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ASSESSING IMPACT OF CLIMATE CHANGE ON OKLAHOMA BRIDGE DECK AND SUPERSTRUCTURE DETERIORATION USING NATIONAL BRIDGE INVENTORY DATA

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ASSESSING IMPACT OF CLIMATE CHANGE ON OKLAHOMA BRIDGE DECK AND SUPERSTRUCTURE DETERIORATION USING NATIONAL BRIDGE INVENTORY DATA

A THESIS APPROVED FOR THE
SCHOOL OF CIVIL ENGINEERING AND ENVIRONMENTAL SCIENCE

BY

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Dedication

To the Lotus Feet of Sri Tirumala Balaji

Acknowledgements

This thesis represents not only my work at the keyboard, it is a milestone in more than two decades of my entire education career. My experience at the University of Oklahoma (OU) has been nothing short of amazing. Since my first day I have felt at home here. But this thesis is also the result of many experiences I have encountered at OU from dozens of remarkable erratic weather changes, which I also wish to acknowledge.

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Table of Contents

List of Tables

List of Figures

Abstract

Bridge deterioration is a prominent problem in the United States. Bridge deck and superstructure elements are often exposed to harsh conditions and their performance is critical in the overall sufficiency of a bridge. Many transportation agencies specify material properties, mix designs, and construction methods to create long-lasting bridges and reduce the possibility of deterioration for typical conditions, but there is another factor that may contribute to the problem: “Climate Change”. The impact of a changing climate may be more severe in a state with diverse climate conditions, such as Oklahoma. According to the American Society of Civil Engineers (ASCE) 2013 Report Card for America’s Infrastructure, bridge conditions in the state of Oklahoma were rated D+, lower than the national average of C+. Moreover, climate change is emerging as a new force acting upon infrastructure. Therefore, studying the impacts of climate change on existing bridges is necessary. The overarching objective of this research was to assess the impact of climate change on bridge deck and superstructure deterioration in Oklahoma by incorporating climate data from the Oklahoma Mesonet and bridge data from the National Bridge Inventory over time. Data for climate variables identified through investigation of factors affecting bridge deterioration were collected from Mesonet stations representing the different regions of Oklahoma for the 18-year time period over which data were available. Bridge rating records were then collected from the National Bridge Inventory database for bridges within approximately 50 miles of each climate station for the same time period. Climate data from different stations were first compared using statistical methods to identify pairs of locations with differing climate conditions over time. Bridge ratings associated with these climate stations were then compared using the same statistical methods in order to identify possible correlations between climate factors and bridge ratings. Differences in freeze-thaw cycles, annual rainfall, and total solar radiation were found to correlate with differences in deck or superstructure ratings for a number of the climate stations examined, but exact relationships were not clearly identifiable by the methods used.

1. Introduction

Most of the world's land surface transportation relies heavily on bridges. Since prehistoric times man has built bridges by imitating nature. Tree bark, stone slabs, wood and a host of other materials that can hold weight, were used to build bridges to cross rivers or streams. Concrete is currently the most-used construction material for bridges in the United States, and throughout the world. A typical bridge has three main elements, as shown in Figure 1. First, the deck, which is the traffic carrying roadway or pedestrian walkway surface of a bridge. Second, the superstructure, which is the platform that supports the traffic and includes the deck slab and girders. It also connects one substructure element to the other. Third, the substructure, which transfers the loaded weight of the bridge to the foundations. The substructure consists of components such as abutments at the ends and intermediate column supports, also called piers or bents.

