Louisiana Transportation Research Center

Final Report 645

Evaluation of Counting Device for Pedestrians and Bicyclists

by

Yasser Ismail

Southern University

4101 Gourrier Avenue | Baton Rouge, Louisiana 70808
(225) 767-9131 | (225) 767-9108 fax | www.ltrc.lsu.edu

TECHNICAL REPORT STANDARD PAGE

1. Title and Subtitle
Evaluation of Counting Device for Pedestrians and Bicyclists

2. Author(s)
Yasser Ismail

3. Performing Organization Name and Address
Electrical Engineering Department
College of Sciences and Engineering,
Southern University and A&M College,
Pinchback Hall, Room 427
Baton Rouge, LA 70813

4. Sponsoring Agency Name and Address
Louisiana Department of Transportation and Development
P.O. Box 94245
Baton Rouge, LA 70804-9245

5. Report No.
FHWA/LA.17/645

6. Report Date
March 2021

7. Performing Organization Code
LTRC Project Number: 19-1SA
SIO Number: DOTLT1000284

8. Type of Report and Period Covered
Final report
9/2018 – 11/2019

9. No. of Pages
121

10. Supplementary Notes
Conducted in Cooperation with the U.S. Department of Transportation, Federal Highway Administration

12. Key Words
Pedestrians and bicyclists counts; Evaluation of an online Counting Device

13. Abstract
This study evaluates the automatic counting feature of two sensors to count pedestrians and bicyclists. The first sensor (sensor A) is a hardware/software system that is used to detect, classify, and count different objects. It is composed of two components: the sensor (hardware) and the software (the data platform). All the components of sensor A are designed to be weatherproof and to easily conform to the specifications of the city planners and the traffic engineers. The second sensor (sensor B) is a professional sensor (or camera) that is also capable of automatically counting objects and capturing videos. Six different locations at New Orleans and Baton Rouge with different conditions (weather, time of the day, traffic volume, and density of pedestrians and bicyclists), were selected for the evaluation process. Sensor B was tested only in one location in New Orleans; that location has a high-traffic volume of pedestrians. The evaluation of sensor A showed that the overall total observations median and mean Absolute Percentage of Error (APE) of the pedestrians during the day-time are 119.72% and 119.15%, and during the night-time are 69.10% and 111.90%. The overall observations median and mean APE of the bicyclists during the day-time are 69.62% and 80.03% and during the night-time are 89.47% and 80.15%. The evaluation of sensor B showed that the overall total observations median and mean APE of the pedestrians and bicyclists are 89.9% and 86.1%, respectively.

Project Review Committee

Each research project will have an advisory committee appointed by the LTRC Director. The Project Review Committee is responsible for assisting the LTRC Administrator or Manager in the development of acceptable research problem statements, requests for proposals, review of research proposals, oversight of approved research projects, and implementation of findings.

LTRC appreciates the dedication of the following Project Review Committee Members in guiding this research study to fruition.

LTRC Administrator/Manager

Julius Codjoe, Ph.D., P.E.
Special Studies Research Administrator

Elisabeta Mitran, Ph.D.
Safety Research Manager

Members

Jessica DeVille, DOTD
Jason Chapman, DOTD
Julius Codjoe, LTRC
Tara Tolford, UNO
John Broemmelsiek, FHWA
Ty Hampton, DOTD

Directorate Implementation Sponsor

Christopher P. Knotts, P.E.
DOTD Chief Engineer

Evaluation of Counting Device for Pedestrians and Bicyclists

By
Yasser Ismail

Department of Electrical Engineering, College of Sciences and Engineering,
Southern University and A&M College
Pinchback Hall, Room 427
Baton Rouge, LA, 70813

LTRC Project No. 19-1SA
SIO No. DOTLT1000284

conducted for
Louisiana Department of Transportation and Development
Louisiana Transportation Research Center

March 2021

Abstract

This study evaluates the automatic counting feature of two sensors to count pedestrians and bicyclists. The first sensor (sensor A) is a hardware/software system that is used to detect, classify, and count different objects. It is composed of two components: the sensor (hardware) and the software (the data platform). All the components of sensor A are designed to be weatherproof and to easily conform to the specifications of the city planners and the traffic engineers. The second sensor (sensor B) is a professional sensor (or camera) that is also capable of automatically counting objects and capturing videos. Six different locations at New Orleans and Baton Rouge with different conditions (weather, time of the day, traffic volume, and density of pedestrians and bicyclists) were selected for the evaluation process. Sensor B was tested only in one location in New Orleans; that location has a high-traffic volume of pedestrians. The evaluation of sensor A showed that the overall total observations median and mean Absolute Percentage of Error (APE) of the pedestrians during the day-time are 119.72% and 119.15% and during the night-time are 69.10% and 111.90%, respectively. The overall observations median and mean APE of the bicyclists during the day-time are 69.62% and 80.03% and during the night-time are 89.47% and 80.15%, respectively. The evaluation of sensor B showed that the overall total observations median and mean APE of the pedestrians and bicyclists are 89.9% and 86.1%, respectively.

Acknowledgments

Thank you to the Louisiana Transportation Research Center (LTRC) for the financial support to finalize this project and the chair of the Electrical Engineering Department at Southern University and A&M College, Fred Lacy, Ph.D., for his support with graduate students who helped in the manual counting phase of the project. A special thanks to the Project Review Committee (PRC) members for their valuable feedback, especially Julius Codjoe, Ph.D., Elisabeta Mitran, Ph.D., and Tara Tolford for their valuable suggestions and feedback during the execution of the project phases. Finally, thank you to the team of Jack Harper Electrical for their technical support to install and maintain all sensors and video cameras.

Implementation Statement

The results of this project are directly applicable for implementation by DOTD as well as for local government entities throughout Louisiana and beyond who are interested in both pedestrians and bicyclists counts. The project provides a framework and guiding principles for evaluating nonmotorized counting systems (i.e., sensor A and sensor B). Both sensor A and sensor B counting systems are not recommended for implementation by the DOTD and Louisiana state. They failed to give robust counting systems for both pedestrians and bicyclists at the selected testing locations and under different conditions (weather, time of the day, traffic volume, and density of pedestrians and bicyclists) in New Orleans and Baton Rouge. Although the rental cost of sensor A is reasonable, the installation and the maintenance fees are extremely high. The research team has no access to sensor A's object tracking algorithm, so it is hard to determine why there is a huge gap between sensor A's counts and the manual counts. Detailed protocol steps of evaluating sensor A and sensor B counting systems are appended to this report. The guiding protocol can be readily implemented for other state validation studies. The research team endeavors to present and publish the findings (after the approval of both sensor A and sensor B companies), which contribute to the overall literature in this field or may be of interest to practitioners in journals with a national audience to facilitate the transfer of research more broadly.

Table of Contents

List of Tables

List of Figures

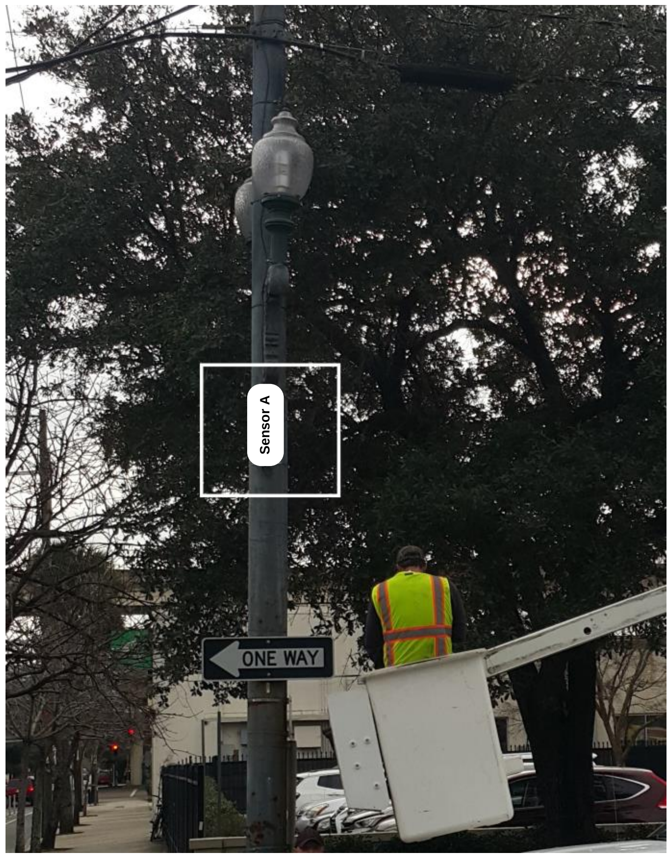
Introduction

Understanding the travel behavior of pedestrians and bicyclists on Louisiana's roadways is critical to evaluating safety outcomes relative to rates of exposure; identifying appropriate, context-sensitive complete streets infrastructure interventions; and understanding overall statewide and location-specific transportation trends. Pedestrians and bicyclist counts, as well as vehicle counts, are important sources of information for planners and policymakers when dictating transportation planning and infrastructure spending. Current and reliable statistics are essential for evaluating the usage of roadways and for optimizing spending and investment.

A wide range of hardware is available to address the challenges associated with pedestrians and bicyclists counting, such as laser beams, infrared counters, and piezoelectric pads. However, most of these sensors fail to give accurate measurements of density. Manual counts performed by humans in the field are common but are labor-intensive and inefficient for large-scale counting programs sought by cities and states today. Also, these counts generally rely on human capacity, and accuracy rates are prone to human error. In areas with a high density of pedestrians and cyclists, the method of manual counting is essentially impractical. As a result, there has been more effort directed into the development of algorithms that minimize human intervention when counting. Sensor A, which is evaluated in this study, is one of such products. It is a hardware-software system that is used for object detection. It is composed of two-component systems: the sensor (hardware) and the software (the data platform). It uses a camera to take multiple snapshots per second of a region under study and then uses image-processing algorithms to count the number of pedestrians and bicyclists. All the components of sensor A are designed to be weatherproof, outdoor functional, and to easily conform to the specifications of city planners and traffic engineers. Sensor A can be mounted to a light or a signal pole at a height of 12-20 ft., and is powered by a grid connection straight from the light pole or by an external solar panel. It is worth mentioning that the used software for object detection and classification is not mentioned in the manual of sensor A.

Figure 1 illustrates sensor A and how it can be installed. It is worth mentioning that an additional video camera will be mounted to the same light pole (or signal pole) and it should cover the same coverage area under study. The recorded video footage will be used for the manual counts' purpose. The manual counts will be used to evaluate the counting performance and robustness of sensor A in counting both pedestrians and bicyclists.

Figure 1. The mounting process of sensor A on a light pole



Sensor B is also an IP camera that is capable of automatically counting objects in addition to capturing video footage. Sensor B is typically designed for the indoor counting process; however, in this project, it was evaluated for the outdoor counting under different weather conditions at a very high traffic volume location in New Orleans. We benefit from its ability to capture video footage for utilizing them in the manual validation process.

The purpose of this study was to evaluate the performance of both sensor A and sensor B to count both pedestrians and bicyclists and compare their counts with the manual counting process under different conditions (weather, time of day, shadows, complex background, and different density of pedestrians and bicyclists). This was achieved by mounting the sensors in six different locations in New Orleans and Baton Rouge. The evaluation process was performed during different weather circumstances including heavy rain and wind and during the day and the night-time.

Literature Review

Pedestrian and bicyclist detection and counting algorithms are used in a wide range of applications related to traffic and self-driving technology. It can help improve pedestrian and bicyclist safety and decrease pedestrian and bicyclist accidents when it is integrated within the automobile safety system. Researchers focused on a hand-crafted method to extract a low-level feature to detect pedestrians and bicyclists by designing manual algorithms. Recently, the researchers started to combine the hand-crafted method with a deep convolutional network to take advantage of the development of deep learning.

The three main stages of the pedestrian and bicyclist detection are (1) region proposals; (2) feature extraction; and (3) region detection (classification) [1]. The traditional regional proposed method used is the sliding window. The other methods used are selective search and EdgeBox [2]. The researchers proposed models that improve each stage separately or a combined solution that takes into consideration more than one stage. Since there is a high development in object detection, there is a great opportunity for improvement in the speed and accuracy of pedestrian and bicyclist detection.

Pedestrian and bicyclist detection could be a necessary task in any intelligent video surveillance system because it provides essential information for the understanding of the video footage. It has an obvious extension to automotive applications because of the ability for enhancing safety systems. However, pedestrian detection is a challenging task due to its complex background as well as various body sizes and postures.

There is a development in the feature extraction stage for the detection of the human; Dala presented a histogram of oriented gradients (HOG) to detect pedestrians [3]. Pitor combines HOG with channel features and calls it aggregated channel features (ACF) [4], and that leads to LDCF; a new approach proposed by Nam [3].

Recently, Sermant employed the convolutional neural network in pedestrian detection and suggested a method called ConvNet [5]. ConvNet was followed by a deepNet that was proposed by Tome [1]. Zhang used a faster R-CNNs (region-based convolutional neural networks) algorithm to detect pedestrians; Region Proposal Network (RPN) combined with the K-means cluster analysis is used to extract regions with a probability of having pedestrians [6]. Researchers have concentrated on utilizing spatial and temporal analysis for improving the robustness of a pedestrian counting algorithm. They avoided the tracking phase and substituted it with spatial-temporal analysis [7]. This technique has also been used to detect objects with a variable background when a moving camera is utilized, that is when both the object as well as the background are moving [8]. A current state-of-the-art technique called YOLO (you only look once), which is proposed by Redmon et al., guarantees quick real-time detection rates [9]. Liu made some modifications to YOLOv2 to be more suited to pedestrian detection [4]. Zhang replaces the standard 3×3 convolutional kernel filter with the abnormal 5×3 convolutional kernel to be more suitable for pedestrian detection [10].

The counting accuracy of both sensor A and sensor B is validated utilizing the manual counts of pedestrians and bicyclists from the collected video data. The performance metrics of counting algorithms were discussed in [11] [12] [13] [14]. These performance metrics can be summarized as follows: (1) accuracy: the measure or degree of agreement between a data value and a source assumed to be correct; (2) completeness: the degree to which data values are present in the attributes that require them; (3) validity: the degree to which data values fall within the respective domain of acceptable values; (4) timeliness: the degree to which data values are provided at the time specified; (5) coverage: the degree to which data values in a sample accurately represent the whole of that which is to be measured; and (6) accessibility: the relative ease with which data can be retrieved by data consumers to meet their needs. We use two performance metrics: (1) the counts of pedestrians and bicyclists provided by the sensors and compare them with the manual counts; and (2) the absolute percent of error (APE) of the counts from both sensors and the manual counts [13]. It is anticipated that the results from this project will assist the LTRC in evaluating the available count technology equipment options and identify preferred alternatives suitable for statewide deployment.

Objective

The primary aims of the project were: (1) verifying the accuracy level of sensor A and sensor B to automatically count pedestrians and bicyclists from real-time video footage; and (2) determining if sensor A and sensor B could deliver robust systems for both near-term and long-term multimodal data collection program opportunities, so that they will make DOTD more efficient in its pedestrians and bicyclists data collection endeavors.

To achieve these aims, the research team were looking to successfully achieve the following:

1. Mounting the sensors at six different locations in New Orleans and Baton Rouge: these locations were carefully selected to provide a different density of pedestrians and bicyclists. The sensors were mounted continuously for three months at New Orleans locations and another three months at Baton Rouge locations.
2. Collecting video footage that covers the same coverage areas of the sensors: the collected video data will be under varying conditions to evaluate the accuracy of the sensors under different circumstances. The video footage was recorded during the day-time and the night-time at the selected locations. Different weather conditions (such as heavy rains and cloudy weather) were considered through the evaluation period. Some of the selected locations provided shadows and complex background conditions to evaluate the ability of the sensors to count in such conditions.
3. Comparing the accuracy of the obtained counts from the sensors with the manual counts from the recorded video footage.

Scope

For this study, the research team used the testing locations approved by the PRC. The evaluation was undertaken on sensor A and sensor B that were leased through this study. The research team engaged representatives from sensor A in the acquisition and installation of the devices. The research team relied on LTRC to provide video cameras for this study, including a professional camera (sensor B) that is capable of automatically counting in addition to capturing videos for manual validation. The PI calibrated and evaluated the automatic counting feature sensor B. It has been agreed to lease three kits of sensor A for six months. During this period, data were collected for three months at sites in New Orleans and the remaining three months at sites in Baton Rouge. The following tasks were followed to achieve the overall scope and objectives of the project:

Task 1: Perform Literature Review

The research team obtained and reviewed documentation (including device manual and technical briefings) of sensor A and sensor B.

Task 2: Acquire Sensor A and Video Camera(s)

The research team relied on LTRC to provide suitable test locations. Three kits of sensor A were leased from the production company. Video cameras (video detection systems) that were used to obtain ground truth data, were borrowed from LTRC.

Task 3: Collect Pedestrian and Cyclist Data

In this task, the research team installed sensor A and sensor B and the video cameras at the agreed test locations and collected pedestrian and bicyclist data. The research team engaged with personnel from sensor A’s company to ensure that the sensors were mounted for optimal collection of data. The performance of sensor A and sensor B was evaluated and compared to manual counting. Sites were selected to represent a variety of preliminary contexts and/or representative of conditions in urbanized areas where pedestrians and bicycles travel, including locations with both high and low anticipated volumes of active users, and representing a variety of facility configurations. At least one intersection was included to evaluate the efficacy of sensor A and sensor B for the intersection flow and/or the turning movement counts.

Task 4: Undertake Comparative Analysis between Sensor A and Sensor B

From the collected data in the previous task, the research team assessed the capability of sensor A and sensor B in providing accurate pedestrian and bicyclist counts by comparing the counts from sensor A and sensor B to the manual counts obtained from the recorded video footage. The research team considered factors such as density, environmental conditions, time of day, shadows, complex background, and lighting conditions.

Task 5: Document Findings

The research team documented all the research efforts into a comprehensive report. Recommendations and a technical summary would also be produced.

Task 6: PRC Review and Issue of Final Report

This task refers to the PRC review of the draft report (from the previous task) and the concurrent update of the report by the research team. This report synthesizes findings and provides recommendations in support of continued complete streets policy implementation.

Methodology

Data Sources

Three kits of sensor A were mounted and evaluated in six different locations in New Orleans and Baton Rouge areas. Several continuous video data readings were recorded utilizing additional video recording cameras that were mounted to cover the same coverage areas of the sensors. Sensor B was used to record real-time video data at LTRC1 (Decatur St. & St. Peter St. location at New Orleans) location. Other locations used additional video cameras that were mounted on the same poles of the sensors and covered the same coverage areas of the sensors. The recorded video data were used for the manual counting process to evaluate sensor A and sensor B. The density of pedestrians and bicyclists vary in the selected locations. Table 1 illustrates the selected locations' names at New Orleans and Baton Rouge, the density of pedestrians and bicyclists, the installed sensors in each location, and the number of video data readings that were used for the evaluation purpose. All recorded video data that were used for comparison and evaluation processes were collected from the recording video cameras. Figure 2 shows the signal and the light poles that were selected to mount both sensor A and the video recording cameras and the corresponding coverage areas.

Table 1. Mounting information of sensor A at New Orleans

New Orleans			
Location	**Density**	**Installed Sensor**	**# of Readings**
Decatur St. & St. Peter St. (LTRC1)	High-traffic	Sensor A & Sensor B	One
Esplanade Ave & N Peters St. (LTRC2)	High-traffic	Sensor A & Video Recording Camera	Two
Howard Ave & Baronne St. (LTRC3)	High-traffic	Sensor A & Video Recording Camera	Three

Baton Rouge			
Location		**Device**	**# of Readings**
Louisiana State University – LSU (LTRC4)	High-traffic	Sensor A & Video Recording Camera	Three
Baton Rouge Community College – BRCC (LTRC5)	Medium-traffic	Sensor A &Video Recording Camera	Three
City Plaza (LTRC6)	Medium-traffic	Sensor A & Video Recording Camera	Three

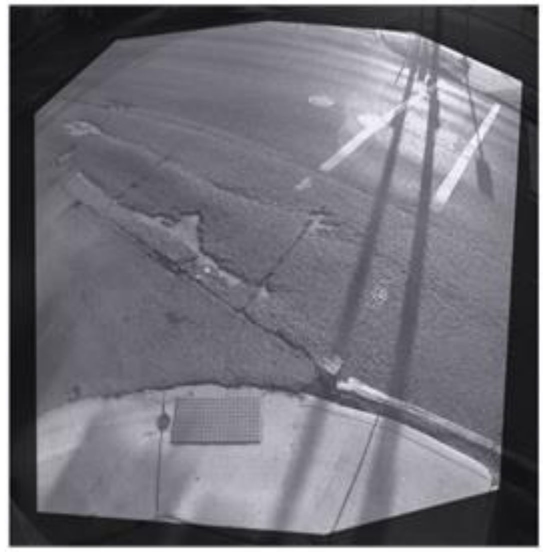
Figure 2. Selected poles to mount sensor A and the corresponding coverage areas

Decatur St. & St. Peter St. (LTRC1)

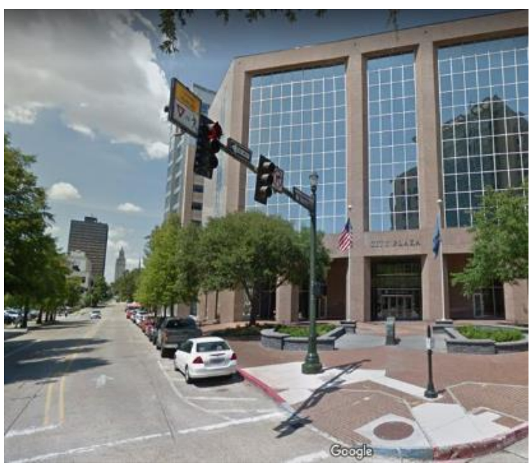
Esplanade Ave & N Peters St. (LTRC2)

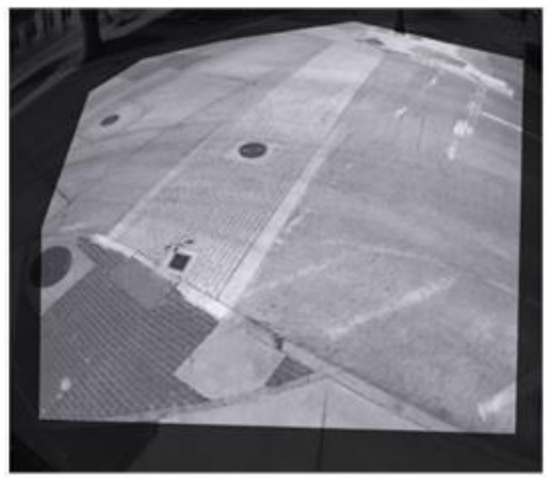
Howard Ave & Baronne St. (LTRC3)

Louisiana State University (LTRC4)



Baton Rouge Community College (LTRC5)





City Plaza (LTRC6)

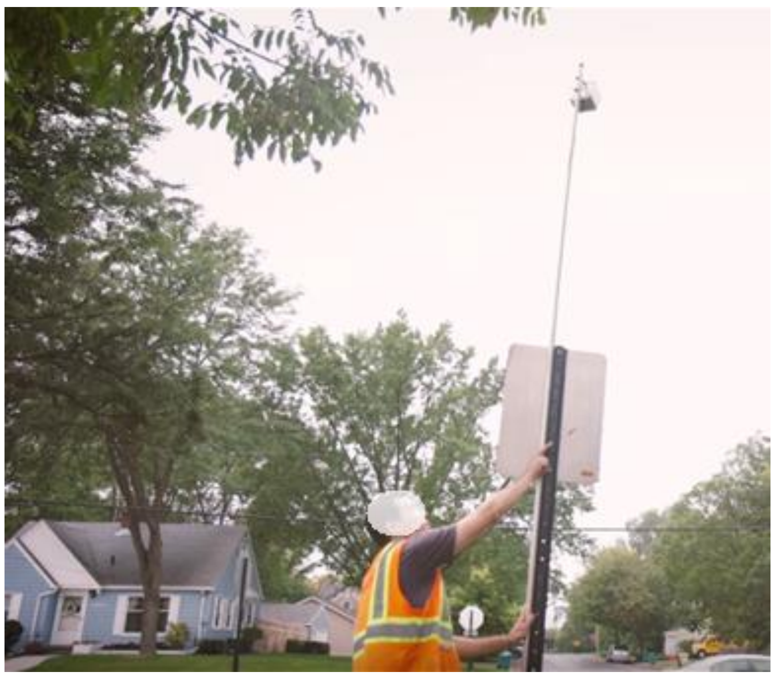
LTRC Cameras Implementation

Three camera systems were borrowed from LTRC to be used for the manual counting purpose. The three cameras are (1) Counting cars CAM 360; (2) Miovision; and (3) COUNTCAM2. The following are the specifications for each camera.

Counting Cars CAM 360

Counting Cars (Serial Number: 1859) is an American manufacturer and maintains an online store for transportation data collection equipment. Installation is easy but does require some tools and hardware. As shown in Figure 3, the camera angle and footage can be viewed on site. Also, the system uses a 64 GB SD card, which makes transferring data efficient. The quality of the footage is 640 x 480 pixels. Minimal parts make storage easy and the maintenance involves storage and battery exchange approximately every 12 days.

Figure 3. Counting Cars Camera System



The following is an itemized list of the components for the camera system including images as seen in Figure 3.

1. Aluminum Pole Amount
2. Camera
3. Battery Pack/Charger
4. Hole Clamp Set
5. Locks/Chains
6. Screen for Viewing Camera Angle
7. 25’ COUNTcam Replacement Camera Cable
8. Outdoor Power Outlets

Miovision Camera System

Miovision is a well-known Canadian company in transportation engineering that focuses on traffic operations, traffic data, and smart city solutions. The installation of the system is easy and does not require professional installation or special software to review the footage. Minimal space is necessary to store the equipment shown in Figure 4.

The system utilizes the Scout camera which records at 30 fps and a 720 x 480 resolution. The video footage is saved in MP4 format and can be viewed in most media players such as Windows Media Player or VLC. The camera stores two SD cards (max of 64 GB each) worth of data and the battery lasts up to seven days. The system requires minimal maintenance; a site visit should be done every three days for replacing storage and seven days for replacing the battery.

The following is an itemized list of the components for the camera system in Figure 4.

1. Scout Control Unit
2. Lock with Key
3. Miovision Ultra SD Card
4. USB SD Card Reader (1)
5. Universal Charger & Regional Power Cord
6. Scout Pole Mount
7. Scout Camera
8. Ratchet Straps
9. TR30 Screw Driver
10. Lock with Key
11. Power Pack

Figure 4. Miovision Camera System

COUNTCAM2

COUNTCAM2 is (Serial Number: E0B94D672598) an American manufacturer and online store that develops and sells durable, cost-effective transportation data collection equipment. The installation of the system is easy and does not require professional installation or special software to review the footage. Minimal space is necessary to store the equipment shown in Figure 5. The video recording operation can be started by a phone application.

The system can record videos at a 720 x 640 resolution. The video footage is saved in MP4 format and can be viewed in most media players such as Windows Media Player or VLC. The camera has a built-in storage memory of a maximum of 64 GB worth of data and the battery lasts up to 50 – 56 hours.

The following is an itemized list of the components for the camera system including images as seen in Figure 5.

1. COUNTcam2 Camera Unit
2. Charger
3. Hose clamp set
4. Lock bracket and padlock
5. Mounting Bracket
6. Download cable

The video cameras that are seen in Figure 3, Figure 4, and Figure 5, are mounted on the same poles of sensors A. The cameras' lenses were adjusted to cover the same coverage areas of sensors A as seen on the right side of Figure 2. The recorded videos during certain periods were used by a graduate student to manually count the number of pedestrians and bicyclists. It is worth mentioning that the manual counting process is only performed within the green areas seen on the right side of Figure 2 to get a fair comparison with sensor A counts.

Figure 5. COUNTCAM2 Camera System

Data Collection and Sensors Installation

Sensor A Installation Process

The installation process of sensors A was done at New Orleans locations by direct wiring to the light and the signal poles to get the required DC voltage. At Baton Rouge locations, sensors A used solar-cells to get the required DC voltage.

The ideal location for sensor A is on a streetlight with the bottom of the sensor located at an elevation of approximately 15 ft. (4.5 meters). The optimal detection of pedestrians begins approximately 10 ft. (3 meters) away from the sensor.

At the Baton Rouge locations, all sensors A were powered through the utilization of solar cells. The solar panel provided 160W of power, its dimensions were 67in. x 26in. (1710 x 666mm), and it weighed 109lbs (49kg). Figure 6 shows the solar-cell system used at the Baton Rouge Community College – BRCC (LTRC5) location. It consists of the solar-cell panel, the battery box, and sensor A.

Based on the recommendations from the manual of sensor A, the maximum accuracy of the device can be obtained after two weeks from the installation time. Two weeks are required to calibrate the device. The research team mounted video cameras at the same locations covered by sensors A. A minimum of 8 hours of video data (with 32 hours being the preferred standard for evaluating accuracy) were used for evaluating the accuracy of sensor A per the selected time. The selected video data represented a variety of days, times, weather conditions, volume levels, etc.

Figure 6. Solar-cell system

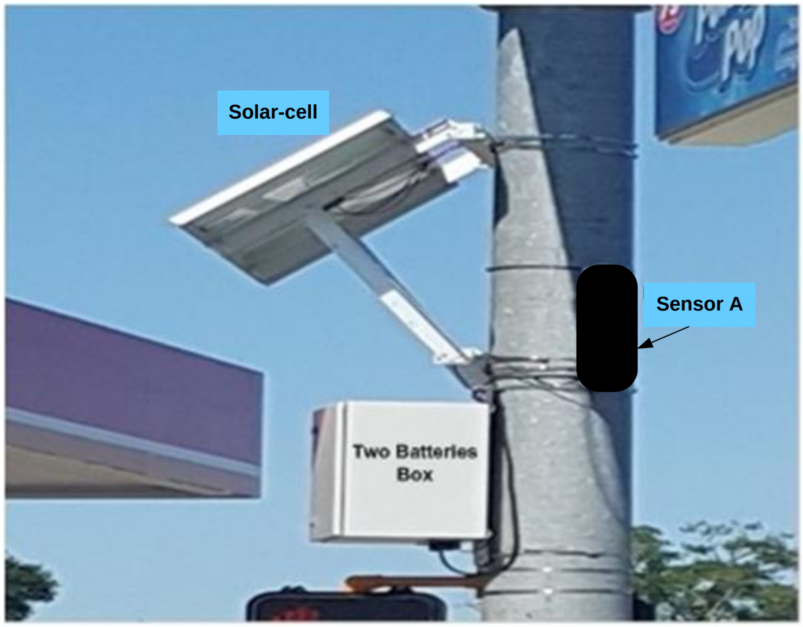


Figure 7 (a) illustrates an example of the original snapshot that was taken by sensor A and the selected coverage area is shown in Figure 7 (b). The counting algorithm of sensor A excludes the outer edges of the original snapshot to get the maximum counting accuracy.

Figure 7. An example of a coverage area by sensor A

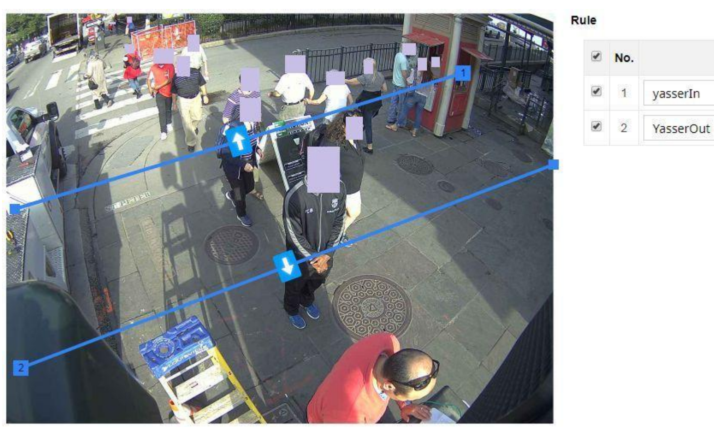
(a) The original snapshot (b) The selected coverage area

Sensor B Installation Process

Sensor B is capable of automatically counting objects in addition to capturing videos that were used for our manual validation purpose. Sensor B has a static IP address that can be used to set-up the device. It is important to select the correct setup parameters to successfully calibrate the camera. The calibration process of sensor B includes the object window decision as seen in Figure 8. The object window size depends on the angle and the height of sensor B's lens. The second calibration step is to determine the location of the passing lines as seen in Figure 9. Sensor B can provide up to eight lines. Any object that passes the line/s as shown in Figure 9 will be automatically counted by sensor B.

Figure 8. The object window decision process by sensor B

Figure 9. The decided passing lines decided on sensor B



Discussion of Results

Comparison Metrics

The accuracy of sensor A and sensor B are determined using two metrics: (1) the counts of pedestrians and bicyclists provided by the sensors. These counts were compared with the manual counts, and the manual counts were calculated by mounting recording cameras that recorded real-time video footage; and (2) the percent of the absolute error (APE) between the counts from the sensors and the manual counts from the mounted recording cameras. The APE is calculated as follows:

$$APE = \left[\left|\frac{Count_{Sensor} - Count_{Manual}}{Count_{Manual}}\right|\right] \times 100\% \qquad (1)$$

where,

$Count_{Sensor}$ and $Count_{Manual}$ are the calculated counts from the sensor and the calculated manual counts from the recording cameras, respectively, within a predefined time interval.

The collected video data was processed in two-time intervals. The day-time interval starts from 6:00 AM to 6:00 PM and the night-time interval starts from 6:00 PM to 6:00 AM. At all the selected locations in New Orleans and Baton Rouge, there was enough light during the night-time that allows counting both the pedestrians and the bicyclists.

Sensors A at New Orleans Locations

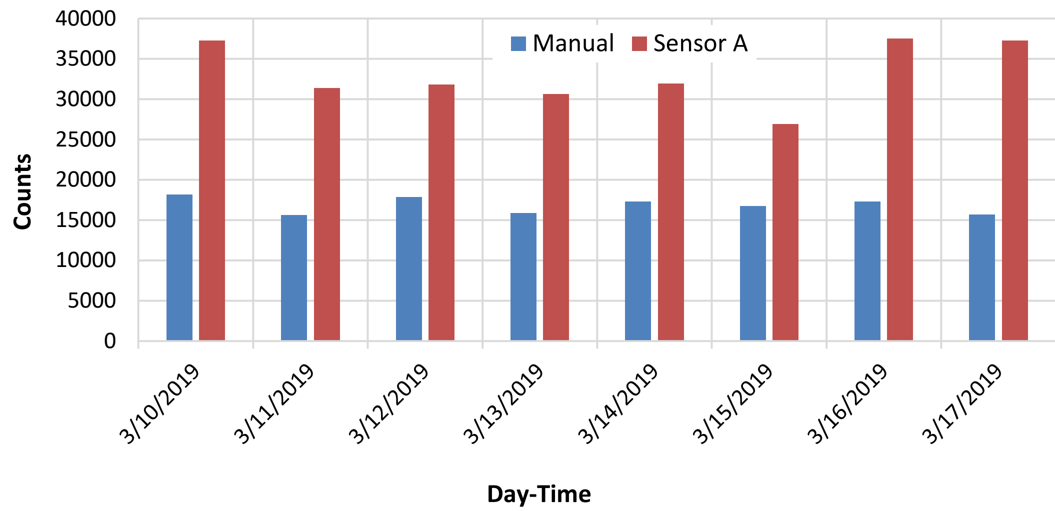
Three kits of sensor A were mounted at three different locations in New Orleans. All sensors at New Orleans locations were mounted to signal or light poles using wired connections. Sensor B can count objects and record video footage; this is why we used it to get the real-time video footage at the LTRC1 location for the manual count purpose. Both sensor A and sensor B were mounted on the same signal pole at the LTRC1 location. Two additional video recording cameras were mounted at the same poles of the sensors A at locations LTRC2 and LTRC3, respectively. For comparison purposes, sensor B and the video recording cameras are adjusted to cover the same coverage area of sensor A mounted at the same pole. The recorded videos were used to evaluate the count accuracy of both sensor A and sensor B. The recording video cameras used batteries that allow up-to seven days of continuous data recording. One continuous reading set for LTRC1, two reading sets for LTRC2, and three reading sets for LTRC3 were used for evaluation sensors A at New Orleans locations.

The recorded video data at LTRC1, LTRC2, and LTRC3 locations were collected under rain and wind conditions during the period from 2/10/2019 to 2/12/2019; from 2/27/2019 to 3/5/2019; and from 3/15/2019 to 3/16/2019 and 4/8/2019.

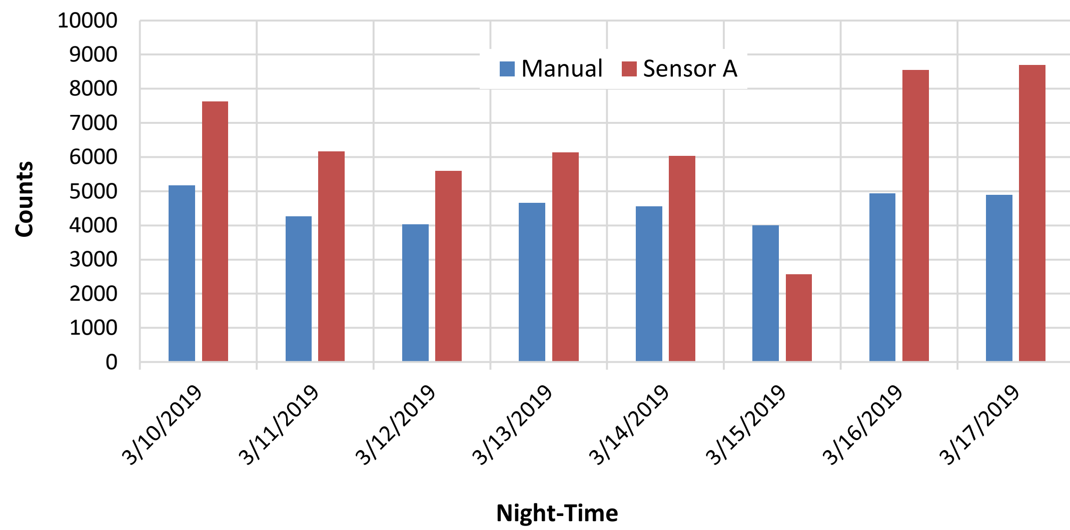
Decatur St & Peter St. (LTRC1)

LTRC1 location has a high-traffic pedestrian volume. In this location, both sensor A and sensor B were mounted at the same pole. Sensor B was used to record real-time video footage to validate the performance of sensor A at LTRC1. The lens of the sensor B was adjusted to cover the same coverage area as sensor A. One continuous recorded video data set was collected in the period from March 10 to March 17 for our evaluation purpose. Pedestrians and bicyclists count during the day-time and the night-time of LTRC1 from March 10 to March 17 are seen in Figure 10 and Figure 11, respectively. Both counts are compared to the manual counts of the video footage captured by sensor B in the same period. There is a significant difference between manual counts and sensor A's counts, especially in the day-time of pedestrians, where there is a heavy traffic volume.

