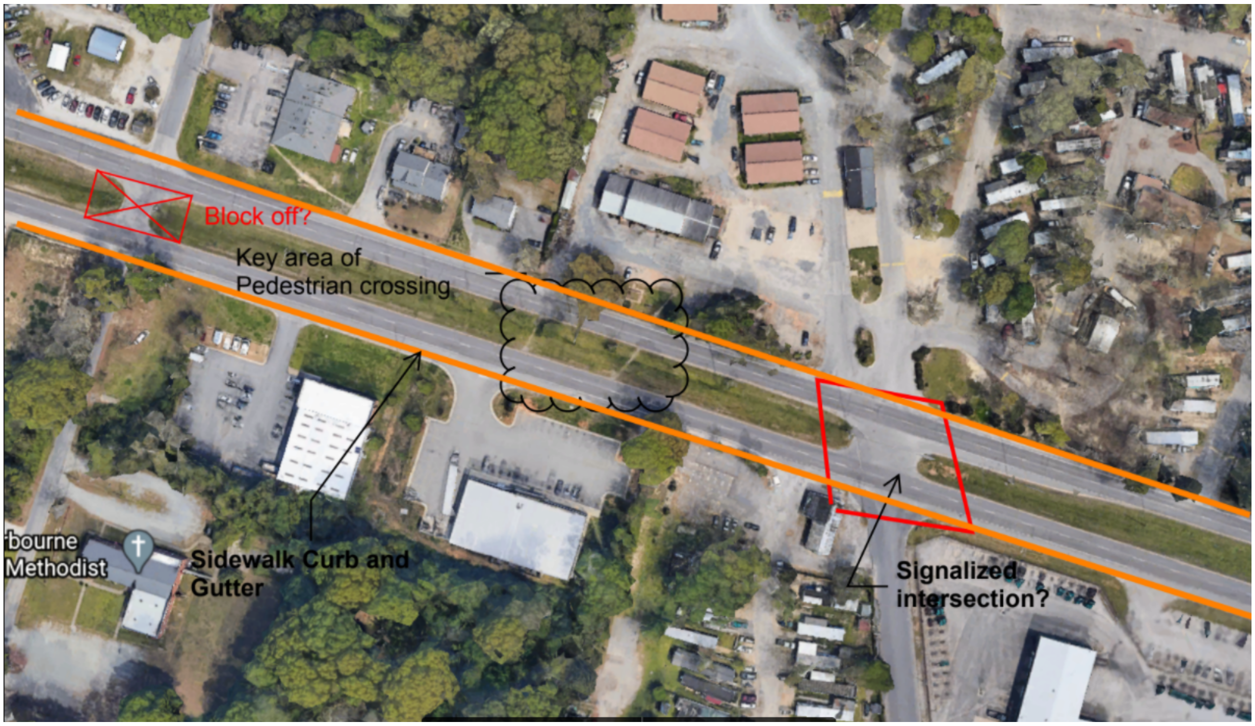


Figure 2) Intersection of Swineford and Jefferson Davis Highway

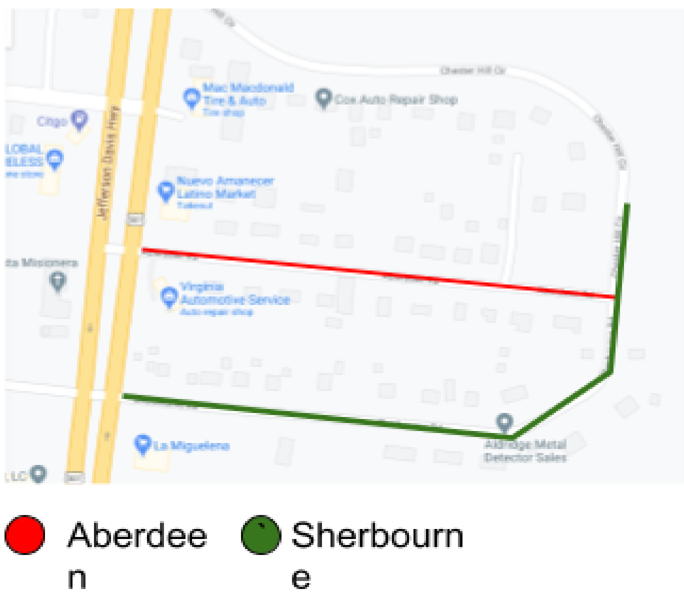


Figure 3) depicts the redundancy of Aberdeen Rd and Sherbourne Rd.

The final part of the segment connects two trailer parks. The group notes that adding sidewalks in this area is imperative for connectivity. The team noticed that a gravel path was already in place on the site visit (Figure 4). It was concluded that sidewalk curb and gutter would make pedestrian travel safer.

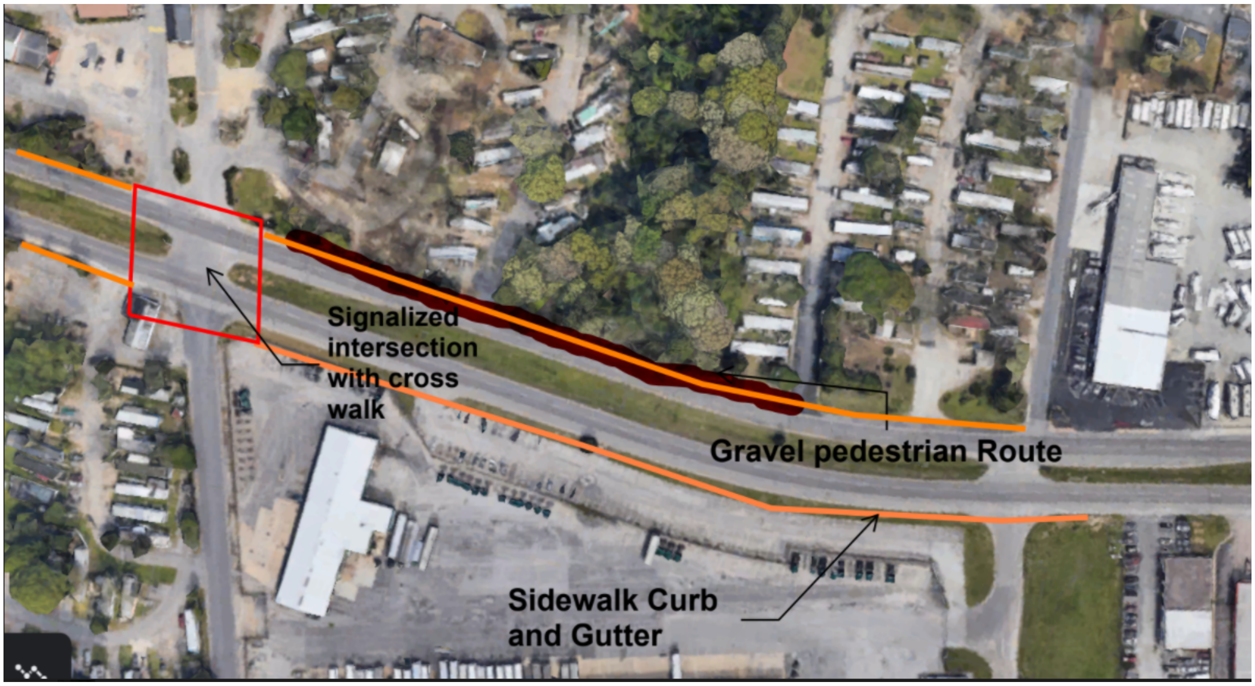


Figure 4) After Swineford intersection ends at Merriewood Rd.

CAD schematic Design:

Once the team began a design in CAD, ideas from the conceptual drawing were altered accordingly. For instance, the team discovered that there was only a survey for one side of the road available, and Timmons Group suggested we focus on that side of the street alone, as well as the medians. Our initial CAD drawings have simple linework illustrating sidewalks and driveways. You will see in the screenshots below that the team has designed sidewalks that begin with a 2.5’ curb and gutter against the existing street, a 4’ buffer strip, and a 5’ sidewalk (Figures 5,6,7). The existing property lines do not allow for this 10’ offset, so the team began exploring easements of property which we will discuss later. Timmons Group also revised that the corridor should end one intersection further than Dundas Rd at Marina Drive. As this design is developed over the break and next semester, median adjustments, as well as stormwater, utilities, and signal warrants, will be designed and drawn in CAD.