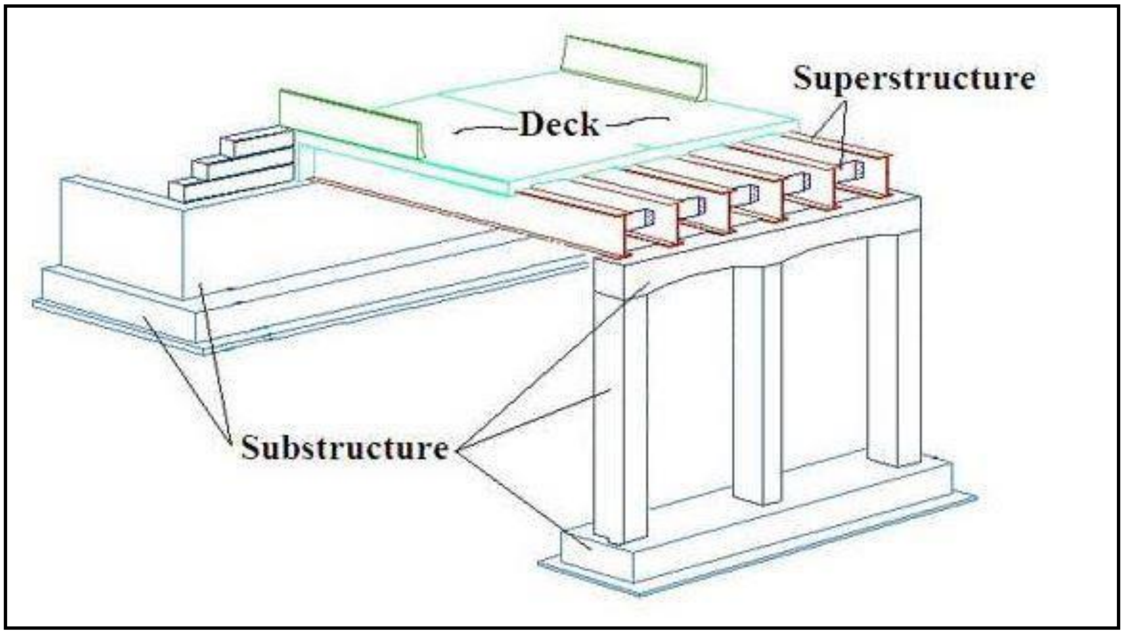


Figure 1. Structural Elements of a Typical Highway Bridge (MDOT, 2017)

Bridge deterioration is a prominent problem in the United States, and various agencies are conducting extensive research to determine the underlying causes, identify maintenance and rehabilitation strategies, and prioritize rehabilitation. Cracking is a preeminent sign of concrete bridge deterioration, and nearly half of the bridges in the United States showed cracking at an early stage (Krauss and Rogalla, 1996). About 97% of the State Highway Agencies have reported early age cracking as the most common distress in bridges (Krauss and Rogalla, 1996). Numerous studies have been performed on this problem, and several causes have been isolated, including thermal movement, freeze-thaw cycles, early age shrinkage, and early age settlement of the foundation soil (Krauss and Rogalla, 1996; Babaei, 2005).

Climate effects, and potentially climate change, may have a large impact on these causes of cracking and may contribute to deterioration in other ways. Climate change can be defined as a change in the state of the climate that persists for an extended period, typically decades or centuries (Wang et al., 2010). Climate change is occurring today as a result of anthropogenic effects, especially related to greenhouse gas emissions, which has caused widespread concern (Wang et al., 2010). Climate change is anticipated to have an impact on concrete bridges through the impacts of extreme weather events, such as intense storms, which could disrupt traffic, delay construction activities, and wash out the soil and culverts that support bridges (Wang et al., 2010). Hence it is important to understand the implications of climate change on existing concrete bridges to facilitate effective asset planning and management (Amekudzi et al., 2010). These implications may be more important in a state with diverse climate conditions, such as Oklahoma.

Very high temperatures can cause buckling of concrete pavements and softening of asphalt roads leading to rutting and subsidence, and can place stress on bridge joints due to expansion. Higher winter temperatures may lead to more precipitation falling as rain rather than snow, which increases drainage problems; and potential extreme low temperatures may cause deterioration in the form of cracking resulting from the expansion of this water during freezing (Amekudzi et al., 2010). Higher winter temperatures can, therefore, cause an increase in frequency of freeze-thaw cycles. It is important to regularly inspect bridges for cracking problems associated with these erratic temperature changes, which would benefit transportation agencies in determining when to make the most cost-effective maintenance measures (Reilly et al., 2006).

Moreover, drastic climate change is likely to increase the vulnerability of bridge infrastructure across the United States (Neumann et al., 2015). Therefore, assessing deterioration of bridge decks and superstructures by incorporating climate impact is necessary. The overarching objective of the research described in this thesis was to assess the relationship between climate data and deterioration of bridge decks and superstructures in Oklahoma. This relationship could then be used in conjunction with current assessment strategies to come up with possible cost effective solutions to counteract climate related problems that may become more prominent in the coming years. The Oklahoma Department of Transportation (ODOT) has always envisioned the development of an aggressive bridge rehabilitation program, but never possessed the resources required to launch a meaningful initiative (ODOT, 2015, p.4). The results presented in this thesis are only an initial step in identifying the relationship between climate effects and bridge condition in Oklahoma, but provide information that may be useful to decision makers related to bridge maintenance in Oklahoma.