Figure 10. The daily pedestrians' count of LTRC1

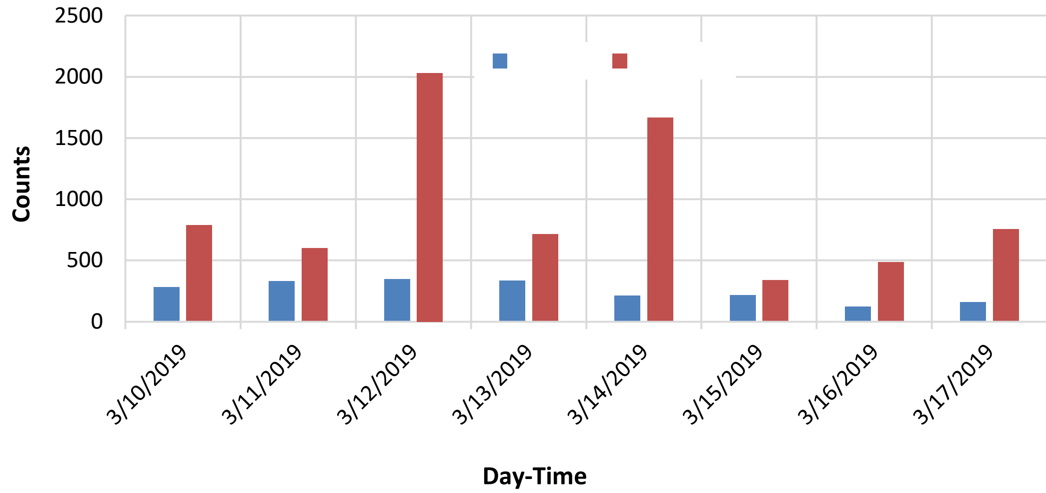


Day-Time	3/10/2019	3/11/2019	3/12/2019	3/13/2019	3/14/2019	3/15/2019	3/16/2019	3/17/2019
Manual	18166	15622	17815	15873	17302	16702	17302	15688
Sensor A	37268	31345	31790	30638	31958	26900	37517	37277

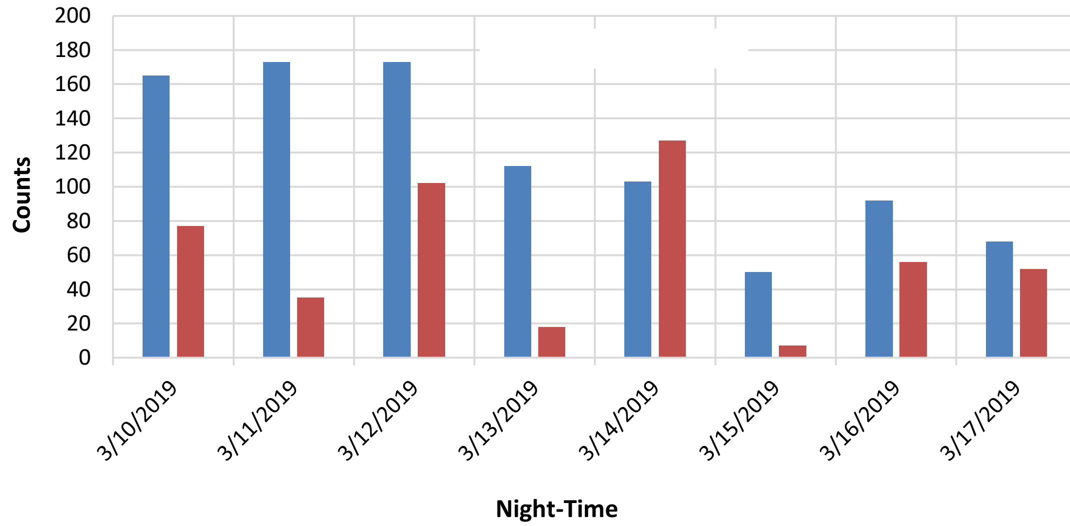


Night-Time	3/10/2019	3/11/2019	3/12/2019	3/13/2019	3/14/2019	3/15/2019	3/16/2019	3/17/2019
Manual	5163	4269	4033	4658	4560	3996	4936	4885
Sensor A	7624	6165	5600	6133	6040	2561	8546	8698

Figure 11. The daily bicyclists' count of LTRC1



Day-Time	3/10/2019	3/11/2019	3/12/2019	3/13/2019	3/14/2019	3/15/2019	3/16/2019	3/17/2019
Manual	280	331	346	337	212	216	123	160
Sensor A	791	603	2032	718	1669	340	484	757

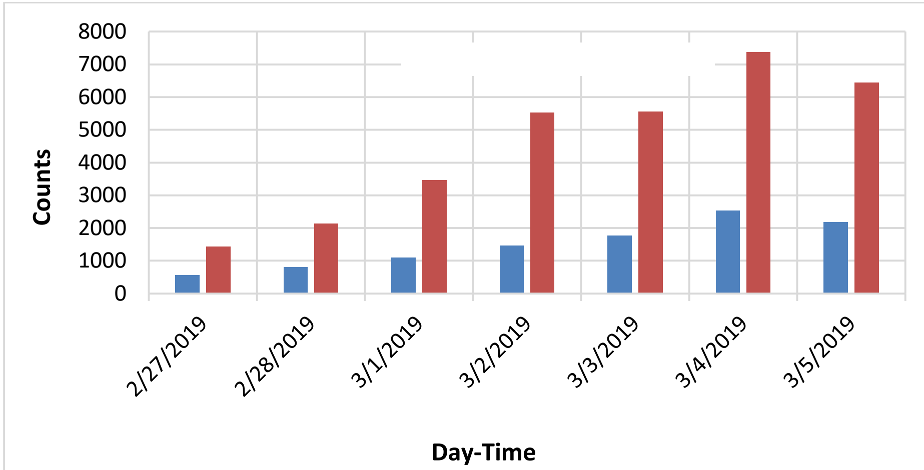


Night-Time	3/10/2019	3/11/2019	3/12/2019	3/13/2019	3/14/2019	3/15/2019	3/16/2019	3/17/2019
Manual	165	173	173	112	103	50	92	68
Sensor A	77	35	102	18	127	7	56	52

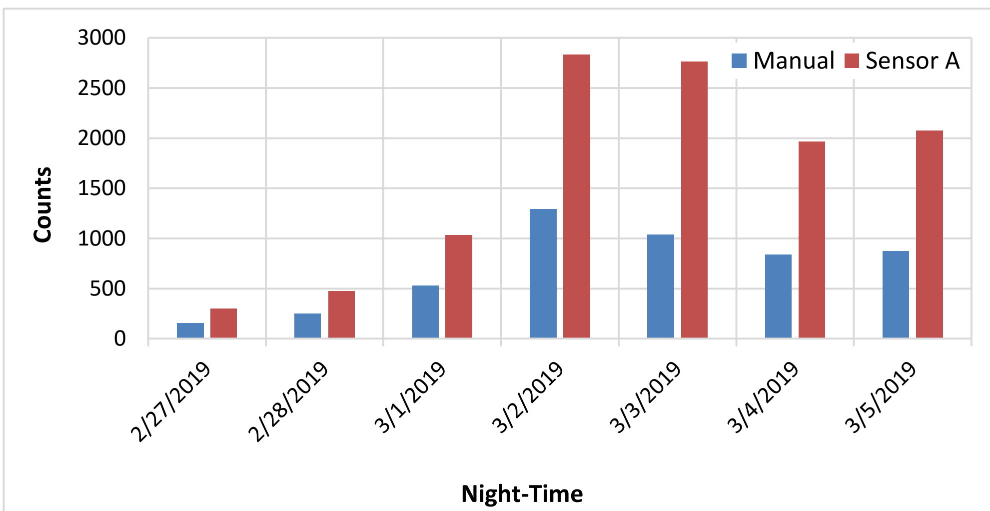
Esplanade Ave & N Peters St. (LTRC2)

LTRC2 location has a high-traffic pedestrians and bicyclists volume. A video recording camera was mounted with sensor A to record the real-time video footage required for the performance validation of sensor A at LTRC2. Two different continuous video data were recorded by the video recording camera. Pedestrians and bicyclists counts, for two (2) recorded video footage data and during the day-time and the night-time of LTRC2 from February 27 to March 5 and from March 11 to March 17, respectively, are seen in Figure 12, Figure 13, Figure 14, and Figure 15. Sensor A's counts are compared to the manual counts of the video footage captured by the recording video camera in the same period. It is clear from Figure 12, Figure 13, Figure 14, and Figure 15 that sensor A at the LTRC2 location failed (most of the time) to accurately count both the pedestrians and the bicyclists during the day-time and the night-time period.

Figure 12. The daily pedestrians' count of LTRC2 from February 27 to March 5

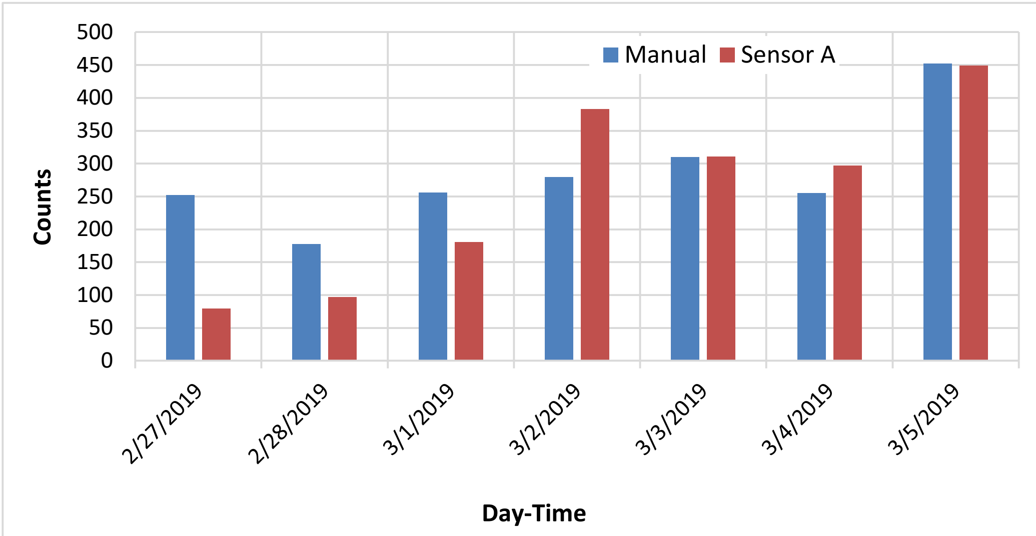


Day-Time	2/27/2019	2/28/2019	3/1/2019	3/2/2019	3/3/2019	3/4/2019	3/5/2019
Manual	558	797	1094	1460	1764	2525	2173
Ssensor A	1438	2138	3463	5517	5555	7382	6447

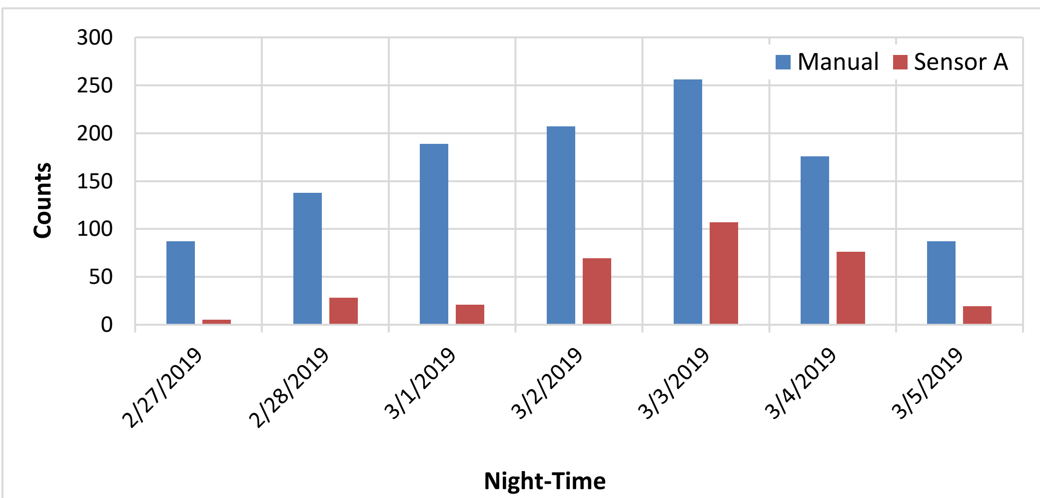


Night-Time	2/27/2019	2/28/2019	3/1/2019	3/2/2019	3/3/2019	3/4/2019	3/5/2019
Manual	157	251	531	1295	1037	842	877
Sensor A	297	474	1034	2834	2760	1968	2075

Figure 13. The daily bicyclists' count of LTRC2 from February 27 to March 5

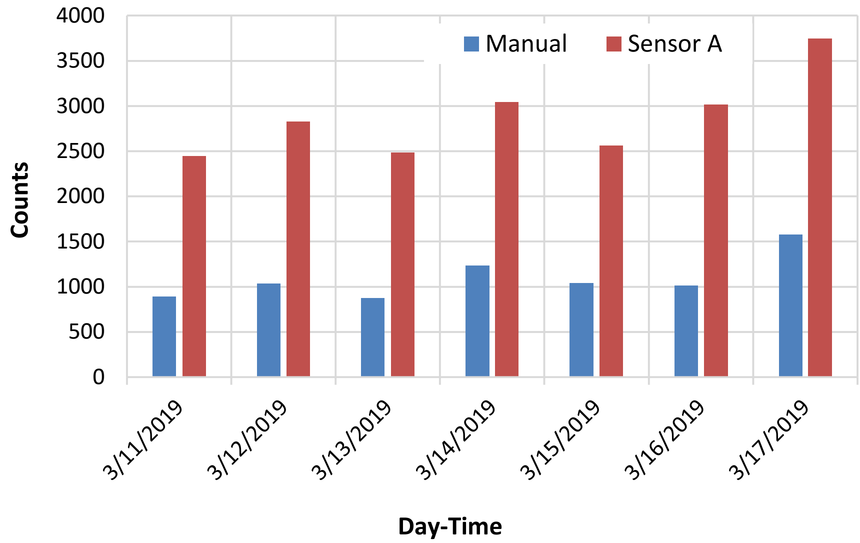


Day-Time	2/27/2019	2/28/2019	3/1/2019	3/2/2019	3/3/2019	3/4/2019	3/5/2019
Manual	252	178	256	279	310	255	452
Sensor A	79	97	181	383	311	297	449

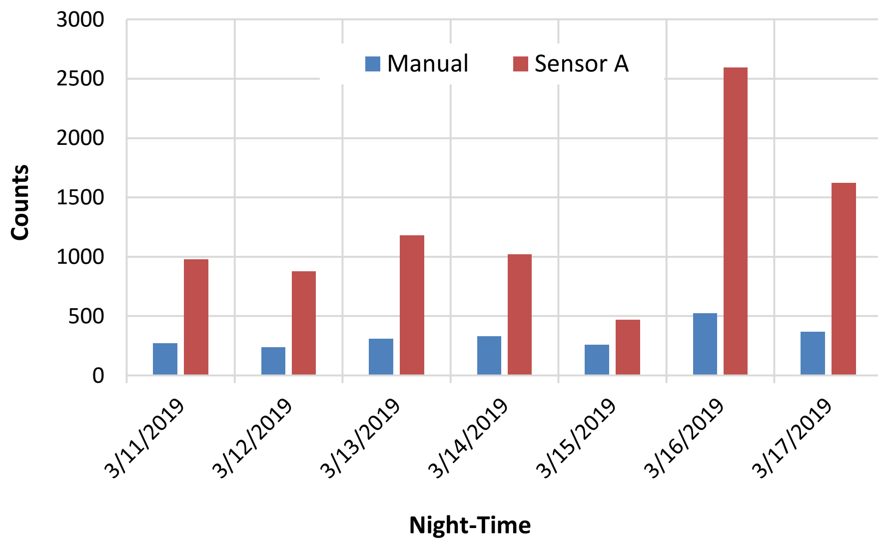


Night-Time	2/27/2019	2/28/2019	3/1/2019	3/2/2019	3/3/2019	3/4/2019	3/5/2019
Manual	87	138	189	207	256	176	87
Sensor A	5	28	21	69	107	76	19

Figure 14. The daily pedestrians' count of LTRC2 from March 11 to March 17

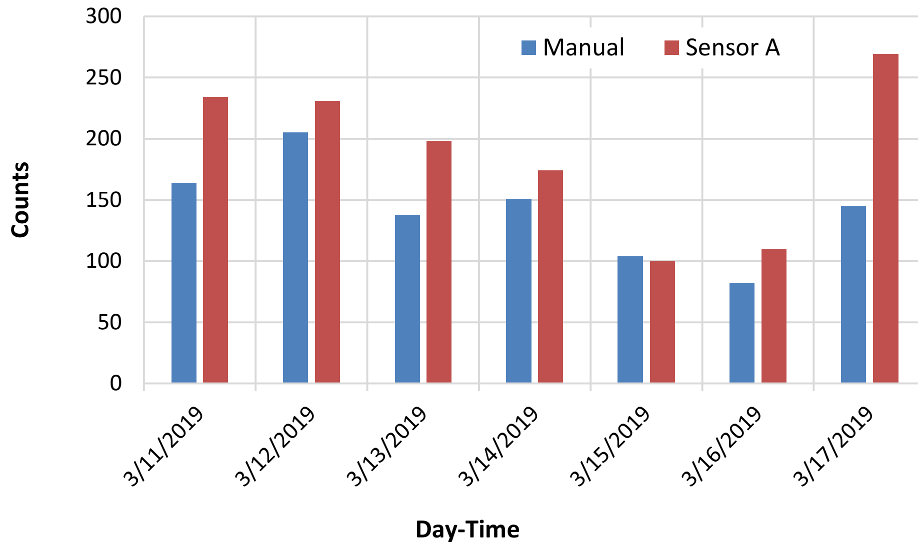


Day-Time	3/11/2019	3/12/2019	3/13/2019	3/14/2019	3/15/2019	3/16/2019	3/17/2019
Manual	891	1035	875	1235	1038	1013	1577
Sensor A	2443	2825	2484	3047	2562	3014	3743

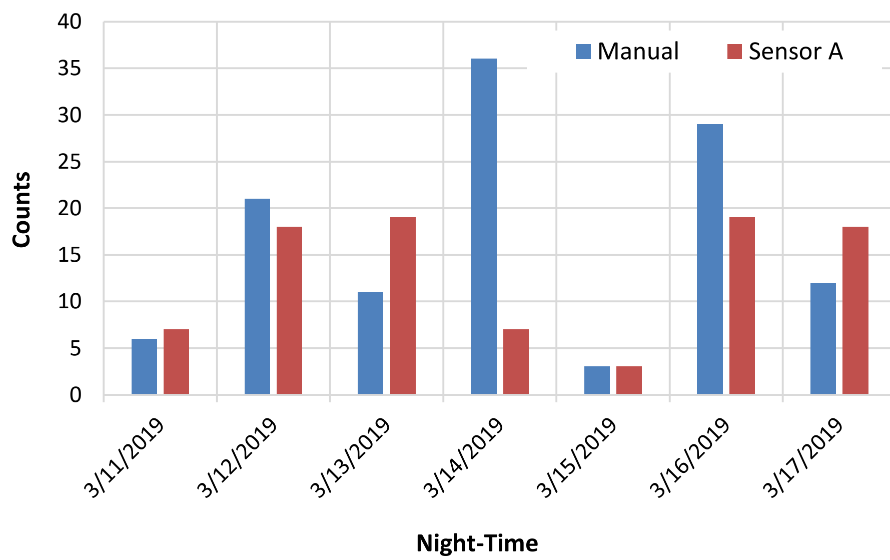


Night-Time	3/11/2019	3/12/2019	3/13/2019	3/14/2019	3/15/2019	3/16/2019	3/17/2019
Manual	272	240	311	331	260	522	366
Sensor A	980	878	1184	1020	468	2596	1622

Figure 15. The daily bicyclists' count of LTRC2 from March 11 to March 17



Day-Time	**3/11/2019**	**3/12/2019**	**3/13/2019**	**3/14/2019**	**3/15/2019**	**3/16/2019**	**3/17/2019**
Manual	164	205	138	151	104	82	145
Sensor A	234	231	198	174	100	110	269

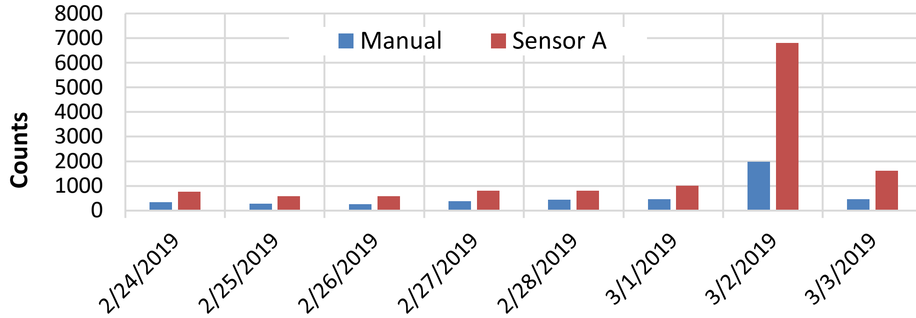


Night-Time	**3/11/2019**	**3/12/2019**	**3/13/2019**	**3/14/2019**	**3/15/2019**	**3/16/2019**	**3/17/2019**
Manual	6	21	11	36	3	29	12
Sensor A	7	18	19	7	3	19	18

Howard Ave & Baronne St. (LTRC3)

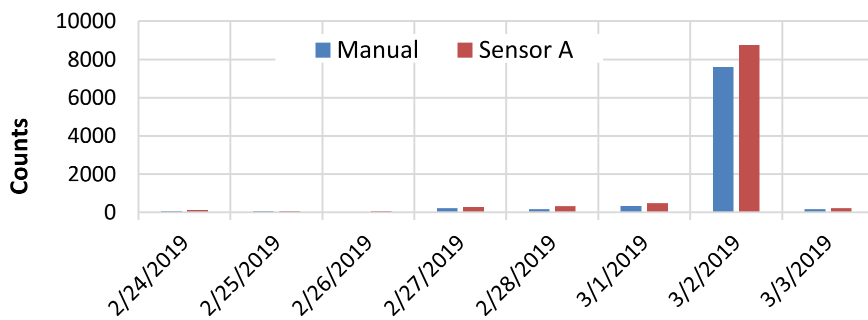
LTRC3 location has a high-traffic pedestrians and bicyclists volume. A video recording camera was mounted with sensor A to record real-time video footage at LTRC3. Three different continuous video data were recorded by the video recording camera. A comparison between the manual and sensor A's counts of the pedestrians and the bicyclists, during the day-time and the night-time of LTRC3 from February 24 to April 13, is seen through Figure 16 to Figure 21. It is noted from the results that sensor A at LTRC3 failed to accurately count both the pedestrians and the bicyclists during the day-time and the night-time period compared to the manual counts.

Figure 16. The daily pedestrians' count of LTRC3 from February 24 to March 3



Day-Time

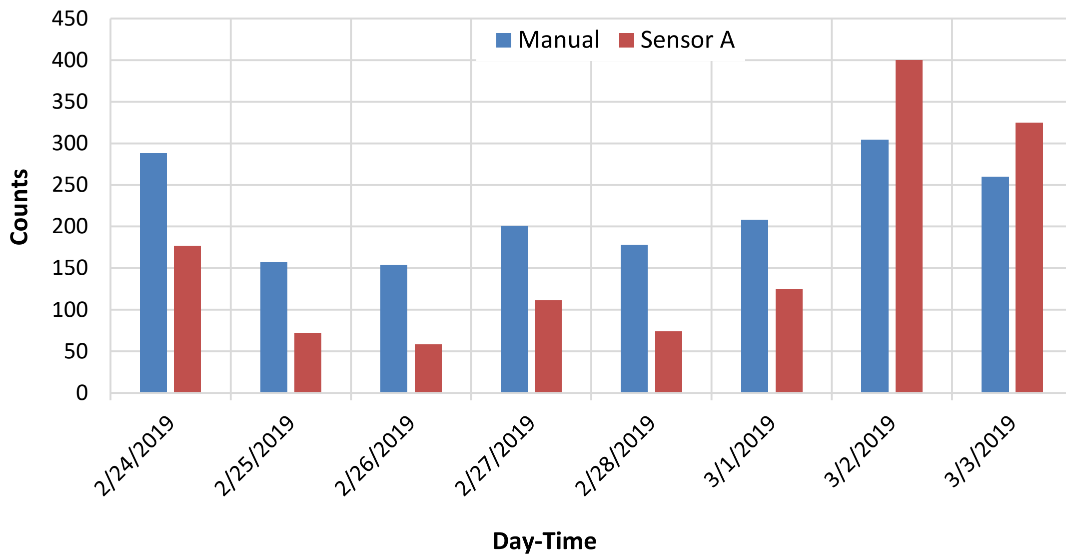
Day-Time	2/24/2019	2/25/2019	2/26/2019	2/27/2019	2/28/2019	3/1/2019	3/2/2019	3/3/2019
Manual	329	263	249	367	416	446	1979	451
Sensor A	759	584	573	781	794	1002	6804	1604



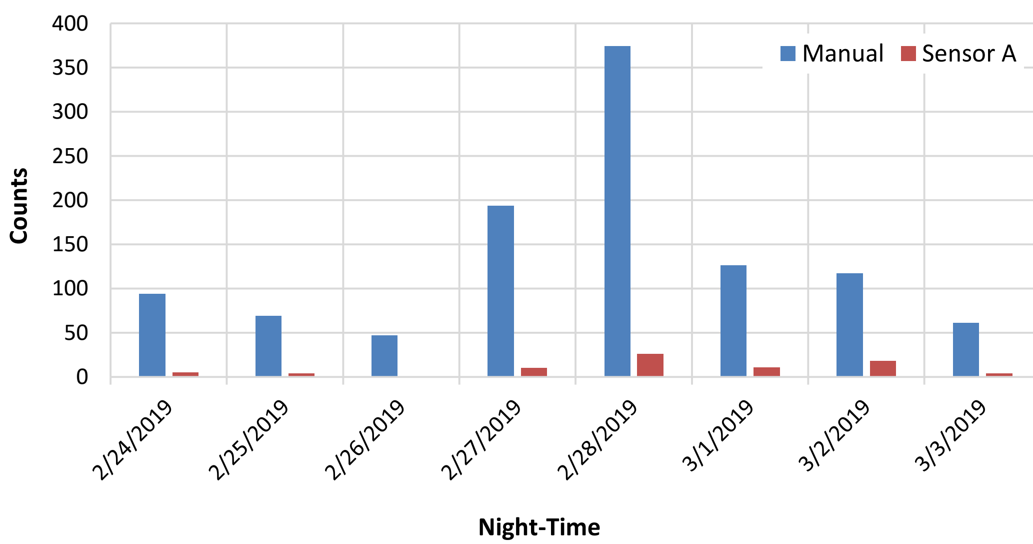
Night-Time

Night-Time	2/24/2019	2/25/2019	2/26/2019	2/27/2019	2/28/2019	3/1/2019	3/2/2019	3/3/2019
Manual	80	70	63	204	155	339	7584	163
Sensor A	123	79	93	288	302	456	8726	210

Figure 17. The daily bicyclists' count of LTRC3 from February 24 to March 3

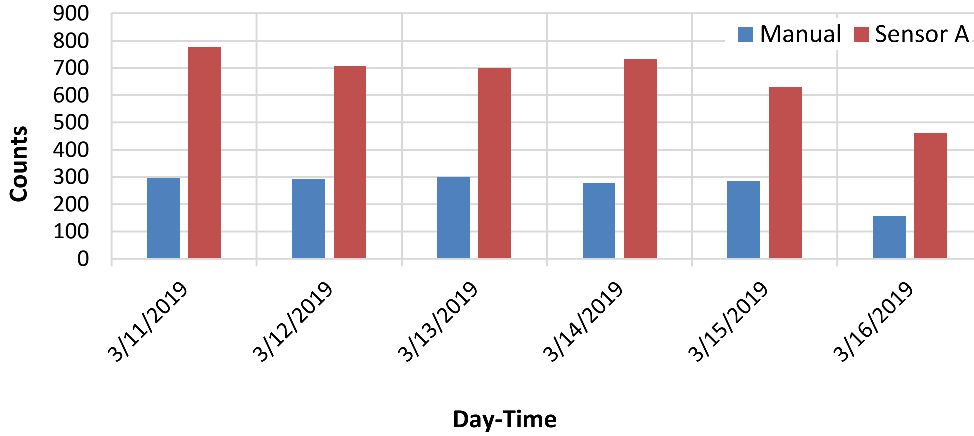


Day-Time	2/24/2019	2/25/2019	2/26/2019	2/27/2019	2/28/2019	3/1/2019	3/2/2019	3/3/2019
Manual	288	157	154	201	178	208	304	260
Sensor A	177	72	58	111	74	125	400	325

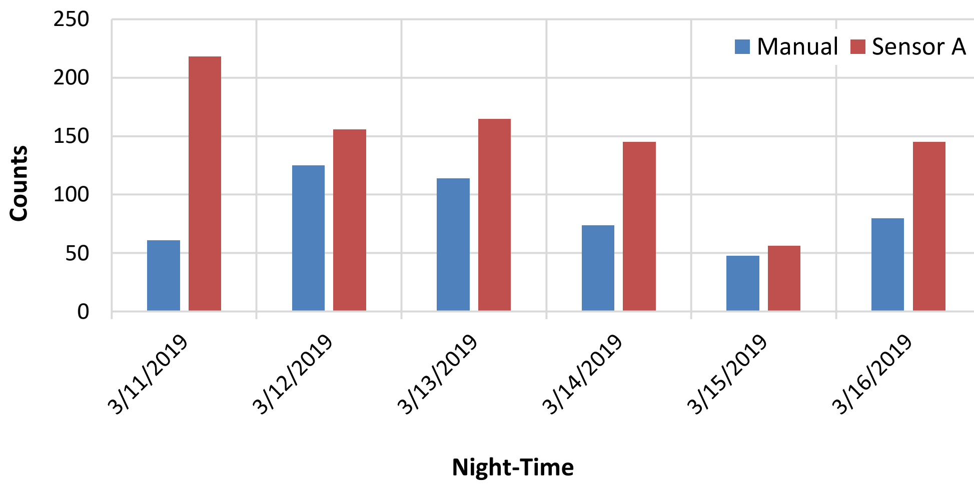


Night-Time	2/24/2019	2/25/2019	2/26/2019	2/27/2019	2/28/2019	3/1/2019	3/2/2019	3/3/2019
Manual	94	69	47	194	374	126	117	61
Sensor A	5	4	1	10	26	11	18	4

Figure 18. The daily pedestrians' count of LTRC3 from March 11 to March 16

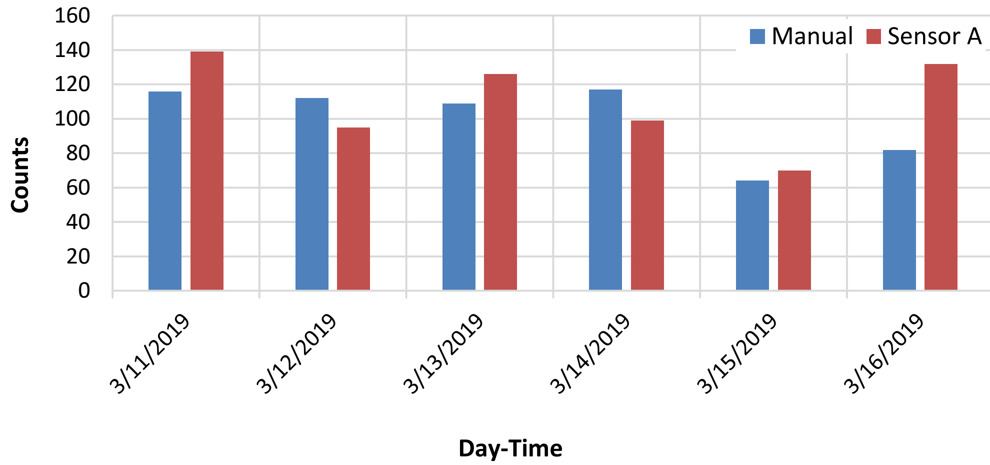


Day-Time	3/11/2019	3/12/2019	3/13/2019	3/14/2019	3/15/2019	3/16/2019
Manual	295	293	299	276	283	158
Sensor A	776	707	698	731	631	462

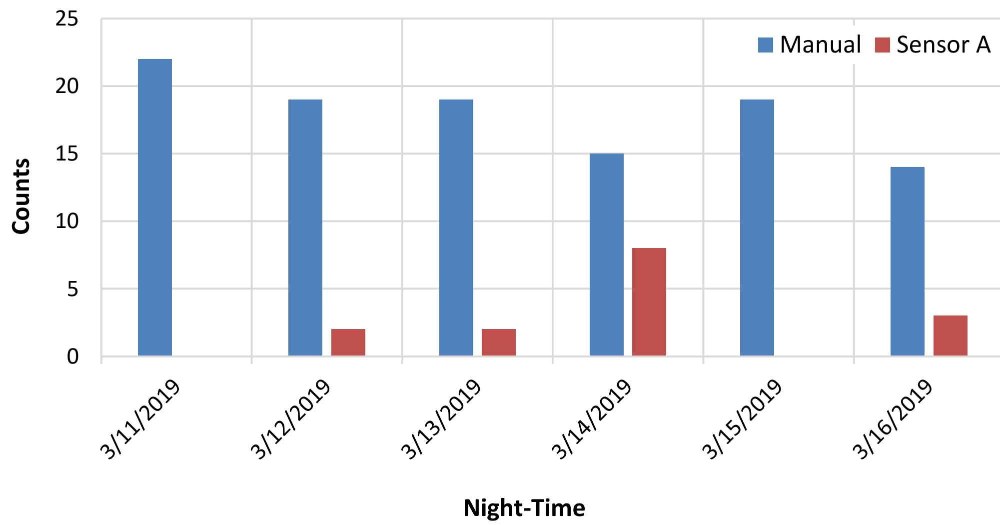


Night-Time	3/11/2019	3/12/2019	3/13/2019	3/14/2019	3/15/2019	3/16/2019
Manual	61	125	114	74	48	80
Sensor A	218	156	165	145	56	145

Figure 19. The daily bicyclists' count of LTRC3 March 11 to March 16

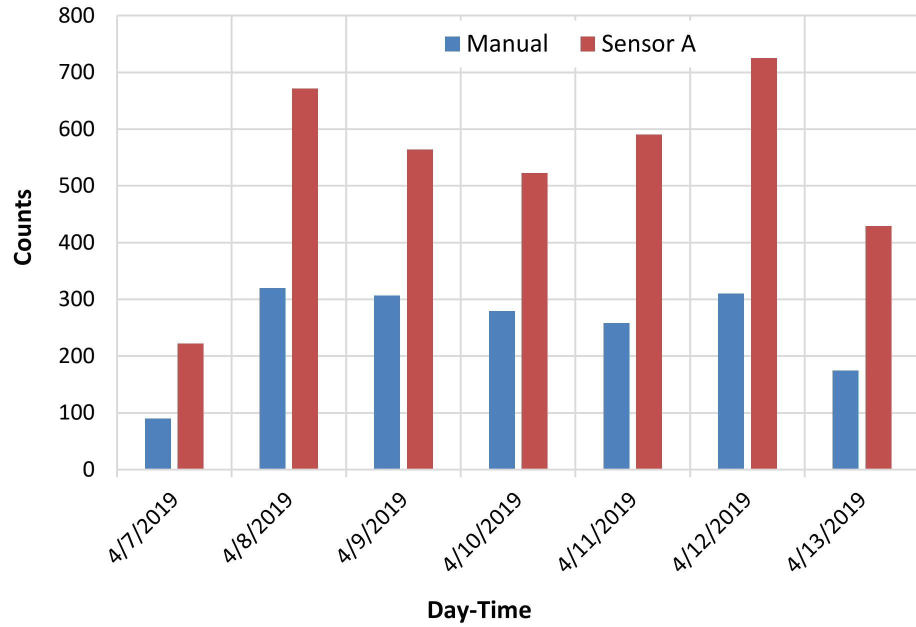


Day-Time	3/11/2019	3/12/2019	3/13/2019	3/14/2019	3/15/2019	3/16/2019
Manual	116	112	109	117	64	82
Sensor A	139	95	126	99	70	132

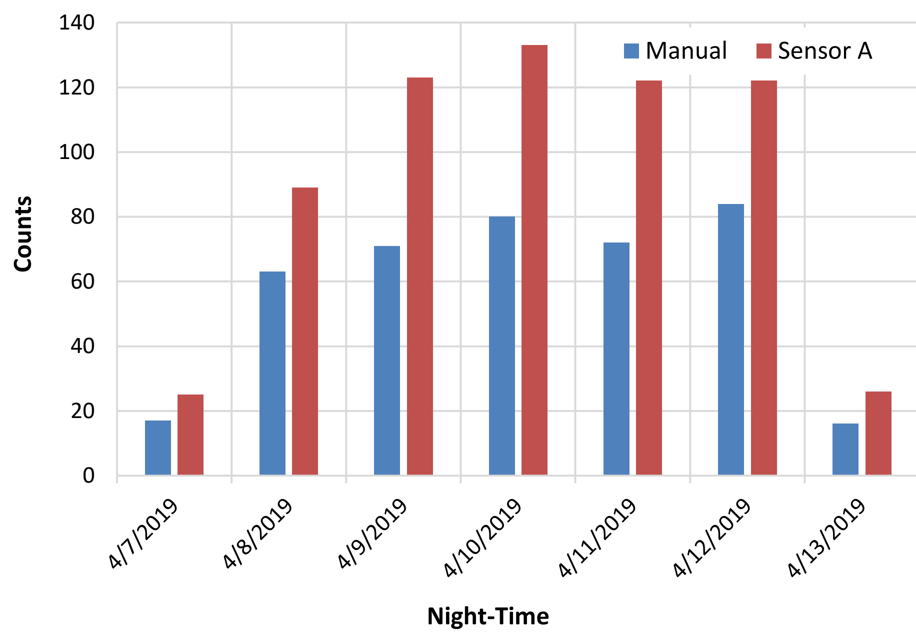


Night-Time	3/11/2019	3/12/2019	3/13/2019	3/14/2019	3/15/2019	3/16/2019
Manual	22	19	19	15	19	14
Sensor A	0	2	2	8	0	3

Figure 20. The daily pedestrians' count of LTRC3 from April 7 to April 13

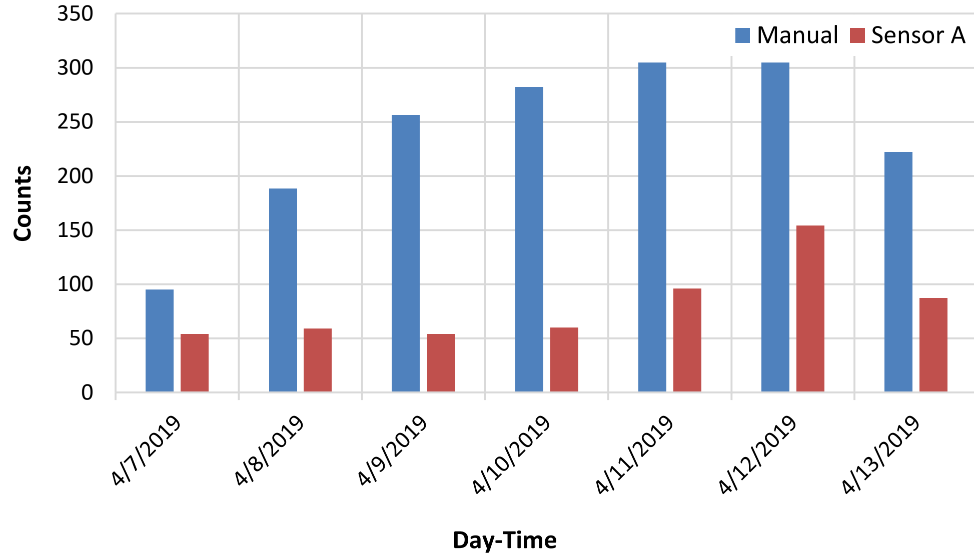


Day-Time	4/7/2019	4/8/2019	4/9/2019	4/10/2019	4/11/2019	4/12/2019	4/13/2019
Manual	90	320	306	279	258	310	174
Sensor A	222	671	564	522	590	725	429

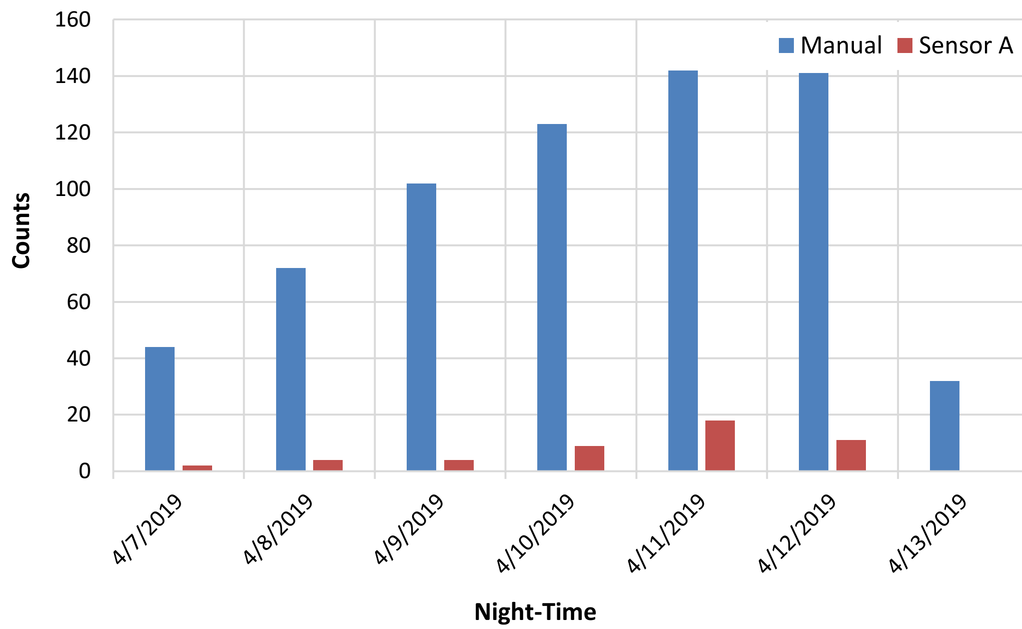


Night-Time	4/7/2019	4/8/2019	4/9/2019	4/10/2019	4/11/2019	4/12/2019	4/13/2019
Manual	17	63	71	80	72	84	16
Sensor A	25	89	123	133	122	122	26

Figure 21. The daily bicyclists' count of LTRC3 from April 7 to April 13



Day-Time	4/7/2019	4/8/2019	4/9/2019	4/10/2019	4/11/2019	4/12/2019	4/13/2019
Manual	95	188	256	282	305	305	222
Sensor A	54	59	54	60	96	154	87



Night-Time	4/7/2019	4/8/2019	4/9/2019	4/10/2019	4/11/2019	4/12/2019	4/13/2019
Manual	44	72	102	123	142	141	32
Sensor A	2	4	4	9	18	11	0

Technical Problems at New Orleans Locations (Sensor A)

The sensor at Esplanade Ave & N Peters St. (LTRC2) was installed on January 15, 2019. It stopped working after two weeks from the installation time due to a technical problem with its lens. There was a leak and rainwater affected the sensor as seen in Figure 22. A replacement sensor was reinstalled on February 20, 2019.

