

PAVEMENT MANAGEMENT RESEARCH PROJECT
Project ID: CEEEn_2017CPST_008

by

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A Capstone project submitted to

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J-U-B Engineers, Inc.

Department of Civil and Environmental Engineering
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Executive Summary

PROJECT TITLE: Pavement Management Research Project
PROJECT ID: CEEEn-2017CPST-008
PROJECT SPONSOR: J-U-B Engineers, Inc.
TEAM NAME: DTR Engineering

J-U-B Engineers, Inc. asked us to conduct a research of literature and local pavement practices to gather data on pavement treatments and Pavement Condition Index (PCI) ranges evaluating if they are appropriate and effective, as well as how long they last. J-U-B Engineers, Inc. is specifically interested in pavement management in Utah Valley. In addition to research in pavement treatments and preventative measures, they are interested in pavement deterioration rates considering the condition of the pavement and subgrade.

The desired outcome of the project is as follows:

- a. PCI ranges in which treatments are appropriate and effective
- b. How various treatments can increase the PCI
- c. How the PCI decreases as time passes after treatment
- d. Database of costs of treatments, with variations in time, quantity and location
- e. Relationship of pavement deterioration rates in Utah Valley with physical characteristics of pavement and subgrade

The results for the desired outcomes are listed in the tables and figures below. The results reflect the data gathered from surveying street superintendents in Utah County. The values given in the results are the recommendations to J-U-B Engineers, Inc. concerning appropriate treatments, effects on PCI, and treatment costs.

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Introduction

Each city in Utah County dedicates thousands of dollars every year to maintaining the miles of paved roads in their cities. Roadways are the single largest asset of most cities. Understanding where to allocate these funds is essential to providing serviceable roads to the residents and visitors that drive these roads. J-U-B Engineers, Inc. asked us to conduct a research of literature and local pavement practices. The purpose of this research was to gather data on pavement treatments and PCI ranges evaluating if they are appropriate and effective, as well as how long each treatment lasts. In addition to research of pavement treatments and preventative measures, they were interested in pavement deterioration rates. The deterioration rates can be measured by determining how the PCI decreases over a given time period.