2. Literature Review

The National Bridge Inventory (NBI) specifies that concrete bridge deterioration, in the form of concrete distress and reinforcement corrosion, has become one of the leading causes of structural deficiency (Russell, 2004). A number of research projects have been conducted on bridge deck cracking, a main cause of bridge deterioration, by the National Cooperative Highway Research Program (NCHRP) and several DOTs, including Michigan, Texas, Oregon, Utah, New Jersey, Minnesota, and Colorado (Brooks, 2000; Brown et al., 2001; Xi et al., 2003; Aktan et al., 2003; Linford and Reaveley, 2004). These transportation agencies are investing considerable time and resources to analyze and solve the problems, and to provide a summary of many factors important to the problem (Russell, 2004). These agencies often specify that material properties, mix designs, and construction methods are the main reasons for concrete bridge distress (Russell, 2004), but there are a number of potential climate factors that may contribute to deck and superstructure distress, which may become more prevalent in the future due to climate change. A review of previous research done on bridge deck and superstructure cracking due to climate change and research using NBI data to assess deterioration is presented in this section.

2.1 Bridge Deck and Superstructure Deterioration

Bridge deck and superstructure deterioration is mainly caused by physical, mechanical, and chemical factors and can be induced by sources external and internal to the concrete structure. Physical and chemical deterioration are primarily related to climate conditions, and mechanical deterioration is greatly influenced by traffic (Wang et al., 2010).

Physical deterioration is associated with freeze-thaw cycles and thermal mismatch between hardened cement paste and aggregates (Wang et al., 2010). Thermal incompatibility can result in cracking since the different materials expand or contract differently with changes in temperature. Mechanical deterioration is associated with abrasion, impact, and erosion, which are primarily a result of traffic (Wang et al., 2010).

Penetration of chemicals from the environment, such as carbonation and chloride induced corrosion, are associated with chemical deterioration (Wang et al., 2010). The reactions between the constituents of the concrete, such as alkali–silica reaction (ASR), alkali–carbonate reaction (ACR), and delayed ettringite formation (DEF), are also associated with chemical deterioration (Wang et al., 2010).

2.2. Mechanisms of Bridge Deck and Superstructure Cracking

Cracking is the most basic form of deterioration in concrete bridge decks and superstructures, and occurs when the tensile stresses in the concrete exceed the tensile strength of the concrete at that time. Concrete shrinkage, temperature changes in the concrete, and self-weight or traffic loads are some sources causing tensile stresses (Wang et al., 2010), but all items described in Section 2.1 eventually lead to cracking.

A detailed study conducted by Brown et al. (2001) explained the mechanisms causing concrete bridge deck and superstructure cracking. The primary factors in the cracking problem, as described in their report, are shrinkage, thermal stresses, and restraint, and descriptions of several items affecting these factors were included (Brown et al., 2001). Brown et al. concludes that the primary source of strain in bridge decks is shrinkage. Even without additional strain from temperature sources, shrinkage can produce enough strain to crack concrete if sufficient restraint is also present (Krauss and Rogalla, 1996).

Another important source of strain in the concrete matrix is the effect of thermal stresses. The concrete first sets at a specific temperature. At this temperature, the concrete matrix gets locked to zero temperature and any changes in temperature from this value will result in volume changes in the concrete. However, both deck and superstructure experience temperature changes from cooling off after the heat of hydration subsides, seasonal and daily temperature changes, and temperature changes from solar radiation on the top surface. These sources lead to significant temperature movements, which occur as a result of thermal expansion and contraction of the concrete. “These thermal stresses induced can both be high and significantly non-uniform” (Krauss and Rogalla, 1996). The dead loads and live loads acting on the structure, along with deflections in the formwork, are other important sources of strain in concrete bridge decks and superstructures. “Several state departments of transportation considered these to be a source of cracking” (Krauss and Rogalla, 1996).

The final important source of strain (according to Brown et al., 2001) in concrete bridge decks and superstructures is the restraint. This follows the principles of modulus of elasticity, wherein the restraint of the bridge deck’s movement converts the strain from shrinkage or thermal movement to stress. In the case of an unrestrained system, strain does not cause cracking. Restraint is of two types: restraint due to ‘internal’ sources and restraint due to ‘external’ sources. The chief external source of restraint in the bridge deck is due to the interaction with the girders that the bridge deck rests upon. The girders restrain the deck’s movement since they will not shrink at the same rate as the bridge deck, unless they are concrete and are cast at the same time and using the same material. In addition, material differences can also cause differential restraint of temperature movements. Rebar, aggregate, and fibers are some of the sources of internal restraint in concrete (Krauss and Rogalla, 1996).

Other factors that influence mechanical cracking are creep and stress relaxation of concrete. These can reduce the stresses on the concrete. According to a report by Altoubat et al. (2001) creep can reduce shrinkage stresses by 50%, thus doubling the capacity of strain at failure. The tensile strength of the concrete is the final factor in the cracking process. After the stresses are created by the factors mentioned above, “whether the concrete finally cracks or not is determined by comparing the stress to the tensile strength of the concrete” (Krauss and Rogalla, 1996).