Figure 22. Defective parts of the sensor at LTRC2 location

Sensors A at Baton Rouge Locations

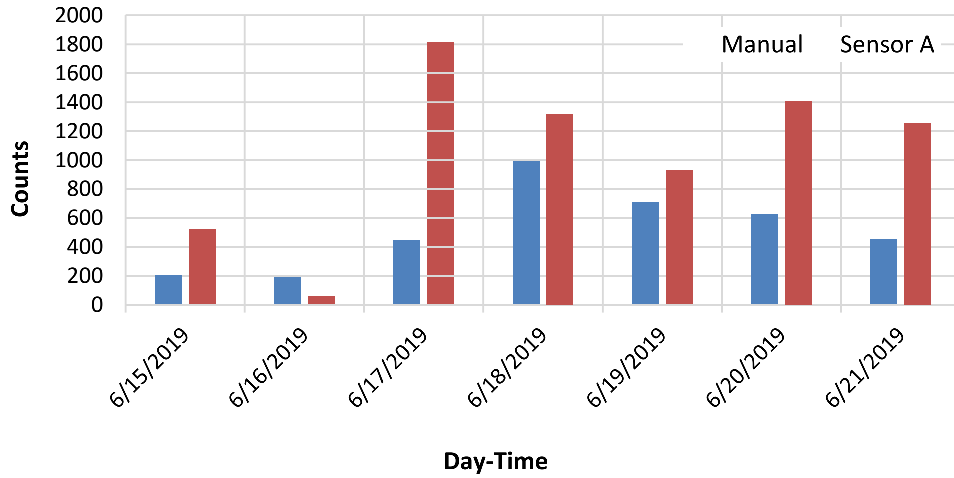
Three kits of sensor A were mounted at three different locations in Baton Rouge. Along with the solar cells, all sensors at Baton Rouge locations were connected to either a signal or a light pole. The City of Baton Rouge did not allow wired connection; this is why solar-cells were used.

The recorded video data at LTRC4, LTRC5, and LTRC6 locations were collected under rain and wind conditions during the period from 6/24/2019 to 6/25/2019; from 7/22/2019 to 7/23/2019 and 7/28/2019; and from 7/30/2019 to 7/31/2019 and 8/2/2019.

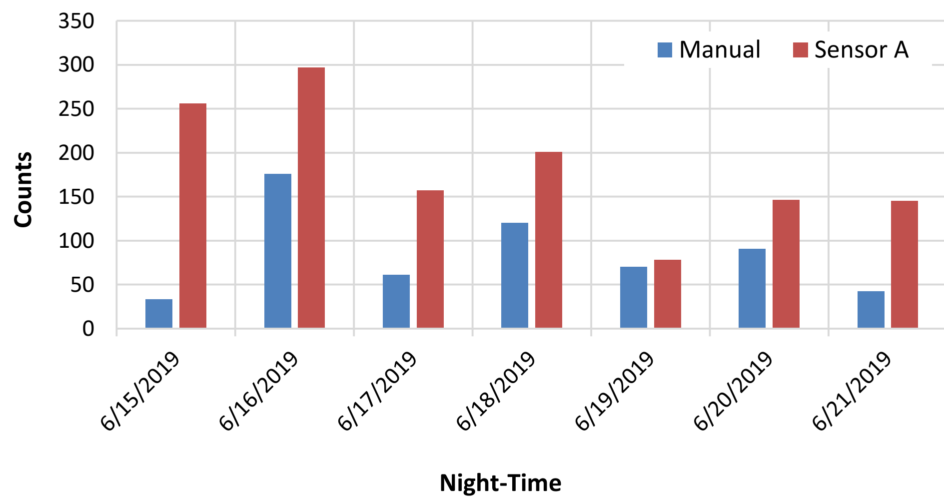
Louisiana State University – LSU (LTRC4)

The LTRC4 location has a high-traffic volume of pedestrians and bicyclists. A video recording camera was mounted with sensor A at LTRC4. The LSU area has a lot of trees that prevented the solar-cell from charging the sensor. Manual charging of the batteries was performed in order to get the needed readings from both sensor A and the recording video camera at LTRC4. Three different continuous video data were recorded by the video recording camera. A comparison between the manual and sensor A's counts of the pedestrians and the bicyclists, during the day-time and the night-time of LTRC4 from June 15 to July 19, is seen through Figure 23 to Figure 28. Sensor A counts failed to match the manual counts in both pedestrians and bicyclists at the LTRC4 location.

Figure 23. The daily pedestrians' count of LTRC4 from June 15 to June 21

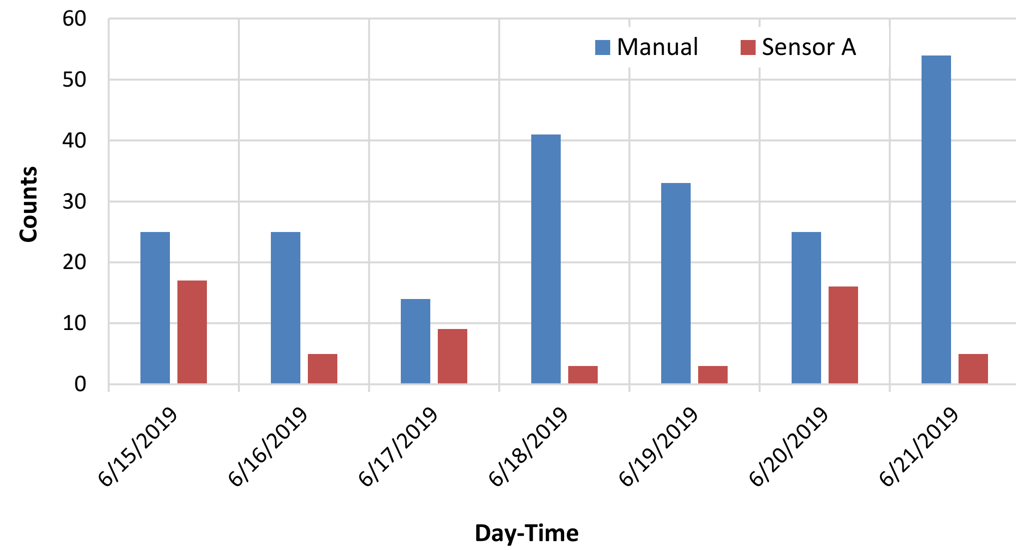


Day-Time	6/15/2019	6/16/2019	6/17/2019	6/18/2019	6/19/2019	6/20/2019	6/21/2019
Manual	207	191	449	991	713	629	453
Sensor A	522	58	1816	1316	934	1411	1258

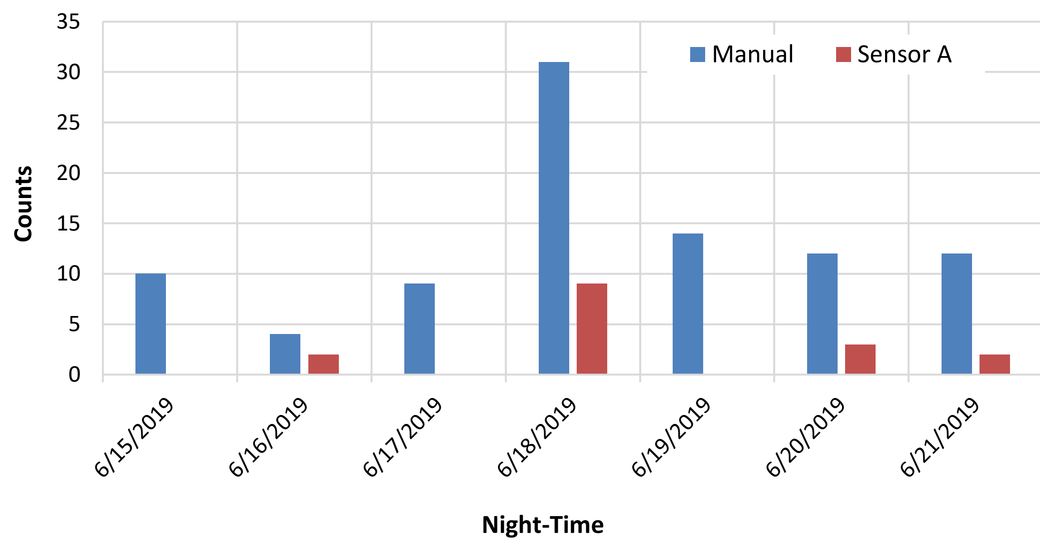


Night-Time	6/15/2019	6/16/2019	6/17/2019	6/18/2019	6/19/2019	6/20/2019	6/21/2019
Manual	33	176	61	120	70	91	42
Sensor A	256	297	157	201	78	146	145

Figure 24. The daily bicyclists' count of LTRC4 from June 15 to June 21

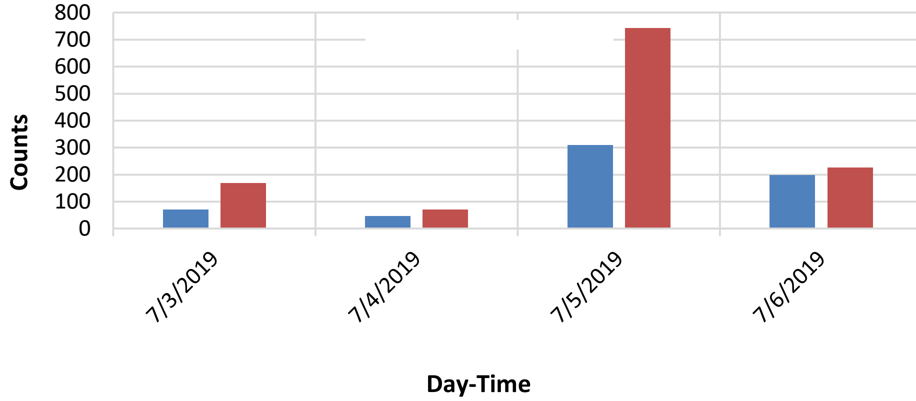


Day-Time	6/15/2019	6/16/2019	6/17/2019	6/18/2019	6/19/2019	6/20/2019	6/21/2019
Manual	25	25	14	41	33	25	54
Sensor A	17	5	9	3	3	16	5

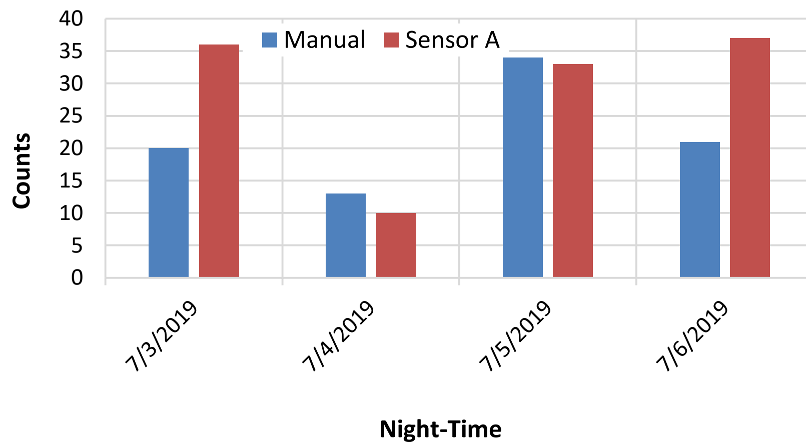


Night-Time	6/15/2019	6/16/2019	6/17/2019	6/18/2019	6/19/2019	6/20/2019	6/21/2019
Manual	10	4	9	31	14	12	12
Sensor A	0	2	0	9	0	3	2

Figure 25. The daily pedestrians' count of LTRC4 from July 3 to July 6

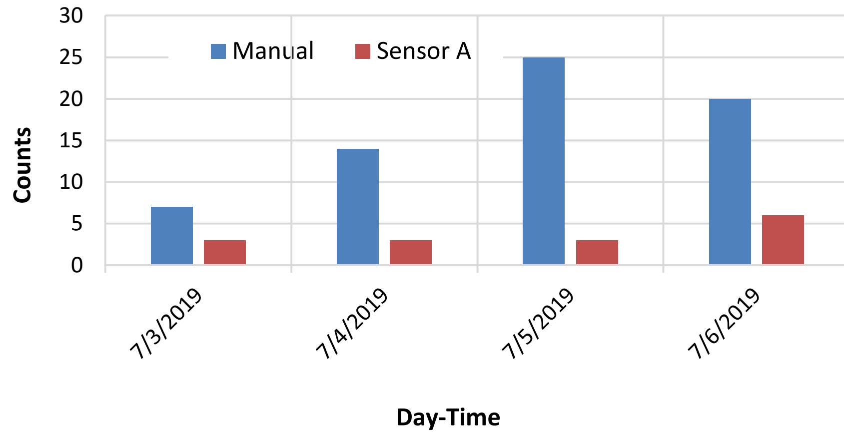


Day-Time	7/3/2019	7/4/2019	7/5/2019	7/6/2019
Manual	70	47	309	199
Sensor A	169	70	742	226

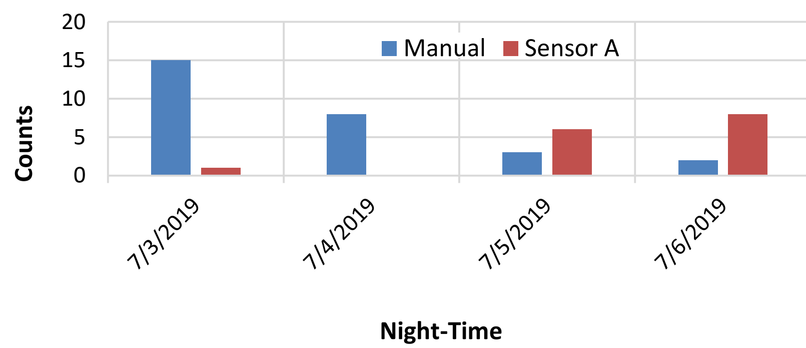


Night-Time	7/3/2019	7/4/2019	7/5/2019	7/6/2019
Manual	20	13	34	21
Sensor A	36	10	33	37

Figure 26. The daily bicyclists' count of LTRC4 from July 3 to July 6

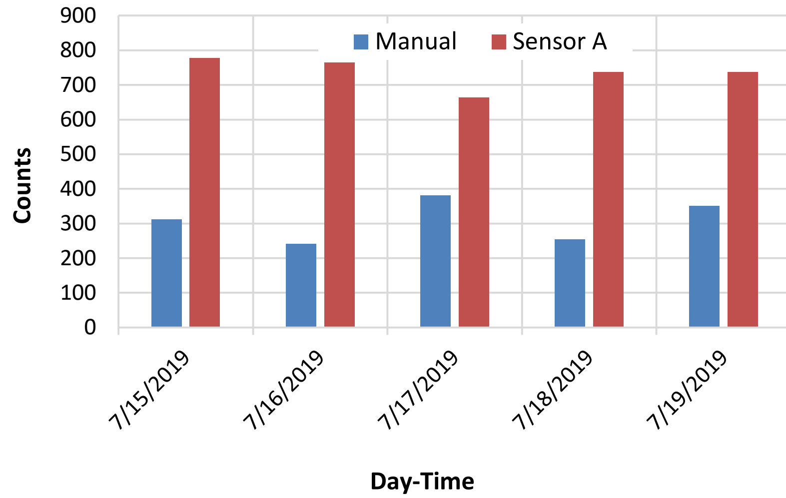


Day-Time	7/3/2019	7/4/2019	7/5/2019	7/6/2019
Manual	7	14	25	20
Sensor A	3	3	3	6

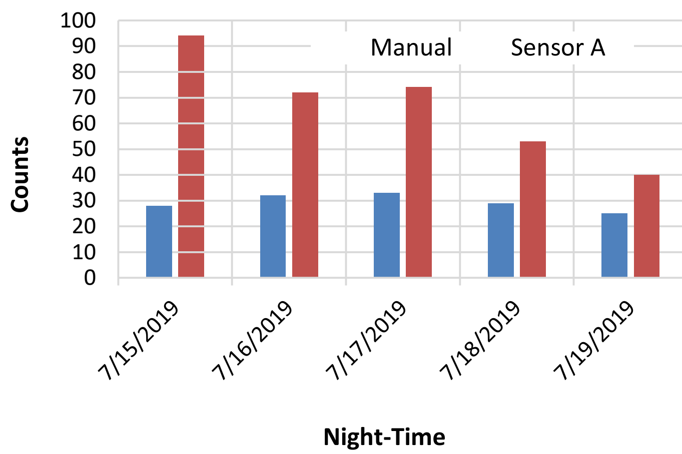


Night-Time	7/3/2019	7/4/2019	7/5/2019	7/6/2019
Manual	15	8	3	2
Sensor A	1	0	6	8

Figure 27. The daily pedestrians' count of LTRC4 from July 15 to July 19

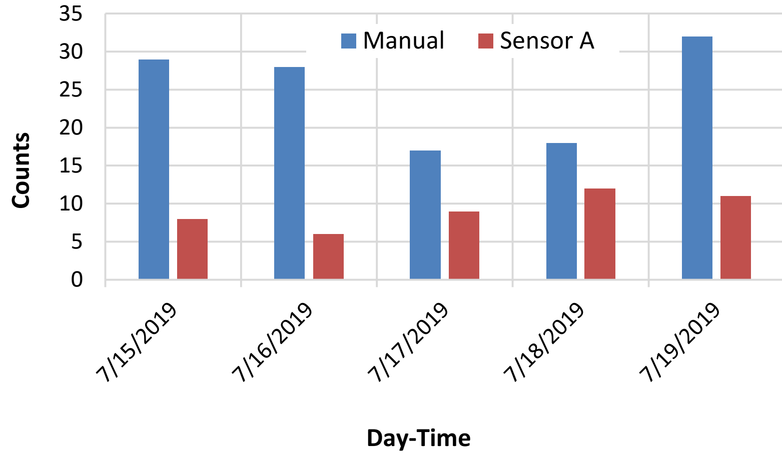


Day-Time	7/15/2019	7/16/2019	7/17/2019	7/18/2019	7/19/2019
Manual	312	241	381	254	350
Sensor A	778	765	663	737	738

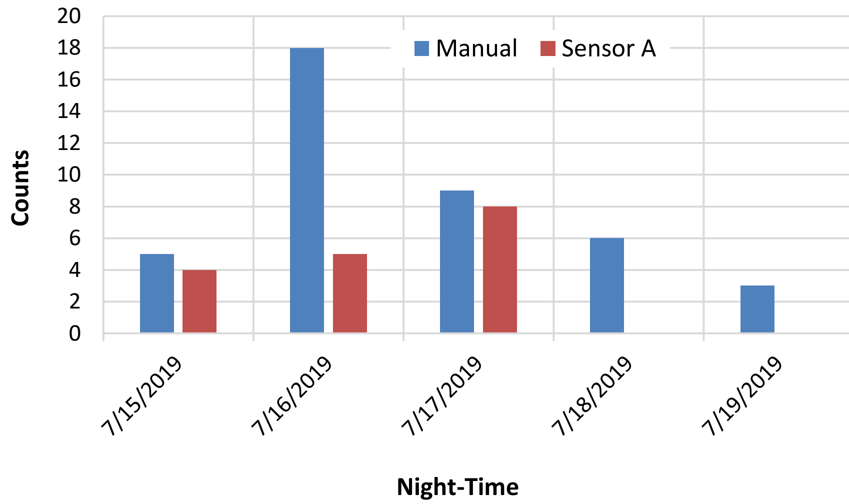


Night-Time	7/15/2019	7/16/2019	7/17/2019	7/18/2019	7/19/2019
Manual	28	32	33	29	25
Sensor A	94	72	74	53	40

Figure 28. The daily bicyclists' count of LTRC4 from July 15 to July 19



Day-Time	7/15/2019	7/16/2019	7/17/2019	7/18/2019	7/19/2019
Manual	29	28	17	18	32
Sensor A	8	6	9	12	11

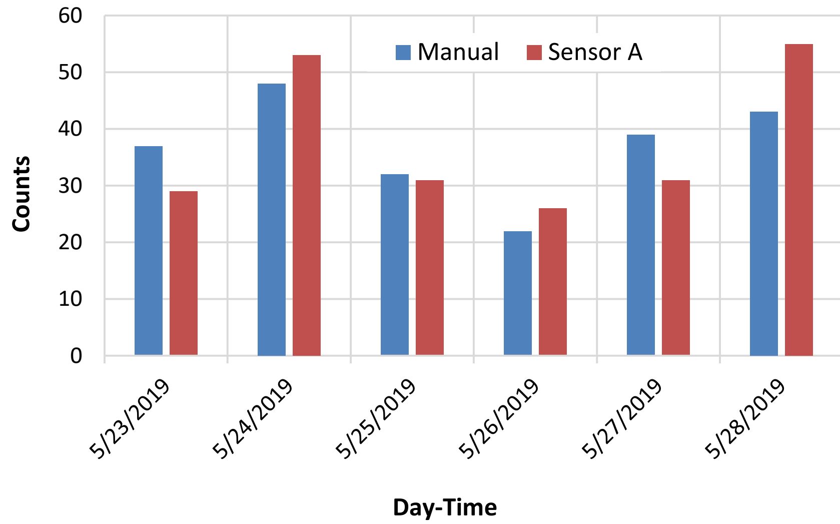


Night-Time	7/15/2019	7/16/2019	7/17/2019	7/18/2019	7/19/2019
Manual	5	18	9	6	3
Sensor A	4	5	8	0	0

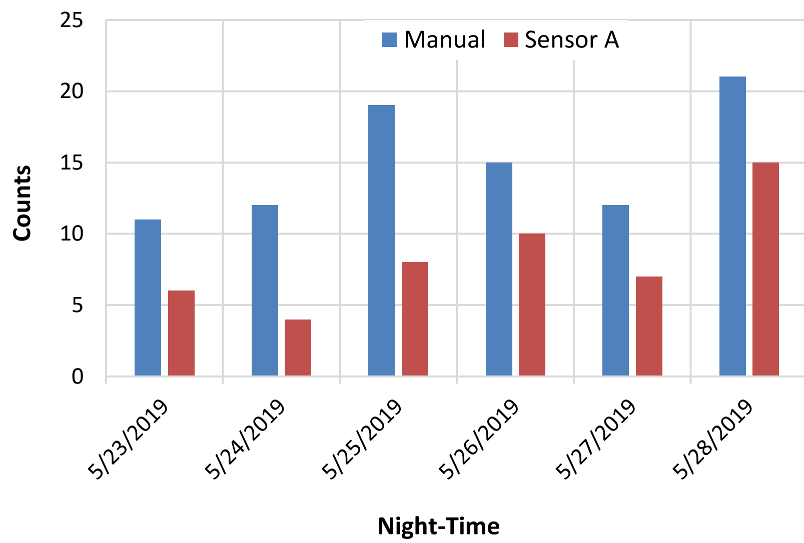
Baton Rouge Community College – BRCC (LTRC5)

The LTRC5 location has a medium-traffic volume of pedestrians and bicyclists. A video recording camera was mounted with sensor A to record real-time video footage required for the performance validation of sensor A at LTRC5. Three different continuous video data were recorded by the video recording camera. A comparison between the manual and sensor A's counts of the pedestrians and the bicyclists during the day-time and the night-time from May 23 to June 26, is seen through Figure 29 to Figure 34. Sensor A's counts and manual counts are very close to each other on most days, however, the overall counts of sensor A failed to exactly match the manual counts.

Figure 29. The daily pedestrians' count of LTRC5 from May 23 to May 28

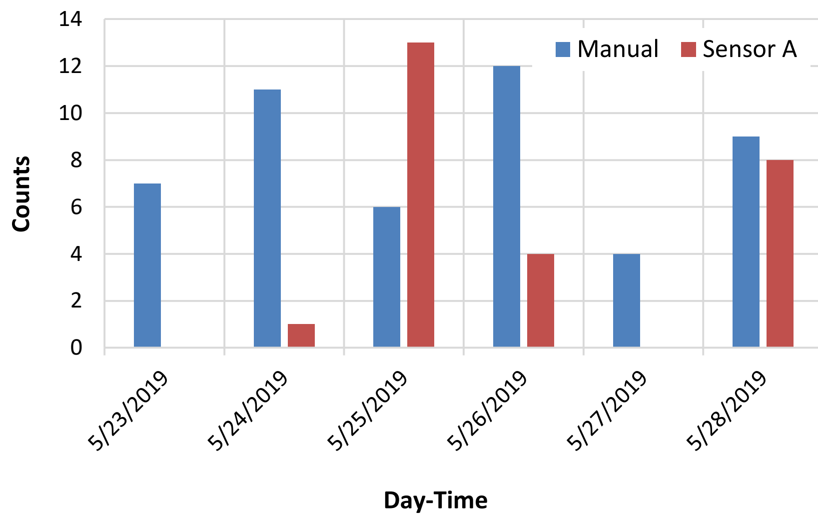


Day-Time	5/23/2019	5/24/2019	5/25/2019	5/26/2019	5/27/2019	5/28/2019
Manual	37	48	32	22	39	43
Sensor A	29	53	31	26	31	55

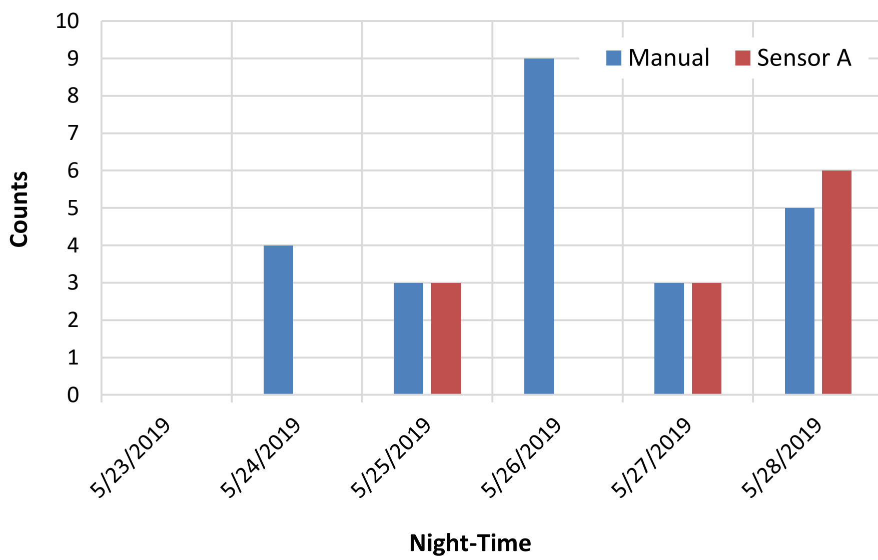


Night-Time	5/23/2019	5/24/2019	5/25/2019	5/26/2019	5/27/2019	5/28/2019
Manual	11	12	19	15	12	21
Sensor A	6	4	8	10	7	15

Figure 30. The daily bicyclists' count of LTRC5 from May 23 to May 28

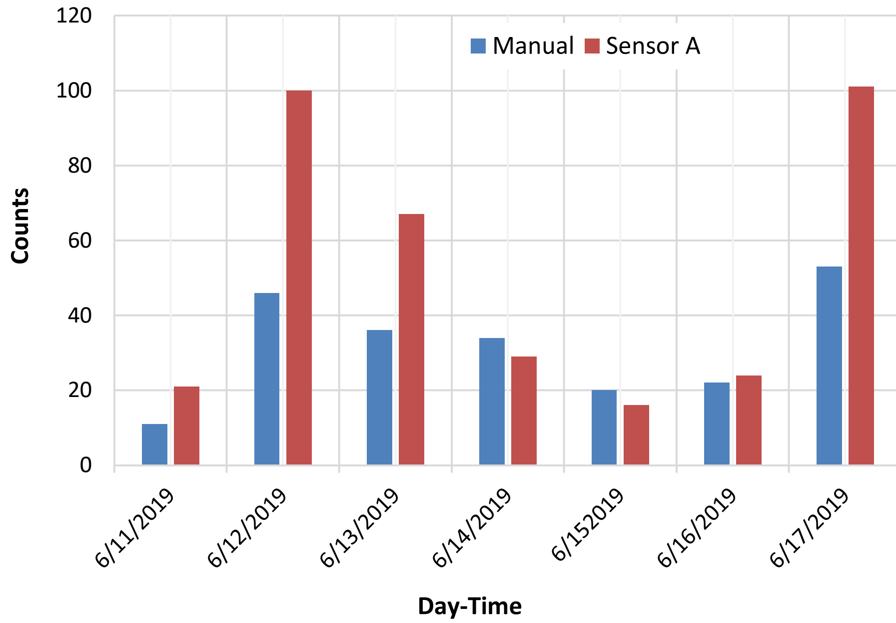


Day-Time	5/23/2019	5/24/2019	5/25/2019	5/26/2019	5/27/2019	5/28/2019
Manual	7	11	6	12	4	9
Sensor A	0	1	13	4	0	8

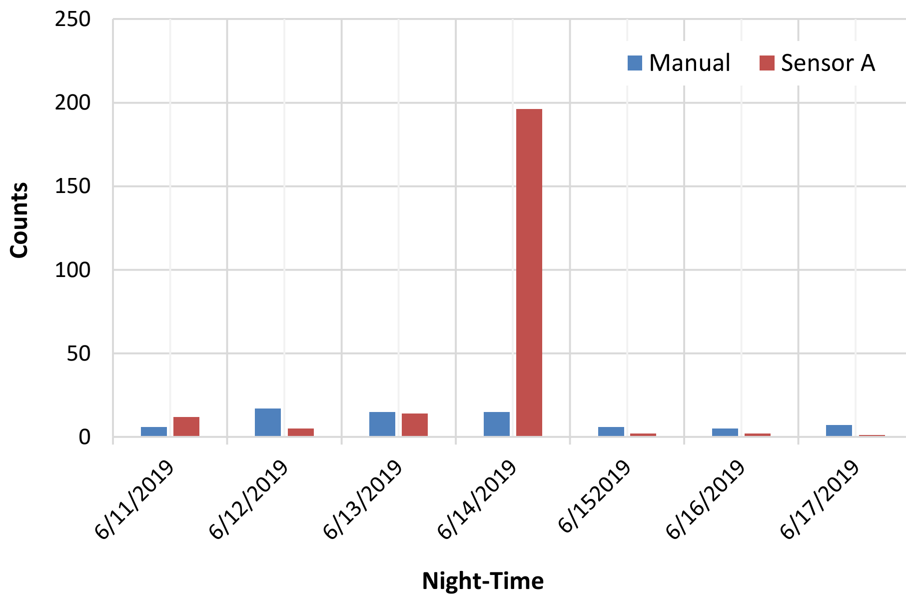


Night-Time	5/23/2019	5/24/2019	5/25/2019	5/26/2019	5/27/2019	5/28/2019
Manual	0	4	3	9	3	5
Sensor A	0	0	3	0	3	6

Figure 31. The daily pedestrians' count of LTRC5 from June 11 to June 17

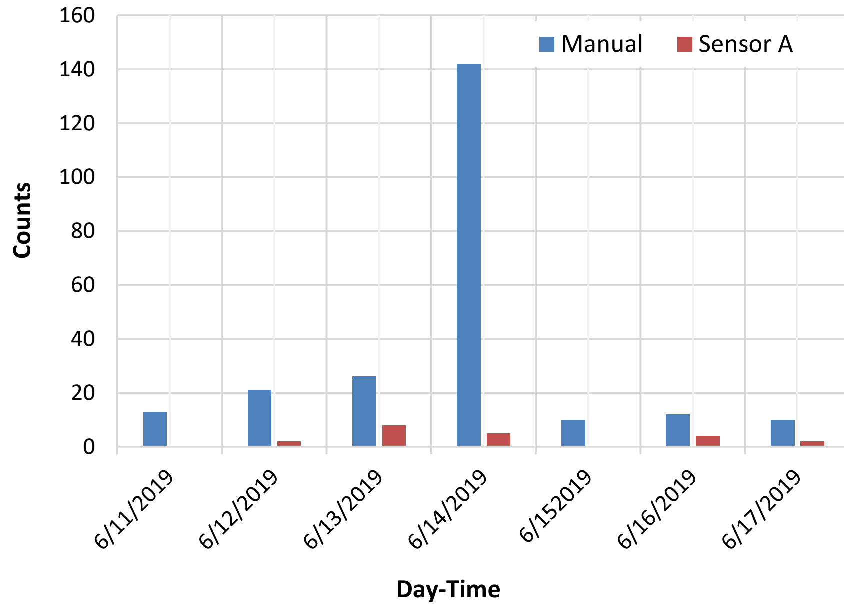


Day-Time	6/11/2019	6/12/2019	6/13/2019	6/14/2019	6/152019	6/16/2019	6/17/2019
Manual	11	46	36	34	20	22	53
Sensor A	21	100	67	29	16	24	101

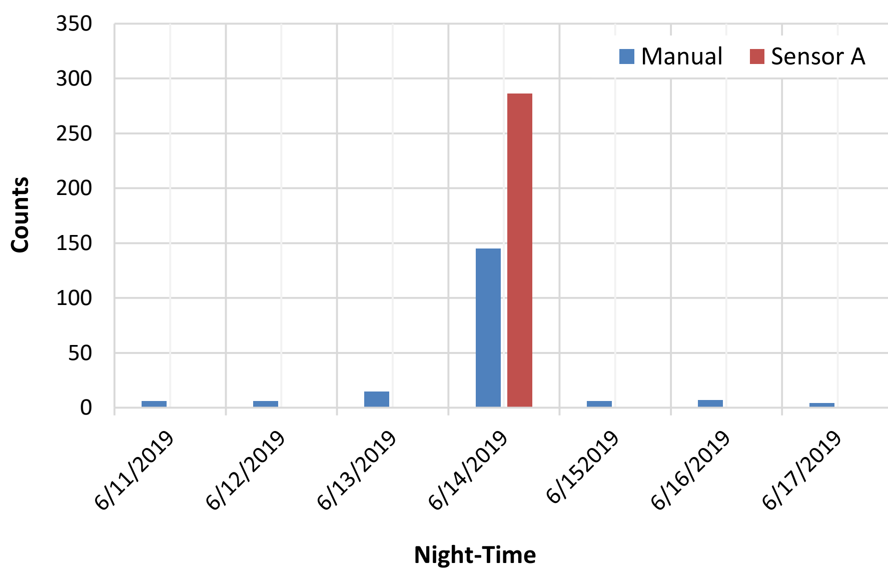


Night-Time	6/11/2019	6/12/2019	6/13/2019	6/14/2019	6/152019	6/16/2019	6/17/2019
Manual	6	17	15	15	6	5	7
Sensor A	12	5	14	196	2	2	1

Figure 32. The daily bicyclists' count of LTRC5 from June 11 to June 17

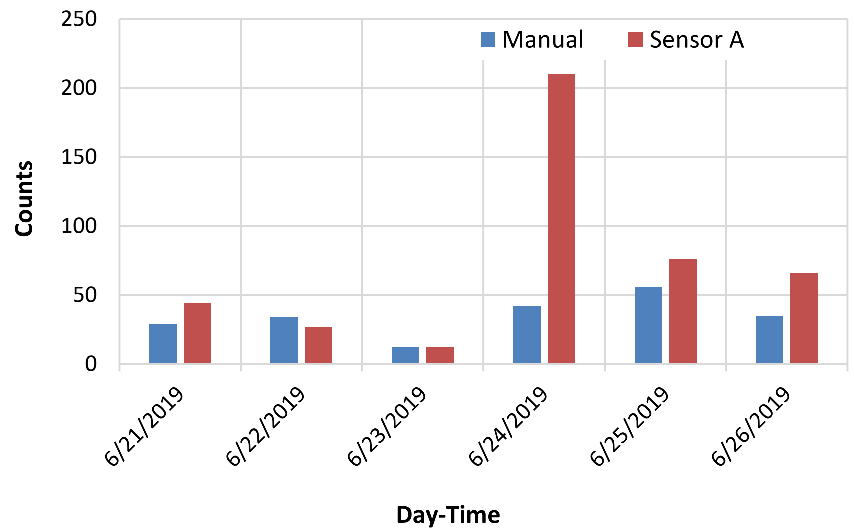


Day-Time	6/11/2019	6/12/2019	6/13/2019	6/14/2019	6/152019	6/16/2019	6/17/2019
Manual	13	21	26	142	10	12	10
Sensor A	0	2	8	5	0	4	2

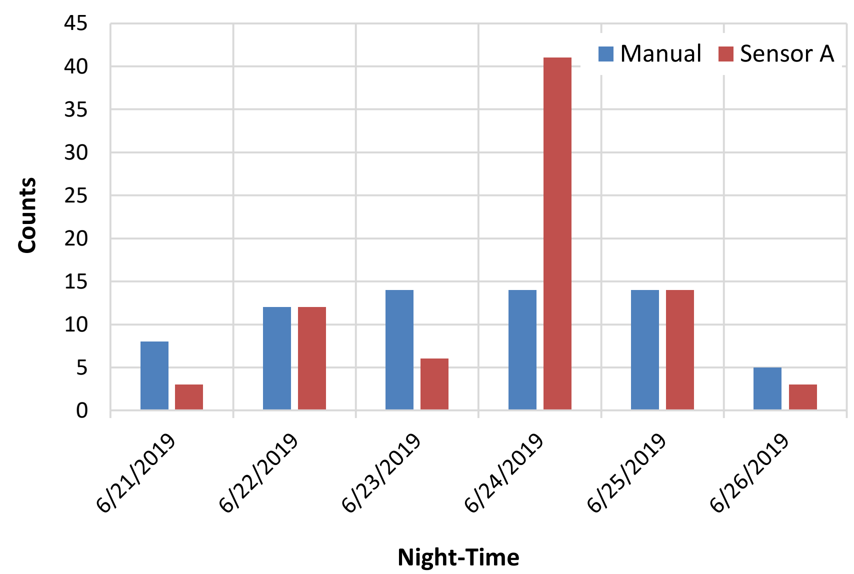


Night-Time	6/11/2019	6/12/2019	6/13/2019	6/14/2019	6/152019	6/16/2019	6/17/2019
Manual	6	6	15	145	6	7	4
Sensor A	1	0	0	286	0	0	0

Figure 33. The daily pedestrians' count of LTRC5 from June 21 to June 26

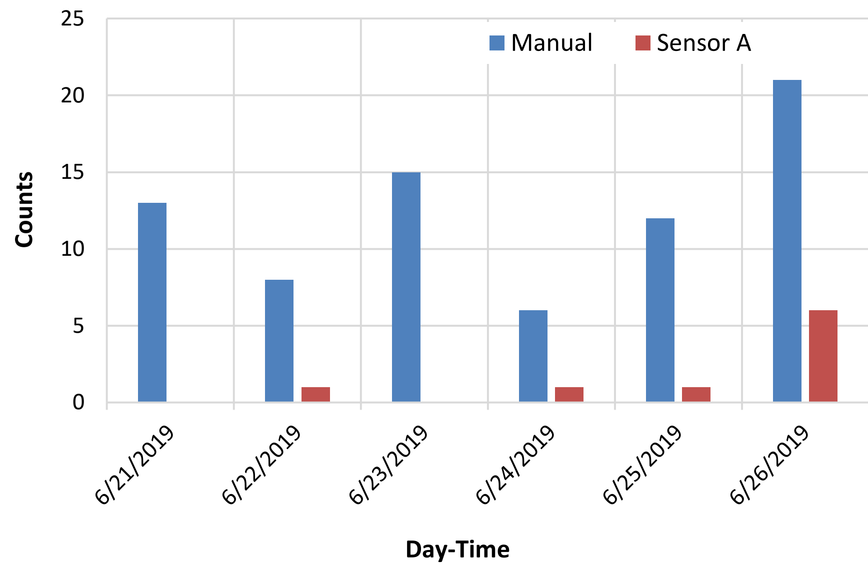


Day-Time	6/21/2019	6/22/2019	6/23/2019	6/24/2019	6/25/2019	6/26/2019
Manual	29	34	12	42	56	35
Sensor A	44	27	12	210	76	66

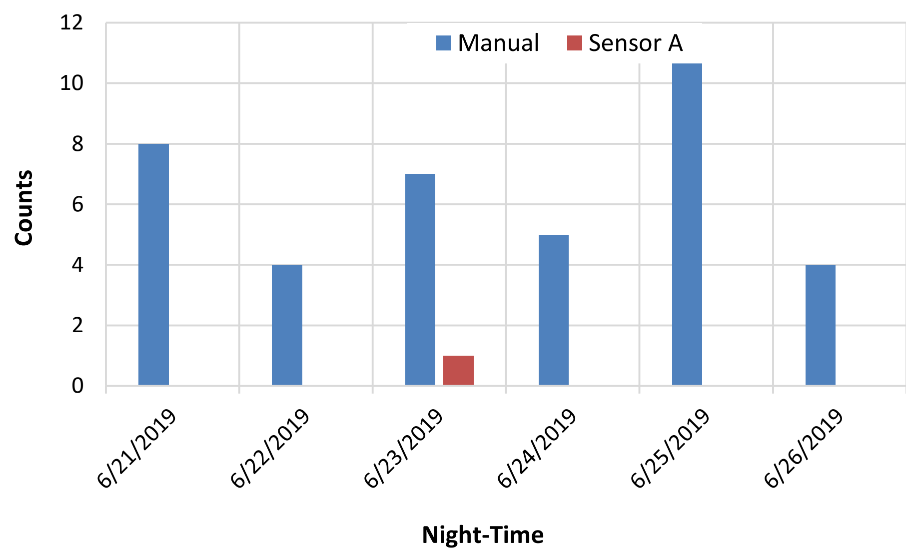


Night-Time	6/21/2019	6/22/2019	6/23/2019	6/24/2019	6/25/2019	6/26/2019
Manual	8	12	14	14	14	5
Sensor A	3	12	6	41	14	3

Figure 34. The daily bicyclists' count of LTRC5 from June 21 to June 26



Day-Time	6/21/2019	6/22/2019	6/23/2019	6/24/2019	6/25/2019	6/26/2019
Manual	13	8	15	6	12	21
Sensor A	0	1	0	1	1	6

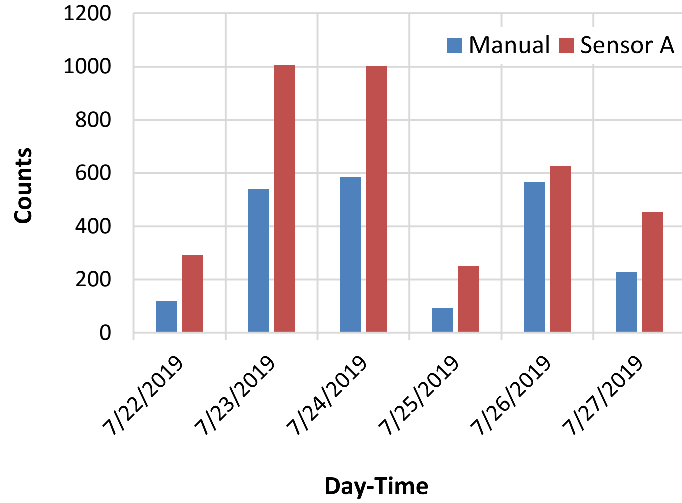


Night-Time	6/21/2019	6/22/2019	6/23/2019	6/24/2019	6/25/2019	6/26/2019
Manual	8	4	7	5	11	4
Sensor A	0	0	1	0	0	0

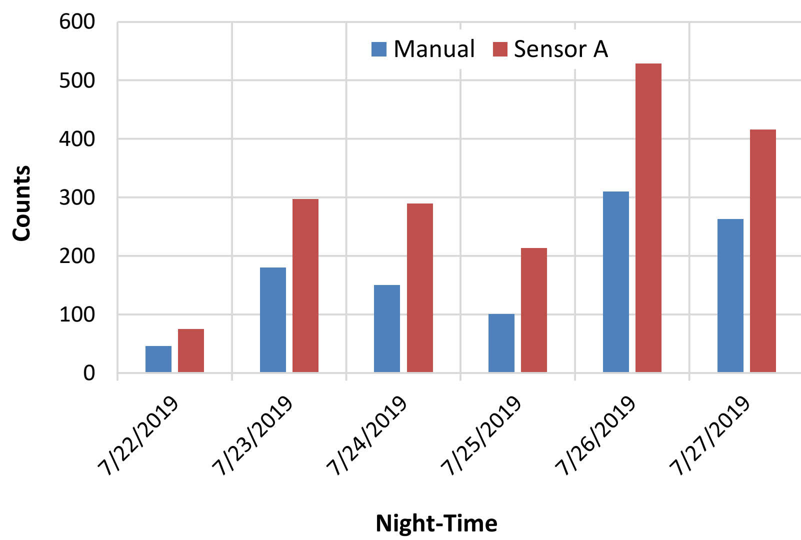
City Plaza (LTRC6)

The LTRC6 location has a medium-traffic volume of pedestrians and bicyclists. Three different continuous video data were recorded by a video recording camera that is mounted to cover the same coverage area of sensor A. A comparison between the manual and sensor A's counts of the pedestrians and the bicyclists during the day-time and the night-time from July 22 to August 6, is seen through Figure 35 to Figure 40. It is noted from the figures that the overall counts of sensor A failed to match the manual counts at the LTRC6 location.