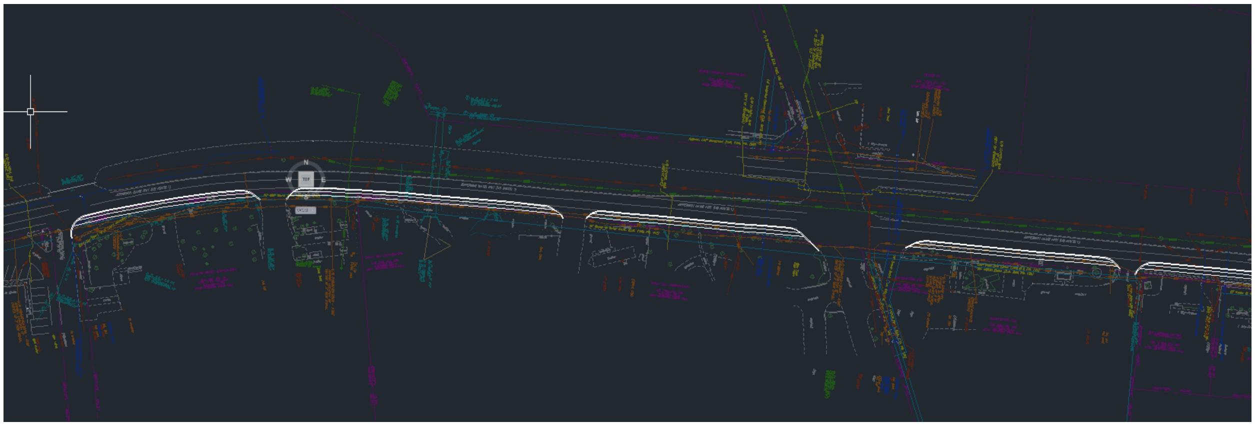


Figure 5) Intersection of Merrie Wood Rd to the Hispanic Center

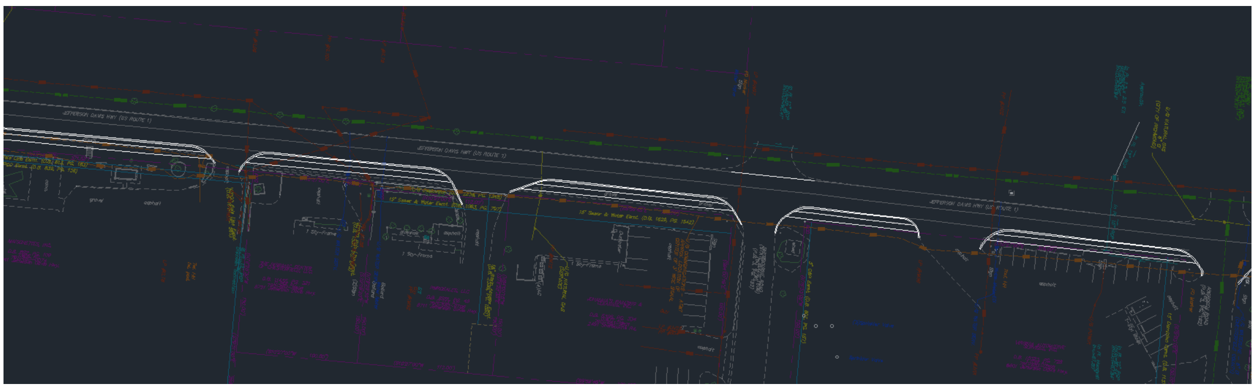


Figure 6) Hispanic Center to the intersection of Aberdeen Rd

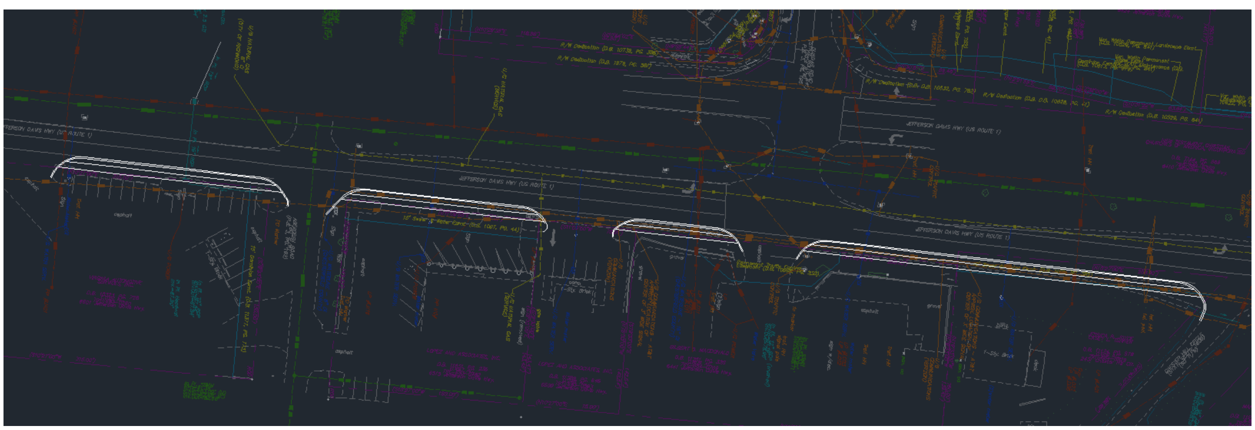


Figure 7) Intersection of Aberdeen Rd to the intersection of Chester Hill Rd

Semester 2

Right of Way:

After presenting the initial CAD design, which included a slight change in road geometry along the last section of the segment, both Professor Smith, as well as Timmons, advised the team to consider purchasing right of way. To do such the team used GIS data and Chesterfield residential value assessments. The justification and cost calculation is as follows.

In a high pedestrian traversed area, sidewalks are to be proposed on the Northbound side of Jefferson Davis Highway. For the safety of the pedestrians, it is ideal that a 4 ft grass strip be introduced in addition to a 2.5 ft curve and gutter and 5 ft sidewalk. To accommodate for the 10 ft of pedestrian structure, easements are required. Businesses should donate the land due to increased foot traffic while residential parcels would benefit from tenant appeal. Even more, we have reason to believe that the increase in accessibility translates to an increase in property value.

5.7.1

Easements are acquired for such purposes as drainage, slope maintenance, detours, channel changes, *sidewalks*, and construction staging areas that are outside the highway right of way. Permanent easements are required, for example, *where there is a permanent transportation improvement or a continuing need for maintenance.* The decision as to the need for easements is made at the field inspection stage and the approved plans will reflect whether temporary or permanent easements are required and their purpose (VDOT, 2016).

The parcels are as illustrated in Figure 8 and zoned as shown in Table 1

Figure 8) Illustrates parcels where easements require purchase

Label	Zone	Acres	SF	Value Assessment	Cost per SF	Easement Required (SF)	Cost
A	Trailer Park			$1,230,600.00	$0.85		
B	Trailer Park	24.04	1047182.4	$3,306,400.00	$0.00	2832	$2,409.90
C	Multi-family residential	1.96	85377.6	$1,653,900.00	$0.05	N/A	N/A
D	Commercial	0.34	14810.4	$102,100.00	$0.15	N/A	N/A
E	Commercial	0.37	16117.2	$275,400.00	$0.06	N/A	N/A
F	Commercial	0.66	28749.6	$421,400.00	$0.07	N/A	N/A
G	Commercial	1	43560	$249,800.00	$0.17	857	$149.44
H	Commercial		0	$515,500.00	$0.00	N/A	N/A
I	Commercial	0.26	11325.6	$103,100.00	$0.11	770	$84.58
J	Commercial	0.86	37461.6	$249,900.00	$0.15	493	$73.90
K	Single Family Residential	0.36	15721	$133,100.00	$0.12	3252	$384.11
						Total	$3,101.94

Table 1) This table shows both the zone use of the parcels as well as estimated property value as of 2020 from Chesterfield GIS data.

Using the Assessment Value from Chesterfield residential appraisals in 2020 ("Real Estate"), the Gross Easement method could then be used to calculate the value of acquisition (Figure 9). Before this step could be done, using excel, the estimated area that the sidewalk would take up on each parcel was determined (Table 1). The total cost in easements was calculated to be $3,101.94 (Table 1). Though this value seemed minimal, Timmons Group assured the team that this would be some of the cheapest land in the area. This of course goes back to the area being in a socioeconomic disparity.

Value of the Property:								
Land	45,000 SF	x	$1.00			=		$45,000
Value of the Acquisition:								
Fee Acquisition	5,000 SF	x	$1.00			=	$5,000	
Gross Ease. Area	3,700 SF	x	$1.00	x	30%	=	$1,110	
	Total Value of the Acquisition					=		$6,110
Value of the Remainder Before Damages/Enhancements:						=		$38,890

Figure 9) sample calculation provided from VDOT appraisal guide using the Gross Easement Method (VDOT, 2011)

Traffic Signal Warrant:

Beyond the need for a signal at Swineford and Jefferson Davis Highway evaluated by the team during the site visit, Timmons group advised the team to put together a traffic signal warrant. The team was limited due to the inability to make multiple trips to the site. The team was able to use available GIS and VDOT data to develop a traffic signal warrant. Much like the right of way, students received feedback from Timmons' group over winter break.

Figure 10 depicts the intersection in question, from the Swineford point of view. During the site visit, the team noted that it took a substantial amount of time to make a left turn from Swineford to travel northbound on Jefferson Davis Highway. The team also noticed that making this turn was difficult due to the poor sight distance of the cars traveling southbound. Much the same, when traveling north, and attempting to turn left onto Swineford, there was again a substantial wait for the vehicles traveling southbound to clear. While Jefferson Davis Highway is 45 mph, drivers far exceed this speed limit. From the perspective of a pedestrian, the intersection is extremely wide (100 ft across). The northbound side of the road is bisected by the entrance of an apartment complex. Traveling north, approximately 400 ft on the same side of the road, is a bus stop. On the Southbound side of the road, there is a bus stop approximately 600 ft away. To facilitate and promote safe crossing at this intersection as well as provide efficient platooning of vehicles, the team proposes a signalized intersection at Swineford and Jefferson Davis Highway.

Figure 10) Google street view of the proposed intersection

In order to validate a signalized intersection as planned at Swineford and Jefferson Davis Highway, the team completed a traffic signal warrant. Due to covid restrictions, the team relied heavily on GIS data as provided by VDOT as well as a prior site visit. A compilation of engineering study data can be found in table 1 below (Table 2).