Schedule

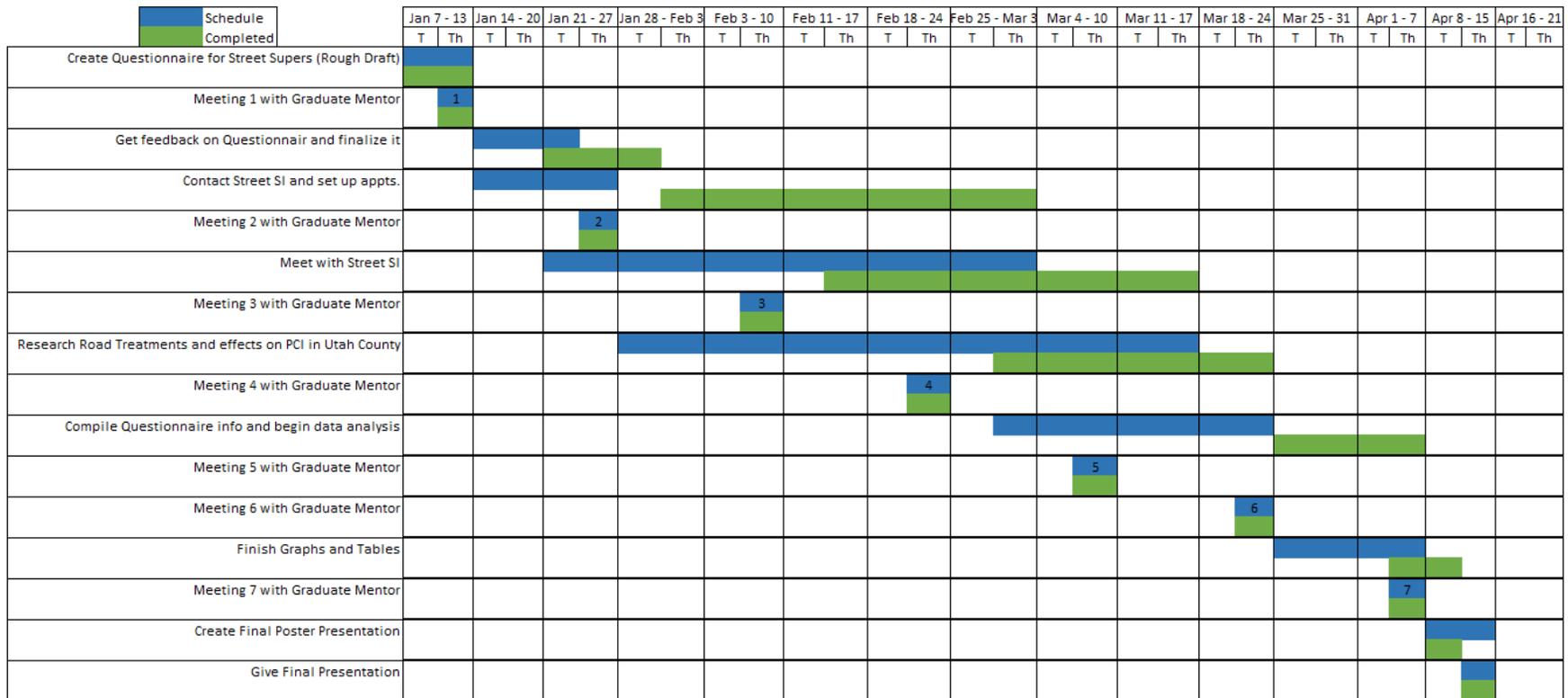


Figure 1: A figure of the project schedule

Team members met weekly at the designated class period, every Tuesday and Thursday, for a two to three-hour time period. Team members used these meetings to discuss any challenges to their work.

Assumptions & Limitations

For our capstone project, we are assuming that all of the municipalities use PCI to rate the quality of their roads. This may cause small amounts of confusion initially, but our survey explains what PCI is and how we use it to determine the quality of roads.

Design and Analysis Process

In order to provide accurate information on PCI differences through pavement treatments, we created a questionnaire. This questionnaire was given to various street superintendents in Utah County to help us understand what treatments would best suit certain pavement issues. An example of the questionnaire is shown below in Figures 2 and 3.

	Which of the following treatment types do you use?	How much does this treatment cost per square foot?	How long before re-treatment is needed?	Which types of distresses does this treat?											
	Select all that apply	Enter a dollar value	Enter a time in months	Fatigue Cracking	Alligator Cracking	Edge Cracking	Block Cracking	Transverse Cracking	Longitudinal Cracking	Potholes	Patch Deterioration	Rutting	Shoving	Raveling/Weathering	Bleeding
Spot Repairs	<input type="checkbox"/>			<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Crack Seal	<input checked="" type="checkbox"/>	0.04	36	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Minor Patching	<input checked="" type="checkbox"/>	1.10	60	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
Rejuvenators	<input type="checkbox"/>			<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Chip Seal	<input type="checkbox"/>			<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Cape Seal	<input type="checkbox"/>			<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Slurry Seal	<input type="checkbox"/>			<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
High Density Mineral Bond	<input checked="" type="checkbox"/>	0.16	84	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Microsurface	<input checked="" type="checkbox"/>	0.21	84	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Major Patching	<input checked="" type="checkbox"/>	2.10	120	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
Overlay	<input checked="" type="checkbox"/>	1.20	96	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Mill and Overlay	<input checked="" type="checkbox"/>	1.30	120	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
Pulverize Asphalt and Repeave	<input checked="" type="checkbox"/>	1.65	180	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Replace Asphalt and Base	<input checked="" type="checkbox"/>	4.20	240	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Other	<input type="checkbox"/>			<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Figure 2: An example of Questionnaire results from Provo City

Q41. How does Crack Seal improve the quality of the road (in terms of PCI)? 0 =Failed, 100 = Good