Figure 35. The daily pedestrians' count of LTRC6 from July 22 to July 27

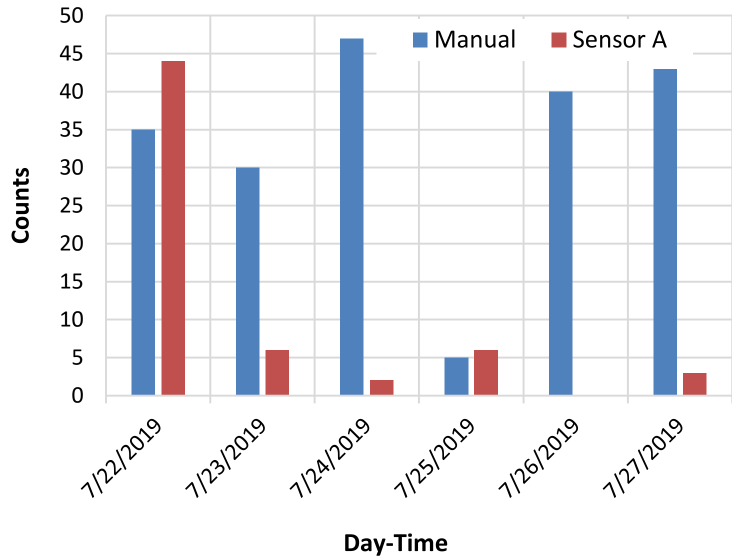


Day-Time	7/22/2019	7/23/2019	7/24/2019	7/25/2019	7/26/2019	7/27/2019
Manual	118	539	584	92	566	227
Sensor A	293	1004	1003	250	625	453

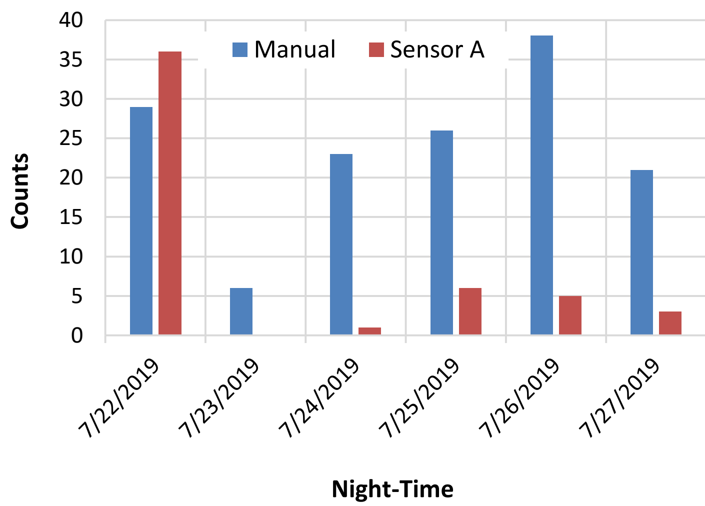


Night-Time	7/22/2019	7/23/2019	7/24/2019	7/25/2019	7/26/2019	7/27/2019
Manual	46	180	150	100	310	263
Sensor A	75	297	289	213	528	416

Figure 36. The daily bicyclists' count of LTRC6 from July 22 to July 27

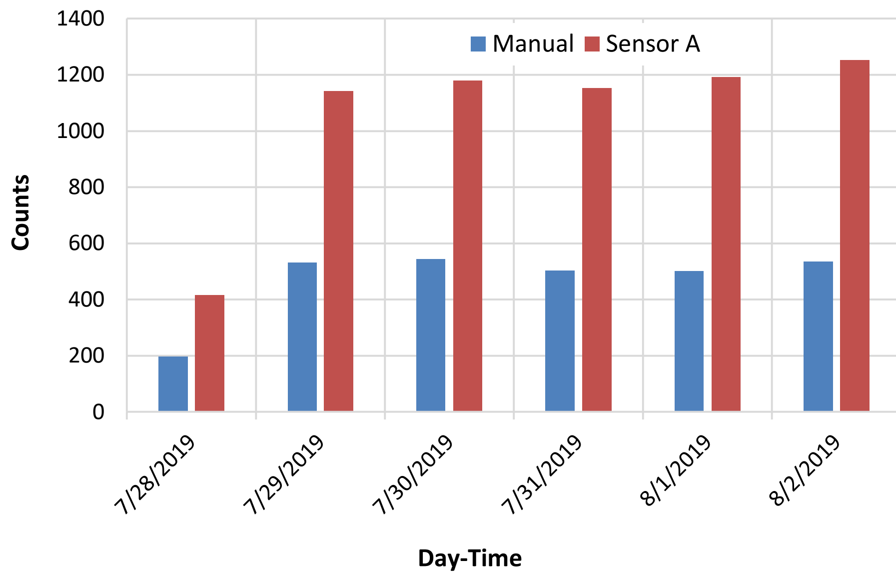


Day-Time	7/22/2019	7/23/2019	7/24/2019	7/25/2019	7/26/2019	7/27/2019
Manual	35	30	47	5	40	43
Sensor A	44	6	2	6	0	3

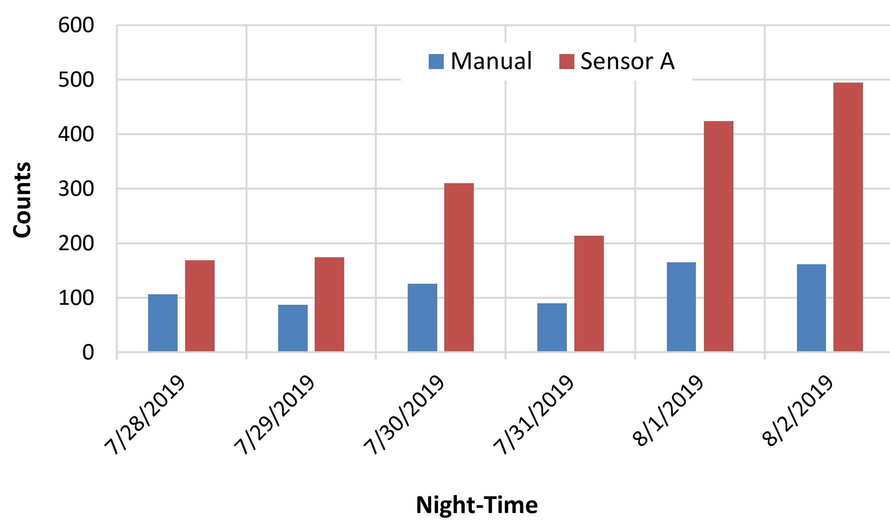


Night-Time	7/22/2019	7/23/2019	7/24/2019	7/25/2019	7/26/2019	7/27/2019
Manual	29	6	23	26	38	21
Sensor A	36	0	1	6	5	3

Figure 37. The daily pedestrians' count of LTRC6 from July 28 to August 2

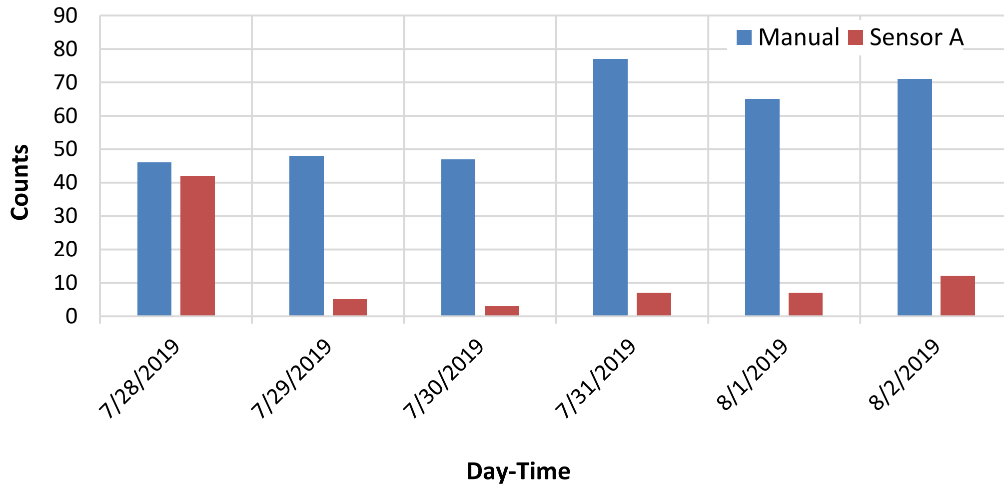


Day-Time	7/28/2019	7/29/2019	7/30/2019	7/31/2019	8/1/2019	8/2/2019
Manual	197	533	544	504	502	536
Sensor A	416	1143	1180	1153	1192	1253

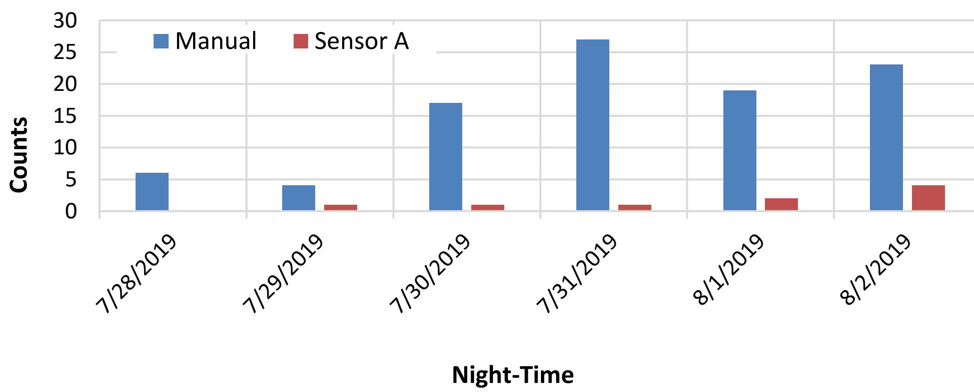


Night-Time	7/28/2019	7/29/2019	7/30/2019	7/31/2019	8/1/2019	8/2/2019
Manual	106	86	125	90	165	161
Sensor A	168	174	310	214	424	495

Figure 38. The daily bicyclists' count of LTRC6 from July 28 to August 2

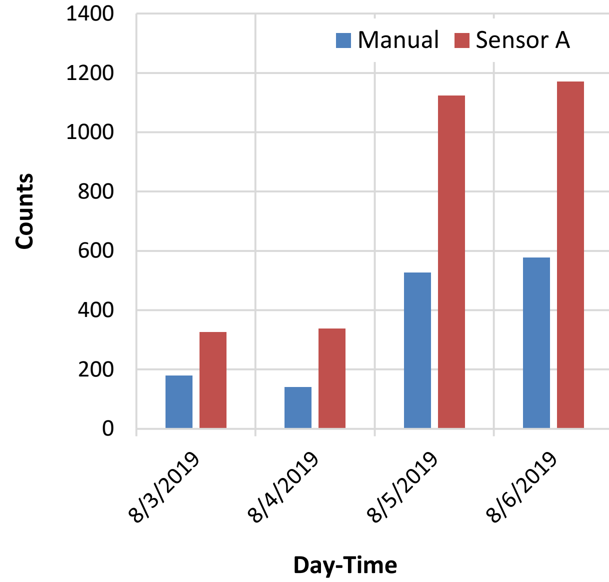


Day-Time	7/28/2019	7/29/2019	7/30/2019	7/31/2019	8/1/2019	8/2/2019
Manual	46	48	47	77	65	71
Sensor A	42	5	3	7	7	12

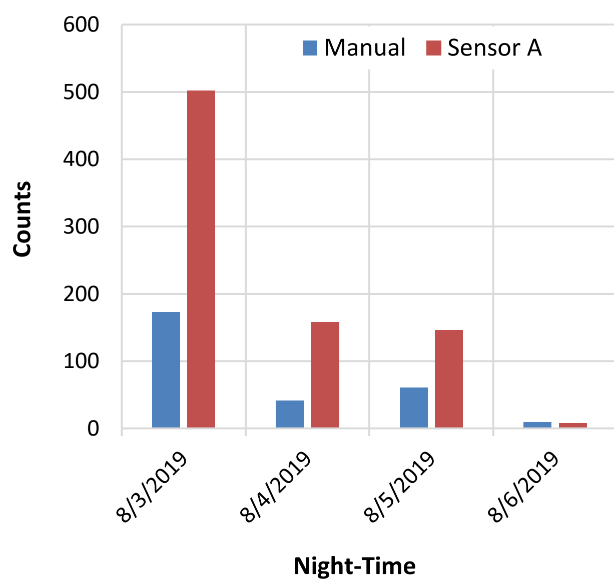


Night-Time	7/28/2019	7/29/2019	7/30/2019	7/31/2019	8/1/2019	8/2/2019
Manual	6	4	17	27	19	23
Sensor A	0	1	1	1	2	4

Figure 39. The daily pedestrians' count of LTRC6 from August 3 to August 6

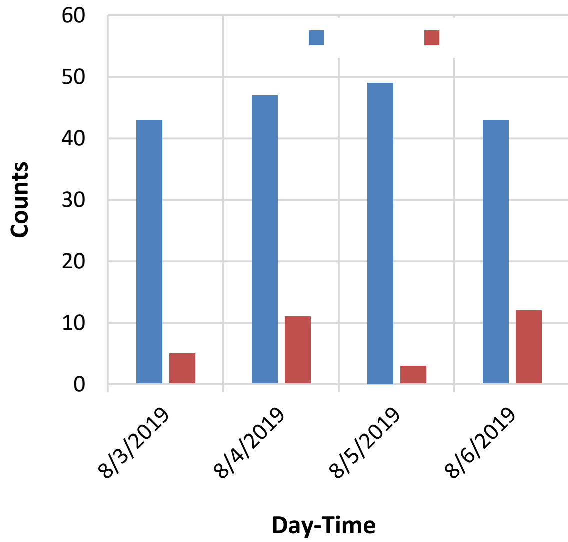


Day-Time	8/3/2019	8/4/2019	8/5/2019	8/6/2019
Manual	179	141	526	577
Sensor A	325	338	1123	1171

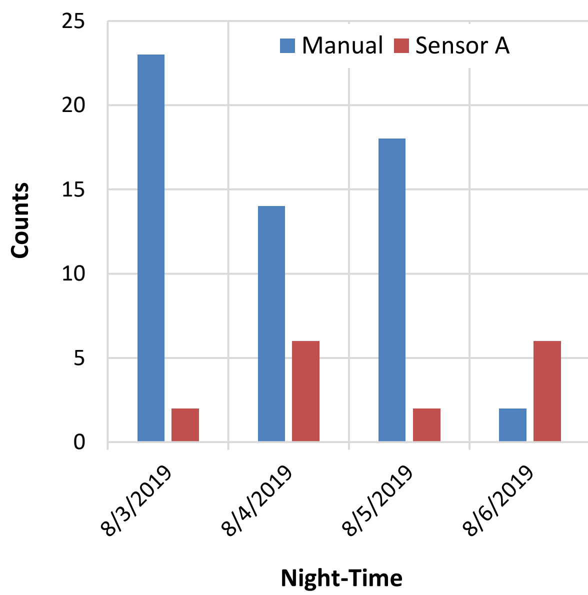


Night-Time	8/3/2019	8/4/2019	8/5/2019	8/6/2019
Manual	173	41	61	9
Sensor A	502	158	146	8

Figure 40. The daily bicyclists' count of LTRC6 from August 3 to August 6



Day-Time	8/3/2019	8/4/2019	8/5/2019	8/6/2019
Manual	43	47	49	43
Sensor A	5	11	3	12



Night-Time	8/3/2019	8/4/2019	8/5/2019	8/6/2019
Manual	23	14	18	2
Sensor A	2	6	2	6

Technical Problems in Baton Rouge Locations

The main problem encountered at Baton Rouge locations was getting the required permissions from city officials to mount the sensors. Structural analysis for the selected poles at Baton Rouge and the "no wired connections" were restrictions to mount the sensors at Baton Rouge locations. Additionally, removing the solar-cells and reinstalling them due to storms, heavy rains, and winds was another restriction that caused a delay in the data collection process and caused an additional cost for installing and reinstalling the solar cells at Baton Rouge locations. Finally, the LSU area has many trees that prevent the solar-cells from charging the batteries of the sensor. To avoid this problem, batteries were manually replaced several times to get the readings from the sensor.

Absolute Percentage of Error (APE)

Table 2 and Table 3 show a comparison of the calculated APE of the pedestrians and the bicyclists' counts (sensor A and manual counts) for all six locations at New Orleans and Baton Rouge. The APE is calculated for each location during either the day-time or the night-time for all the collected data for that location. The APE of all the collected data for one location is represented with median, mean, maximum (max), and minimum (min). The results of the six locations in New Orleans and Baton Rouge are presented in the last row of Table 2 and Table 3.

Table 2 shows that the overall total observations median and mean APE of the pedestrians during the day-time are 119.72% and 119.15% and during the night-time are 69.10% and 111.90%, respectively. Table 3 shows that the overall observations median and mean APE of the bicyclists during the day-time are 69.62% and 80.03% and during the night-time are 89.47% and 80.15%, respectively. The overall max and the min APE of sensor A for pedestrians and bicyclists are shown at the bottom of Table 2 and Table 3. From the APEs shown in Table 2 and Table 3, researchers conclude that sensor A failed to accurately count the pedestrians and bicyclists in the six selected locations compared to the manual counts and under different conditions (weather, time of day, traffic volume, and density of pedestrians and cyclists).

Table 2. APE of all pedestrians' readings at New Orleans and Baton Rouge locations

Absolute Percentage of Error (Pedestrians)					
New Orleans		**Median**	**Mean**	**Max**	**Min**
LTRC1	Day-Time	96.83	97.19	137.61	61.06
	Night-Time	41.63	47.77	78.06	31.67
LTRC2	Day-Time	179.04	184.56	277.88	137.35
	Night-Time	151.38	190.25	397.32	80.00
LTRC3	Day-Time	130.70	141.22	255.65	84.31
	Night-Time	47.06	59.73	257.38	12.86
New Orleans Total Average Observations	Day-Time	137.61	147.14	277.88	61.06
	Night-Time	69.44	100.00	397.32	12.86
Baton Rouge		**Median**	**Mean**	**Max**	**Min**
LTRC4	Day-Time	132.23	123.62	304.45	13.57
	Night-Time	78.10	131.03	675.76	2.94
LTRC5	Day-Time	21.62	59.32	400.00	0.00
	Night-Time	57.89	116.97	1206.67	0.00
LTRC6	Day-Time	113.97	110.52	171.74	10.42
	Night-Time	107.66	118.70	285.37	11.11
Baton Rouge Total Average Observations	Day-Time	90.57	95.56	400.00	0.00
	Night-Time	68.75	121.92	1206.67	0.00
Overall Total Average Observations	**Day-Time**	**119.72**	**119.15**	**400.00**	**0.00**
	Night-Time	**69.10**	**111.90**	**1206.67**	**0.00**

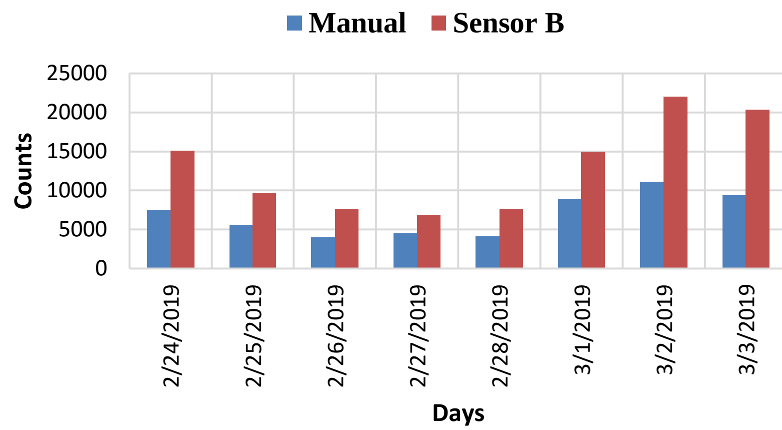
Table 3. APE of all bicyclists' readings at New Orleans and Baton Rouge locations

Absolute Percentage of Error (Bicyclists)					
New Orleans		**Median**	**Mean**	**Max**	**Min**
LTRC1	Day-Time	238.00	284.54	687.26	57.41
	Night-Time	47.19	53.75	86.00	23.30
LTRC2	Day-Time	31.72	31.13	85.52	0.32
	Night-Time	62.43	56.53	94.25	0.00
LTRC3	Day-Time	44.78	44.73	78.91	9.38
	Night-Time	93.44	90.78	100.00	46.67
New Orleans Total Average Observations	Day-Time	44.78	84.92	687.26	0.32
	Night-Time	84.62	72.74	100.00	0.00
Baton Rouge		**Median**	**Mean**	**Max**	**Min**
LTRC4	Day-Time	71.21	65.55	92.68	32.00
	Night-Time	96.67	92.25	300.00	11.11
LTRC5	Day-Time	90.91	85.38	116.67	11.11
	Night-Time	100.00	78.23	100.00	0.00
LTRC6	Day-Time	88.80	75.03	100.00	8.70
	Night-Time	89.18	90.26	200.00	24.14
Baton Rouge Total Average Observations	Day-Time	83.33	75.91	116.67	8.70
	Night-Time	95.65	86.40	300.00	0.00
Overall Total Average Observations	**Day-Time**	**69.62**	**80.03**	**687.26**	**0.32**
	Night-Time	**89.47**	**80.15**	**300.00**	**0.00**

Results of Sensor B

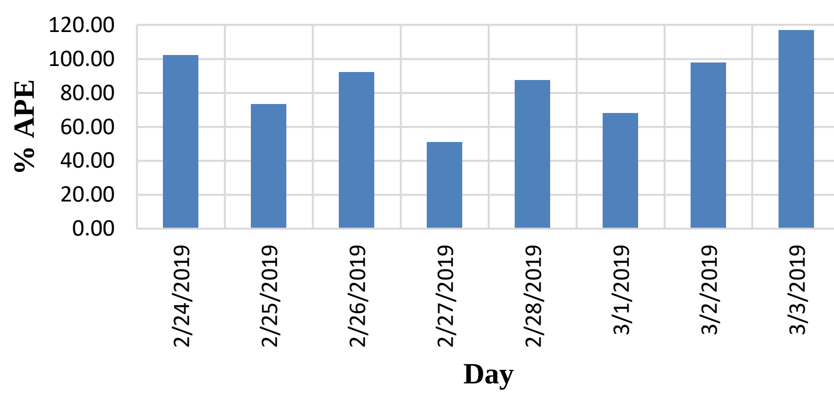
Sensor B is used for both automatic counting and recoding video footage that we used for manual counting purposes. The calibration and the setup of the sensor B are done as mentioned before in the methodology section. Sensor B is only capable of counting objects that fit the calibrated window-size. It means that sensor B cannot classify the type of objects as sensor A does. Sensor B was mounted at the LTRC1 location that had a high-traffic volume of pedestrians. Figure 41 represents the daily count of the sensor B and the manual counts for the period from February 24 to March 3. It is worth mentioning that the manual counting process considered two calibration lines as seen in Figure 9. The Absolute Percentage of Error (APE) for sensor B is seen in Figure 42. It is clear from Figure 42 that sensor B failed to match the manual counts in the outdoor environment. During the evaluation period shown in Figure 41 and Figure 42, the median APE is 89.9%; the average APE is 86.1%; and the maximum and the minimum APE are 116.99% and 50.87%, respectively.

Figure 41. The daily pedestrians' and bicyclists count of sensor B at LTRC1



Day	2/24/2019	2/25/2019	2/26/2019	2/27/2019	2/28/2019	3/1/2019	3/2/2019	3/3/2019
Manual	7482	5619	3993	4525	4091	8883	11116	9377
Sensor B	15125	9738	7671	6827	7679	14937	21995	20347

Figure 42. The APE of pedestrians and bicyclists count of sensor B



Day	2/24/2019	2/25/2019	2/26/2019	2/27/2019	2/28/2019	3/1/2019	3/2/2019	3/3/2019
APE%	102.15	73.30	92.11	50.87	87.70	68.15	97.87	116.99

Conclusions

This study evaluates the automatic counting feature of two sensors (sensor A and sensor B) to count both pedestrians and bicyclists. Additionally, the study evaluates the capability of the two (2) sensors to deliver robust systems for both near-term and long-term multimodal data collection program opportunities, so that they will make DOTD more efficient in its pedestrians and bicyclists data collection endeavors. Sensor A was evaluated at six different locations in New Orleans and Baton Rouge. The collected video data are obtained during the day-time and the night-time and under different conditions such as heavy rains, storms, different density volumes of pedestrians and bicyclists, the complicated background of the recorded video footage, and shadows of pedestrians and bicyclists. The condition varieties gave the research team a clear vision of the robustness of the evaluated sensors and their availability to work under the varying climate conditions at Louisiana, especially in New Orleans and Baton Rouge areas. To be sure that the sensors were celebrated correctly to give the best-expected performance, all sensors were continuously mounted for three months at New Orleans locations and another three months at Baton Rouge locations.

The evaluation process was performed by comparing the collected counts of sensors A and B to the manual counts that were obtained from video recording cameras which covered the same coverage area of the evaluated sensors. Sensor B was evaluated at one heavy traffic volume location in New Orleans. The obtained results and analysis indicated that both sensors A and B failed to provide robust counting systems for pedestrians and bicyclists under different conditions (weather, time of the day, traffic volume, and density of pedestrians and bicyclists). The reason for the low accuracy of both sensor A and sensor B to match the manual count is not clear since the entire counting algorithm for both sensors is proprietary.

The evaluation of sensor A showed that the overall total observations median and mean Absolute Percentage of Error (APE) of the pedestrians during the day-time are 119.72% and 119.15% and during the night-time are 69.10% and 111.90%, respectively. While the overall total observations median and mean APE of the bicyclists during the day-time are 69.62% and 80.03% and during the night-time are 89.47% and 80.15%, respectively. The evaluation of sensor B showed that the overall total observations median and mean

Absolute Percentage of Error (APE) of the pedestrians and bicyclists are 89.9% and 86.1%, respectively.

The research team recommends developing a simple counting system and use the same recorded video footage to evaluate the newly developed hardware/software system and compare its performance with the performance of both sensors A and B. It is concluded from processing the collected data of both sensors A and B that they both couldn’t develop a robust automated system that can replace manual counting statewide.

Recommendations

The results obtained from this study show that the Absolute Percent of Error (APE) of the pedestrians and bicyclists counts obtained by sensor A is high at the selected testing locations in New Orleans and Baton Rouge. Both sensors A and B failed to give robust counting systems for both pedestrians and bicyclists at the selected testing locations and under different conditions (weather, time of the day, traffic volume, and density of pedestrians and bicyclists). Although the rental cost of sensor A is reasonable, the installation and the maintenance fees are extremely high. The research team has no access to sensor A's object tracking algorithm, so it is hard to expect why there is a huge gap between sensor A's counts and the manual counts. The research team recommends continuing this project to develop a simple counting system that will be able to accurately count pedestrians and bicyclists. The targeted developed system will include both the counting software and the hardware (IP Camera). The targeted developed system is expected to use the same recorded video footage from LTRC Project Number: 19-1SA to evaluate the newly developed hardware/software system and compare its performance with the performance of the evaluated counting system in LTRC Project Number: 19-1SA.

Acronyms, Abbreviations, and Symbols

Term	Description
A	Ampere
APE	Absolute Percentage of Error
BRCC	Baton Rouge Community College
C	Celsius
DC	Direct Current
DOTD	Louisiana Department of Transportation and Development
ft.	foot (feet)
FHWA	Federal Highway Administration
F	Fahrenheit
g	Gram
hrs	Hours
in.	inch(es)
lb.	pound(s)
IP	Internet Protocol
LTRC	Louisiana Transportation Research Center
m	meter(s)
PRC	Project Review Committee
PI	Principle Investigator
UNO	The University of New Orleans

References

[1] D. Tomè, F. Monti, L. Baroffio, L. Bondi, M. Tagliasacchi, and S. Tubaro, "Deep Convolutional Neural Networks for Pedestrian Detection," *ELSEVIER: Signal Processing: Image Communication,* vol. 47, pp. 482-489, September 2016.

[2] J. Uijlings, K. Van De Sande, T. Gevers and A. Smeulders, "Selective Search for Object Recognition," International journal of computer vision, vol. 104, no. 2, pp. 154-171, 2013.

[3] W. Nam, P. Dollár and J. Han, "(2014). Local Decorrelation for Improved Pedestrian Detection," Advances in Neural Information Processing Systems (NIPS 2014), pp. 424-432, 2014.

[4] Z. Liu, Z. Chen, Z. Li, and W. Hu, "An Efficient Pedestrian Detection Method Based on YOLOv2," Hindawi: Mathematical Problems in Engineering, 2018.

[5] P. Sermanet, K. Kavukcuoglu, S. Chintala and Y. LeCun, "Pedestrian Detection with Unsupervised Multi-stage Feature Learning," in IEEE Conference on Computer Vision and Pattern Recognition, 2014.

[6] H. Zhang, Y. Du, S. Ning, Y. Zhang, S. Yang, and C. Du, "Pedestrian Detection Method Based on Faster R-CNN," in 2017 13th IEEE International Conference on Computational Intelligence and Security (CIS), 2017.

[7] S. Ren, K. He, R. Girshick and J. & Sun, "Faster r-cnn: Towards Real-time Object Detection with Region Proposal Networks," Advances in neural information processing systems, pp. 91-99, 2015.

[8] J. Redmon, S. Divvala, R. Girshick, and A. Farhadi, "You Only Look Once: Unified, Real-time Object Detection," in Proceedings of the IEEE conference on computer vision and pattern recognition, 2016.

[9] W. Liu, D. Anguelov, D. Erhan, C. Szegedy, S. Reed, C. Fu, and A. Berg, "Ssd: Single Shot Multibox Detector," in European conference on computer vision, Springer, Cham, 2016.

[10] W. Zhang, L. Tian, C. Li, and H. Li, " An SSD-based Crowded Pedestrian Detection Method," in International Conference on Control, Automation and Information Sciences (ICCAIS), 2018.

[11] S. Turner, "Defining and Measuring Traffic Data Quality," Transportation Research Record: Journal of the Transportation Research Board, vol. 1870, pp. 62-69, 2004.

[12] J. Roll, "Evaluating Streetlight Estimates of Annual Average Daily Traffic in Oregon," Oregon Department of Transportation, Salem, OR United States, 2019.

[13] T. Tolford, M. Izadi, C. Ash, and J. Codjoe, "ITS Support for Pedestrians and Bicyclists Count: Developing a Statewide Multimodal Count Program," Louisiana Transportation Research Center, Baton Rouge, USA, 2019.

[14] J. Codjoe, Y. Holamoge, R. Tian, C. Ash, and W. Saunders, "ITS Support for Pedestrians and Bicyclists Count: Developing a Statewide Multimodal Count Program," Louisiana Transportation Research Center, Baton Rouge, USA, 2019.

Appendix

Protocol Steps of Evaluating Similar Counting Systems

One of our recommendations is to keep moving and evaluate existing counting systems. The following steps could be followed to evaluate any counting device:

1. Select sites that have different traffic volumes.
2. Mount the counting device based on the provided setup information by the vendor.
3. Safety issues should be considered while mounting the devices.
4. Mount recording video cameras that could cover the same area of the counting device.
5. It is very important to be sure that the covered area of both the recording camera and the counting device is the same.
6. Based on the algorithm used to count the objects, the captured data frame may be clipped from the edges as seen in Figure 7 (b). The recorded data frames from the used recording camera should match the actual covered area by the counting device.
7. There is a calibrating period for each counting device that should be considered to get accurate counts. This period may vary from a counting device to another one. The calibrating period can be obtained directly from the vendor's technical support team.
8. After the calibrating period, start recording your video data under different conditions (night-time, daytime, rains, winds, etc.).
9. Once the continuous recoded data is obtained, manual counts could be performed under the condition that the actual coverage area of the counting device should be used for the manual counting process.
10. The manual counts should be compared to the provided counts from the evaluated device during the same period.
11. The video recording operation may be repeated to get more data that could be used for manual counting and the evaluation process.
12. The transmission frame rate that is used by the counting device should be known; it may affect the count performance.
13. Some cases that should be considered, while recording the video data, such as

having a case while the captured video frames are full of objects (pedestrians as an example). This will help evaluating the counting device counting very high-traffic volume.

14. The Absolute Percentage of Error is used in this study to compare the performance of the evaluated counting device. Any other accuracy parameter can be used for the evaluation purpose.

Structural Analysis Performed at Southern University

Based on the request made by the city of Baton Rouge to perform structural analysis for all poles that were used in Baton Rouge, we attached here a copy of the performed analysis by Ron Lee, Adjunct Faculty Member at Southern University. The structural analysis was performed based on the specifications of all the installed equipment that were provided by the sensor A team and the used poles information that was provided by the city of Baton Rouge. The followings are the letter sent to the city of Baton Rouge that includes the structural analysis, the specifications of the installed equipment, and all information provided by the city that was used for calculating the structural analysis of all poles we used in Baton Rouge locations. The research team believes that such structural analysis information will be important for those who are interested to mount any device on a pole at Baton Rouge.

Figure 43. Structural analysis #1

STATE OF LOUISIANA
ALEX HAK-CHUL SHIN
License No. 37336
PROFESSIONAL ENGINEER
IN
CIVIL ENGINEERING

July 3, 2019

From: Ron Lee, PE, Alex Shin, PE

To: Sarah Edel

Cc: Ingolf Partenheimer, Yasser Ismail

Date: July 3, 2019

Subject: Structural calculations of solar panels for LTRC grant project

As part of a Louisiana Transportation and Research Center (LTRC) grant project, our team would like to install sensors and solar panels on strain poles at three locations in Baton Rouge. As per your e-mailed request on May 7, 2019 to Yassir Ismail, we have performed calculations to determine the additional loads caused by the equipment on the traffic structures. This memo describes our calculations. Please review and let us know if this level of calculation will be sufficient for your needs.

Background

In order to obtain pedestrian data, the following equipment will be installed:

- The ***solar power system*** is rated for 90 mph winds and weighs approximately 190 pounds (including battery weight).
- The ***wireless sensor*** weighs about 5 pounds.

The equipment will be installed on strain poles at a height of approximately 12 feet at three locations:

- Highland @ Veteran's: NE Quadrant
- North Blvd. @ 4th St/St. Ferdinand: NE Quadrant
- Florida St. @ Foster: SE Quadrant

The equipment will require no wiring and will be attached using bands. No modification of existing structures will be required. An example setup is shown in the photo below.

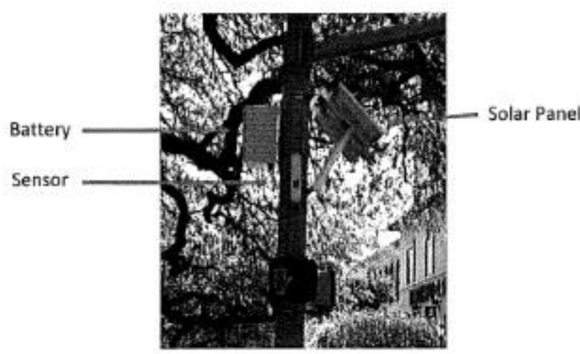


Figure 44. Structural analysis #2

After the monitoring period (90 days) is complete, the equipment will be removed from the poles. If during the monitoring period a storm is forecast where winds would exceed 70 mph, the equipment will be removed prior to the storm.

Calculation

Calculation of loads were performed using the AASHTO Standard Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals, Sixth Edition. Sections 3.4 through 3.8 of AASHTO describe the procedure for calculating loads for individual items, and then grouping them into appropriate group combinations. In the calculation that follows, values are determined for Group Loads I (dead load only) and II (dead load plus wind loads). It was assumed that:

- The sensor (5 lbs) does not significantly increase the strain pole load, and therefore only the solar panels and battery need to be considered.
- The wind loads from the solar panel can be approximated as being equal to the rectangular solar panel portion only. The contribution of wind on the solar panel mount is considered insignificant.
- The battery pack is assumed to be installed 12 feet above ground level, and the solar panel is installed directly above the battery pack (15 feet above ground level).
- The angle of inclination of the solar panels is 35 degrees.
- The worst-case wind scenario is wind approaching from the side on which the battery and solar panels are installed.