	North Bound	South Bound	Swineford
Average Daily Traffic [1]	21000	21000	960
Vehicle Type [1]	4 Tire: 96.07 Bus: 0.822 Truck: 3.101	4 Tire: 96.07 Bus: 0.822 Truck: 3.101	N/A
Pedestrian Crash data [2]	1 ped	N/A	1 ped
Nearby Facilities	Apartment complex	Dollar general	Recreation center, religious centers
Speed Limit [2]	45 mph	45 mph	25 mph

Table 2) Engineering Study Data collected using GIS due to Covid Restrictions

1: It is estimated by dividing the total daily volumes during a specified time period by the number of days in the period ("Traffic")
2: Matt.Franklin@timmons.com_Timmons_Group (ArcGIS)

Using the information found in Table 2, the warrants provided by MUTCD were followed to identify if warrants were satisfied or not. Language is taken directly from the MUTCD, followed by justification for each Warrant either written or using a provided graphic. For ease of understanding, the students have placed key relevant words in bold.

Warrant 1: Eight-Hour Vehicular Volume

The Interruption of Continuous Traffic, ***Condition B,*** *is intended for application at locations where Condition A is not satisfied and where the traffic volume on a major street is so heavy that traffic on a minor intersecting street suffers excessive delay or conflict in entering or crossing the major street* ("Part 4").

It was concluded that Condition A was not met, because a large volume of intersecting traffic was not the principal reason for installing a traffic signal. Rather, Condition B, the Volume on a major street impeding the movement onto or from minor road was the intended argument.

If it is ***not reasonable or feasible*** *to count actual traffic volumes, such as at a proposed intersection in the preliminary engineering phase and therefore not yet open to traffic, ADT* *projections may be utilized to satisfy Warrant 1. The **ADT** values are shown in Table 4C-V1* ("Part 4").

Because the team could not travel to and from the site in order to count traffic data, ADT values from VDOT were employed.

*If the posted or statutory speed limit or the 85th-percentile speed on the major street exceeds **40 mph**, or if the intersection lies within the built-up area of an isolated community having a population of less than 10,000, **the traffic volumes in the 70 percent columns in Table 4C-V1 in this Supplement may be used in place of the 100 percent columns*** ("Part 4").

Because the Major Street Exceeded 40 mph the traffic volumes in the 70% column were used in place of the 100% columns.

Table 4C-V1. Traffic Signal Warrant Using Average Daily Traffic Estimate

(To be used only when traffic counts are not available, such as at a future intersection)

Condition A—Minimum Vehicular Volume

Number of lanes for moving traffic on each approach		Vehicles per day on major street (total of both approaches)				Vehicles per day on higher-volume minor-street approach (one direction only)			
Major Street	Minor Street	100%[a]	80%[b]	70%[c]	56%[d]	100%[a]	80%[b]	70%[c]	56%[d]
1	1	8,000	6,400	5,600	4,480	2,400	1,920	1,680	1,344
2 or more	1	9,600	7,680	6,720	5,376	2,400	1,920	1,680	1,344
2 or more	2 or more	9,600	7,680	6,720	5,376	3,200	2,560	2,240	1,792
1	2 or more	8,000	6,400	5,600	4,480	3,200	2,560	2,240	1,792

Condition B—Interruption of Continuous Traffic

Number of lanes for moving traffic on each approach		Vehicles per day on major street (total of both approaches)				Vehicles per day on higher-volume minor-street approach (one direction only)			
Major Street	Minor Street	100%[a]	80%[b]	70%[c]	56%[d]	100%[a]	80%[b]	70%[c]	56%[d]
1	1	12,000	9,600	8,400	6,720	1,200	960	850	680
2 or more	1	14,400	11,520	10,080	8,064	1,200	960	850	680
2 or more	2 or more	14,400	11,520	10,080	8,064	1,600	1,280	1,120	896
1	2 or more	12,000	9,600	8,400	6,720	1,600	1,280	1,120	896

[a] Basic minimum hourly volume for urban areas
[b] Used for combination of Conditions A and B after adequate consideration of other remedial measures in urban areas
[c] May be used when the major-street speed exceeds 40 mph or in an isolated community with a population of less than 10,000
[d] May be used for combination of Conditions A and B after adequate consideration of other remedial measures when the major-street speed exceeds 40 mph or in an isolated community with a population of less than 10,000

The ADT of Jefferson Davis Highway is *21000 veh/day* which is greater than the *10,080 veh/day* shown in the graphic for Condition B on the major road. *960 veh/day* is also greater than

850 veh/day shown in the graphic for minor streets. So It was concluded that warrant 1 was satisfied.

Warrant 1 = Satisfied

Warrant 2: Four-Hour Vehicular Volume

Due to covid the restrictions, the team was unable to collect hour vehicular volume. As shown prior, there was an alternative to use Average Daily traffic. However, for Warrant two, no alternative is present. In order to finish the traffic signal warrant, the team will calculate the average hourly traffic from the average daily traffic for the purpose of this study (Equations 1 & 2).

$$21000\ \frac{VEH}{DAY} = \frac{1\ DAY}{24\ HOURS} = 875\ veh/hour$$ North and Southbound ……………………Equation 1

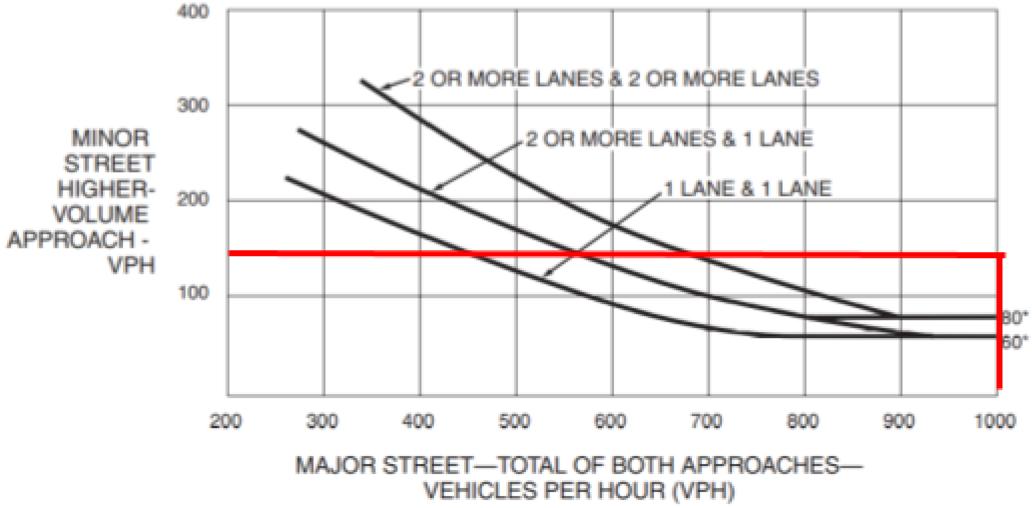
$$960\ \frac{VEH}{DAY} = \frac{1\ DAY}{24\ HOURS} = 40\ veh\ /\ hour$$ Swineford……………………………………Equation 2

The Four-Hour Vehicular Volume signal warrant conditions are intended to be applied where the volume of intersecting traffic is the principal reason to consider installing a traffic control signal (MUTCD).

If the posted or statutory speed limit or the 85th-percentile speed on the major street exceeds 40 mph, or if the intersection lies within the built-up area of an isolated community having a population of less than 10,000, Figure 4C-2 may be used in place of Figure 4C-1 (MUTCD).

Figure 4C-2. Warrant 2, Four-Hour Vehicular Volume (70% Factor)

(COMMUNITY LESS THAN 10,000 POPULATION OR ABOVE 40 MPH ON MAJOR STREET)



*Note: 80 vph applies as the lower threshold volume for a minor-street approach with two or more lanes and 60 vph applies as the lower threshold volume for a minor-street approach with one lane.

The need for a traffic control signal shall be considered if an engineering study finds that, for each of any 4 hours of an average day, the plotted points representing the vehicles per hour on the major street (total of both approaches) and the corresponding vehicles per hour on the higher-volume minor-street approach (one direction only) all fall above the applicable curve in Figure 4C-1 for the existing combination of approach lanes. On the minor street, the higher volume shall not be required to be on the same approach during each of these 4 hours (MUTCD).

As illustrated in figure 4C-2, for any 4-hour average plotted, the line falls above the applicable curve of 2 or more lanes, meaning warrant 2 is satisfied.

WARRANT 2 = Satisfied

Warrant 3 Peak Hour

The Peak Hour signal warrant is intended for use at a location where traffic conditions are such that for a minimum of 1 hour of an average day, the minor-street traffic suffers undue delay when entering or crossing the major street (MUTCD).

The team did not have the required data to perform this warrant. Another site visit would need to be conducted. The team had to then label this warrant as inconclusive.

INSUFFICIENT DATA

Warrant 4 Pedestrian Volume

The Pedestrian Volume signal warrant is intended for application where the traffic volume on a major street is so heavy that pedestrians experience an excessive delay in crossing the major street (MUTCD).

The team did not have the required data to perform this warrant. Another site visit would need to be conducted

INSUFFICIENT DATA

Warrant 5 School Crossing

The School Crossing signal warrant is intended for application where the fact that schoolchildren cross the major street is the principal reason to consider installing a traffic control signal. For the purposes of this warrant, the word "school children" includes elementary through high school students (MUTCD).

Warrant 5 = not satisfied

Warrant 6 coordinated signal system

Progressive movement in a coordinated signal system sometimes necessitates installing traffic control signals at intersections where they would not otherwise be needed to maintain proper platooning of vehicles (MUTCD).

On a two-way street, adjacent traffic control signals do not provide the necessary degree of platooning, and the proposed and adjacent traffic control signals will collectively provide a progressive operation (MUTCD).