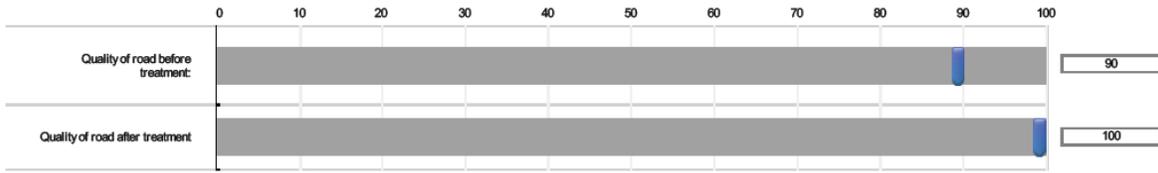


Figure 3: An example of PCI results from Provo City

We will provide a list of treatments and descriptions of each treatment, the types of distresses they are used to treat, the PCI ranges in which each is used, and the effect each has on PCI. We will also provide a database of the cost for each.

Results

Figure 4 shows how roads deteriorate over time. Figure 4 was created using the results from the data collected from the street superintendents. The graph shows how early treatments can have a significant impact if used at the appropriate time. If early preventative maintenance is provided to roads, this will extend the life of the road and prevent large and costly repairs. Rehabilitation treatments will have a greater effect on the service life of the road but will cost more than routine preventative maintenance. As the age of the road increases, the deterioration rate also increases.

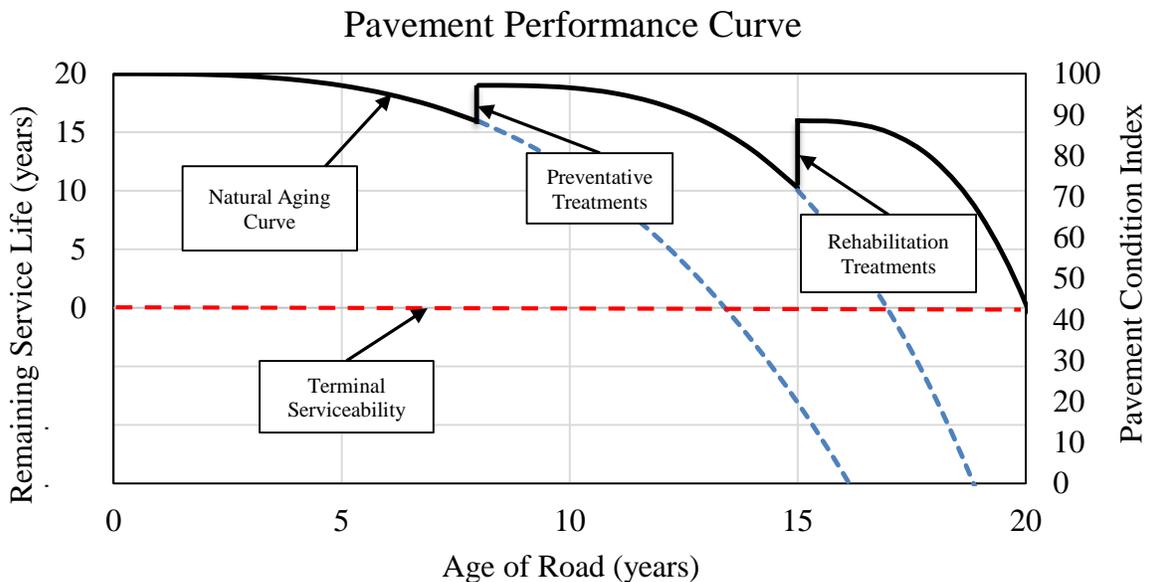


Figure 4: A graph of road deterioration rates

Table 1 is a list of each treatment that was studied. The list shows the average cost of each treatment and an average time period each treatment typically lasts. The averages for these results were taken from typical values found online in Utah County and from the survey results given by the street superintendents in Utah County.