Based on these and other conservative assumptions, the following Group I and Group II loads were calculated (see Table 1):

Group 1 (Dead load only)
Vertical load: 190 lbs, 0.5 feet from pole surface
Group 2 (Dead load + Wind load)
Vertical load: 321 lbs, 0.5 feet from pole surface
Horizontal load: 188 lbs, 0.5 feet from pole surface

Figure 45. Structural analysis #3

Table 1. Equipment load calculations

Variable	Value		Units	Notes
	Battery	Solar Panel		
Wind speed (V)	90.00	90.00	mph	Equipment will be removed if wind speeds greater than 70 mph are forecasted
Dead Load (D)	81.00	109.00	lb	From RemotePro Data Sheet (RPST12M, 160W, 100Ah 12V Battery). See attachment.
Wind Importance Factor (I_r)	1.00	1.00		Table 3-2 of AASHTO (50-year recurrence interval)
Height and Exposure Factor (K_z)	0.87	0.87		Table 3-5 of AASHTO (<5.0 meters in height)
Gust factor (G)	1.14	1.14		AASHTO-recommended value for luminaires
Drag coefficient (C_d)	2.00	1.12		Based on Table 3-6 of AASHTO. Solar panel was assumed to be shaped like a sign panel (L/W ratio = 67"/26" = 0.39). Battery pack was assumed to be square.
Wind design pressure (P_z)	41.13	23.03	psf	AASHTO Equation 3-1: $P_z = 0.00256 K_z G V^2 I_r C_d$
Area facing wind	2.33	6.94	ft^2	Battery pack is 24"x15". Solar panel is 67"x26", and tilted at 35 degrees.
Wind load	95.97	159.80	lb	pressure times area
Vertical wind load	0.00	130.91	lb	For solar panels, vertical component = cos(35)*wind load
Horizontal wind load	95.97	91.64	lb	For solar panels, vertical component = sin(35)*wind load
Group 1 (Dead load only)				
Resultant Vertical load	190.00		lb	Battery + solar panel loads added together
Location of resultant vertical load	0.50		ft away from pole surface	Assuming center of gravity is equal to the center of volume. Battery is 14" deep. Solar Panel is 67"x26", and tilted at 35 degrees.
Group 2 (Dead load + Wind load)				
Resultant Vertical load	320.91		lb	Dead load + wind load
Location of resultant vertical load	0.48		ft away from pole surface	
Resultant Horizontal load	187.62		lb	
Location of resultant horizontal load	0.52		ft away from pole surface	

Information Provided by the city of Baton Rouge

Figure 46. City of Baton Rouge #1

DEPARTMENT OF TRANSPORTATION AND DEVELOPMENT

INTRADEPARTMENTAL CORRESPONDENCE

IN REPLY REFER TO
FILE NO.

REFERRED TO

____ REFERRED FOR ACTION
____ ANSWER FOR MY SIGNATURE
____ FOR FILE
____ FOR YOUR INFORMATION
____ FOR SIGNATURE
____ RETURN TO ME
____ PLEASE SEE ME
____ PLEASE TELEPHONE ME
____ FOR APPROVAL
____ PLEASE ADVISE ME

BY ____ DATE ____
BY ____ DATE ____
BY ____ DATE ____

MEMORANDUM

TO: BILL TEMPLE. P.E.
CHIEF ENGINEER

FROM: LEI WANG, P.E. LW
TRAFFIC OPERATIONS

SUBJECT: REQUEST FOR APPROVAL --TRAFFIC SIGNAL MAST ARM DESIGN PARAMETER SELECTION

DATE: SEPTEMBER 21, 2009

We are requesting your review and approval for the following design factors for traffic signal mast arm poles according to the Standard Specifications for Structural Supports for Highway Signs, Luminaries, and Traffic Signals, Fifth Edition 2009, published by the American Association of State Highway and Transportation Officials.

- Basic Wind Speed –130 mph

According to the wind map in the design specifications, the State of Louisiana falls within various wind zones ranging from 90 mph to 140 mph. The 140 mph zone was not considered due to its limited geographic coverage area (about 10 miles from the coast line). Our preliminary designs have indicated that wind speed itself has a minimal impact on the mast arm size. Therefore, to simplify the design process, we are recommending to use a 130 mph wind speed to calculate the static load for the entire state of Louisiana.

- Wind Importance Factor I_r – 1.00

50 years is the recommended minimal design life for traffic signals according to the manual.

RECOMMENDED FOR APPROVAL 9/21/09 DATE

RECOMMENDED FOR APPROVAL DATE

W. Temple APPROVED 10.12.09 DATE

AN EQUAL OPPORTUNITY EMPLOYER
A DRUG FREE WORKPLACE

Figure 47. City of Baton Rouge #2

September 21, 2009
Page 2 of 4

- Fatigue Category – II

We recommend category II for all mast arm designs unless specified by the design engineer for the project due to unusual circumstances, such as excessive long arms, load, etc.

- Galloping Fatigue – No

No galloping fatigue will be considered in the design. Instead, the specifications allow the owner to install an approved vibration mitigation device if a galloping problem appears.

- Natural Wind Gust Fatigue – Yes

The traffic signal mast arms will be designed to resist fatigue induced by natural wind gusts.

- Truck Induced Gust Fatigue – No

The specifications allow the owner to exclude truck induced gust fatigue in the design of overhead cantilevered traffic signal support structures.

I have attached a cost estimate under different design factors for your reference. If you have any questions, please contact this office.

Cc:

Ed Courville – section 45
Peter Allain – section 53
Kurt Brauner – section 25

130 mph wind zone

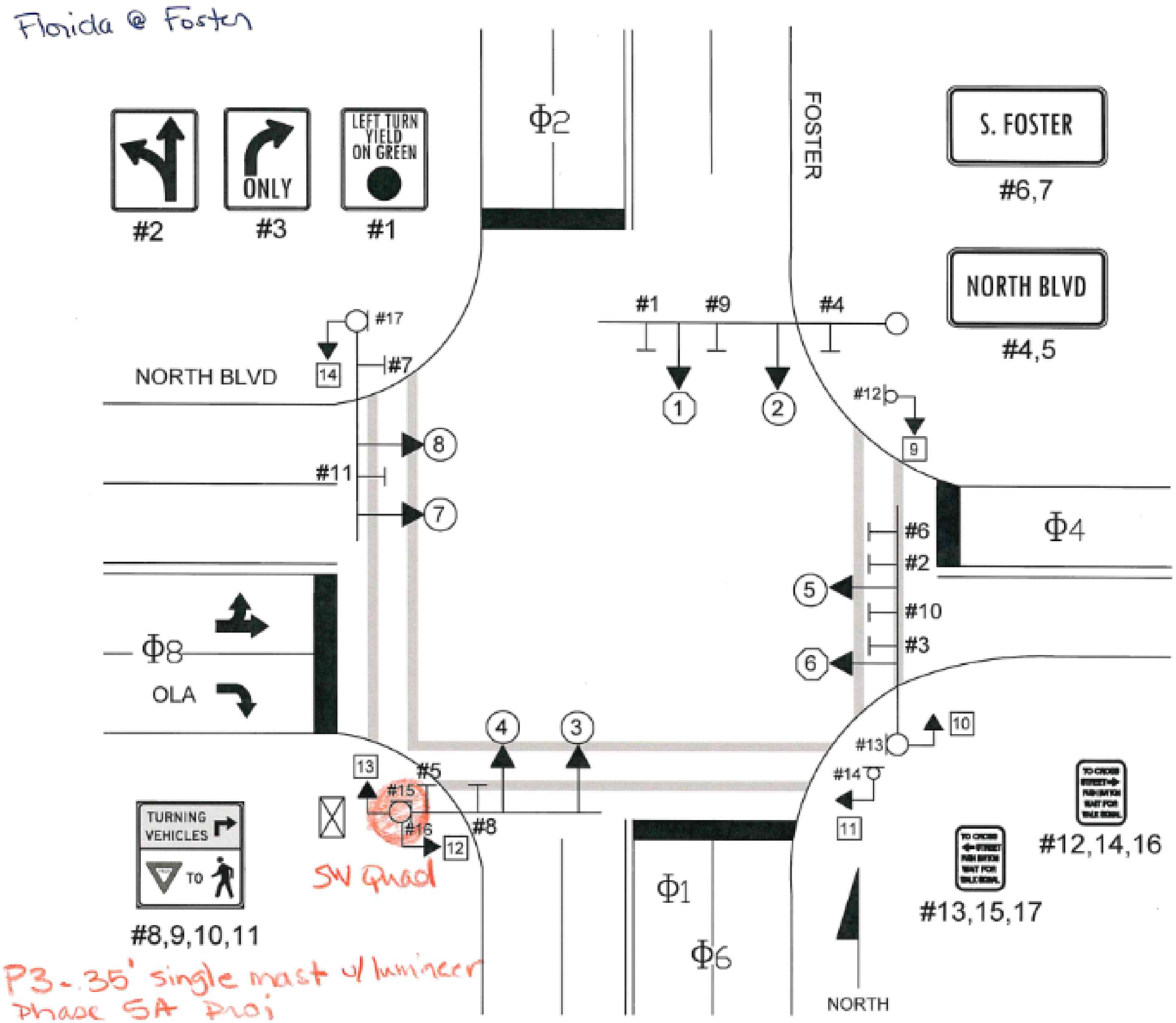
Arm length	importance factor	Galloping factor	Valmont		Union Metal (no truck)		Pelco (cat 1a and 2a)	
			weight in lbs\par		cost in dollar		cost in dollars	
30' ARM	CAT2	NO GALLOPING			5436	100%		
30' ARM	- CAT 1 -	NO GALLOPING	1410	100%	5685	105%	3752	100%
30' ARM	- CAT 2 -	GALLOPING -	2000	142%	5932	109%	4410	118%
30' ARM	- CAT 1 -	GALLOPING -	2500	177%	6186	114%	5318	142%
42' ARM	- CAT 2 -	NO GALLOPING	2230	100%	6602	100%	5269	100%
42' ARM	- CAT 1 -	NO GALLOPING	2290	103%	6867	104%		
42' ARM	- CAT 2 -	GALLOPING -	3100	139%	7785	118%	6222	118%
42' ARM	- CAT 1 -	GALLOPING -	3760	169%	7976	121%	8192	155%
55' ARM	- CAT 2 -	NO GALLOPING	3330	100%	8766	100%	8170	100%
55' ARM	- CAT 1 -	NO GALLOPING	3590	108%	8766	100%		
55' ARM	- CAT 2 -	GALLOPING -	5350	161%	9657	110%	11199	137%
55' ARM	- CAT 1 -	GALLOPING -	6450	194%	11388	130%	14378	176%

Note:

The cost estimates are based on the manufacture's preliminary design calculations and should not be compared due to different design details. This is only meant to compare the design impact for various design factors.

Figure 48. City of Baton Rouge #3

Figure 49. City of Baton Rouge #4



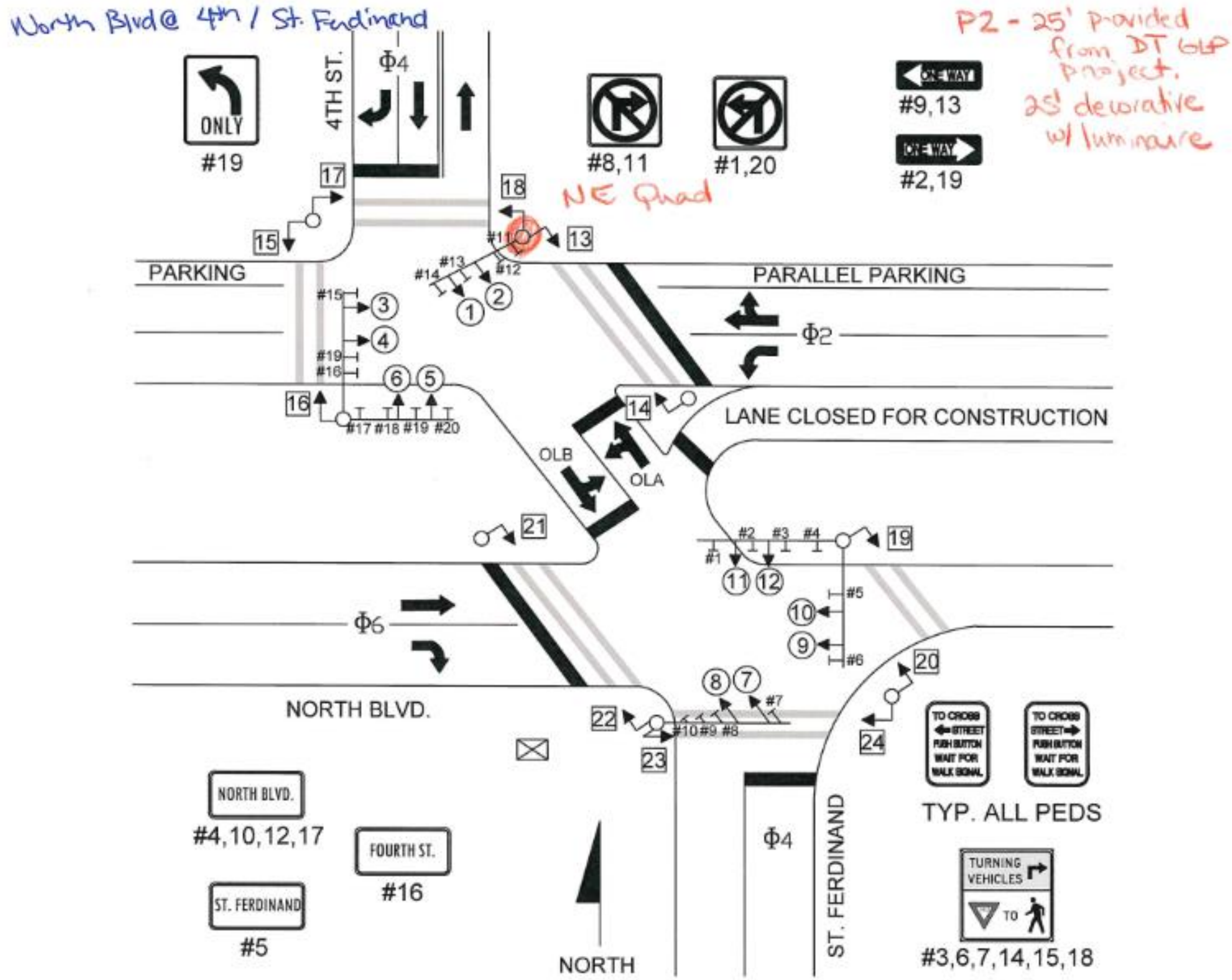


Figure 50. City of Baton Rouge #5

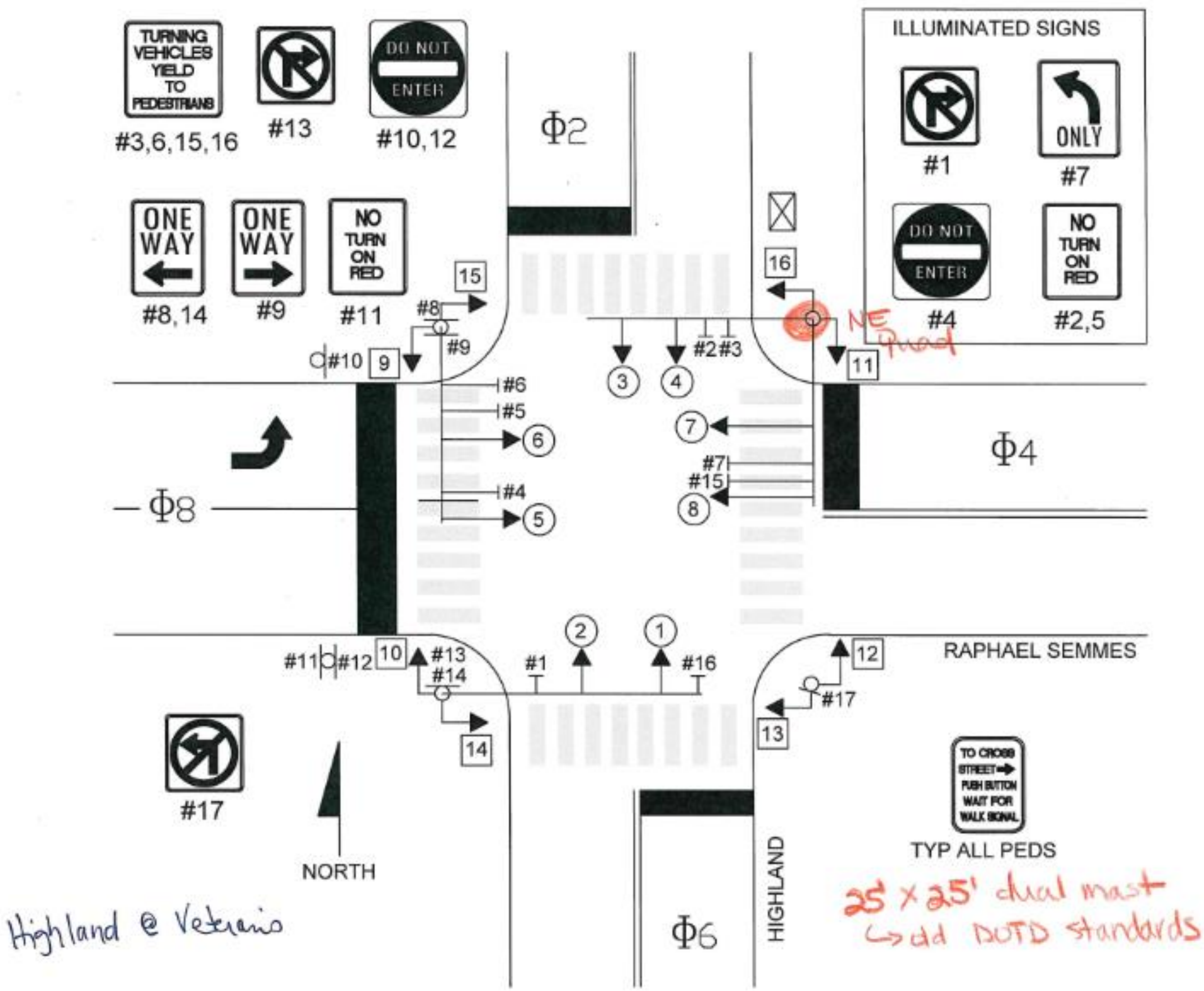
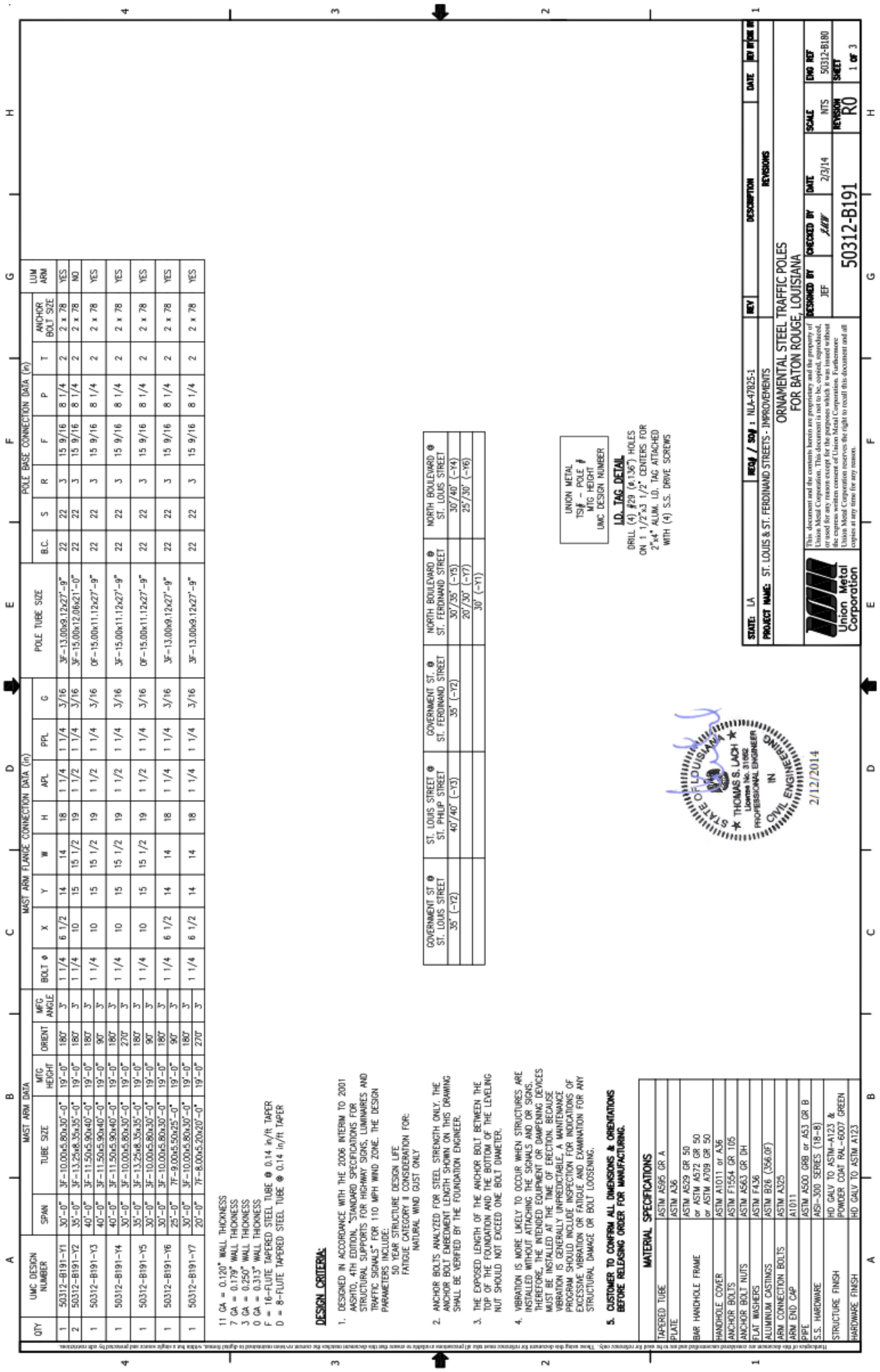


Figure 51. City of Baton Rouge #6

Figure 52. City of Baton Rouge #7



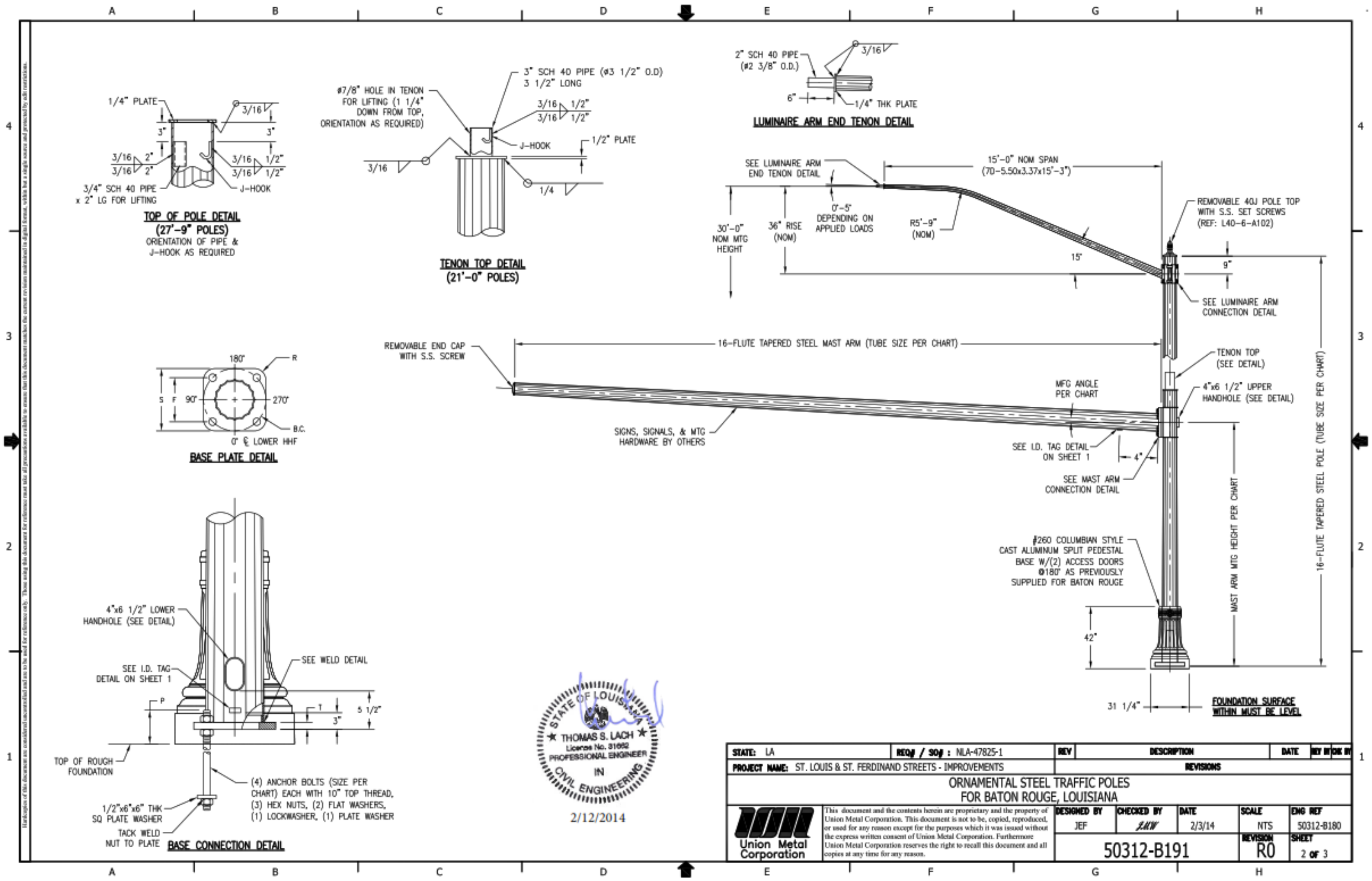


Figure 53. City of Baton Rouge #8

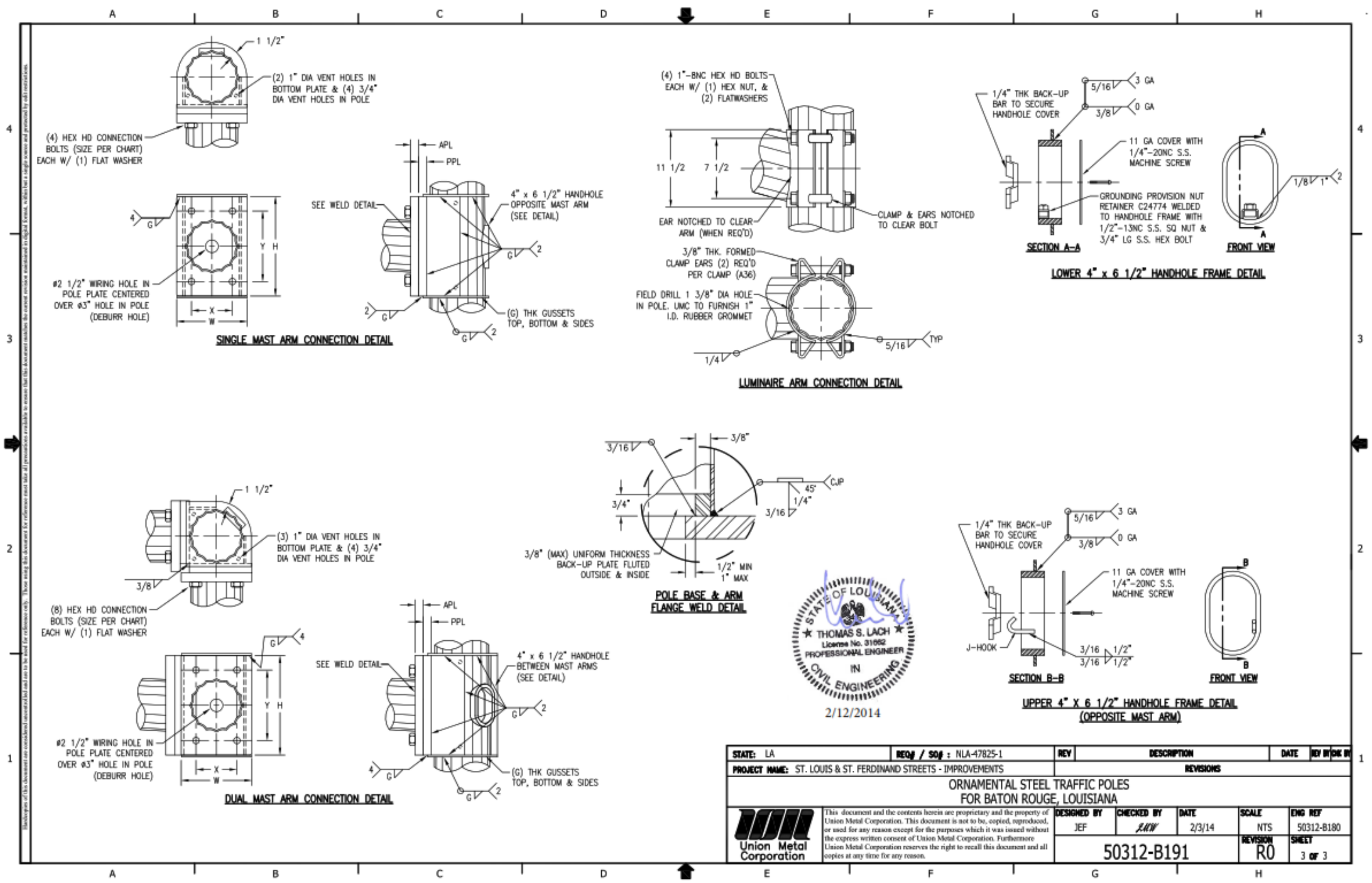


Figure 54. City of Baton Rouge #9

Figure 55. City of Baton Rouge #10

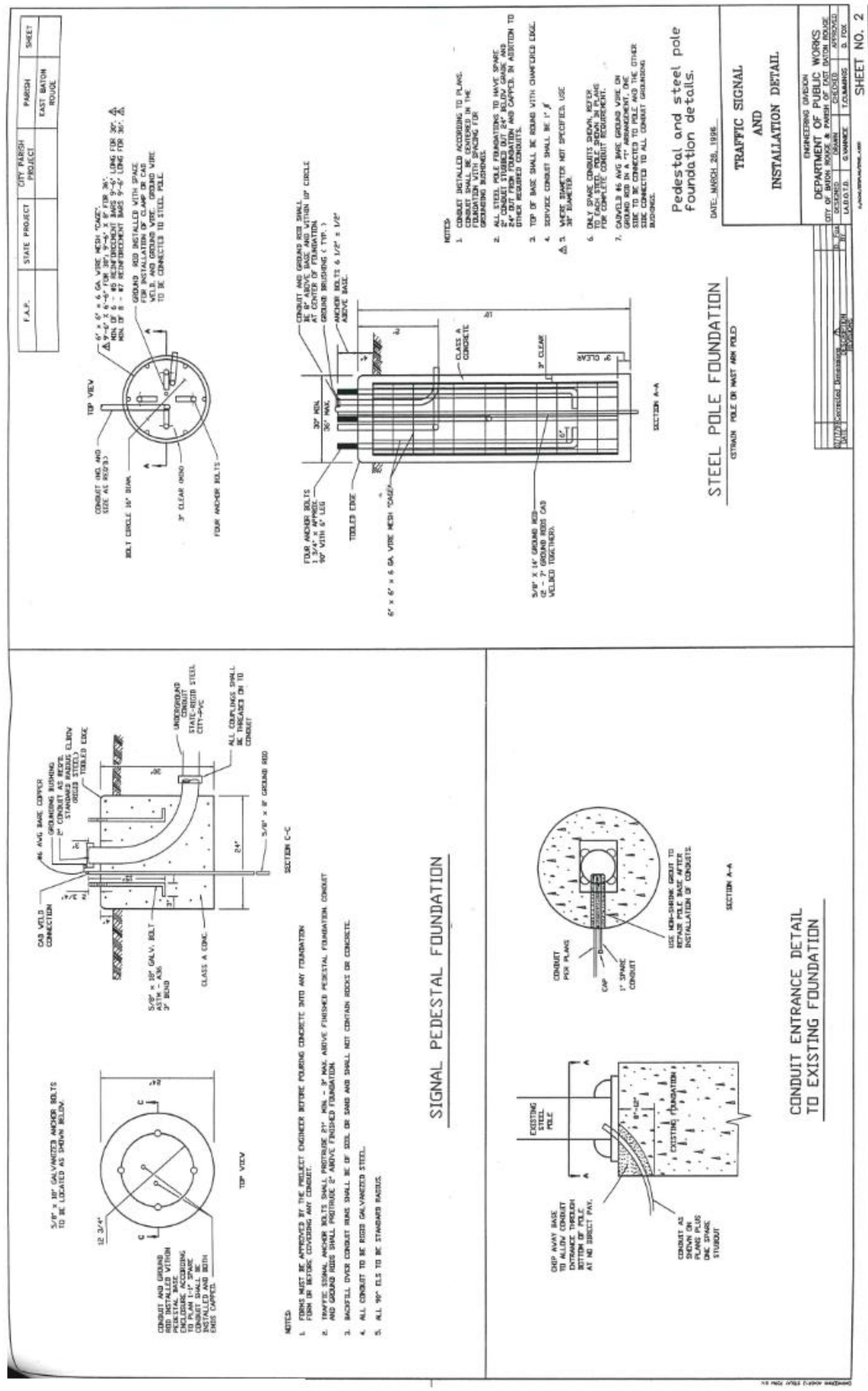


Figure 56. City of Baton Rouge #11

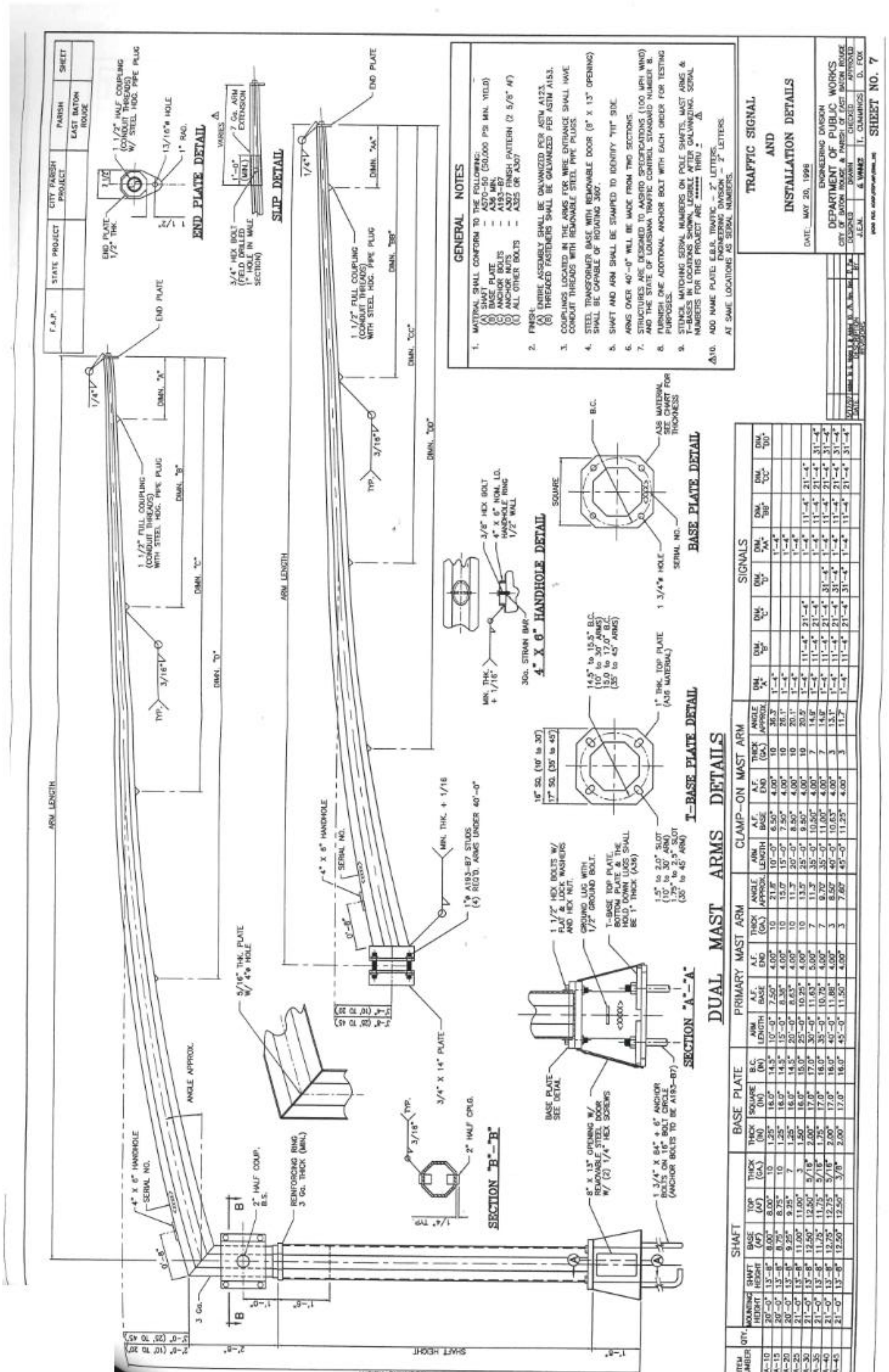
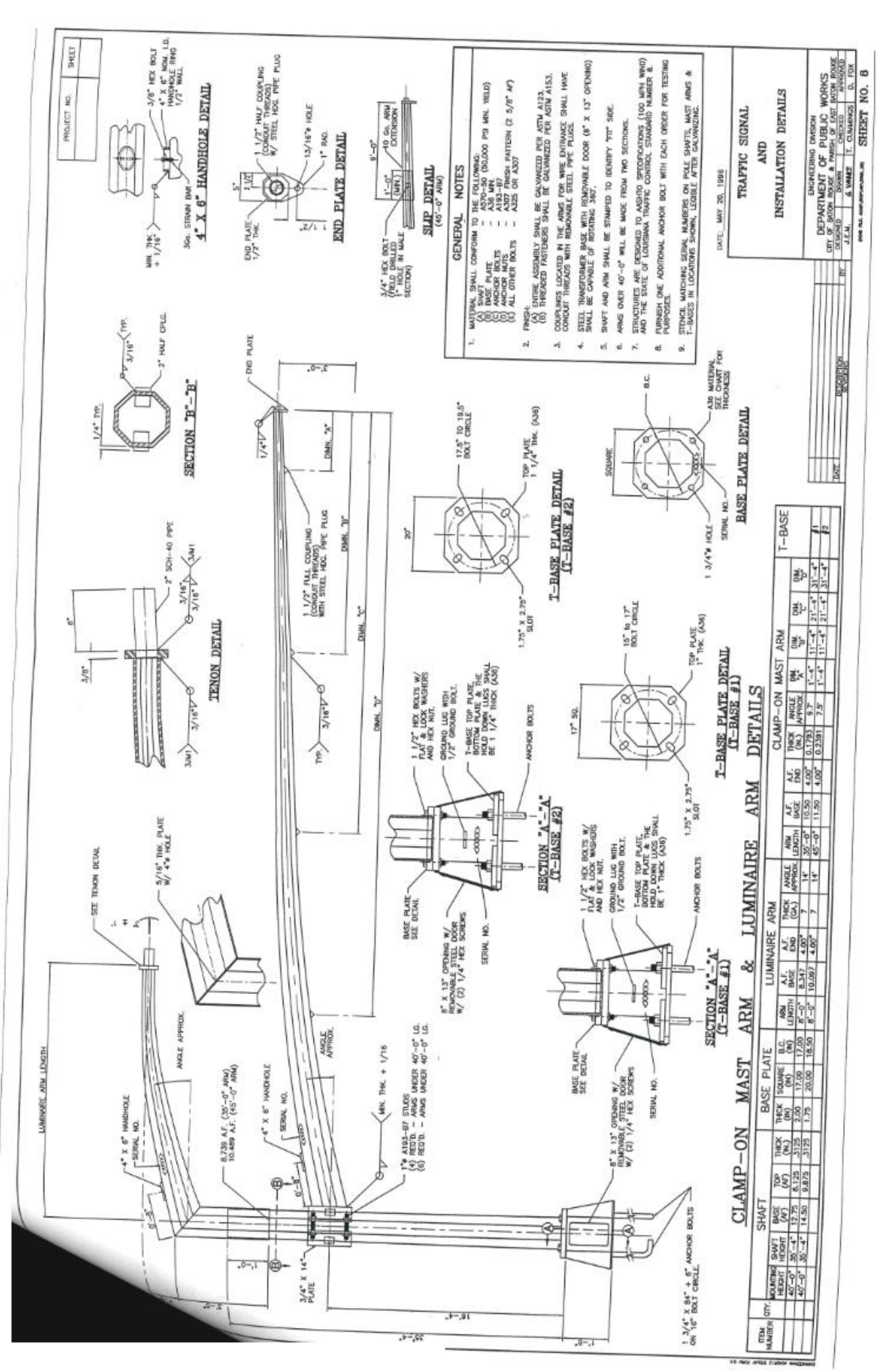


Figure 57. City of Baton Rouge #12



PROJECT NO.	SHEET

TRAFFIC SIGNAL WORK

GENERAL

THE TRAFFIC SIGNAL WORK, EQUIPMENT, AND MATERIALS INDICATED WITHIN THESE NOTES UNLESS SPECIFIED OTHERWISE SHALL BE PERFORMED BY THE CONTRACTOR IN ADDITION AND ACCORDING TO THE WORK REQUIREMENTS WITHIN THE CONTRACT DOCUMENTS.