From a site visit conducted on October 19, 2020, the team found that making a left or right-hand turn from Swineford onto either Jefferson Davis highway north or south took a considerable amount of time. Prior to Swineford, traveling north, the nearest signalized intersection was found to be approximately 1600 feet at Dundas and Jefferson Davis Highway. Due to the long wait time experienced, we propose that another signal is needed to maintain proper platooning.

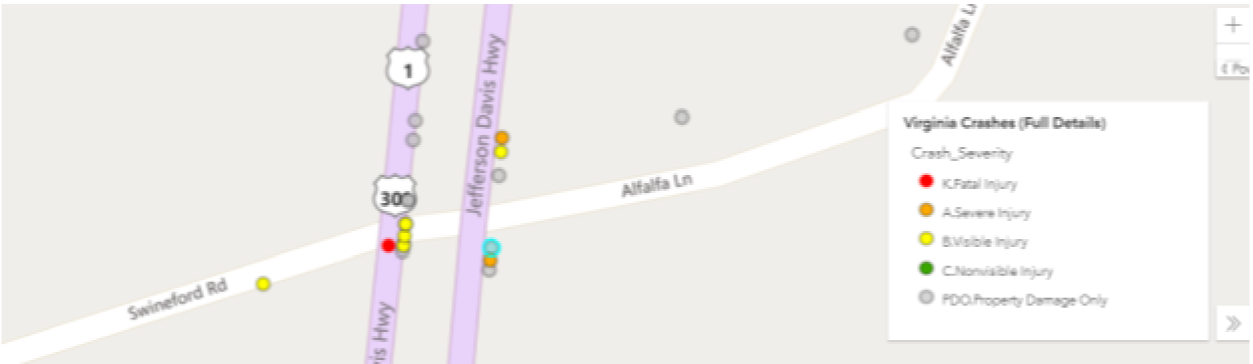
Warrant 6 = Satisfied

Warrant 7 Crash Experience

Part A of warrant 7 reads *Adequate trial of alternatives with satisfactory observance and enforcement has failed to reduce the crash frequency (MUTCD)*

The team does not have historic data regarding changes made to this intersection. The team notes that the current stop sign in use at the minor road, Swineford, is not sufficient given the crashes illustrated in section B shown below.

B. Five or more reported crashes, of types susceptible to correction by a traffic control signal, have occurred within a 12-month period, each crash involving personal injury or property damage apparently exceeding the applicable requirements for a reportable crash



Although there is evidence of several crashes in the area, these crashes did not happen within a 12-month period. And so, warrant 7 was unsatisfied

WARRANT 7 = Not satisfied

Warrant 8 Roadway Network

Installing a traffic control signal at some intersections might be justified to encourage concentration and organization of traffic flow on a roadway network (MUTCD).

The need for a traffic control signal shall be considered if an engineering study finds that the common intersection of two or more major routes ***meets one or both*** *of the following criteria:*

- *The intersection has a total existing, or immediately projected, entering volume of at least 1,000 vehicles per hour during the peak hour of a typical weekday and has 5-year projected traffic volumes, based on an engineering study, that meet one or more of Warrants 1, 2, and 3 during an average weekday* ✅

A major route as used in this signal warrant shall have at least one of the following characteristics:

- *A. It is part of the street or highway system that serves as the principal roadway network for through traffic flow.* ✅
- *C. It appears as a major route on an official plan, such as a major street plan in an urban area traffic and transportation study.* ✅

WARRANT 8 = Satisfied

Warrant 9 Intersection Near A Grade Crossing

The Intersection Near a Grade Crossing signal warrant is intended for use at a location where none of the conditions described in the other eight traffic signal warrants are met, but the proximity to the intersection of a grade crossing on an intersection approach controlled by a STOP or YIELD sign is the principal reason to consider installing a traffic control signal (MUTCD).

WARRANT 9 = Not satisfied

Crossing at Marina Drive.

Students were not made aware of the requirement to cross route one at Marian drive. From our first meeting with Timmons the team was informed that the project ended at Mariana drive as we previously thought it stopped at Dundas. This document both shows the connection as well as proposed ideas for crossing. During the February meeting, the lack of data in terms of pedestrian crossing rates was discussed. The team is waiting to receive more information to justify a HAWK crossing signal. The team was also told they were on the right track, that it was a HAWK signal needed rather than a signalized intersection given redundancy. Given this feedback, the team is confident that they are on schedule despite the delay of this information.

Marina Drive Connection/Crossing

The team plans to extend the proposed sidewalk to join the pre-existing sidewalk at Marina Drive. The sidewalk located at Marina matches the ideal dimensions proposed by the team. In more detail, there is a 5ft sidewalk, 4 ft grass buffer, and 2.5 ft curb (Figure 11).

Figure 11) pre-existing sidewalk at Marina Drive

The team was tasked with providing pedestrian infrastructure for safe crossing at the intersection of Marina Drive and Jefferson Davis Highway. Currently, the intersection consists of several stop signs, including stop signs in the median (Figure 12). While the team considered adding traffic signals, it was concluded that it could not be justified given the signalized intersection of Dundas a mer *500 ft away*. There would be a period where traffic traveling northbound would be stopped, but not traffic traveling southbound.

Figure 12) Stop sign intersection at Marian Drive and Jefferson Davis Highway.

So, when Justifying the implementation of a crosswalk, the team used both engineering judgment as well as the Traffic Engineering Division Instructional and Informational Memorandum. The approach, traveling both north and south on Jefferson Davis Highway is uncontrolled. This means there is currently no signalization or yielding before the proposed location of the crossing. Table 2 indicated whether the addition of a crosswalk was possible and to what extent additional safety features were required (Figure 13). Jefferson Davis Highway has a speed of 45 mph as well as an ADT of approximately 21000 for both the north and southbound direction (Traffic Volume). The "roadway configuration" can be considered 6 lanes Given these credentials, the needed pedestrian improvement falls into category D (Figure 14). As students anticipated, more safety precautions outside of a marked crossing are necessary.

Table 2. Recommendations for Considering Marked Crosswalks and Other Needed Pedestrian Improvements Across Uncontrolled Approaches

Roadway Configuration	Roadway ADT and Speed Limit: 1,500 to 9,000 VPD				9,000 to 12,000 VPD				12,000 to 15,000 VPD				More than 15,000 VPD			
	≤ 30 MPH	35 MPH	40 MPH	≥ 45 MPH	≤ 30 MPH	35 MPH	40 MPH	≥ 45 MPH	≤ 30 MPH	35 MPH	40 MPH	≥ 45 MPH	≤ 30 MPH	35 MPH	40 MPH	≥ 45 MPH
2 Lanes (undivided two-way street or two-lane one-way street)	A	A	B	B	A	A	B	B	A	A	B	B	B	B	B	C
3 Lanes with refuge island OR 2 Lanes with raised median*	A	A	B	B	A	B	B	B	A	A	B	B	B	B	B	C
3 Lanes (center turn lane)	A	A	B	B	A	B	B	B	A	B	B	C	B	C	C	C
4 Lanes (two-way street with no median)	A	B	C	C	B	B	C	C	B	C	C	D	C	C	C	D
5 Lanes with refuge island OR 4 lanes with raised median*	A	A	B	B	A	B	B	C	B	B	C	C	B	B	C	D
5 Lanes (center turn lane)	A	B	C	C	B	B	C	C	C	C	C	D	C	C	C	D
6 Lanes (two-way street with* or without median)	A	B	D	D	B	B	D	D	D	D	D	D	D	D	D	D

Source: Guidance for Installation of Pedestrian Crosswalks on Michigan State Trunkline Highways (Michigan Department of Transportation, 2014)

Figure 13) Crosswalk justification

Condition D	**Marked crosswalks shall not be installed**

Figure 14) Crosswalk category

Because the speed limit to cross is too high for a safe crossing, the team considered the following options to slow traffic: Raised crossing, Speed Treatments, Pedestrian Islands. To stop Traffic Completely, the team then began considering using either Flashing Beacons or a Pedestrian Hybrid Beacon. Flashing Beacons or rectangular rapid flashing beacons (RRFBs) provide an enhanced warning for Vehicles. Because there are 6 lanes to cross (2 through lanes and 1 turn both north and southbound) the system would have to be much like that shown in figure 15. Specifically, there would need to be some sort of pedestrian island (Figure 15). Given the large preexisting median, the team feels as though the incorporation of this would be viable.