Table 1: Cost and Lifetime of Treatments

Treatment Type	Average Cost (\$/ft²)	Lifetime of Treatments (years)
Chip Seal	0.14	5
Crack Seal	0.06	3
High Density Mineral Bond	0.15	6
Major Patching	2.10	10
Microsurface	0.24	7
Mill and Overlay	1.84	12
Minor Patching	1.10	5
Overlay	1.50	10
Pulverize Asphalt and Repave	2.51	18
Replace Asphalt and Base	4.27	20
Slurry Seal	0.19	5
Spot Repairs	0.15	2

Table 3 is a list of the PCI ranges in which it is appropriate to apply treatment and the approximate increase that it will have on the PCI of the road. The averages for these results were taken from typical values found online in Utah County and from the survey results given by the street superintendents in Utah County.

Table 2: PCI Ranges and Increase in PCI

Treatment Type	PCI range to apply treatment	Approximate increase in PCI
Chip Seal	100-94	6
Crack Seal	94-61	10
High Density Mineral Bond	88-61	13
Major Patching	80-46	15
Microsurface	80-49	23
Mill and Overlay	80-45	35
Minor Patching	90-56	13
Overlay	80-50	28
Pulverize Asphalt and Repave	60-35	49
Replace Asphalt and Base	50-25	60
Slurry Seal	90-76	24
Spot Repairs	100-47	29

Table 3 shows the types of distresses that each treatment type is meant to treat. These results were gathered from the survey of the street superintendents.

Table 3: Types of Distresses for Each Treatment

Treatment Options	Types of Distresses											
	Fatigue Cracking	Alligator Cracking	Edge Cracking	Block Cracking	Transverse Cracking	Longitudinal Cracking	Potholes	Patch Deterioriation	Rutting	Shoving	Raveling/ Weathering	Bleeding
Spot Repairs	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>					
Crack Seal	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Minor Patching	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
Rejuvenators	<input type="checkbox"/>											
Chip Seal	<input type="checkbox"/>											
Cape Seal	<input type="checkbox"/>											
Slurry Seal	<input type="checkbox"/>											
High Density Mineral Bond	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
Microsurface	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
Major Patching	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
Overlay	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
Mill and Overlay	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
Pulverize Asphalt and Repave	<input checked="" type="checkbox"/>											
Replace Asphalt and Base	<input checked="" type="checkbox"/>											

Lessons Learned

While creating the survey to distribute to the street superintendents, we were having a rough time using language that would communicate our ideas and questions. This was an integral part of converting our data into something that street superintendents and engineers could understand. In order to come up with user friendly questions, we made a prototype survey and presented it to our sponsors, student mentor, and faculty advisor. After receiving feedback, we updated our survey and set up a meeting with the Provo street superintendent. From a street superintendent perspective, he was able to discuss what he understood and where he struggled. By getting the perspectives of both sides and reviewing with many parties, we were able to produce a good, finished product. This allowed us to minimize the time required to take the survey and receive better feedback from Utah County street superintendents.

Conclusion

With the data compiled, we were able to meet most of the demands of the established deliverables in the project proposal that was submitted to J-U-B Engineers, Inc. earlier this year. The information provided in the results section gives J-U-B Engineers, Inc. information on the costs and lifetimes of certain treatments in Utah valley. The results section also gives a PCI range of when to use each treatment and the treatment's effect on the PCI. There were other deliverables that we were unable to complete, which will be addressed in the Recommendations section of this report. Many challenges presented themselves during the course of this project. The more severe challengers were establishing our desired outcome to street superintendents and receiving feedback in a timely manner. However, we were able to overcome the challenges with help from our sponsor, our graduate student mentor, and faculty advisor.

Recommendations

If this project were to be expounded upon and taken forward, we would recommend a few improvements to the data collection process. First, due to lack of data from street superintendents, we were not able to gather information regarding the subgrade and soil beneath the roads throughout Utah County. This information could be modeled and compared with the rate of deterioration of the roads in Utah County. Second, communication with the local municipalities could be improved. In order to get a high level of responses and information, it is important to meet with the street superintendents in person.

Appendix A