THE FOLLOWING NOTES ARE TYPICAL FOR THE REMOVAL AND INSTALLATION OF TRAFFIC SIGNAL EQUIPMENT WORK FOR THE CITY/PARISH OF EAST BATON ROUGE DEPARTMENT OF PUBLIC WORKS.

Emergency Contacts. THE CONTRACTOR SHALL FURNISH THE CITY-PARISH WITH TWO LOCAL TELEPHONE NUMBERS FOR EMERGENCY USE IN CONTACTING THE IMSA LEVEL TWO (2) EMPLOYEES (SEE NOTE 1) OF THE CONTRACTOR REGARDING INCIDENTS INVOLVING THE CONTRACTOR'S CONSTRUCTION. THE CONTRACTOR SHALL RESPOND TO ANY EMERGENCY CALL IN ACCORDANCE WITH THE SCHEDULE DETAILED BELOW. SHOULD THE CITY-PARISH OR LADOTD BE REQUIRED TO TAKE OVER THIS DUTY DUE TO DELAYED RESPONSE, THE CONTRACTOR SHALL BE BILLED FOR ALL CITY-PARISH OR LADOTD EXPENSES INCURRED IN DOING SO. THE CONTRACTOR SHALL MAINTAIN AN ADEQUATE SUPPLY OF COMPONENT PARTS FOR THE SPECIFIC TYPE OF TRAFFIC SIGNALS BEING MAINTAINED DURING CONSTRUCTION. THE CITY-PARISH TRAFFIC ENGINEERING DIVISION WILL NOT FURNISH MATERIALS (EXCEPT AT THE DISCRETION OF THE CHIEF TRAFFIC ENGINEER) FOR USE ON THE CONTRACTOR MAINTAINED TRAFFIC SIGNALS.

PRIORITY ITEM	TIME OF OCCURRENCE	REQUIRED RESPONSE
NO SIGNAL INDICATION	6AM-6PM MON. THRU FRI.	TWO (2) HOURS
NO SIGNAL INDICATION	6PM-6AM AND WEEKENDS	FOUR (4) HOURS
SIGNAL HUNG UP, CONFLICT	6AM-6PM MON. THRU FRI.	ONE (1) HOUR
SIGNAL HUNG UP, CONFLICT	6PM-6AM AND WEEKENDS	TWO (2) HOURS
SIGNAL KNOCKDOWN	6AM-6PM MON. THRU FRI.	ONE (1) HOUR
SIGNAL KNOCKDOWN	6PM-6AM AND WEEKENDS	TWO (2) HOURS

Traffic Flow and Safety. THE CONTRACTOR SHALL MAINTAIN TRAFFIC FLOW DURING CONSTRUCTION AND SHALL COMPLY WITH ALL GOVERNING LAWS, ORDINANCES AND REGULATIONS REGARDING SAFETY, SO AS TO INSURE SAFETY OF THE WORKMEN AND THE TRAVELING PUBLIC DURING CONSTRUCTION.

Police Supervision. THE CONTRACTOR SHALL PROVIDE POLICE SUPERVISION (225-389-3874) OF TRAFFIC AT ANY TIME THE TRAFFIC SIGNAL SYSTEM IS NOT IN OPERATION AT NO DIRECT PAY. POLICE SUPERVISION SHALL CONTINUE UNTIL ALL EQUIPMENT HAS BEEN INSTALLED AND MADE OPERATIONAL IN ACCORDANCE WITH THE PLANS AND SPECIFICATIONS.

Infrastructure Protection. THE CONTRACTOR SHALL PROTECT ALL EXISTING SIDEWALKS, CURB, AND DRIVEWAYS FROM DAMAGE DURING INSTALLATION OF SIGNAL EQUIPMENT AT NO DIRECT PAY. THE CONTRACTOR SHALL REPLACE AT NO DIRECT PAY-WITH AN APPROVED QUALITY EQUAL TO OR BETTER THAN THE ORIGINAL, ANY SIDEWALK, CURB, OR OTHER ITEMS DAMAGED DURING THE CONSTRUCTION. REPLACEMENT OF DAMAGED CURBS, SIDEWALKS AND DRIVEWAYS SHALL BE IN ACCORDANCE WITH THE STANDARD SPECIFICATIONS OF THE AGENCY OR OWNER HAVING JURISDICTION AND TO THE AGENCY'S OR OWNERS SATISFACTION.

UTILITIES

Underground and Overhead Utilities. THE LOCATION AND TYPE OF EXISTING UTILITIES SHOWN ON THE PLANS ARE NOT GUARANTEED TO BE ACCURATE NOR ALL INCLUSIVE. BEFORE PERFORMING ANY EXCAVATIONS, THE CONTRACTOR SHALL CONTACT (AT A MINIMUM) THE ENTITIES LISTED BELOW TO VERIFY THE EXACT LOCATION, DEPTH OR HEIGHT OF ALL UNDERGROUND OR OVERHEAD UTILITIES IN THE CONSTRUCTION ZONE:

"LOUISIANA ONE CALL" (DOTTIE)................................TELEPHONE NO. 811 OR 1-800-272-3020
CITY-PARISH DPW TRAFFIC ENGINEERING DIVISION .....TELEPHONE NO. (225) 389-3246
CITY-PARISH DPW SANITARY SEWER DIVISION...........TELEPHONE NO. (225) 389-4858
CITY-PARISH DPW DRAINAGE......................................TELEPHONE NO. (225) 389-3196
NORTH MAINTENANCE LOT...TELEPHONE NO. (225) 389-5187
SOUTH MAINTENANCE LOT..TELEPHONE NO. (225) 389-3250
EAST MAINTENANCE LOT...TELEPHONE NO. (225) 389-4880
LOUISIANA DEPARTMENT OF TRANSPORTATION AND DEVELOPMENT
TRAFFIC SERVICES DIVISION..TELEPHONE NO. (225) 935-0100

THE CITY-PARISH AND LADOTD ARE NOT "LOUISIANA ONE CALL" MEMBERS AND MUST BE CONTACTED INDEPENDENTLY FOR UTILITY LOCATIONS. OTHER APPROPRIATE INDIVIDUAL UTILITY COMPANIES MAY ALSO NEED TO BE CONTACTED AND IT SHALL BE THE CONTRACTOR'S RESPONSIBILITY TO DO SO. NOTICE SHALL BE GIVEN AND SHALL INCLUDE A SPECIFIC LOCATION REQUEST FOR EXCAVATION OR DEMOLITION WORK TO BE PERFORMED AT LEAST FORTY-EIGHT (48) HOURS, BUT NOT MORE THAN ONE HUNDRED (100) HOURS, EXCLUDING WEEKENDS AND HOLIDAYS, IN ADVANCE OF ACTUAL WORK COMMENCEMENT. THE CONTRACTOR SHALL BE SOLELY LIABLE FOR ANY DAMAGES CAUSED BY FAILURE TO COMPLY WITH THESE INSTRUCTIONS. THE CONTRACTOR SHALL BE RESPONSIBLE FOR MAKING INDEPENDENT INVESTIGATIONS, INCLUDING SUBSURFACE INVESTIGATIONS, AS NECESSARY (AT NO DIRECT PAY).

TRAFFIC SIGNAL EQUIPMENT REMOVAL

GENERAL

Salvageable Equipment. CITY-PARISH TRAFFIC SIGNAL EQUIPMENT AND CONTROL DEVICES AS DESIGNATED BY THE PLANS OR AS DIRECTED BY THE PROJECT ENGINEER SHALL BE DELIVERED BY THE CONTRACTOR TO THE CITY-PARISH TRAFFIC ENGINEERING DIVISION, 329 CHIPPEWA ST., BATON ROUGE LA. STATE TRAFFIC SIGNAL EQUIPMENT AND CONTROL DEVICES SHALL BE DELIVERED TO LADOTD TRAFFIC SERVICES SECTION, 7686 TOM DRIVE, BATON ROUGE, LA. DISPOSAL OF NON-SALVAGEABLE ITEMS SHALL BE AS DIRECTED BY THE PROJECT ENGINEER.

Foundations. THE CONTRACTOR SHALL DISPOSE OF EXISTING TRAFFIC SIGNAL CONTROLLER AND POLE BASE FOUNDATION AS DIRECTED BY THE PROJECT ENGINEER. POLE BASE FOUNDATION SHALL BE REMOVED TO A MINIMUM DEPTH OF 24" BELOW FINAL GROUND ELEVATION AND BACKFILLED WITH SUITABLE MATERIAL.

Detector loops. THE CONTRACTOR SHALL CONTACT CITY-PARISH TRAFFIC ENGINEER AT 389-3246, A MINIMUM FOURTY-EIGHT (48) HOURS, EXCLUDING WEEKENDS AND HOLIDAYS, PRIOR TO THE DESTRUCTION OF EXISTING TRAFFIC SIGNAL DETECTORS.

TRAFFIC SIGNAL SYSTEM CONSTRUCTION

GENERAL

Match Existing. NEW EQUIPMENT FURNISHED INCLUDING BUT NOT LIMITED TO POLES, MAST ARMS, SIGNAL HEADS, PEDESTRIAN HEADS, RAISED FOUNDATIONS, ETC. SHALL MATCH, INCLUDING COLOR, OR BE AESTHETICALLY EQUAL TO, THAT WHICH EXISTS IN THE AREA AND IS SCHEDULED TO REMAIN, UNLESS STATED OTHERWISE IN THE PLANS AND/OR SPECIFICATIONS.

Incidental Items. THE CONTRACTOR SHALL FURNISH AND INSTALL ALL INCIDENTAL ITEMS INCLUDING, BUT NOT LIMITED TO NUTS, BOLTS, INSULATORS, FASTENINGS, TEMPORARY TRAFFIC CONTROL DEVICES, ETC. THAT IS NECESSARY FOR THE PROPER CONSTRUCTION OF THE TRAFFIC SIGNAL PROJECT BUT NOT SPECIFICALLY CALLED FOR, AS DIRECTED BY THE PROJECT ENGINEER, AT NO DIRECT PAY. ALL INCIDENTAL METALLIC HARDWARE SHALL BE HOT-DIPPED GALVANIZED STEEL OR STAINLESS STEEL.

Excavation Caution. ANY EXCAVATION PERFORMED BY THE CONTRACTOR IN PROXIMITY TO EXISTING TRAFFIC SIGNAL POLES OR DOWN GUYS MUST BE DONE WITHOUT UNDERMINING THEIR STABILITY. ALL RESTORATION WORK TO PRE-EXISTING CONDITIONS SHALL BE PERFORMED AT THE CONTRACTOR'S EXPENSE AND TO THE SATISFACTION OF THE AGENCY HAVING JURISDICTION.

Field Locations. THE LOCATIONS OF POLES, SIGNALS, LOOP DETECTORS, SYSTEM SENSORS, CONTROLLERS AND JUNCTION BOXES AS SHOWN ON PLANS ARE APPROXIMATE. THE EXACT LOCATIONS SHALL BE DETERMINED IN THE FIELD. THE CONTRACTOR SHALL MAKE ADJUSTMENTS IN LOCATIONS TO CONFORM TO EXISTING FIELD CONDITIONS.

SIGNAL POLE & FOUNDATION

Location. THE PROPOSED LOCATION OF EACH SIGNAL POLE FOUNDATION SHALL BE APPROVED BY THE TRAFFIC ENGINEER PRIOR TO INSTALLATION. THE CONTRACTOR SHALL INSTALL THE FOUNDATION AS SOON AS POSSIBLE AFTER APPROVAL AND SHALL NOT ORDER POLES UNTIL FOUNDATION INSTALLATION IS COMPLETED. CONTRACTOR SHALL NOTIFY TRAFFIC ENGINEERING IMMEDIATELY IF CONFLICTS ARE FOUND AT THE APPROVED LOCATION.

Inspection. POLE INSTALLATIONS SHALL BE INSPECTED AT SEVERAL STAGES, INCLUDING BUT NOT LIMITED TO FOUNDATION EXCAVATION, BOLT, REBAR AND CONDUIT INSTALLATIONS, POLE SET FOR PROPER RAKE, LUMINAIRE INSTALLATIONS, WIRING, GROUNDING AND BONDING. CONTRACTOR SHALL COORDINATE WORK WITH PROJECT ENGINEER FOR APPROVAL OF INSTALLATION. INSPECTION OF ANY WORK ITEM SHALL NOT RELIEVE THE CONTRACTOR OF ANY OBLIGATION TO PROPERLY FULFILL THE CONTRACT REQUIREMENTS.

CONDUCTORS/CABLES

Installation Methods. CONDUCTORS AND CABLES FROM SIGNAL HEADS AND DETECTORS SHALL BE RUN IN UNDERGROUND CONDUIT, ON POLES OR ON MESSENGER CABLE, AND SHALL FOLLOW THE MOST DIRECT ROUTE TO THE CONTROLLER CABINET.

Traffic Control Cable. TRAFFIC CONTROL CABLE SHALL BE CONTINUOUS (NO SPLICES) FROM CONTROLLER CABINET TO LOOP JUNCTION BOXES AND FROM CONTROLLER CABINET TO SERVICE DISCONNECT BOX. ON STRAIN POLE INSTALLATIONS, SIGNAL CABLE SHALL BE CONTINUOUS FROM CONTROLLER CABINET TO DISPLAY. ON MAST ARM INSTALLATIONS, SIGNAL CABLE SHALL BE CONTINUOUS FROM CONTROLLER CABINET TO SIGNAL HEAD ON MAST ARM. WHEN TERMINAL BLOCK IS USED, SIGNAL CABLE SHALL BE CONTINUOUS FROM CONTROLLER CABINET THROUGH TERMINAL BLOCK/HANDHOLE AT POLE BASE TO DISPLAY.

Fiber Optic Cable. FIBER OPTIC CABLE SHALL BE INSTALLED IN ACCORDANCE WITH THE LATEST INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS STANDARDS ASSOCIATION (IEEE-SA) REQUIREMENTS.

CONDUIT

Underground Conduit Installation. UNDERGROUND CONDUITS SHALL BE POLYETHYLENE CHLORIDE (PEC), SCHEDULE EIGHTY (80), AND SHALL BE INSTALLED AT A MINIMUM DEPTH OF THIRTY SIX (36) INCHES BELOW NEW OR EXISTING GRADE.

Boring Method. CONDUIT INSTALLED WITHIN DRIP LINE OF TREES OR UNDER EXISTING PAVED DRIVEWAYS, THAT ARE NOT SCHEDULED TO BE RECONSTRUCTED AS PART OF THE PROJECT, SHALL BE INSTALLED BY BORING METHODS THAT HAVE BEEN REVIEWED AND APPROVED BY THE PROJECT ENGINEER. MINIMUM DEPTH IS THIRTY-SIX (36) INCHES BELOW GRADE, WHETHER NEW OR EXISTING GRADE.

Cleaning. CONDUITS SHALL BE CLEANED BY COMPRESSED AIR AND A PROPERLY SIZED CONDUIT PISTON OR MANDREL PRIOR TO CABLE INSTALLATION.

Conduit Capacity. PRIOR TO CONDUIT INSTALLATION, THE CONTRACTOR SHALL VERIFY THAT NO MORE THAN FORTY PERCENT (40%) OF THE CAPACITY AREA IS REQUIRED FOR THE PROPOSED CONDUCTORS. ANY CONDUITS FOUND INADEQUATE SHALL BE BROUGHT TO THE ATTENTION OF THE PROJECT ENGINEER PRIOR TO INSTALLATION. THE CONTRACTOR WILL BE REQUIRED TO REMOVE AND REPLACE INSTALLED CONDUIT WITH APPROPRIATE SIZED CONDUIT IF CONTRACTOR FAILS TO NOTIFY PROJECT ENGINEER.

PAVEMENT MARKINGS

Marking Layout. THE LAYOUT OF NEW PAVEMENT MARKINGS FOR ALL INTERSECTIONS SHALL BE APPROVED PRIOR TO COMMENCEMENT OF THE WORK.

DECEMBER 4, 2008

DATE	DESCRIPTION REVISIONS	BY

STANDARD PLAN NO. 906-01	DATED DECEMBER 4, 2008	SHEET NO. 1 OF 6

GENERAL NOTES

ENGINEERING DIVISION
DEPARTMENT OF PUBLIC WORKS
CITY OF BATON ROUGE & PARISH OF EAST BATON ROUGE

DESIGNED	DRAWN	CHECKED	APPROVED
T.E.D.	G. VANNICE	D. ROSENQUIST	I. PARTENHEIMER

906–01

Figure 58. City of Baton Rouge #13

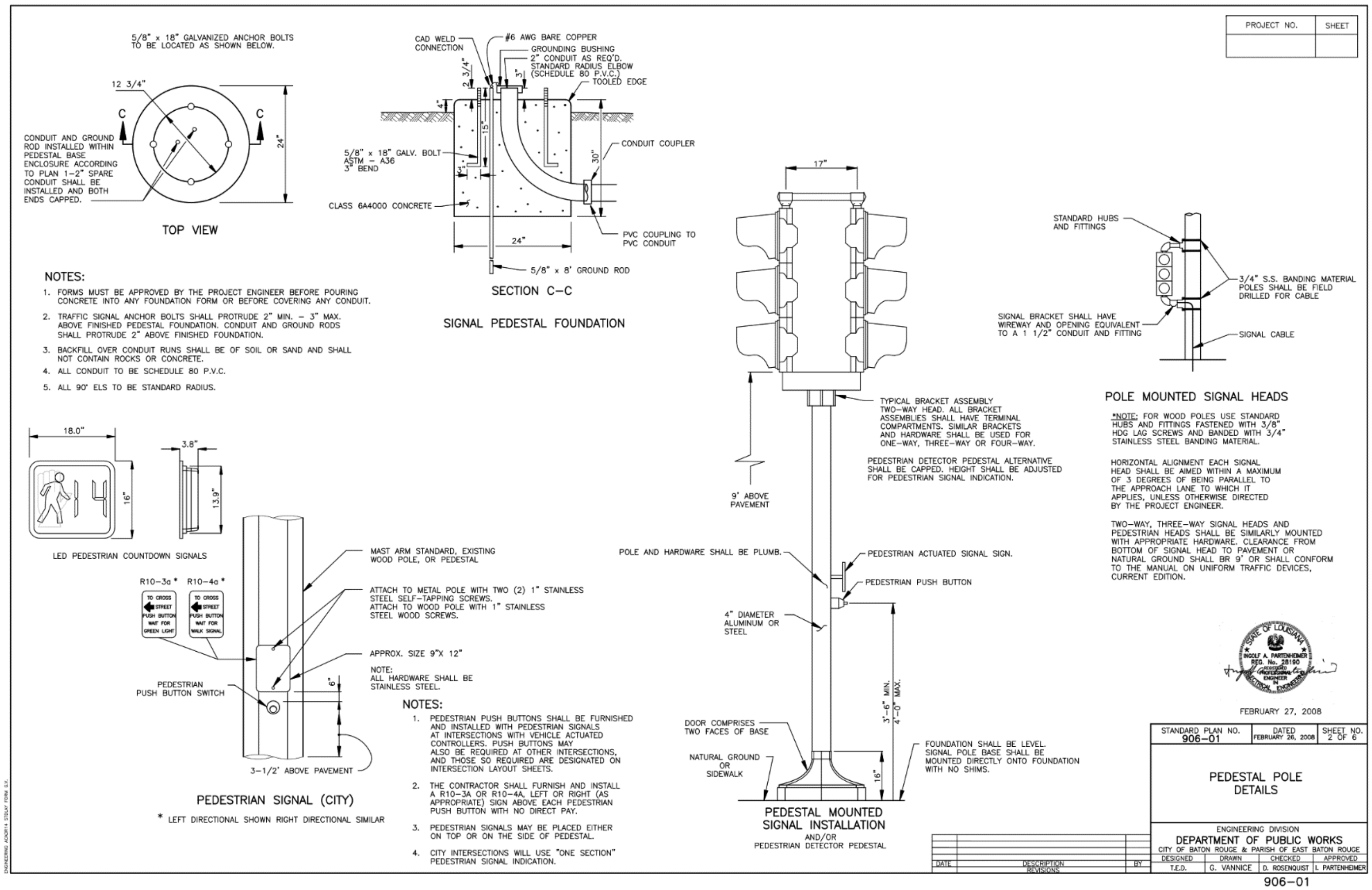


Figure 59. City of Baton Rouge #14

Figure 60. City of Baton Rouge #15

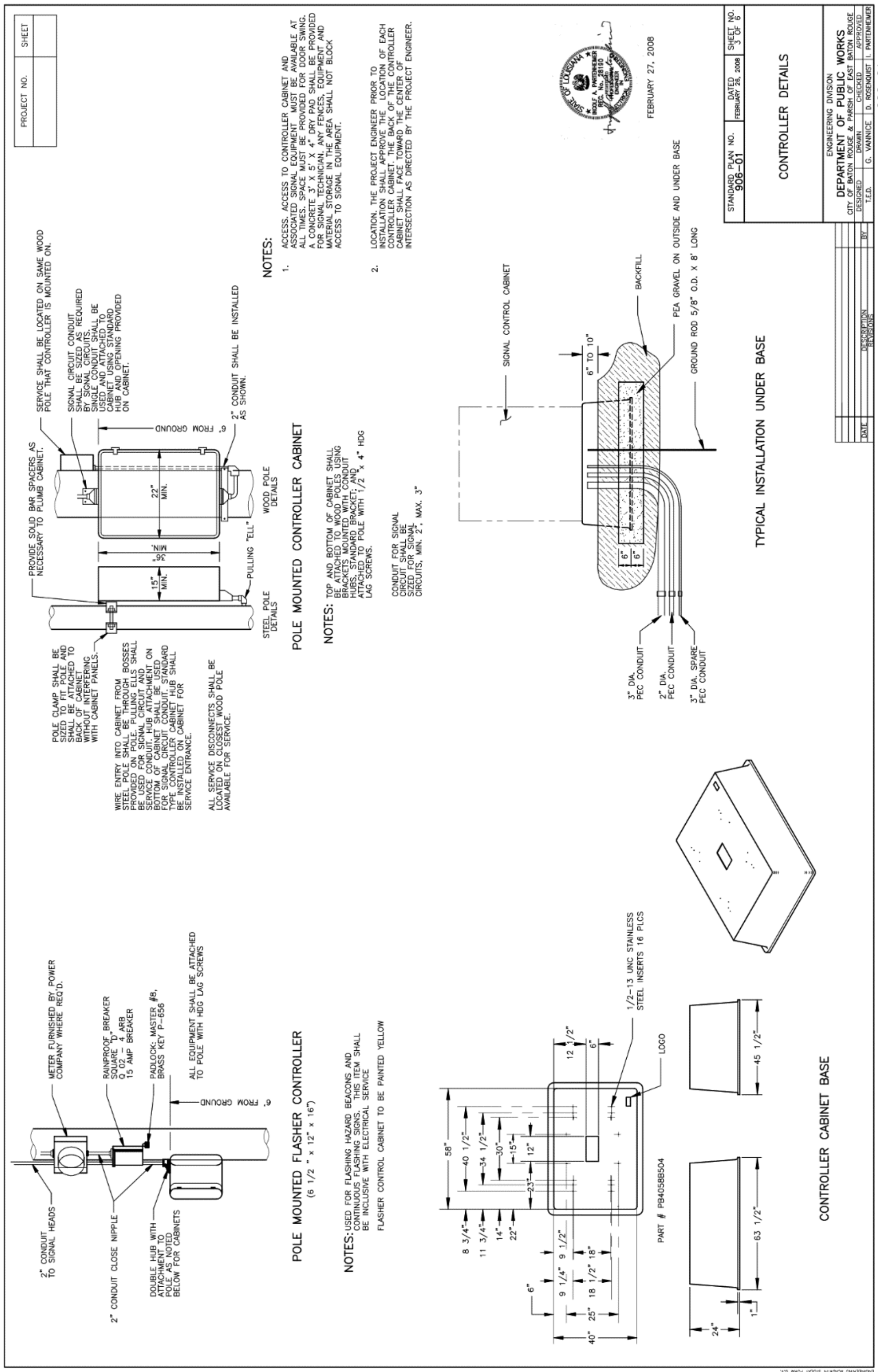
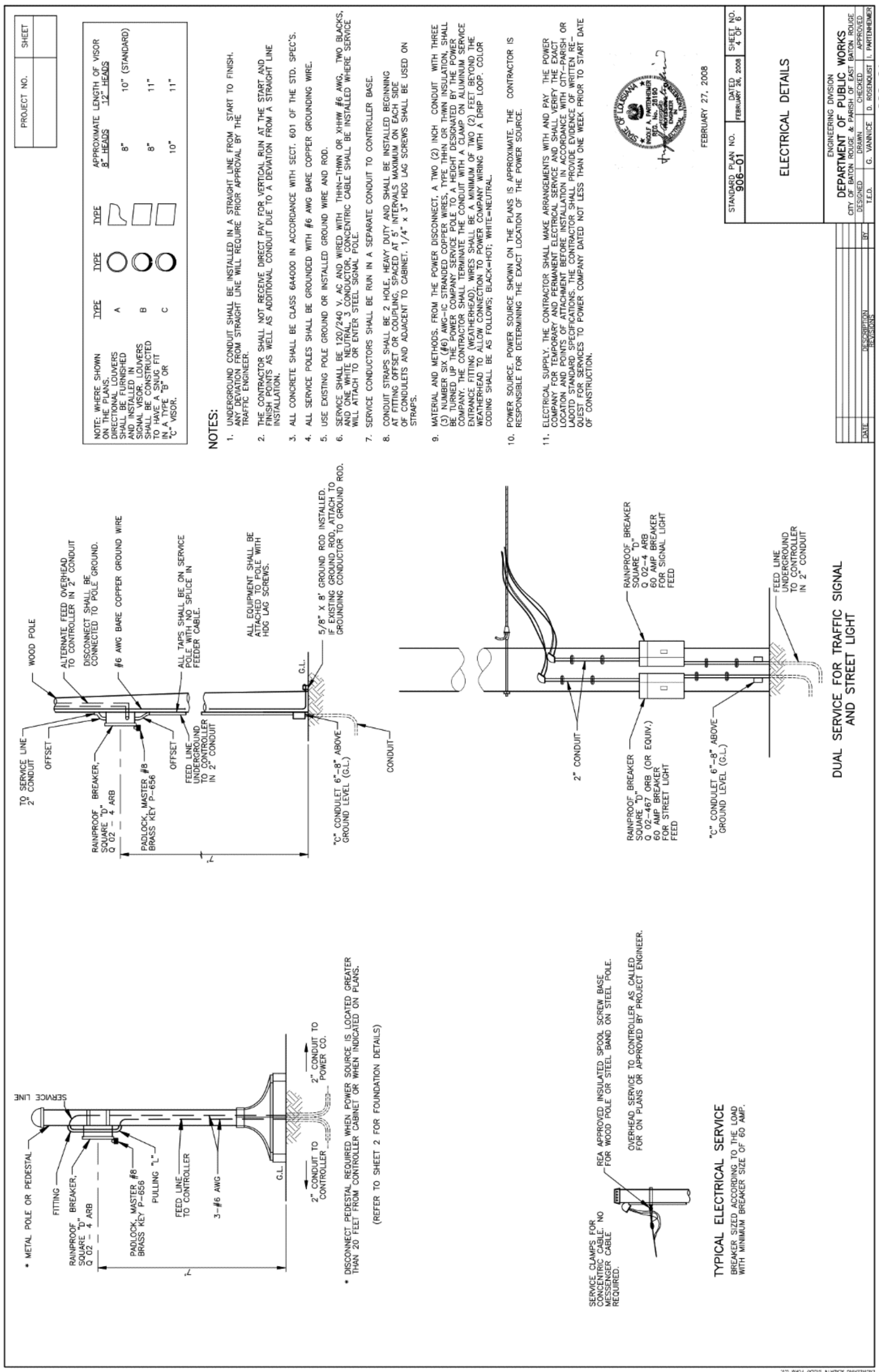
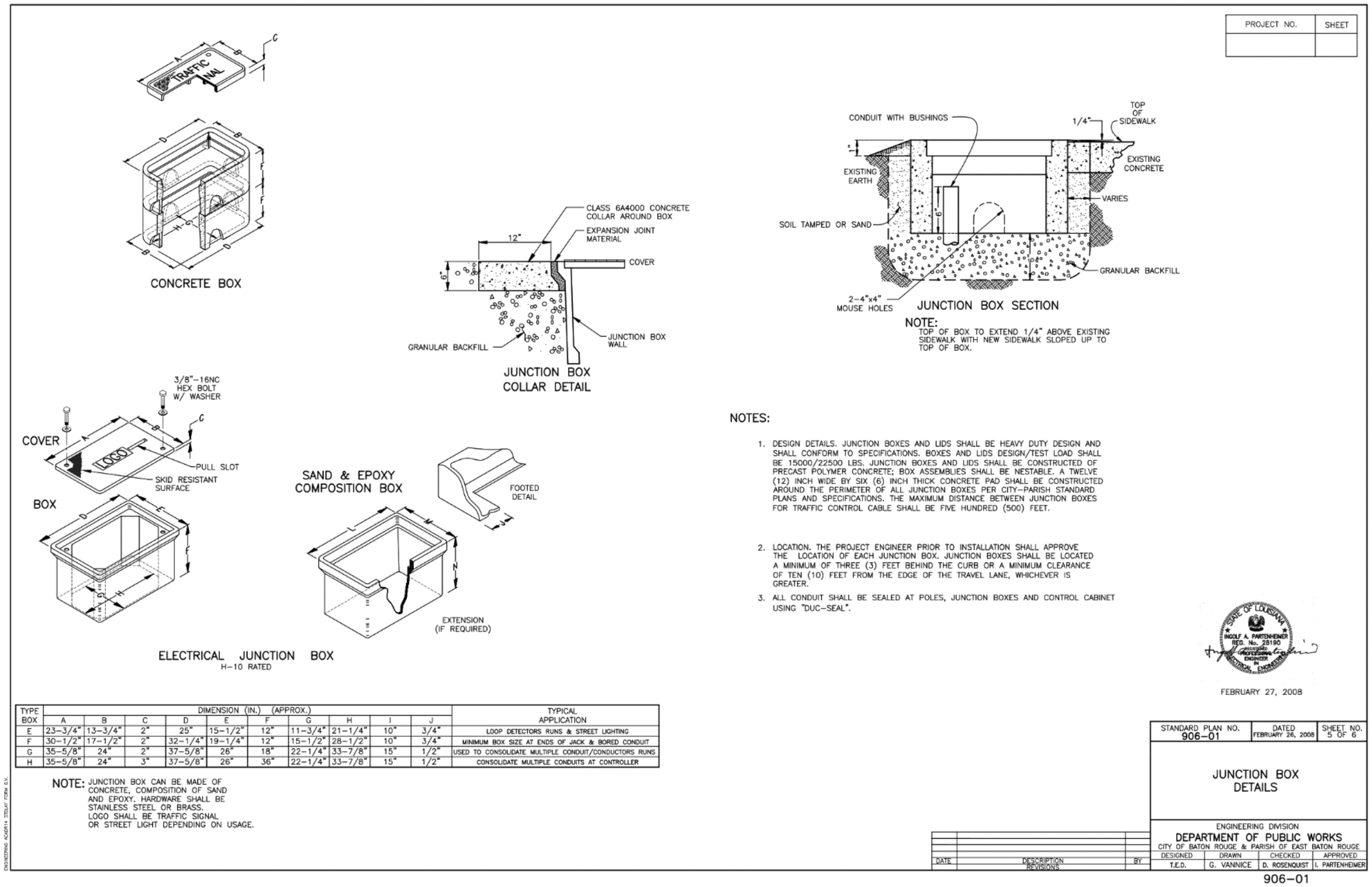


Figure 61. City of Baton Rouge #16





TYPE BOX	DIMENSION (IN.) (APPROX.)										TYPICAL APPLICATION
	A	B	C	D	E	F	G	H	I	J	
E	23-3/4"	13-3/4"	2"	25"	15-1/2"	12"	11-3/4"	21-1/4"	10"	3/4"	LOOP DETECTORS RUNS & STREET LIGHTING
F	30-1/2"	17-1/2"	2"	32-1/4"	19-1/4"	12"	15-1/2"	28-1/2"	10"	3/4"	MINIMUM BOX SIZE AT ENDS OF JACK & BORED CONDUIT
G	35-5/8"	24"	2"	37-5/8"	26"	18"	22-1/4"	33-7/8"	15"	1/2"	USED TO CONSOLIDATE MULTIPLE CONDUIT/CONDUCTORS RUNS
H	35-5/8"	24"	3"	37-5/8"	26"	36"	22-1/4"	33-7/8"	15"	1/2"	CONSOLIDATE MULTIPLE CONDUITS AT CONTROLLER

NOTE: JUNCTION BOX CAN BE MADE OF CONCRETE, COMPOSITION OF SAND AND EPOXY. HARDWARE SHALL BE STAINLESS STEEL OR BRASS. LOGO SHALL BE TRAFFIC SIGNAL OR STREET LIGHT DEPENDING ON USAGE.

NOTES:

1. DESIGN DETAILS. JUNCTION BOXES AND LIDS SHALL BE HEAVY DUTY DESIGN AND SHALL CONFORM TO SPECIFICATIONS. BOXES AND LIDS DESIGN/TEST LOAD SHALL BE 15000/22500 LBS. JUNCTION BOXES AND LIDS SHALL BE CONSTRUCTED OF PRECAST POLYMER CONCRETE; BOX ASSEMBLIES SHALL BE NESTABLE. A TWELVE (12) INCH WIDE BY SIX (6) INCH THICK CONCRETE PAD SHALL BE CONSTRUCTED AROUND THE PERIMETER OF ALL JUNCTION BOXES PER CITY-PARISH STANDARD PLANS AND SPECIFICATIONS. THE MAXIMUM DISTANCE BETWEEN JUNCTION BOXES FOR TRAFFIC CONTROL CABLE SHALL BE FIVE HUNDRED (500) FEET.

2. LOCATION. THE PROJECT ENGINEER PRIOR TO INSTALLATION SHALL APPROVE THE LOCATION OF EACH JUNCTION BOX. JUNCTION BOXES SHALL BE LOCATED A MINIMUM OF THREE (3) FEET BEHIND THE CURB OR A MINIMUM CLEARANCE OF TEN (10) FEET FROM THE EDGE OF THE TRAVEL LANE, WHICHEVER IS GREATER.