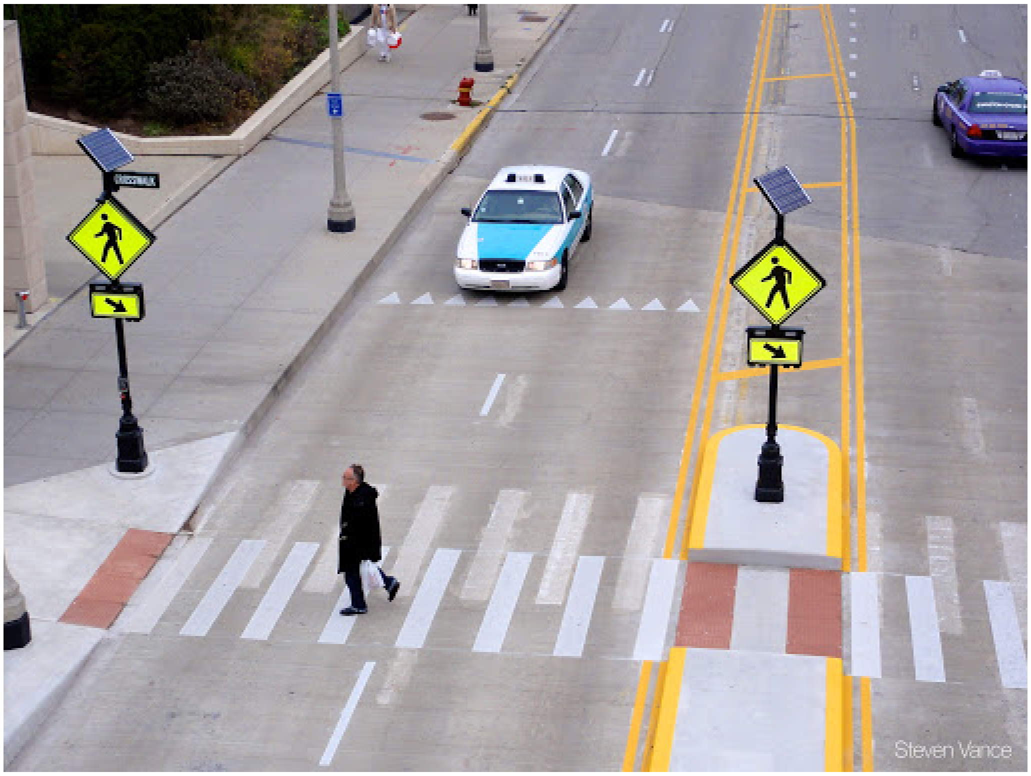


Figure 15) Flashing Beacon (Federal Highway Administration)

The Pedestrian Hybrid Beacon or High-Intensity Activated Crosswalk (HAWK) is a more advanced version of the flashing beacon (Figure 16). While implementing a HAWK is more expensive and requires more maintenance, it is less expensive than the traditional traffic signal (Bushell, M. A., et al.). A HAWK is only activated when it is needed by pedestrians. Much like the flashing beacon, due to the wide median, a pedestrian island would be provided.

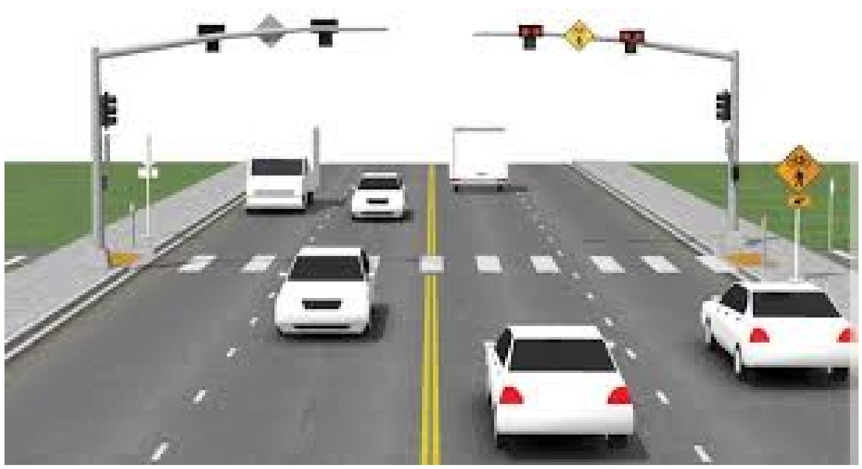


Figure 16) Pedestrian Hybrid Beacon

Chapter 4F of the Manual on uniform traffic control devices (MUTCD) contains provisions on the implementation of Pedestrian Hybrid Beacons. By such standard, the team would need to include signs and pavement markings in the design. Jefferson Davis Highway would be considered a high-speed road by MUTCD. With Pedestrian crossing data provided by Timmons Group, the team found that the Pedestrian Volume was never close to the required 20 pedestrians per hour (Appendix 3). Ultimately the PHB would be considered over design for the pedestrian crossing volume in this area.

After Ruling out PHB, the team decided that the best option would be RRFBs. It is explicitly stated within the traffic Engineering Division Instructional and Informational Memorandum, that RRFBs are an appropriate additional crossing treatment for scenarios that fall within Category D.

Using MUTCD, students were able to further justify the use of RRFBs using figure 17. Note that the blue line and circle correspond to “RRFB lower threshold.”

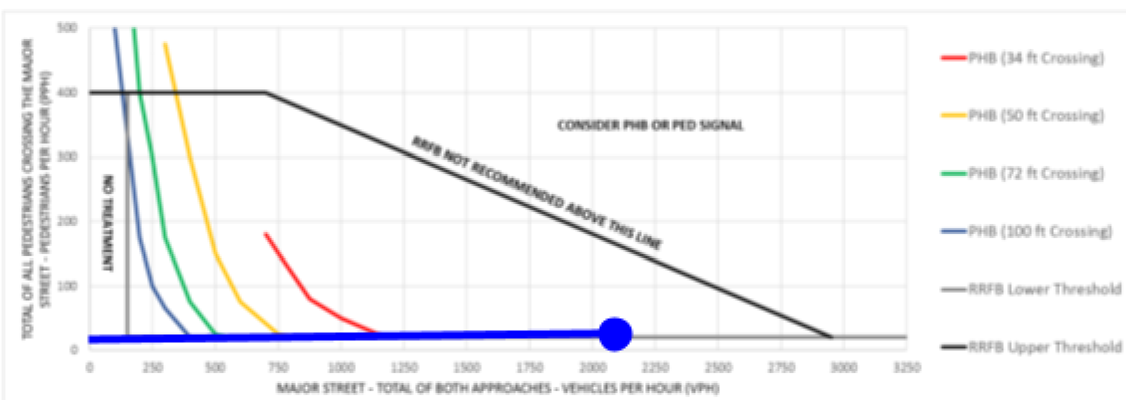


FIGURE 2 – Installation of RRFBs and PHBs on High Speed Roadways (> 35 mph)

Source: 2009 MUTCD, Section 4F and Pedestrian Crossing Treatment Installation Guidelines, City of Boulder

Figure 17) RRFB Justification

Water analysis

Prior to the meeting the team also sent Timmons a very rough draft regarding the understanding of water analysis (Figure 21). The team anticipated needing more help with this section given the addition of curb and gutter. The meeting clarified the key direction of water, by emphasizing two outfalls. The team will further evaluate contours and how water might fall given survey data. It is likely that a structure will need to cross route 1 to direct water from storm water drains. Calculations such as “spread calc" will be done in accordance with VDOT manuals to ensure inlets are spread accordingly. The team will investigate the use of filters as a form of stormwater management.

Currently, there is no stormwater management piping along Jefferson Davis Highway (northbound), instead, there are stormwater easements, ditches, culverts, and swales (Figure 18 & 19). These ditches however are ineffective due to pedestrian traffic which causes debris as well as physical changes. The team notes that the ditches also make foot traffic in these areas unsafe.

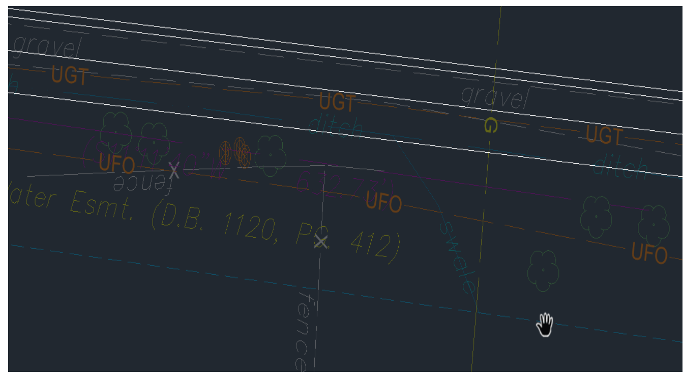


Figure 18 (left), shows an image from google earth depicting a culvert, while Figure 19 (right) shows the ditch, swale combination used to divert water away from the road.

Grate Inlets corresponding to sewer lines shown on CAD led students to believe that water from the northbound side of the road needed to someone makes it here (figure 20). This leads to an issue when it comes to redirecting water that is currently flowing in a ditch to a channelized flow in a pipe.

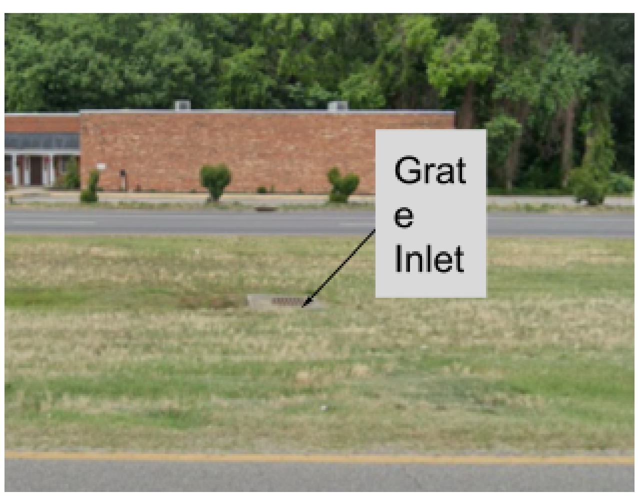


Figure 20) One of many grate inlets located Within the median of Jefferson Davis Highway.

Using Survey Data, the team noted two outfalls, located within the median. Visuals of these outfalls can be seen in figure 21. The team would have to cross Jefferson Davis Highway with a pipe in order to connect the desired stormwater system to these outfalls. The team was provided with topographic data, however, due to technical difficulties, GIS was employed to

determine the movement of water during a rain event.

Figure 21) Outfalls as proposed by Timmons Group

Figure 22 (left) and figure 23 (right) illustrate the swales found on the site.

From this analysis, it was determined that much of the water on site was running northbound. Still, between Swineford and Merriewood there is a swale; already addressed by an outfall in the survey data. So, we propose inserting a pipe to connect with an inlet prior to the Swineford intersection.

Conclusion

The main goal for the civil engineers was to produce a solution possible of being executed today. The addition of pedestrian infrastructure in the form of a 5ft sidewalk, 4ft grass buffer, and 2.5ft curb and gutter greatly improves connectivity within the area. The addition of crosswalks at the planned signalized intersection at Swineford Road as well as flashing beacons intended to cross Marina Drive enhances pedestrian safety. Working with Timmons Group, the team ensured plans were justified using a traffic signal warrant, right of way calculation, as well as water analysis. Software such as CAD and Bluebeam proved effective for presenting our work. In addition to this document, plan sheets were developed to further visualize our project. Those plan sheets are attached to this report as a separate document.

Appendix 1

Sample of schedule made with project libre

	Name	Duration	Start	Finish	Predecessors
1	**⊟Fall semester**	61 days	**9/1/20 8:00 AM**	**11/24/20 5:00 PM**	
2	Research	44 days	9/1/20 8:00 AM	10/30/20 5:00 PM	
3	Determination of Goals	22 days	10/1/20 8:00 AM	10/30/20 5:00 PM	
4	Meeting and Coordination	39 days	10/1/20 8:00 AM	11/24/20 5:00 PM	
5	Site Visit	5 days	10/19/20 8:00 AM	10/23/20 5:00 PM	
6	Concept Design	6 days	10/30/20 8:00 AM	11/6/20 5:00 PM	5
7	Schematic Desgin	12 days	11/9/20 8:00 AM	11/24/20 5:00 PM	6
8	**⊟Spring Semester**	72 days	**2/1/21 8:00 AM**	**5/11/21 5:00 PM**	
9	Meetins and coordination	65 days	2/1/21 8:00 AM	4/30/21 5:00 PM	
10	Right of Way Data Sheet	10 days	2/1/21 8:00 AM	2/12/21 5:00 PM	
11	Signal Plans	20 days	3/2/21 8:00 AM	3/29/21 5:00 PM	
12	site plans	30 days	3/31/21 8:00 AM	5/11/21 5:00 PM	
13	Title Sheet	7 days	4/7/21 8:00 AM	4/15/21 5:00 PM	
14	Location on Map	7 days	4/21/21 8:00 AM	4/29/21 5:00 PM	
15	Index on Sheets	2 days	4/30/21 8:00 AM	5/3/21 5:00 PM	

Appendix 2

Progress Report 02/15

Where we left off

The team finished last semester by submitting a CAD design, traffic signal warrant, and price estimate to Timmons group. We received feedback from Timmons Group during winter break (December).

Direct feedback from Timmons is shown in blue. How we plan to address each point is described as follows.

Feedback

This submission, as with subsequent work, would benefit greatly from a narrative explanation of the design and improvements being proposed. It is generally a good idea to outline the rationale behind the location, geometry, alignment, etc. shown in your design.

The team will use the end of year report submitted for last semester's course as a narrative to explain work. Our submission to Timmons consisted of the CAD file, cost estimate and traffic signal warrant. This report will provide the Timmons group with substantial rationale behind the location geometry and alignment.

Add annotation to your drawing: dimensioning, labeling, callouts, etc.

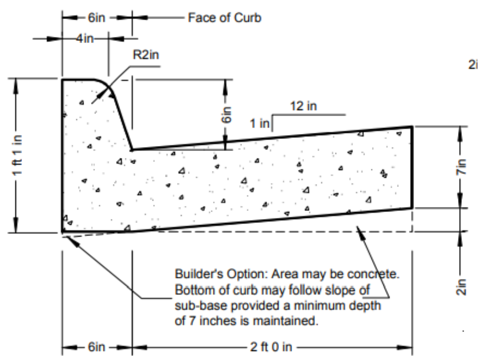
Dimensions, labeling and callouts will be added to the current CAD drawing and ultimately plotted with the “correct” labeling as provided by Timmons’ Group standards.

Early submittals (often done as exhibits) often have aerial imagery shown in the background to provide a pictorial representation of the existing conditions. Just something to consider

The team will insure to include aerial images from google Earth with the next submission in exhibits specifically. The team will be sure to provide exhibits with future submissions to give more detail in more more intricate areas of the site.

It appears that curb has been specified on the eastern side of US Route 1. Please justify the use of curb.

> *Have you considered the drainage impacts of adding curb? Water will be concentrated and there may be storm inlets required. The approach of adding curb and/or curb and gutter is fine…we just want to make sure the ramifications have been considered.*
> *Typically curb and gutter is specified in this situation, not just curb*
> *The curb as drawn appears to be 1' wide (VDOT curb and gutter is 2.5' wide)*
> *There are multiple types of curb & gutter (or curb) depending on the design speed of the road*



Curb and Gutter detail provided by [Microsoft Word - RDM_AppnB_drfcvr.doc (virginia.gov)]

The team was not aware of the required curb dimension. Inorder to address this, research was done to consider which VDOT style curb needed to be used. According to the VDOT Road Design Manual appendix B (B-19), "CG-6 may be used in urban and suburban settings on streets having a design speed not greater than 45 mph." The speed limit on Jefferson Davis Highway is 45 mph so CG-6 may be used in our design. In regard to how this affects our design, the curb & gutter will need to be expanded in CAD to 2.5 ft rather than the 1 ft it is at currently. This may affect right of way cost but not extensively. It is believed that the curb adds more security for pedestrians. The impact of water and utilities will be addressed in the coming weeks.

Please justify the use of sidewalk (5') vs. shared-use path (8-10')

> *Has the team considered cost of each?*

The main reason for choosing a sidewalk vs a shared use path was the space available to be used in design and construction. To prevent drive lanes from becoming too narrow, the team must be conservative with designs that would take up larger areas of space. Because of this, the team did not even dive into the cost comparison between the two types of paths.

Has the team considered the type of road user (pedestrian vs. cyclist)? The project is currently designed for pedestrians, only.

While students first considered a sidewalk due to the amount of pedestrians in comparison to cyclists, this offset could have been due to the lack of safety for cyclists. That being said, the team also chose a sidewalk due to the small amount of space within the right of way. In the preliminary design, students attempted to place a slight curvature in the road to allow for more space. This however proved to be too complicated, as it made more sense to purchase right of way.

Please justify the terminus of the project at the northern end: how will pedestrians reach their final destination?

The project should be designed to convey pedestrians to the northwest corner of US Route 1 and Dundas Road (there are existing handicap ramps at each corner on the west side of US Route 1)

Has the team considered crossings of US Route 1 at any point along the corridor (at Swineford, at the proposed signal)? Why or why not?

The team does plan to introduce a crossing point at jefferson davis Highway and swineford road. The justification is that this crossing point is nearest to the apartment complex which the team observed the most pedestrians. Not far from this crossing point is also two bus stations on either side of the road.

Has the team considered impacts to existing utilities?

Utilities and water is where the team will be next shifting their focus in the coming weeks.

Has the team looked at the overall existing drainage facilities/patterns and considered what improvements, if any, may be necessary?

Utilities and water is where the team will be next shifting their focus in the coming weeks.

How will the medians be modified at Swineford and Dundas be modified with the proposed signals / modifications?

There is already a signal at Dundas, so the median here will not need to be modified.

Remember that improvements must extend to Marina Drive, not Dundas. Pedestrians and/or cyclists must be able to cross from the east to the west side of US Route 1 at Marina Drive. How would you recommend that this crossing occur? With what signal or other apparatus?
CAD: all linework is drafted on the same layer. Please draft improvements on proper National CAD Standard layers.

The fact that pedestrians and cyclists must be able to cross at Marina Dr. was news to the team in these comments. The team will work to make adjustments and add a crossing. From preliminary first discussions, the team has discussed a cross walk as well as a possible signal system. Over the next few weeks the team will meet again to discuss more options and add them to the CAD drawn design.
The team will also work to make adjustments so that all drawings meet National CAD standards.

Appendix 3

Pedestrian counts for Marina Drive

Peggy Malone & Associates, Inc.
(888) 247-8602

NOTE: 20 SB Left U-Turns AM
38 SB Left U-Turns PM

File Name : 1_US 1 & Marina Drive_Apt Complex AM
Site Code :
Start Date : 10/13/2020
Page No : 1

Groups Printed- Cars

	US 1 Southbound					Marina Dr Westbound					US 1 Northbound					Apt Ent/Exit Eastbound					
Start Time	Right	Thru	Left	Peds	App. Total	Right	Thru	Left	Peds	App. Total	Right	Thru	Left	Peds	App. Total	Right	Thru	Left	Peds	App. Total	Int. Total
07:00 AM	0	139	10	0	149	0	0	5	0	5	1	160	1	0	162	1	0	2	1	4	320
07:15 AM	1	154	7	0	162	9	1	9	0	19	1	199	0	0	200	0	0	2	0	2	383
07:30 AM	2	114	10	0	126	3	0	8	0	11	0	242	2	0	244	2	0	3	0	5	386
07:45 AM	1	176	5	1	183	3	0	1	0	4	4	201	0	0	205	0	1	3	0	4	396
Total	4	583	32	1	620	15	1	23	0	39	6	802	3	0	811	3	1	10	1	15	1485
08:00 AM	1	154	5	0	160	2	0	3	0	5	2	144	1	1	148	1	0	3	0	4	317
08:15 AM	1	108	4	1	114	2	0	3	0	5	2	146	0	0	148	0	0	1	0	1	268
08:30 AM	0	110	4	0	114	1	0	6	0	7	0	131	0	1	132	0	0	3	0	3	256
08:45 AM	2	123	5	0	130	3	0	6	0	9	2	138	0	1	141	3	0	0	0	3	283
Total	4	495	18	1	518	8	0	18	0	26	6	559	1	3	569	4	0	7	0	11	1124
Grand Total	8	1078	50	2	1138	23	1	41	0	65	12	1361	4	3	1380	7	1	17	1	26	2609
Apprch %	0.7	94.7	4.4	0.2		35.4	1.5	63.1	0		0.9	98.6	0.3	0.2		26.9	3.8	65.4	3.8		
Total %	0.3	41.3	1.9	0.1	43.6	0.9	0	1.6	0	2.5	0.5	52.2	0.2	0.1	52.9	0.3	0	0.7	0	1	