3. ALL CONDUIT SHALL BE SEALED AT POLES, JUNCTION BOXES AND CONTROL CABINET USING "DUC-SEAL".

Figure 62. City of Baton Rouge #17

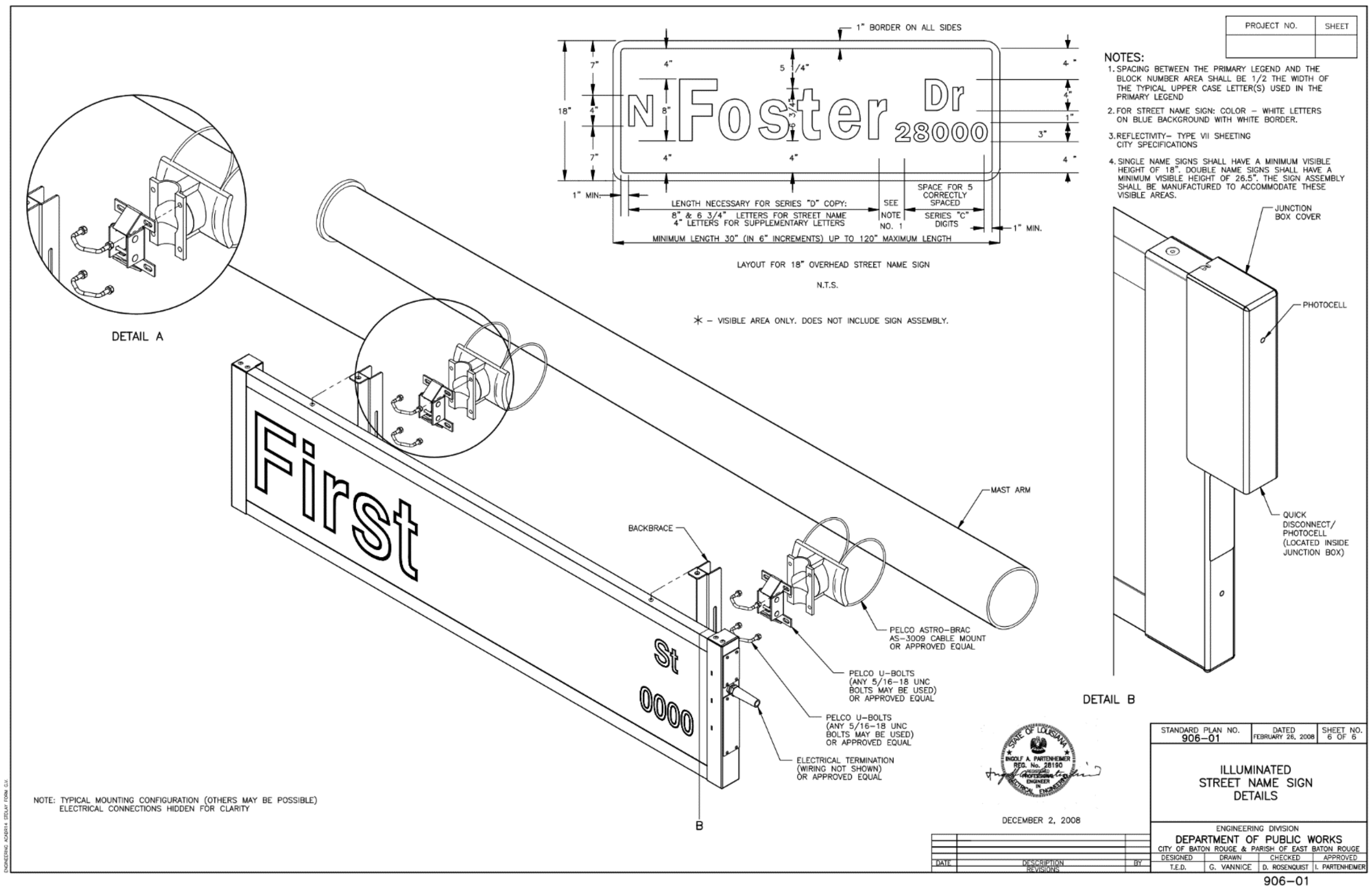


Figure 63. City of Baton Rouge #18

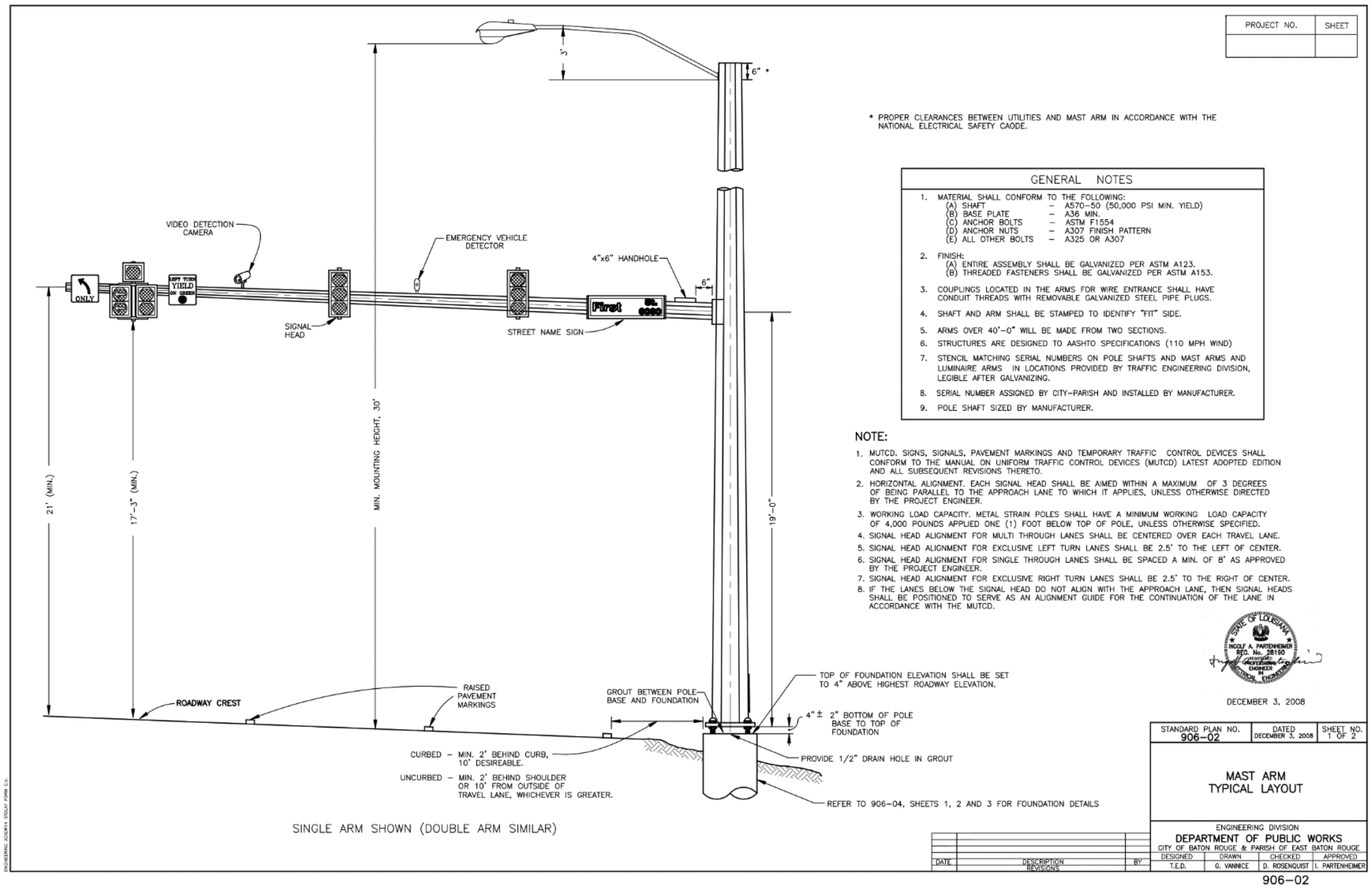


Figure 64. City of Baton Rouge #19

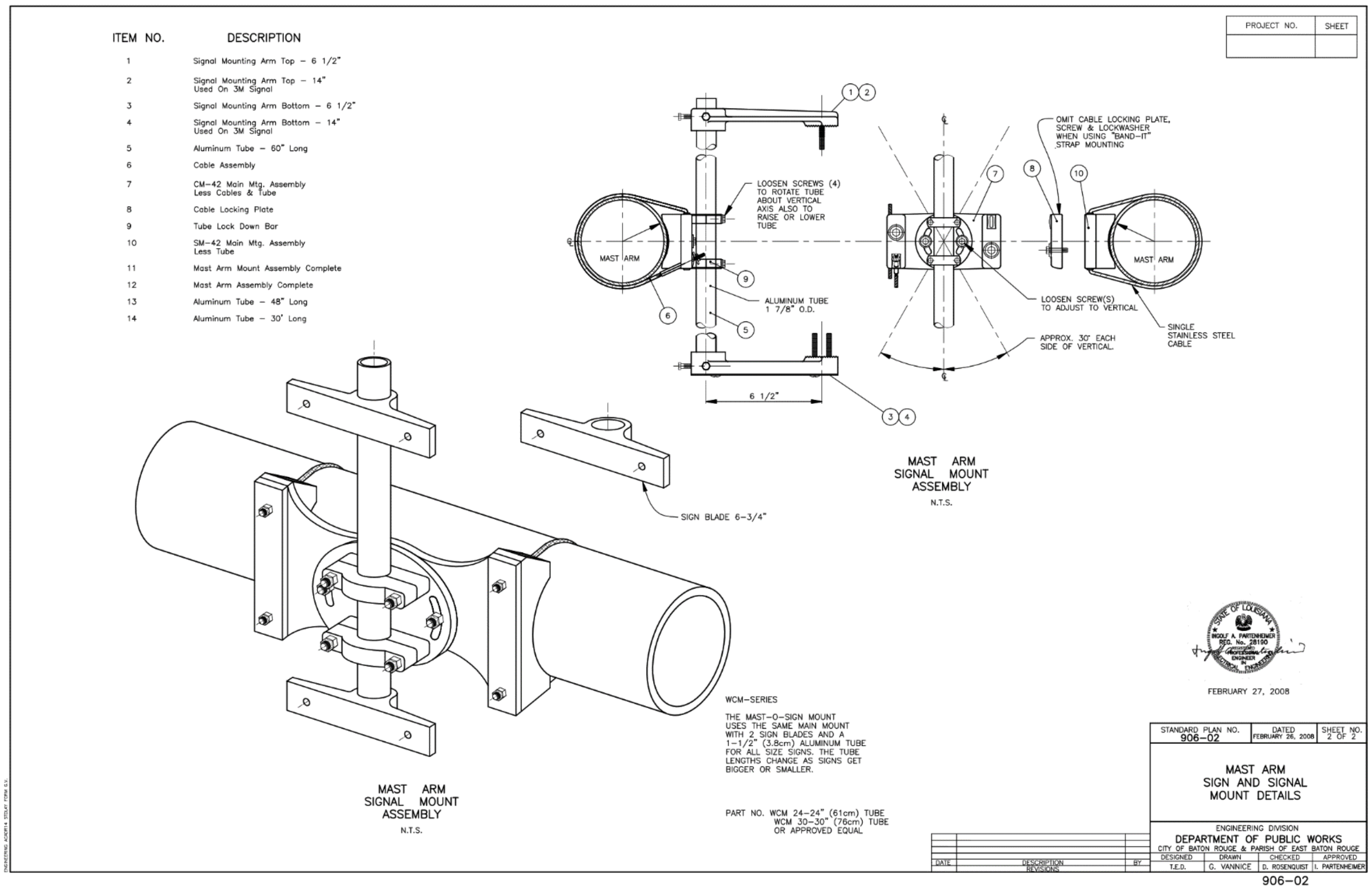


Figure 65. City of Baton Rouge #20

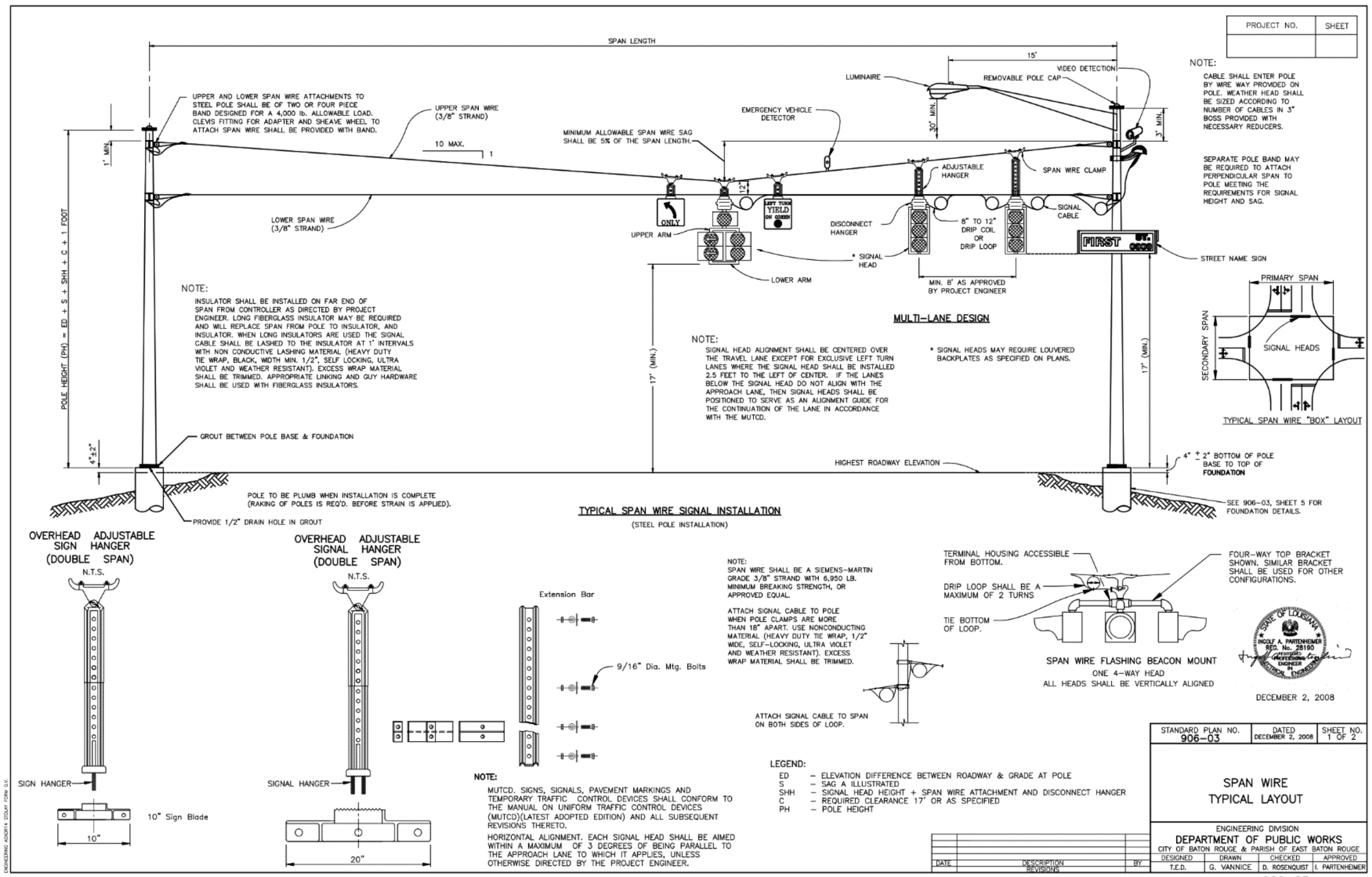


Figure 66. City of Baton Rouge #21

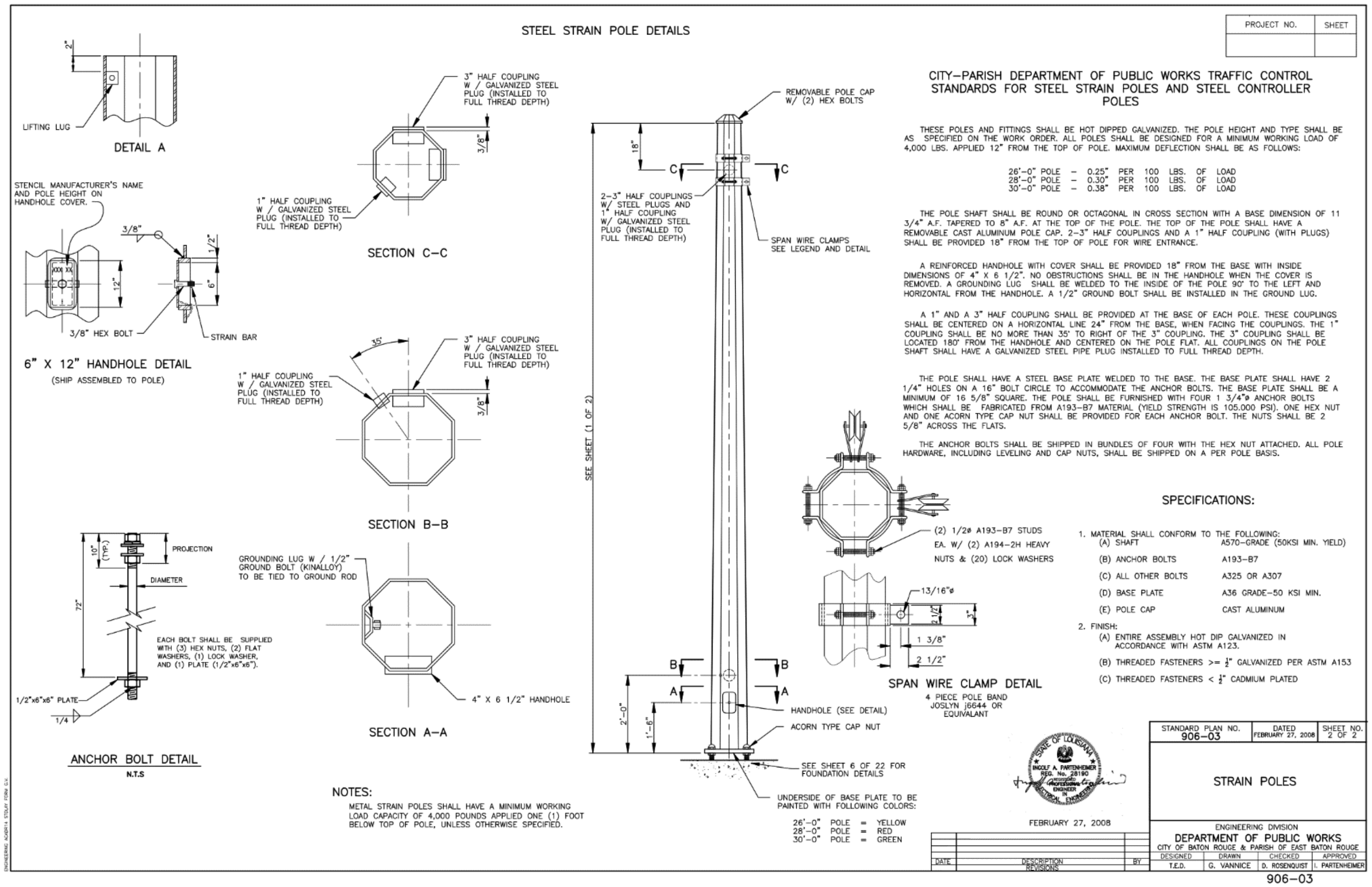
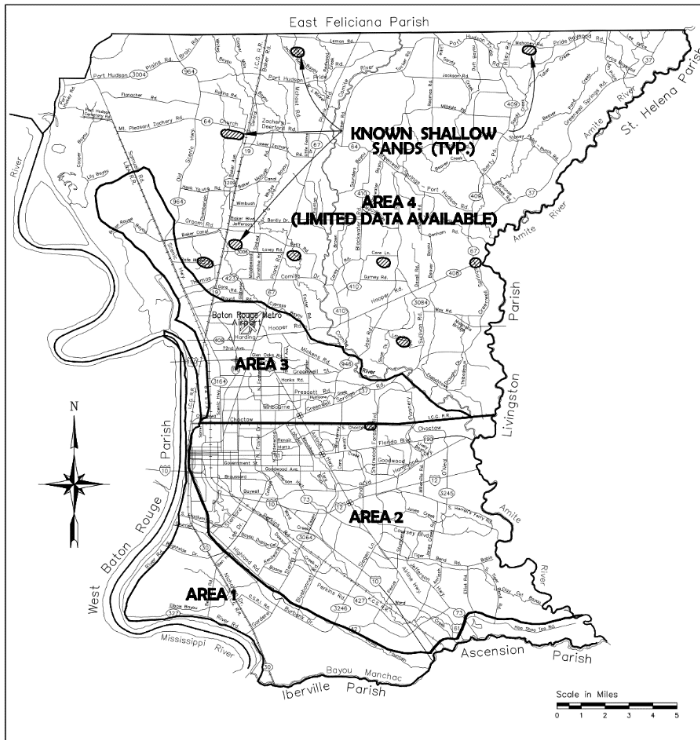


Figure 67. City of Baton Rouge #22



SOIL MAP OF EAST BATON ROUGE PARISH

PROJECT NO.	SHEET

SOIL AREA DESCRIPTIONS:

AREA 1: THIS AREA CONSISTS OF RECENT MISSISSIPPI RIVER DEPOSITS AND IS BOUNDED BY THE MISSISIPPI RIVER, BAYOU MANCHAC AND THE PLEISTOCENE TERRACE BLUFFS. ON THE NORTH EDGE OF THESE DEPOSITS, HIGHLAND ROAD IS GENERALLY THE BOUNDARY FROM MYRTLE AVENUE TO SIEGEN LANE.

AREA 2: THIS IS AN AREA OF THE PLEISTOCENE TERRACE LOCATED GENERALLY NORTH AND EAST OF HIGHLAND ROAD. IT IS BOUNDED ON THE WEST BY THE MISSISIPPI RIVER BLUFF, ON THE EAST BY THE AMITE RIVER, AND ON THE NORTH BY THE ICG RAILROAD TRACKS.

AREA 3: THIS IS AN AREA OF THE PLEISTOCENE TERRACE BOUNDED ON THE SOUTH BY THE ICG RAILROAD TRACKS, ON THE WEST BY THE MISSISIPPI RIVER BLUFF, ON THE NORTH BY LILLY BAYOU AND U.S. HWY. 61 (FROM IRENE TO ALSEN), AND ON THE NORTH AND EAST BY CYPRESS BAYOU AND THE COMITE RIVER. LIMITED DATA IS AVAILABLE IN THE EASTERN PART OF THIS AREA.

AREA 4: THIS AREA IS THE REMAINDER OF THE PARISH TO THE NORTH OF AREA 3 BETWEEN THE MISSISSIPPI RIVER ON THE WEST AND THE AMITE RIVER ON THE EAST. IN THIS AREA ONLY VERY LIMITED GEOTECHNICAL DATA IS AVAILABLE. SHALLOW SANDS CAN OFTEN BE ENCOUNTERED IN THIS AREA.

DESIGN NOTES:

1. FOUNDATION LOADS WERE CALCULATED IN ACCORDANCE WITH THE 2006 INTERIM TO THE AASHTO "STANDARD SPECIFICATIONS FOR STRUCTURAL SUPPORTS FOR HIGHWAY SIGNS, LUMINARIES AND TRAFFIC SIGNALS." LOADS ARE BASED ON A 110 MPH WIND WITH GUST FACTOR OF 1.14.
2. BROM'S METHOD WAS USED TO CALCULATE THE ULTIMATE LATERAL BEARING CAPACITY OF THE SOILS.
3. ALL POLE LOCATIONS WHERE THE NATURAL GROUND IS BELOW ELEVATION 20 SHOULD BE INVESTIGATED WITH SITE SPECIFIC BORINGS, AS SHOULD SIGNALS FOUNDED IN ROADWAY FILLS.
4. ANY SIGNAL TO BE PLACED IN THE FLOOD PLAIN OF AN EXISTING OR OLD CREEK OR RIVER SHOULD BE INVESTIGATED WITH SITE SPECIFIC BORINGS.
5. SIGNALS LOCATED IN THE REGIONS DESIGNED AS LIMITED DATA ON THE ATTACHED PARISH MAP SHOULD BE INVESTIGATED WITH SITE SPECIFIC BORINGS.

CONSTRUCTION NOTES:

6. DEPENDING ON FIELD CONDITIONS, GROUND WATER MAY BE ENCOUNTERED DURING THE CONSTRUCTION OF THESE DRILLED SHAFT FOUNDATIONS. PRIOR TO COMMENCEMENT OF DRILLING OPERATIONS THE CONTRACTOR SHALL BE REQUIRED TO HAVE ON SITE THE PROPER TEMPORARY CASING TO BE USED IF NECESSARY.
7. IF THE SOIL CONDITIONS DIFFER FROM THE SOIL PROFILE SHOWN, THE CONTRACTOR SHALL IMMEDIATELY NOTIFY THE PROJECT ENGINEER.
8. NO EXCAVATION AROUND DRILLED SHAFT SHALL BE ALLOWED WITHOUT PRIOR APPROVAL FROM THE ENGINEER.
9. ALL CONCRETE SHALL HAVE MINIMUM 4,000 PSI 28 DAY STRENGTH. MAST ARMS SHALL NOT BE ERECTED ON POLES BEFORE CONCRETE DESIGN STRENGTH HAS REACHED 3,000 PSI.
10. CONCRETE SHALL BE PLACED BY MEANS OF TREMIE PIPE OR DEPOSITED NEAR THE BOTTOM OF THE HOLE BY MEANS OF A PUMP. WHEN TEMPORARY CASING IS USED, THE TOP SURFACE OF WET CONCRETE MUST BE KEPT A MINIMUM OF TWO FEET ABOVE THE BOTTOM OF THE CASING.
11. TOP OF FOUNDATION SHALL BE ROUND WITH CHAMFERED EDGE.
12. ALL REINFORCING STEEL SHALL BE ASTM A615, GRADE 60.
13. SPLICES IN HOOP TIES SHALL BE ALTERNATED BETWEEN QUARTER POINTS.
14. ANCHOR BOLTS SHALL BE FABRICATED FROM ASTM F1554, GRADE 55 STEEL AND HOT DIPPED GALVANIZED IN ACCORDANCE WITH ASTM A153.
15. ANCHOR BOLTS SHALL BE HELD IN PLACE WITH A TEMPLATE CAPABLE OF SECURING BOLTS IN THE PROPER LOCATION, ORIENTATION, ELEVATION AND PLUMB.
16. ANCHOR BOLT ACCESSORIES SHALL BE AS FOLLOWS:
    NUTS – ASTM A563
    WASHERS – ASTM F436
    STRUCTURAL STEEL PLATES – ASTM A36
    HOT DIP GALVANIZING – ASTM A153
17. CONDUIT SHALL BE SCHEDULE 80 PVC AND BE INSTALLED ACCORDING TO THE PLANS. ALL CONDUITS SHALL BE CENTERED IN THE FOUNDATION WITH SPACING TO ALLOW THE INSTALLATION OF GROUNDING BUSHINGS.
18. ALL STEEL POLE FOUNDATIONS TO HAVE A SPARE CONDUIT INSTALLED AND SEALED (IN THE SAME DIRECTION AS THE OTHER CONDUIT BEING USED) BELOW GRADE AND BROUGHT TO THE NEAREST JUNCTION BOX.
19. SERVICE CONDUIT SHALL BE MIN. 1" DIAMETER.
20. ONLY SPARE CONDUITS ARE SHOWN, REFER TO EACH STEEL POLE SHOWN IN PLANS FOR COMPLETE CONDUIT REQUIREMENT.
21. CAD WELD #6 AWG BARE COPPER GROUND WIRE ON GROUND ROD IN A "T" ARRANGEMENT, WITH ONE SIDE TO BE CONNECTED TO POLE AND THE OTHER SIDE CONNECTED TO ALL CONDUIT GROUNDING BUSHINGS.
22. FOR DETAILS NOT SHOWN HERE SEE POLE MANUFACTURER'S DETAILS FOR EACH POLE TYPE.

SOIL PROFILE LEGEND*

AREA NO.	DEPTH (FT.)	SHEAR STRENGTH (KSF)	VISUAL DESCRIPTION
1	5–20	0.40	SOFT GRAY CLAY & SILTY CLAY
2	5–10 10–16 16–20	0.50 0.60 1.00	MEDIUM BROWN, TAN & GRAY CLAY & SILTY CLAY STIFF TAN & GRAY CLAY & SILTY CLAY
3	5–10 10–20	0.50 1.20	MEDIUM BROWN, TAN & GRAY CLAY & SILTY CLAY STIFF TAN & GRAY CLAY & SILTY CLAY
4	5–9 9–20	0.35 1.20	SOFT TAN & GRAY SILTY CLAY STIFF TAN & GRAY CLAY & SILTY CLAY

* LOWER STRENGTH OR WATER BEARING SANDS OR SILTS REQUIRE SPECIAL DESIGN

STATE OF LOUISIANA
BRYAN K. HARMON
REG. No. 22595
REGISTERED PROFESSIONAL ENGINEER IN CIVIL ENGINEERING

DECEMBER 2, 2008

DATE	DESCRIPTION	BY
	REVISIONS	

STANDARD PLAN NO.	DATED	SHEET NO.
906–04	DECEMBER 2, 2008	1 OF 4

SIGNAL POLE
FOUNDATION DETAILS
(GENERAL INFORMATION)

ENGINEERING DIVISION
DEPARTMENT OF PUBLIC WORKS
CITY OF BATON ROUGE & PARISH OF EAST BATON ROUGE

DESIGNED	DRAWN	CHECKED	APPROVED
H. THOM	D. KNOTT	D. ROSENQUIST	B. HARMON

906–04

Figure 68. City of Baton Rouge #23

Figure 69. City of Baton Rouge #24

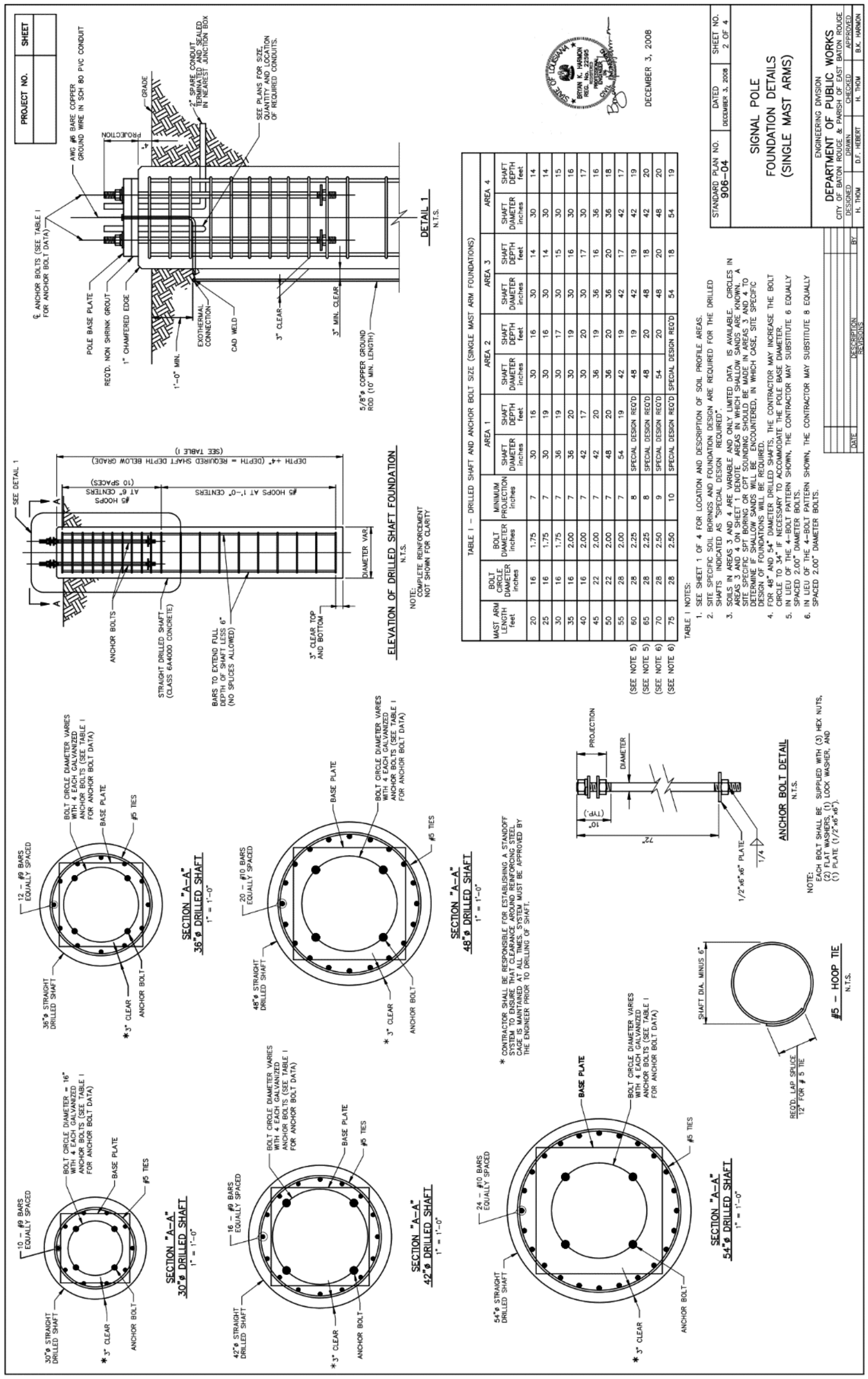


Figure 70. City of Baton Rouge #25

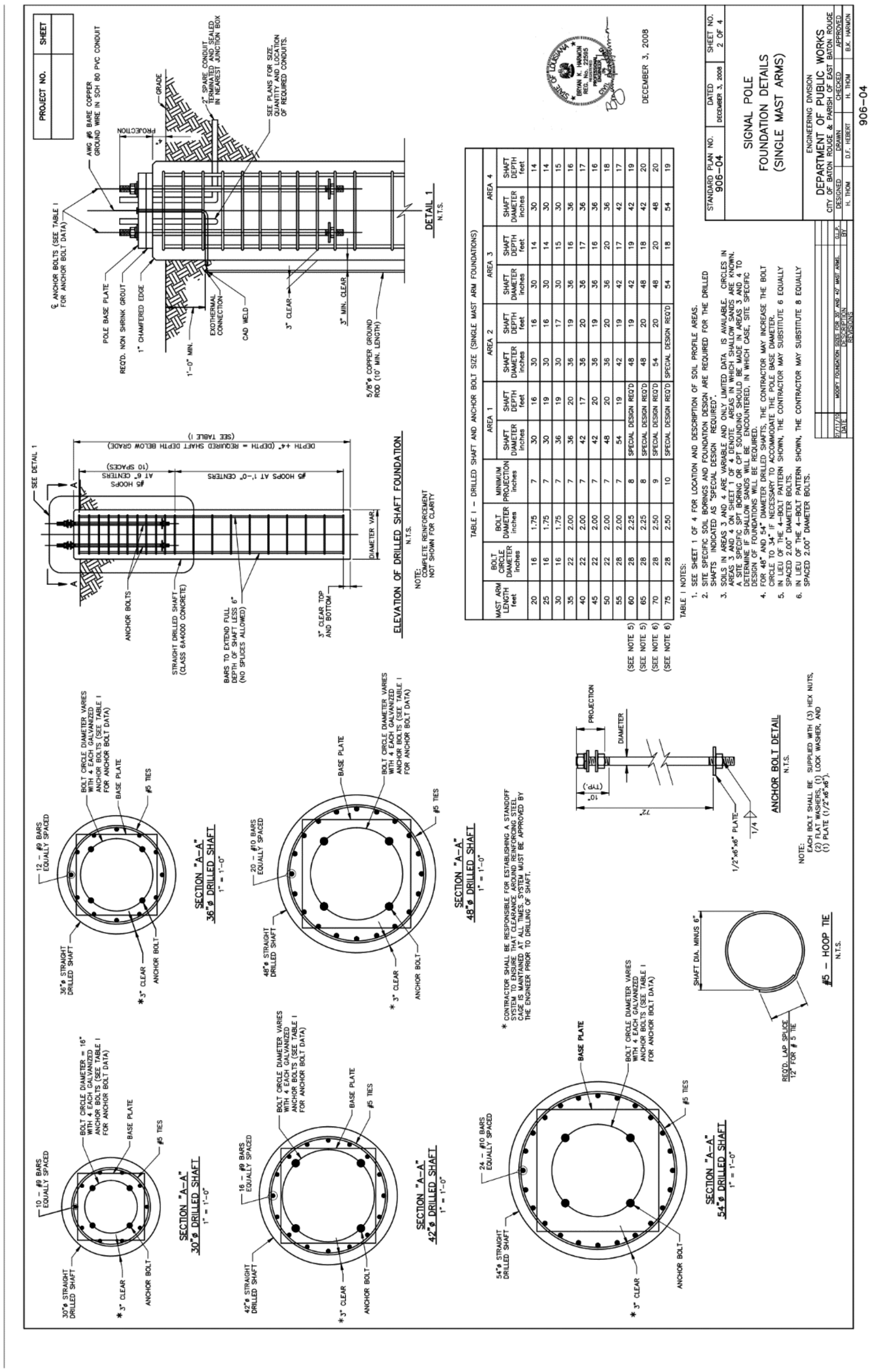
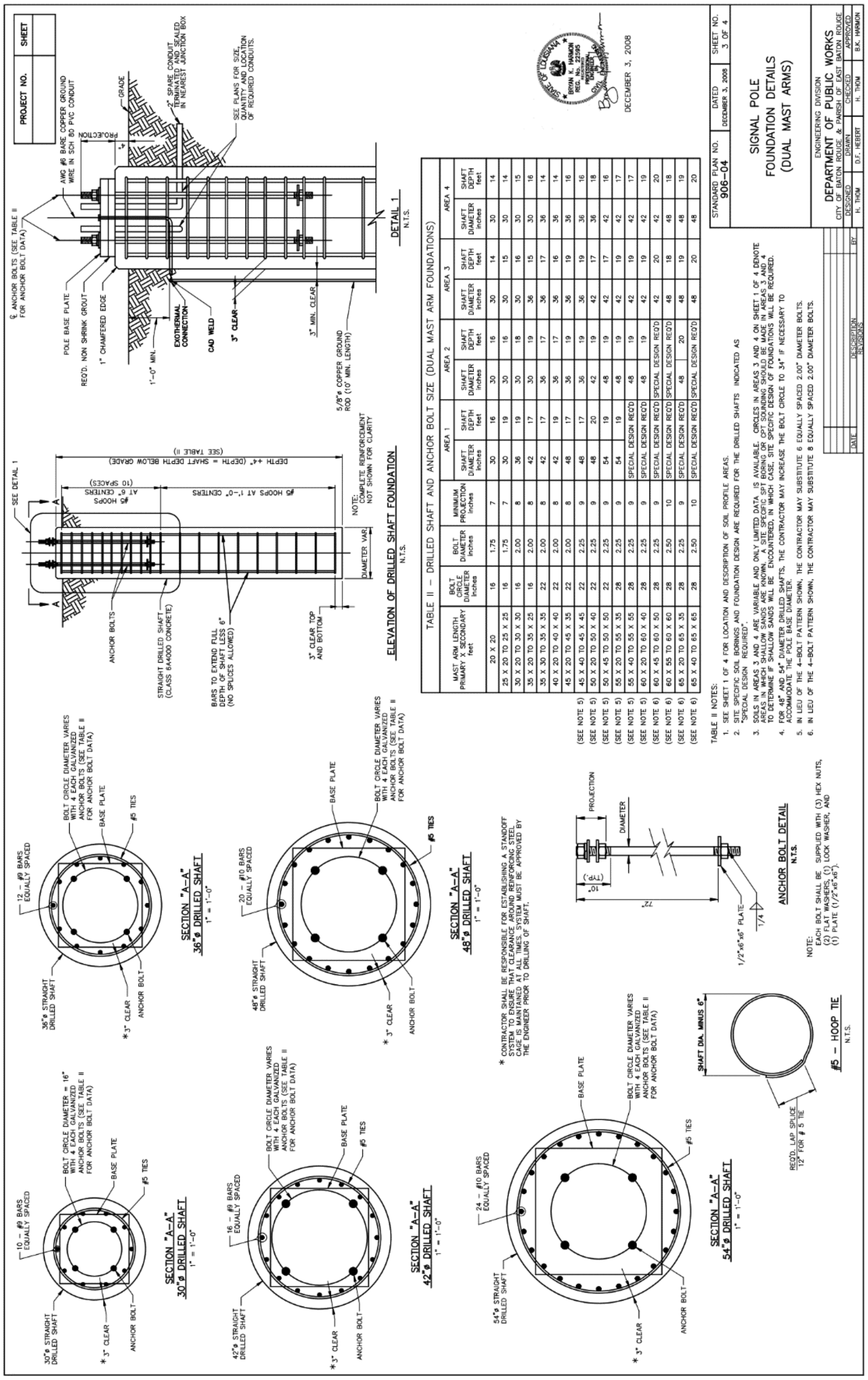
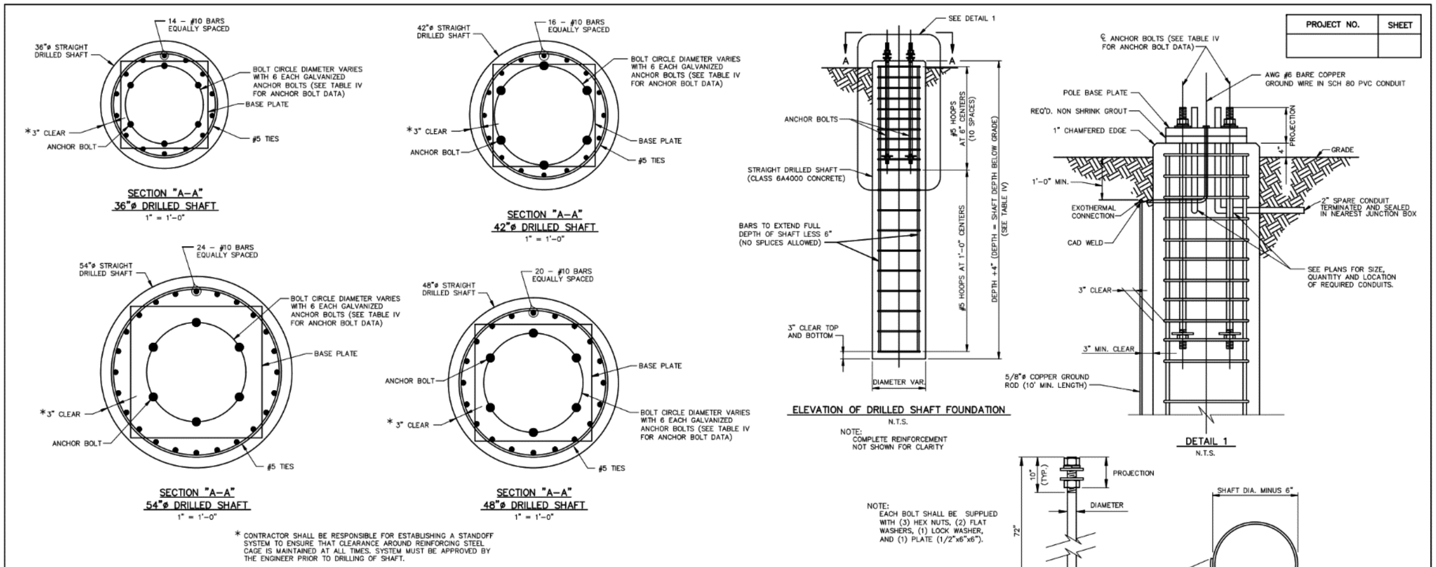


Figure 71. City of Baton Rouge #26





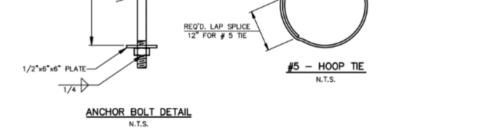


TABLE III – REQUIRED FOUNDATION DESIGN GROUPS FOR SPAN WIRE COMBINATIONS

SECONDARY SPAN LENGTH (ft.)	PRIMARY SPAN LENGTH (ft.) 75	85	95	105	115	125	135	145	155	165
75	A	B	B	C	C	D	D	E	E	F
85		B	C	C	D	D	E	E	F	F
95			C	D	D	E	E	F	F	G
105				D	E	E	F	F	G	G
115					E	F	F	G	G	H
125						F	G	G	H	H
135							G	H	H	I
145								H	I	I
155									I	J
165										J

TABLE III NOTES:

1. ENTER THE TABLE USING THE PRIMARY AND SECONDARY SPAN LENGTHS WHICH ARE EQUAL TO OR GREATER THAN THE REQUIRED SPAN LENGTHS.
2. DETERMINE THE REQUIRED FOUNDATION DESIGN GROUP.
3. SEE TABLE IV FOR REQUIRED ANCHOR BOLTS AND DRILLED SHAFT DIAMETER AND DEPTH.

TABLE IV – DRILLED SHAFT AND ANCHOR BOLT SIZE (STRAIN POLE FOUNDATIONS)

FOUNDATION DESIGN GROUP	MAXIMUM DESIGN MOMENT AT BASE OF POLE (FOOT-KIPS)	MINIMUM REQUIRED DEFLECTION RATE OF POLE 25' ABOVE BASE (INCHES/100 lbs.)	BOLT CIRCLE DIAMETER (INCHES)	BOLT DIAMETER (INCHES)	MINIMUM PROJECTION (INCHES)	AREA 1 SHAFT DIAMETER (INCHES)	AREA 1 SHAFT DEPTH (FEET)	AREA 2 SHAFT DIAMETER (INCHES)	AREA 2 SHAFT DEPTH (FEET)	AREA 3 SHAFT DIAMETER (INCHES)	AREA 3 SHAFT DEPTH (FEET)	AREA 4 SHAFT DIAMETER (INCHES)	AREA 4 SHAFT DEPTH (FEET)
A	155.00	0.050	24	1.75	7	42	20	36	18	36	17	36	17
B	165.00	0.050	24	1.75	7	42	20	36	19	36	17	36	17
C	175.00	0.050	24	1.75	7	48	20	36	19	36	17	36	18
D	185.00	0.050	24	2.00	8	48	20	36	19	42	17	36	18
E	195.00	0.050	24	2.00	8	54	20	36	19	42	17	36	18
F	205.00	0.030	28	2.00	8	54	20	42	19	42	18	42	17
G	215.00	0.030	28	2.00	8	SPECIAL DESIGN REQUIRED		42	19	42	18	42	18
H	225.00	0.030	28	2.00	8	SPECIAL DESIGN REQUIRED		42	19	42	18	42	18
I	235.00	0.030	28	2.00	8	SPECIAL DESIGN REQUIRED		48	18	42	18	42	18
J	245.00	0.030	28	2.00	8	SPECIAL DESIGN REQUIRED		48	18	48	18	48	18

TABLE IV NOTES:

1. SEE SHEET 1 OF 4 FOR LOCATION AND DESCRIPTION OF SOIL PROFILE AREAS.
2. SITE SPECIFIC SOIL BORINGS AND FOUNDATION DESIGN ARE REQUIRED FOR THE DRILLED SHAFTS INDICATED AS "SPECIAL DESIGN REQUIRED".
3. SOILS IN AREAS 3 AND 4 ARE VARIABLE AND ONLY LIMITED DATA IS AVAILIABLE CIRCLES IN AREAS 3 AND 4 ON SHEET 1 OF 4 DENOTE AREAS IN WHICH SHALLOW SANDS ARE KNOWN. A SITE SPECIFIC SPT BORING OR CPT SOUNDING SHOULD BE MADE IN AREAS 3 AND 4 TO DETERMINE IF SHALLOW SANDS WILL BE ENCOUNTERED, IN WHICH CASE, SITE SPECIFIC DESIGN OF FOUNDATIONS WILL BE REQUIRED.