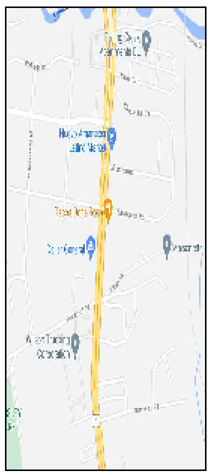
	US 1 Southbound				Marina Dr Westbound				US 1 Northbound				Apt Ent/Exit Eastbound				
Start Time	Right	Thru	Left	App. Total	Right	Thru	Left	App. Total	Right	Thru	Left	App. Total	Right	Thru	Left	App. Total	Int. Total
Peak Hour Analysis From 07:00 AM to 08:45 AM - Peak 1 of 1																	
Peak Hour for Entire Intersection Begins at 07:00 AM																	
07:00 AM	0	139	**10**	149	0	0	5	5	1	160	1	162	1	0	2	3	319
07:15 AM	1	154	7	162	**9**	**1**	**9**	**19**	1	199	0	200	0	0	2	2	383
07:30 AM	**2**	114	10	126	3	0	8	11	0	**242**	**2**	**244**	**2**	0	**3**	**5**	386
07:45 AM	1	**176**	5	**182**	3	0	1	4	**4**	201	0	205	0	**1**	3	4	**395**
Total Volume	4	583	32	619	15	1	23	39	6	802	3	811	3	1	10	14	1483
% App. Total	0.6	94.2	5.2		38.5	2.6	59		0.7	98.9	0.4		21.4	7.1	71.4		
PHF	.500	.828	.800	.850	.417	.250	.639	.513	.375	.829	.375	.831	.375	.250	.833	.700	.939

Appendix 4

Plan Sheets drawn in Civil3D

####

JEFFERSON DAVIS HIGHWAY
IMPROVING PEDESTRIAN SAFETY
UNIVERSITY OF VIRGINIA
CAPSTONE



AIMEE BARNES AND HANNA CUSTARD

Organization Name

LEGEND

KEY MAP

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FILE NAME	
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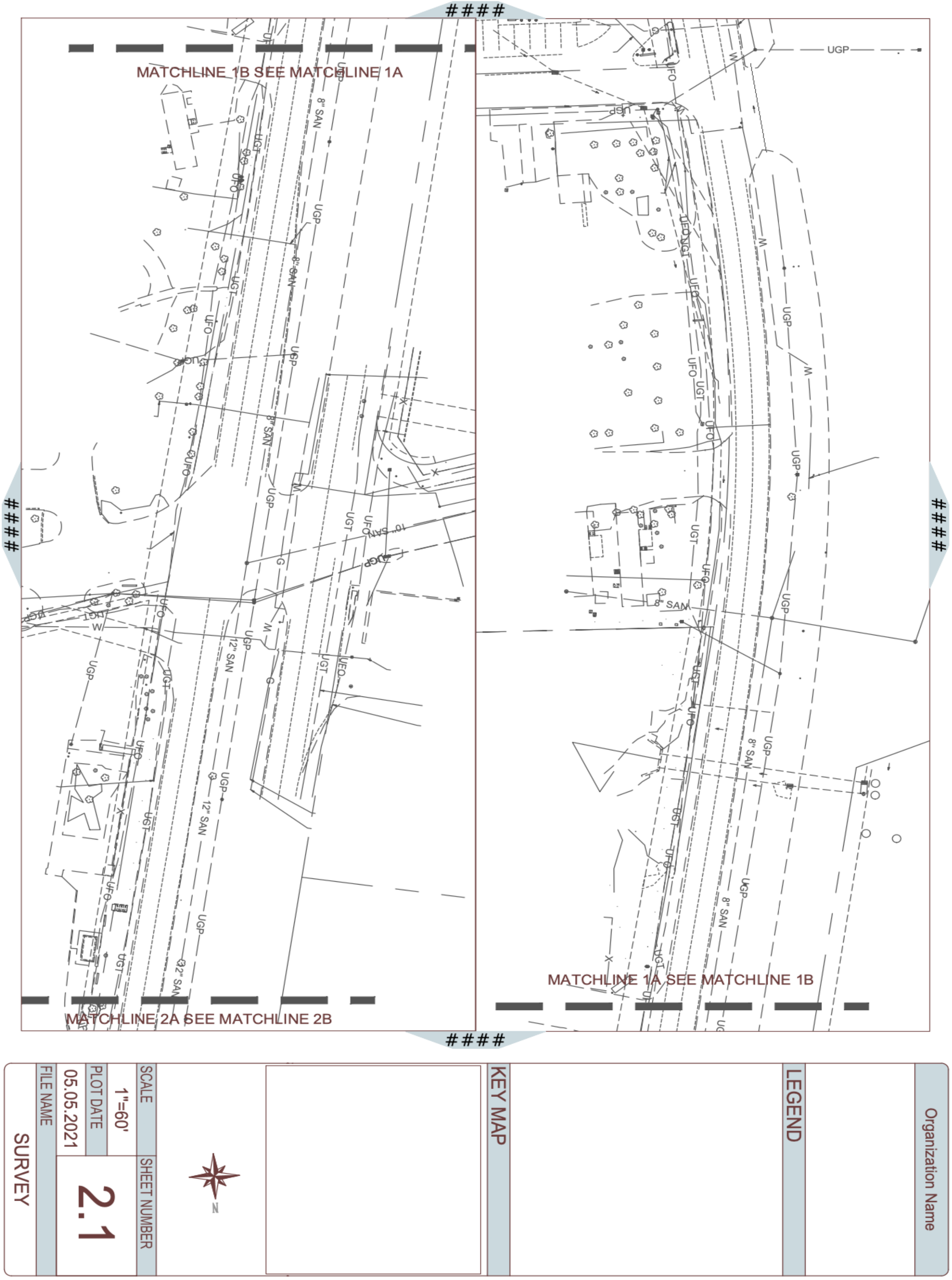
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MATCHLINE 1B SEE MATCHLINE 1A
MATCHLINE 1A SEE MATCHLINE 1B
MATCHLINE 2A SEE MATCHLINE 2B
UGP
UFO
UGT
8" SAN
10" SAN
12" SAN
W
G
KEY MAP
LEGEND
Organization Name
SCALE
1"=60'
PLOT DATE
05.05.2021
FILE NAME
SURVEY
SHEET NUMBER
2.1
N

PRODUCED BY AN AUTODESK STUDENT VERSION

PRODUCED BY AN AUTODESK STUDENT VERSION

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FILE NAME	SURVEY
SHEET NUMBER	2.2

KEY MAP

LEGEND

Organization Name

PRODUCED BY AN AUTODESK STUDENT VERSION

####

####

PRODUCED BY AN AUTODESK STUDENT VERSION

####

PRODUCED BY AN AUTODESK STUDENT VERSION

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Organization Name

LEGEND

KEY MAP

SCALE

1"=60'

PLOT DATE

05.05.2021

FILE NAME

SURVEY

SHEET NUMBER

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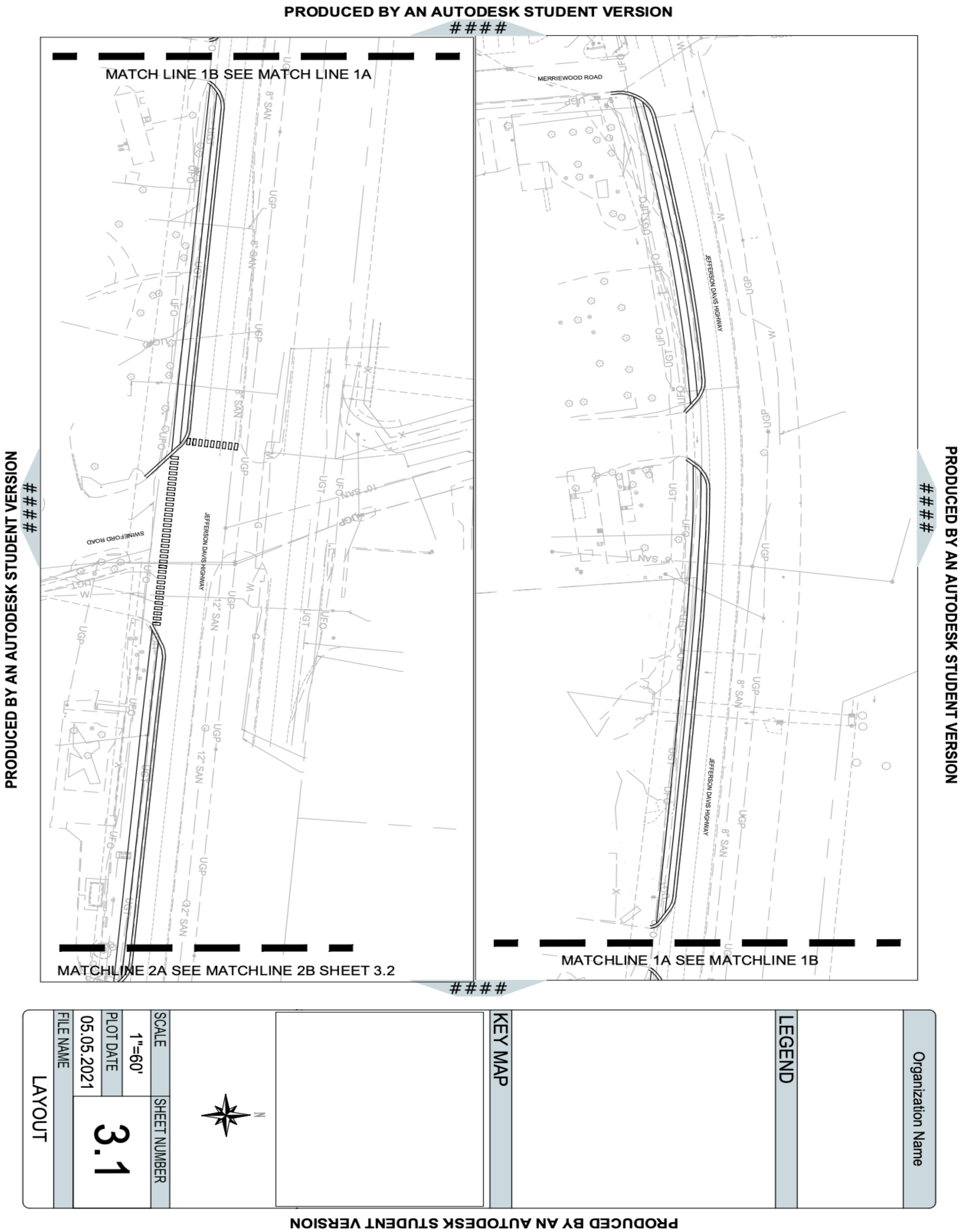
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MATCH LINE 1B SEE MATCH LINE 1A
MERRIEWOOD ROAD
JEFFERSON DAVIS HIGHWAY
SWINEFORD ROAD
MATCHLINE 2A SEE MATCHLINE 2B SHEET 3.2
MATCHLINE 1A SEE MATCHLINE 1B
SCALE
1"=60'
PLOT DATE
05.05.2021
FILE NAME
LAYOUT
SHEET NUMBER
3.1
KEY MAP
LEGEND
Organization Name


PRODUCED BY AN AUTODESK STUDENT VERSION
MATCHLINE 3B SEE MATCHLINE 3A
MATCHLINE 2B SEE MATCHLINE 2A
ABERDEEN ROAD
JEFFERSON DAVIS HIGHWAY
SHERBOURNE ROAD
MATCHLINE 4A SEE MATCHLINE 4B SHEET 3.3
MATCHLINE 3A SEE MATCHLINE 3B
12" SAN
UGP
UFO
SCALE
1"=60'
PLOT DATE
05.05.2021
FILE NAME
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3.2
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LEGEND
Organization Name

####

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Organization Name

LEGEND

KEY MAP

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FILE NAME
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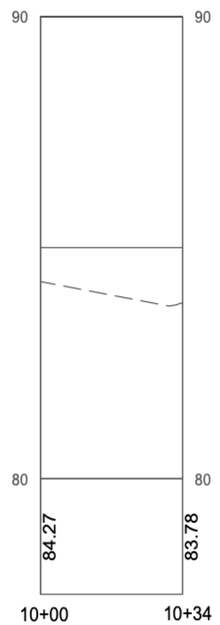
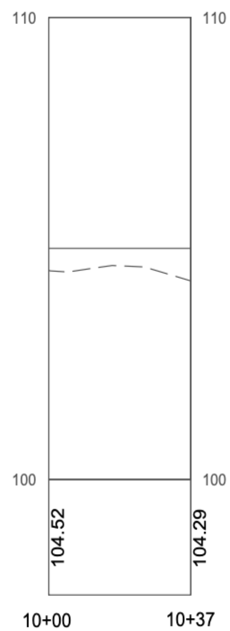
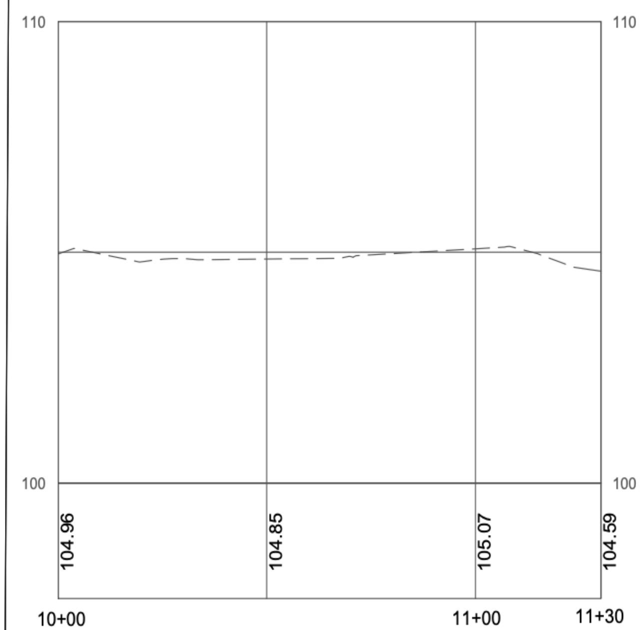


DUNDAS ROAD CROSSWALK



SWINEFORD ROAD CROSSWALK



SWINEFORD ROAD CROSSWALK ALONG JEFFERSON DAVIS HIGHWAY

Organization Name	
LEGEND	
KEY MAP	
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FILE NAME	
PROFILES	

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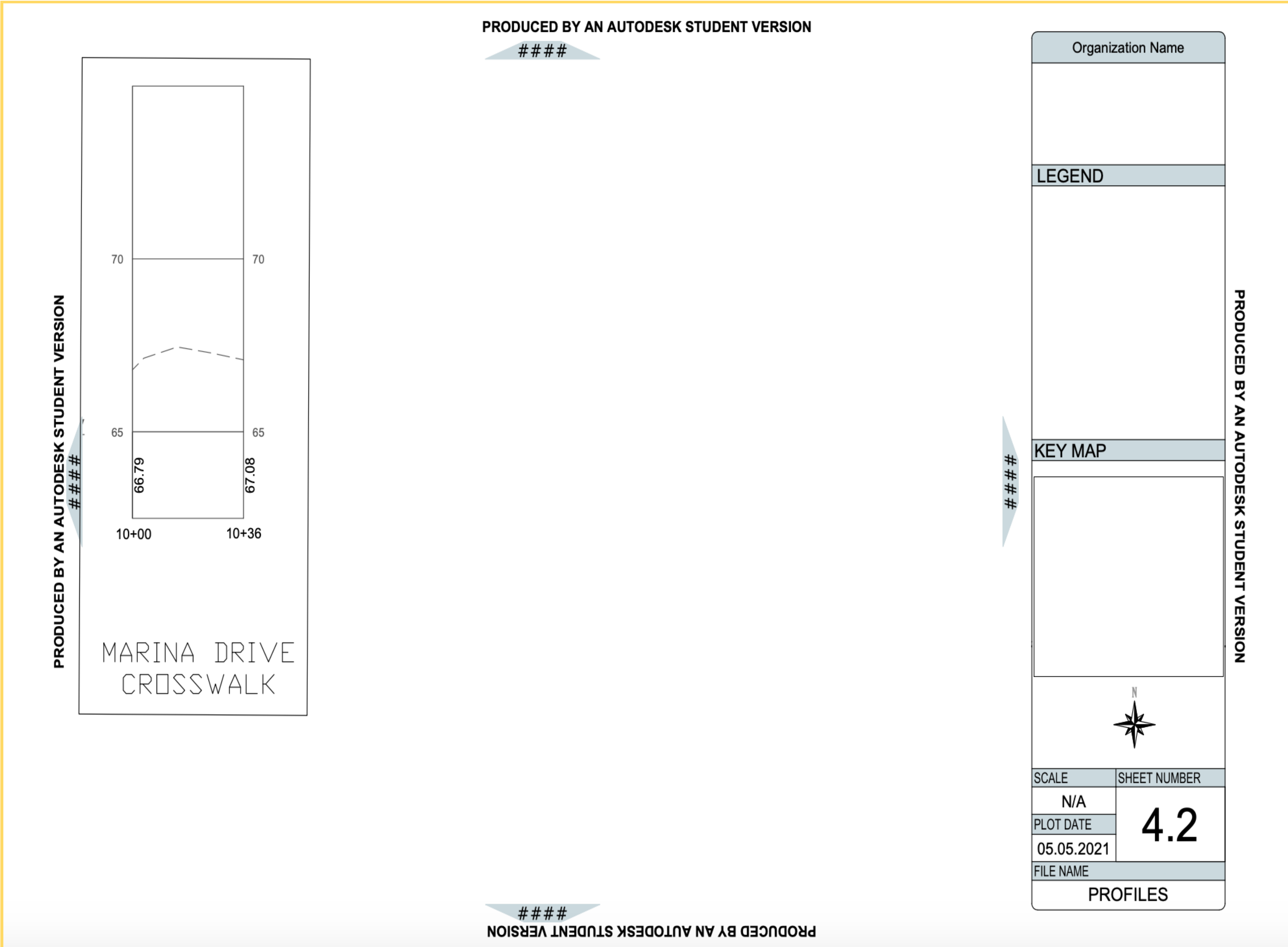
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MARINA DRIVE CROSSWALK
10+00
10+36
66.79
67.08
65
70
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SHEET NUMBER
4.2
FILE NAME
PROFILES

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