STATE OF LOUISIANA – BRYAN K. HARMON – REG. No. 22565 – REGISTERED PROFESSIONAL ENGINEER

DECEMBER 3, 2008

PROJECT NO.	SHEET

STANDARD PLAN NO.	DATED	SHEET NO.
906-04	DECEMBER 3, 2008	4 OF 4

SIGNAL POLE FOUNDATION DETAILS (STRAIN POLES)

ENGINEERING DIVISION
DEPARTMENT OF PUBLIC WORKS
CITY OF BATON ROUGE & PARISH OF EAST BATON ROUGE

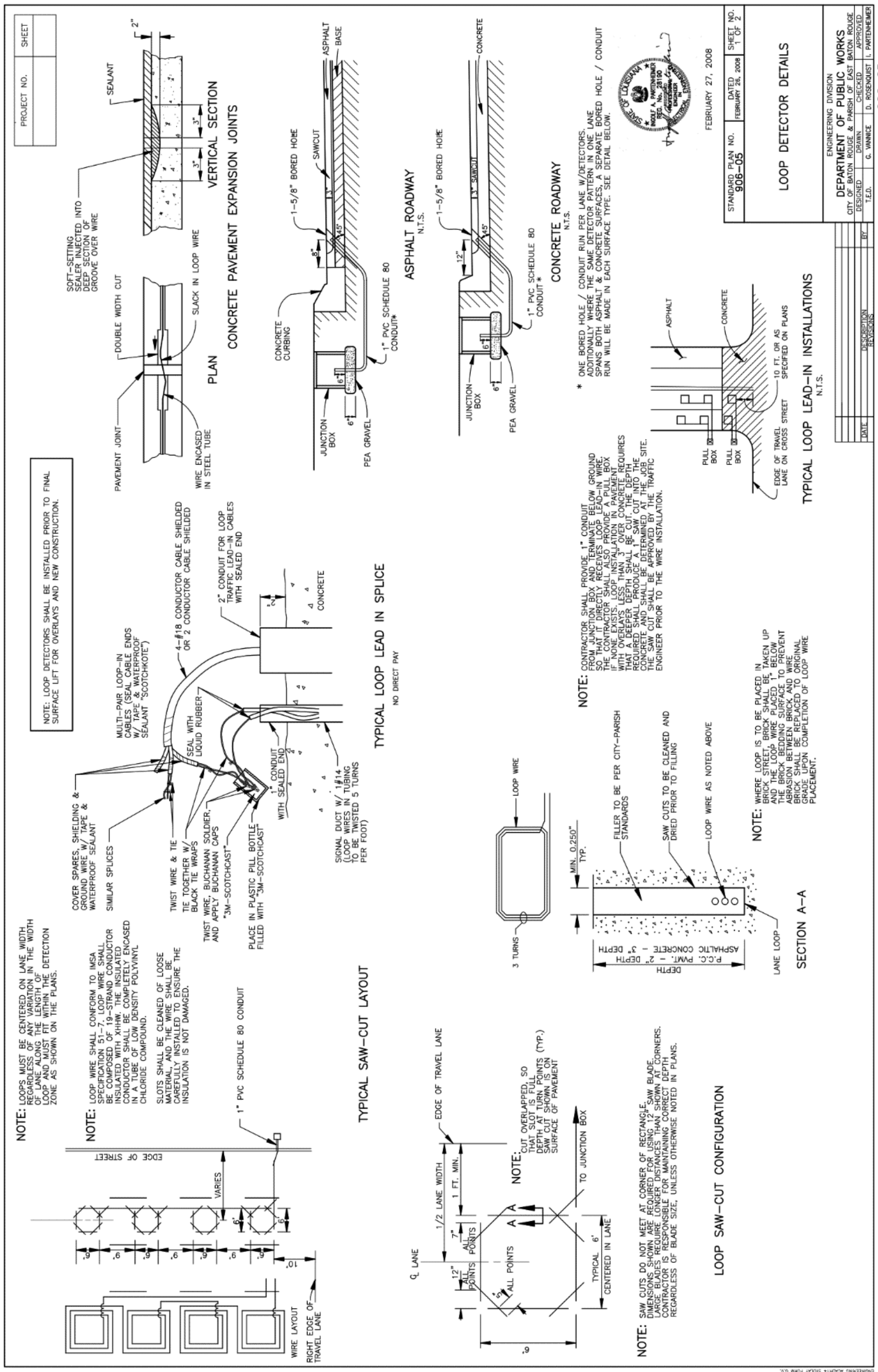
DESIGNED	DRAWN	CHECKED	APPROVED
H. THOM	D.F. HEBERT	H. THOM	B.K. HARMON

DATE	DESCRIPTION REVISIONS	BY

906-04

Figure 72. City of Baton Rouge #27

Figure 73. City of Baton Rouge #28



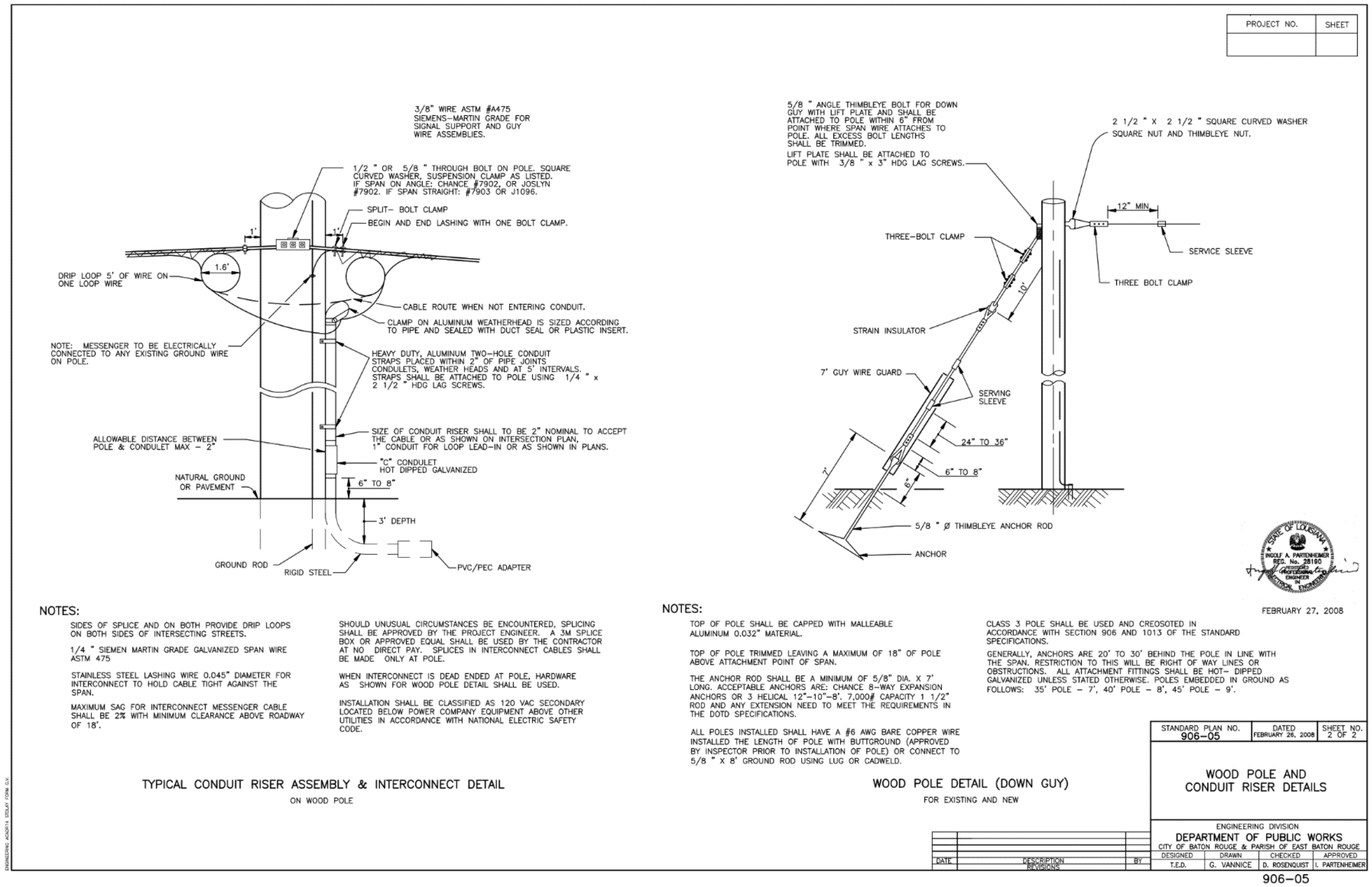


Figure 74. City of Baton Rouge #29

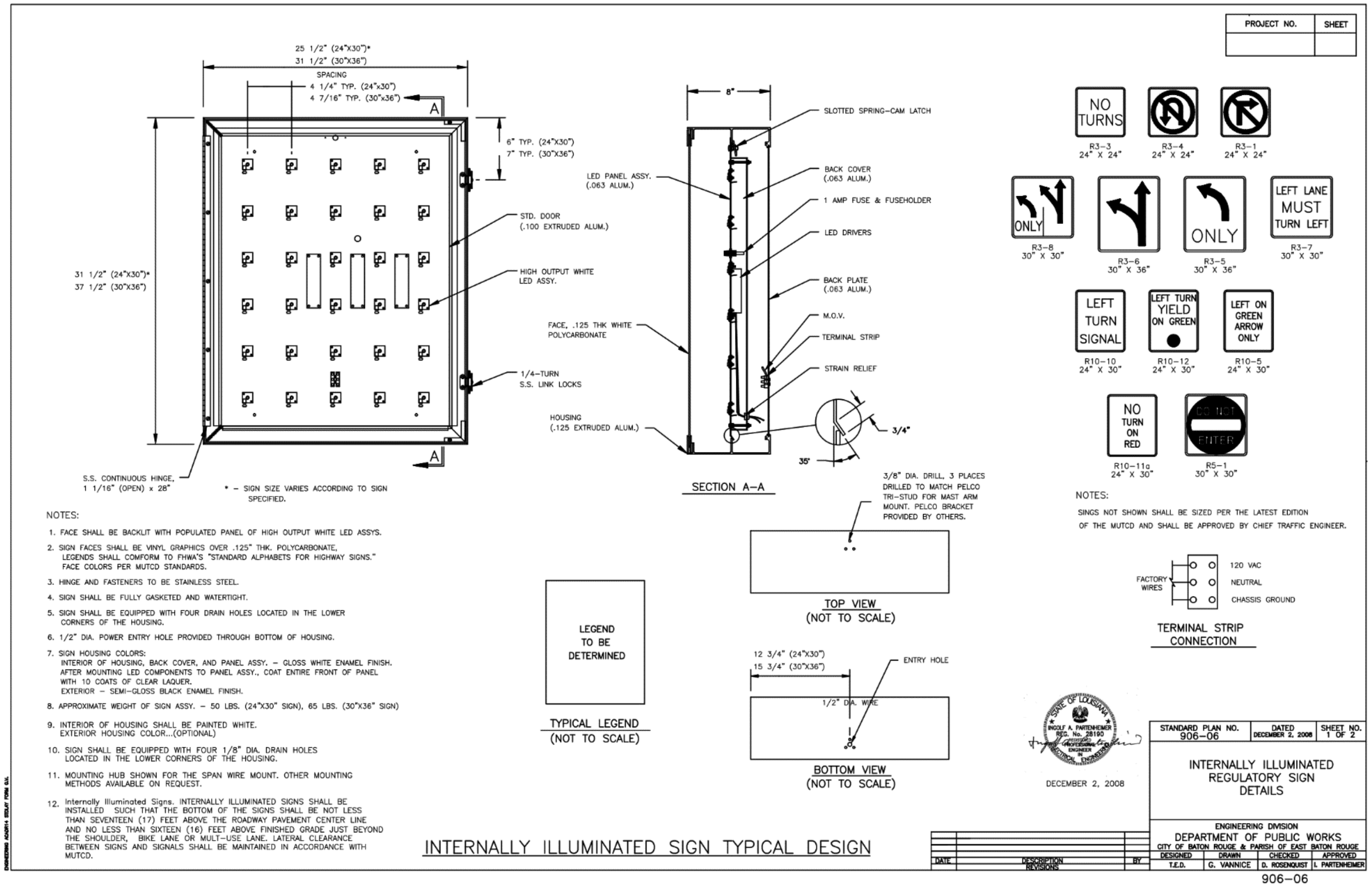
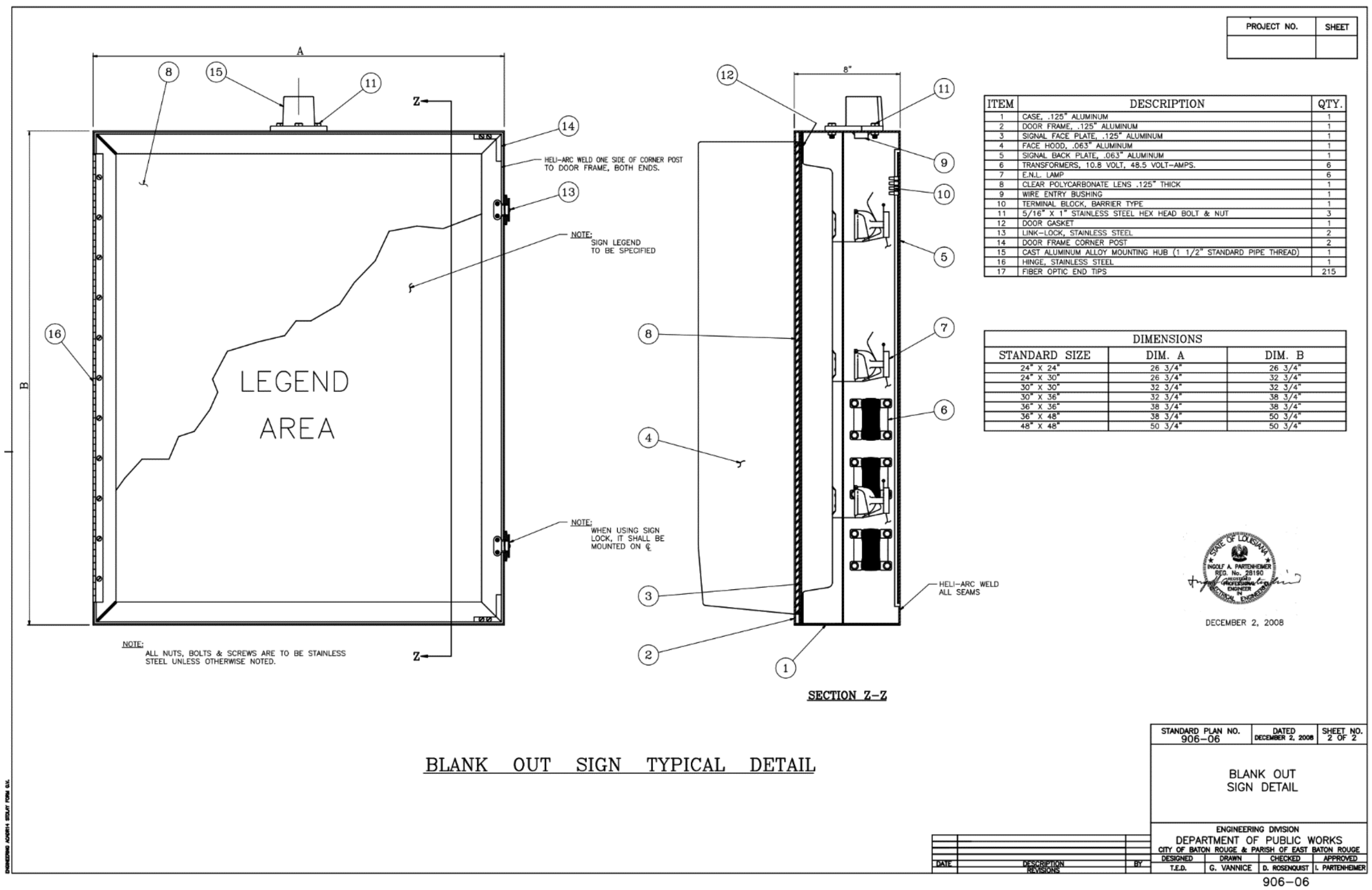


Figure 75. City of Baton Rouge #30



ITEM	DESCRIPTION	QTY.
1	CASE, .125" ALUMINUM	1
2	DOOR FRAME, .125" ALUMINUM	1
3	SIGNAL FACE PLATE, .125" ALUMINUM	1
4	FACE HOOD, .063" ALUMINUM	1
5	SIGNAL BACK PLATE, .063" ALUMINUM	1
6	TRANSFORMERS, 10.8 VOLT, 48.5 VOLT-AMPS.	6
7	E.N.L. LAMP	6
8	CLEAR POLYCARBONATE LENS .125" THICK	1
9	WIRE ENTRY BUSHING	1
10	TERMINAL BLOCK, BARRIER TYPE	1
11	5/16" X 1" STAINLESS STEEL HEX HEAD BOLT & NUT	3
12	DOOR GASKET	1
13	LINK-LOCK, STAINLESS STEEL	2
14	DOOR FRAME CORNER POST	2
15	CAST ALUMINUM ALLOY MOUNTING HUB (1 1/2" STANDARD PIPE THREAD)	1
16	HINGE, STAINLESS STEEL	1
17	FIBER OPTIC END TIPS	215

DIMENSIONS		
STANDARD SIZE	DIM. A	DIM. B
24" X 24"	26 3/4"	26 3/4"
24" X 30"	26 3/4"	32 3/4"
30" X 30"	32 3/4"	32 3/4"
30" X 36"	32 3/4"	38 3/4"
36" X 36"	38 3/4"	38 3/4"
36" X 48"	38 3/4"	50 3/4"
48" X 48"	50 3/4"	50 3/4"

Figure 76. City of Baton Rouge #31

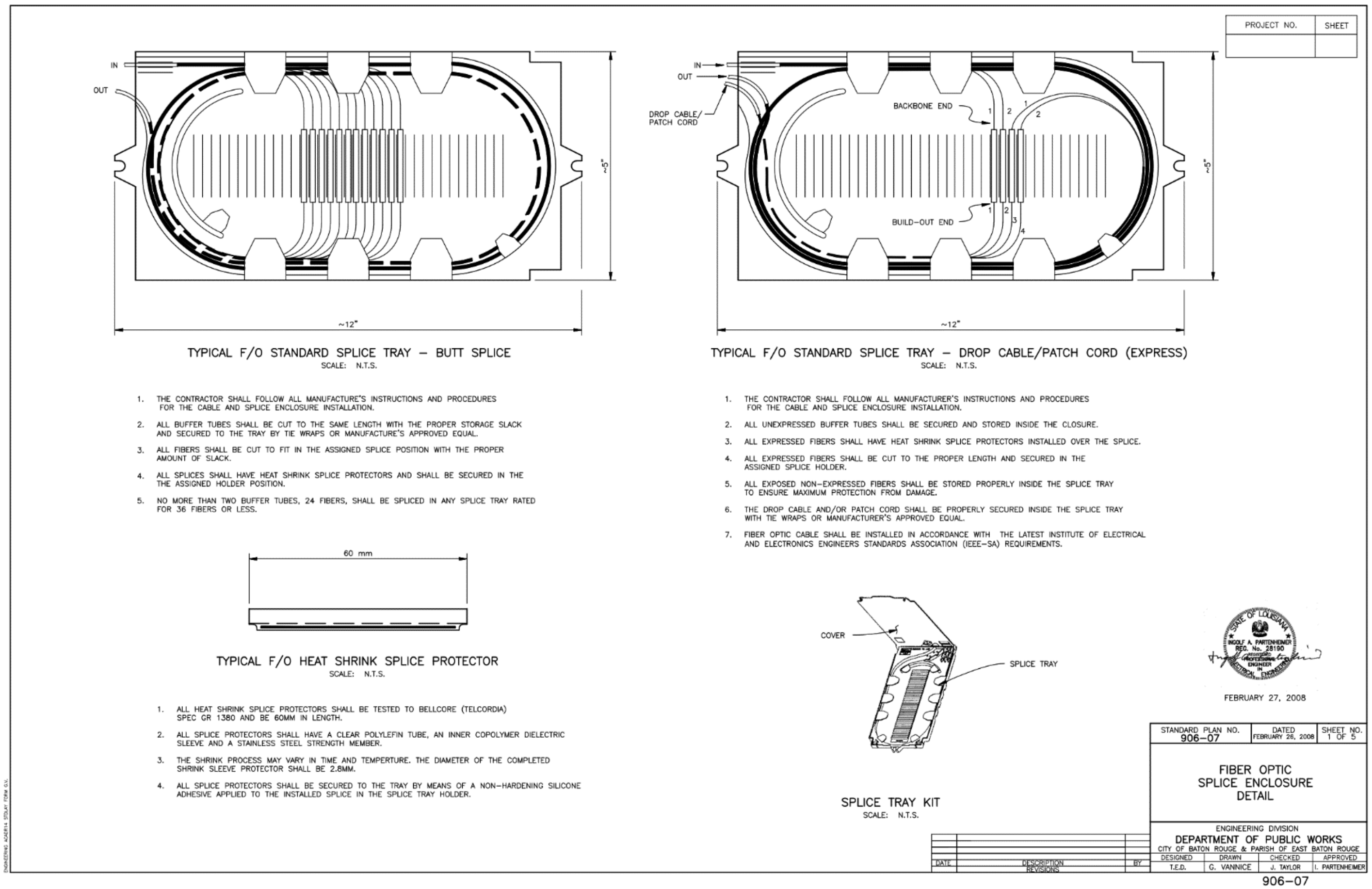
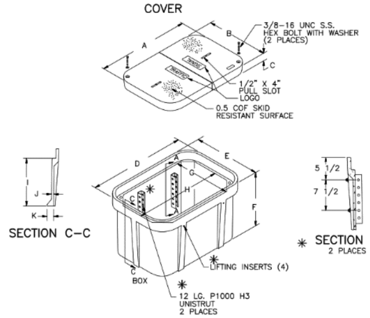


Figure 77. City of Baton Rouge #32

GENERAL NOTES

- (A) CONDUIT FOR FIBER OPTIC CABLE REQUIRED TO UTILIZE LARGE RADIUS BENDS (MINIMUM RADIUS 6") NO ELBOW JOINTS ALLOWED.
- (B) ALL TYPE "I" JUNCTION BOXES SHALL HAVE A MINIMUM OF 50 FEET OF SLACK CABLE.
- (C) ALL UNDERGROUND SPLICES SHALL BE PERFORMED IN A TYPE "J" JUNCTION BOX AND SHALL CONTAIN 100 FEET OF SLACK F/O CABLE FROM EACH REEL.
- (D) ALL CABINET SPLICES SHALL BE PERFORMED IN A TYPE "J" JUNCTION BOX AND SHALL CONTAIN 100 FEET OF SLACK CABLE FROM THE F/O TRUNK LINE AND 50 FEET OF SLACK FROM THE DROP CABLE.
- (E) ALL SPLICES TO BE FUSION UNLESS OTHERWISE NOTED.
- (F) FIBER OPTIC CABLE RUNS TO UTILIZE MIN. 1.25" HDPE CONDUIT.
- (G) TYPE "I" FIBER OPTIC JUNCTION BOXES ARE TO BE USED WHEN NO SPLICING IS REQUIRED.
- (H) TYPE "J" FIBER OPTIC JUNCTION BOXES ARE TO BE USED WHEN SPLICING IS REQUIRED.

PROJECT NO.	SHEET

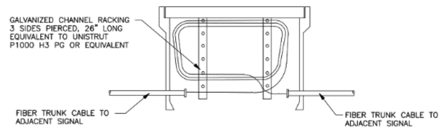


FIBER OPTIC JUNCTION BOX DETAILS
(TYPICAL)

TYPE	DIMENSION (IN.) (APPROX.)										
BOX	A	B	C	D	E	F	G	H	I	J	K
I	47 5/8	30 1/8	3	49 5/8	32 1/8	18	28 1/8	45 5/8	15	1/2	2
J	47 5/8	30 1/8	3	49 5/8	32 1/8	36	28 1/8	45 5/8	15	1/2	2

NOTES:

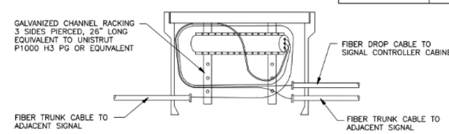
1. JUNCTION BOXES AND COVERS SHALL BE CONSTRUCTED OF A CONCRETE COMPOSITE MATERIAL.
2. JUNCTION BOX SHALL HAVE A HOLLOW BASE.
3. NO "MOUSE TYPE" OPENING SHALL BE PRESENT.
4. BOX DIMENSIONS SHOWN ARE NOMINAL.
5. NOTCHES SHALL BE PROVIDED FOR REMOVING THE COVER.
6. COVER SHALL BOLT DOWN.
7. THE MESSAGE "TRAFFIC SIGNAL" IS TO BE INSCRIBED ON TOP OF THE COVER.
8. INSERTS TO BE CENTERED ON ONE WALL OF TYPE I & J BOXES, 5.625" FROM THE TOP OF EACH BOX.
9. TWO PIECE STEEL PIERCED CHANNEL 11" LONG. TO BE SUPPLIED WITH EACH BOX. CHANNEL TO BE PIERCED ON THREE SIDES.
10. BOLTS TO BE 1/2" x 3/4" LONG STAINLESS STEEL. 1/8" SPACERS TO BE PLACED BETWEEN CHANNELS AND WALL OF JUNCTION BOX.
11. CHANNEL RACKING TO BE FACTORY INSTALLED.



FIBER OPTIC CLOSURE
TYPE I JUNCTION BOX

NOTES:

1. SECURE CABLE SLACK AND CLOSURE TO CHANNEL RACKING VIA UV RESISTANT BLACK NYLON 120–LB (MIN.) TENSILE STRENGTH CABLE TIES.
2. MAINTAIN MINIMUM BEND RADIUS (ACCORDING TO MANUFACTURERS SPECIFICATIONS FOR CABLE AT REST) FOR LARGEST CABLE IN BUNDLE.
3. MAINTAIN 6" CLEARANCE BETWEEN TOP OF PULL BOX AND CABLE/ CLOSURE.
4. ROUTE CABLE EXITING CONDUIT AS TO NOT INTERFERE WITH FUTURE USE OF EMPTY CONDUIT.
5. CABLE SLACK SHALL NOT BE STORED ON THE FLOOR OF THE PULL BOX.



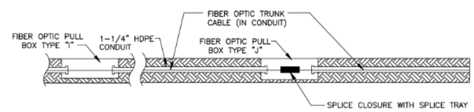
FIBER OPTIC SPLICE CLOSURE
TYPE J JUNCTION BOX

NOTES:

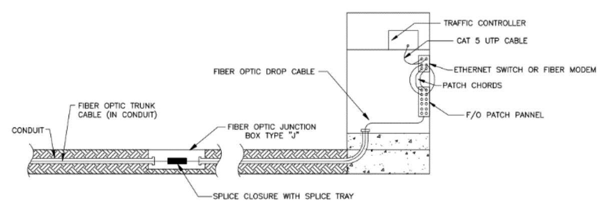
1. CABLES SHALL BE DRESSED IN A COMMON BUNDLE EVERY 3 FEET WITH UV RESISTANT NYLON CABLE TIES OR ELECTRICAL TAPE.
2. SECURE CABLE SLACK AND CLOSURE TO CHANNEL RACKING VIA UV RESISTANT BLACK NYLON 120–LB (MIN.) TENSILE STRENGTH CABLE TIES.
3. MAINTAIN MINIMUM BEND RADIUS (ACCORDING TO MANUFACTURERS SPECIFICATIONS FOR CABLE AT REST) FOR LARGEST CABLE IN BUNDLE.
4. MAINTAIN 6" CLEARANCE BETWEEN TOP OF PULL BOX AND CABLE/ CLOSURE.
5. ROUTE CABLE EXITING CONDUIT AS TO NOT INTERFERE WITH FUTURE USE OF EMPTY CONDUIT.

JUNCTION BOXES NOTES:

1. THE MAXIMUM DISTANCE BETWEEN JUNCTION BOXES USED FOR FIBER OPTIC COMMUNICATIONS CABLE SHALL BE ONE THOUSAND (1000) FEET.
2. THE PROJECT ENGINEER PRIOR TO INSTALLATION SHALL APPROVE THE LOCATION OF EACH JUNCTION BOX. JUNCTION BOXES SHALL BE LOCATED A MINIMUM OF THREE (3) FEET BEHIND THE CURB OR A MINIMUM CLEARANCE OF TEN (10) FEET FROM THE EDGE OF THE TRAVEL LANE, WHICHEVER IS GREATER.



TYPICAL UNDERGROUND SPLICE



UNDERGROUND ENTRANCE
INTO BASE MOUNTED CABINET

FEBRUARY 27, 2008

STANDARD PLAN NO. 906–07	DATED FEBRUARY 26, 2008	SHEET NO. 2 OF 5

FIBER OPTIC
DETAIL

ENGINEERING DIVISION
DEPARTMENT OF PUBLIC WORKS
CITY OF BATON ROUGE & PARISH OF EAST BATON ROUGE

DESIGNED	DRAWN	CHECKED	APPROVED
T.E.D.	G. VANNICE	J. TAYLOR	I. PARTENHEIMER

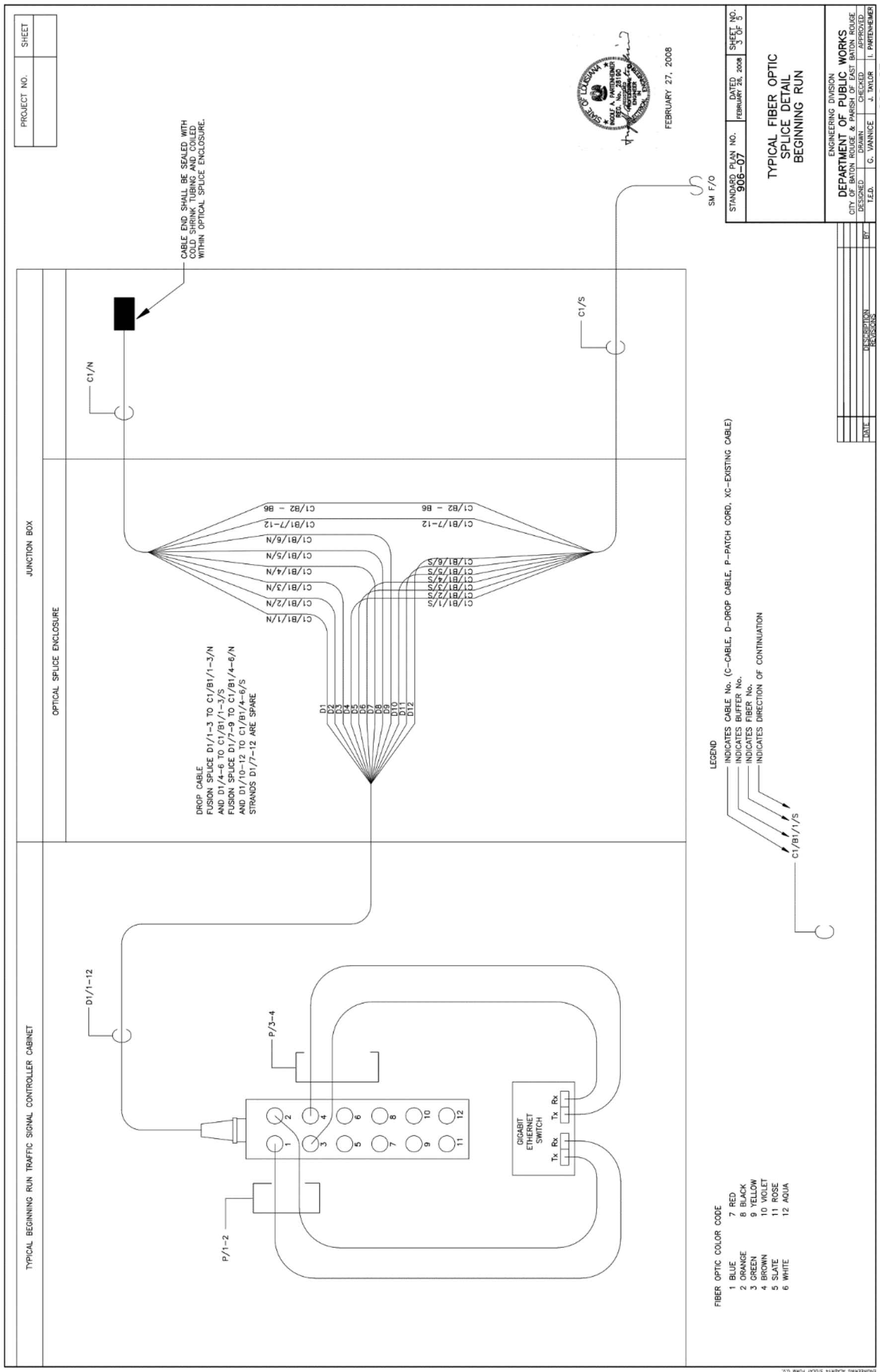
DATE	DESCRIPTION REVISIONS	BY

906–07

ENGINEERING ACADR14 STDLAY FORM G.V.

Figure 78. City of Baton Rouge #33

Figure 79. City of Baton Rouge #34



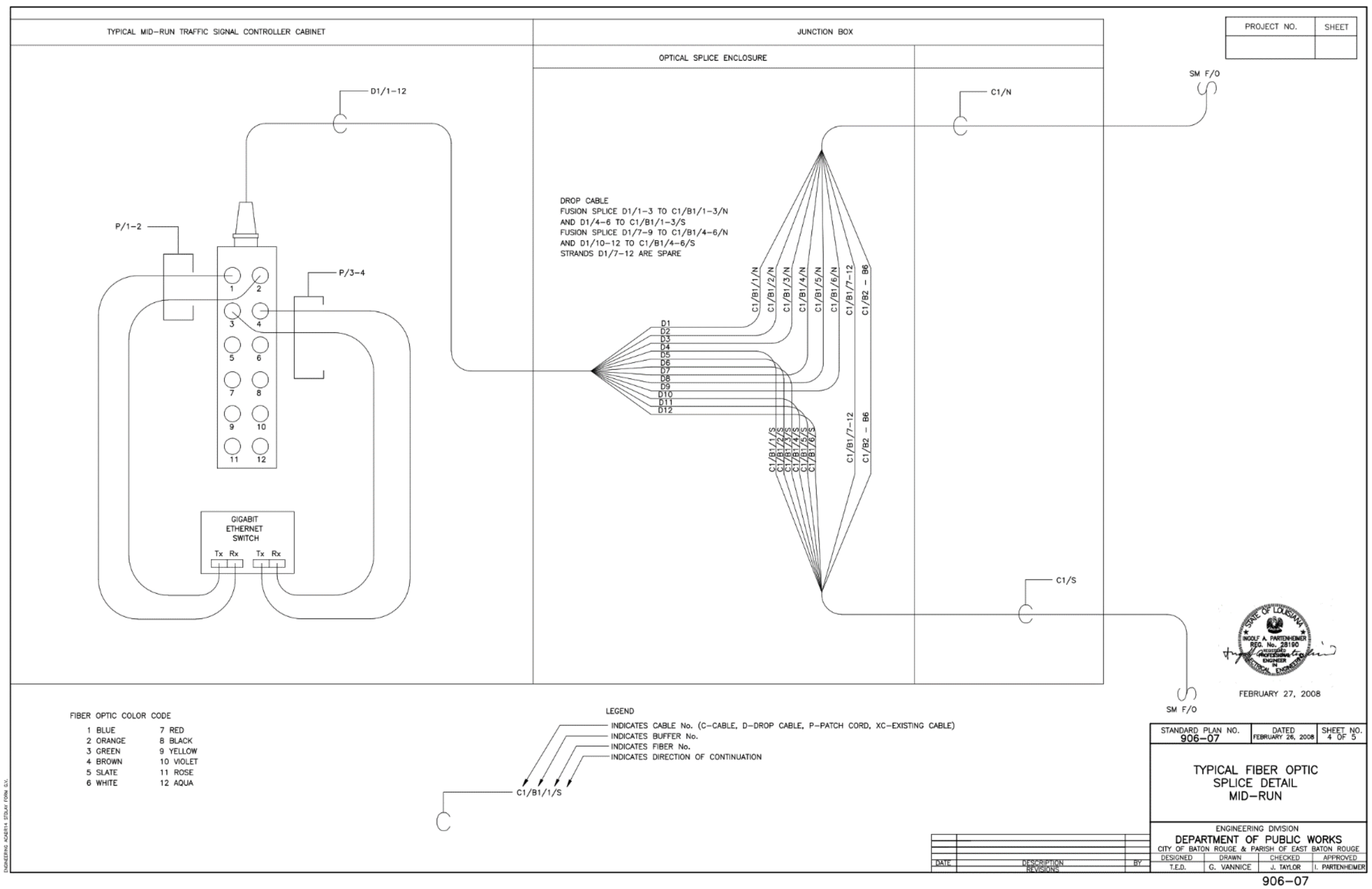
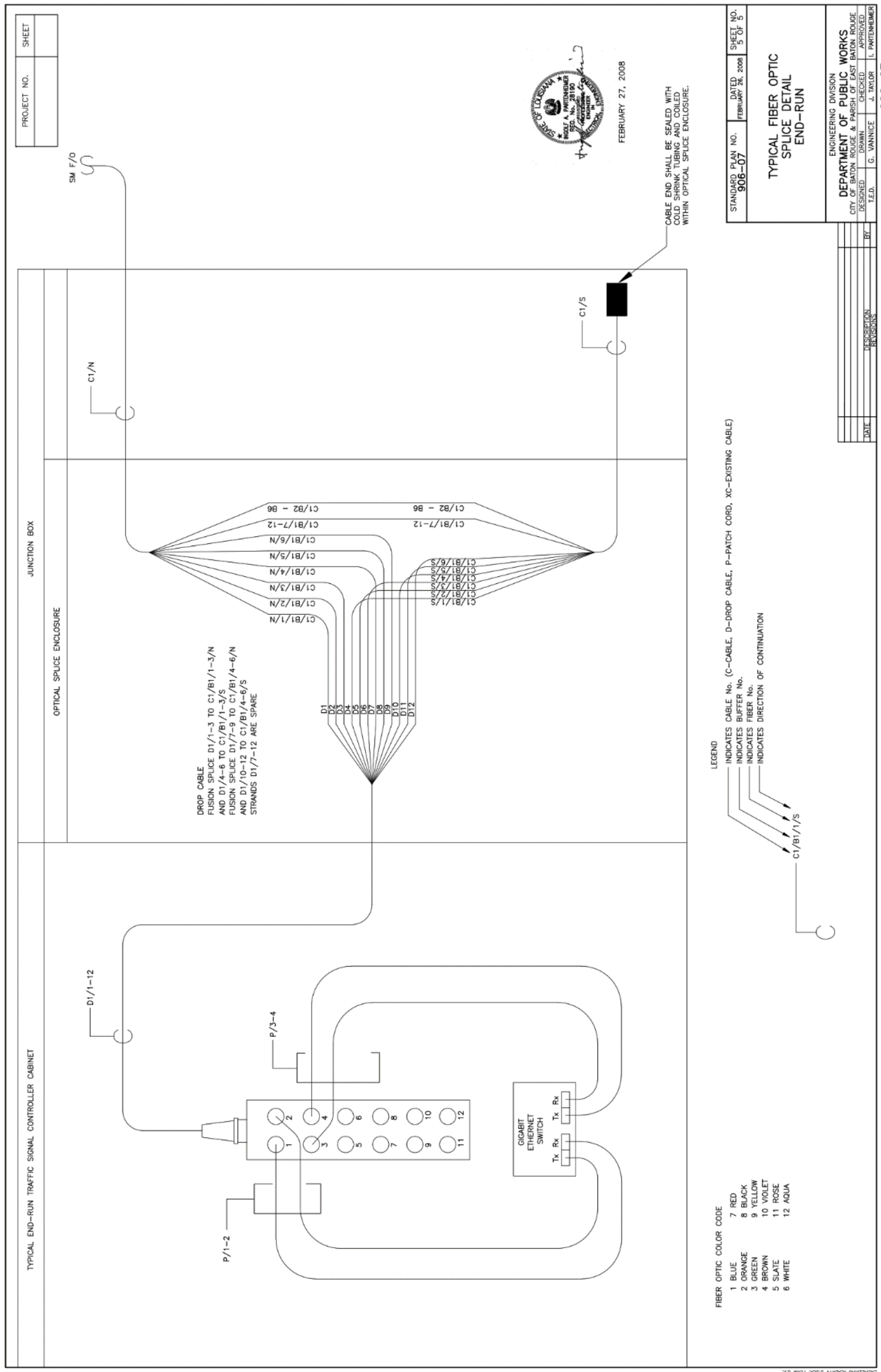


Figure 80. City of Baton Rouge #35

Figure 81. City of Baton Rouge #36



This public document is published at a total cost of $200.
29 copies of this public document were published in this first printing at a cost of $200. The total cost of all printings of this document including reprints is $200. This document was published by Louisiana Transportation Research Center to report and publish research findings as required in R.S. 48:105. This material was duplicated in accordance with standards for printing by state agencies established pursuant to R.S. 43:31. Printing of this material was purchased in accordance with the provisions of Title 43 of the Louisiana Revised Statutes.