2.3. Potential Factors affecting Oklahoma Bridge Deck and Superstructure Deterioration

Several weather and climate factors have the potential to lead to bridge deck and superstructure deterioration. Extreme values of rainfall, solar radiation, temperature, and humidity may be detrimental to concrete in general, and may increase the influence of deterioration mechanisms described in Sections 2.1 and 2.2. The primary modes of attack these weather and climate factors might lead to are described herein: (1) Freeze-thaw cycles (2) Temperature (3) Carbonation, and (4) Chloride-induced corrosion.

2.3.1. Freeze-Thaw Cycles

The mechanical process caused when water contained in concrete expands due to cycles of freezing, then thaws as a result of warming is called a freeze-thaw cycle

(Supernant, 1992). The initial ice crystal formation in concrete begins when water is super cooled below its freezing temperature (Korhonen, 1990). Because of these effects, there is no thermal contraction in concrete until its temperature drops to 27°F or lower (Basham, 1995). If admixtures are present, the freezing temperature may be as low as 20°F (Basham, 1995). The freezing process causes a 9% expansion in the volume of water and dilating pressure builds up within the concrete (Wang et al., 2010). Each cycle of freezing causes the water to migrate into unfrozen pores, further building up pressure. With this amount of pressure built up over time, the thawing process, which normally begins when the weather becomes warmer, has the potential to cause cracking when it starts to melt the ice (Wang et al., 2010). The pore walls of the concrete material resist the expansion when ice forms in the capillaries. This creates a dilating pressure that may be relieved if water is allowed to escape into the non-saturated voids within the concrete. Cracking of the concrete material will occur when the material's structure is unable to resist the pressure (Wang et al., 2010).

If freezing is slow, water redistributes itself by moving towards the colder areas before freezing and forms ice lenses. If freezing is rapid, water has less chance to move towards the colder areas and so it freezes in place, creating uniformly distributed ice crystals. However, these crystals are quite harmful to the concrete material health since they might weaken the bond between cement paste and aggregate (Korhonen, 1990).

Damage to concrete infrastructure and improvement of concrete durability in freezing and thawing exposures can be controlled by using the process of air entrainment (NRMCA, 2004). Entrained air bubbles, which are microscopic in size (0.01 inches or less) and evenly distributed over the paste, provide space to absorb the expansion and relieve the pressure built up when water in the concrete freezes and expands (NRMCA, 2004). In addition to damaging the hardened concrete due to freeze-thaw cycles, an up to 50% strength reduction can occur if concrete freezes before reaching a compressive strength of 500 psi (Supernant, 1992).

2.3.2. Temperature

Temperature changes in concrete are normally caused by environmental conditions or by cement hydration (the exothermic chemical process in which the cement reacts with the water in the concrete mixture producing calcium silicate hydrate binder and other compounds) (Grybosky, 1990). Materials tend to expand and contract when subjected to changes in temperature. Most materials expand when they are heated and contract when they are cooled. This behavior applies for concrete as well. Concrete tends to expand as temperature rises and contract as temperature falls, when free to deform. The size of the concrete structure does not make it immune to the effects of temperature (Grybosky, 1990).

There are two types of temperature loading effects to consider (Keogh and O'Brian, 1999):

1. Changes in effective temperature causing expansion and contraction in the deck resulting in global deformation.
2. Differences in temperature between the top surface of the deck and at various levels throughout the depth of the deck causing the deck to locally distort.

2.3.2.1. Thermal Expansion and Contraction: Uniform Temperature Changes

Uniform changes in temperature, in which the entire depth of the deck and superstructure undergoes an increase or decrease in temperature due to cycles of hot or cold weather, cause axial expansion and contraction, which may lead to large scale increase in stresses (Keogh and O’Brian, 1999). The thickness of the wearing surface and the form of the construction are governing factors in determining the difference between the ambient temperature and effective temperature within a bridge deck (Keogh and O’Brian, 1999). The AASHTO LRFD Bridge Design Specifications section 3.12.2.1 specifies that in “moderate climates, concrete bridges must be designed for temperatures in the range of 10 °F to 80 °F” (AASHTO, 2012).

2.3.2.2. Differential Temperature Changes

In addition to uniform changes, bridges are subjected to differential changes in temperature on a daily basis, such as in the morning when the sun shines on the top of the bridge heating it up faster than the interior parts of the bridge. The reverse phenomenon tends to take place in the evening when the deck is warm in the middle but is cooling down at the top and the bottom surfaces (Keogh and O’Brian, 1999). When one face of a superstructure is exposed to direct sunlight and the other side is in shade then transverse temperature differences occur (Keogh and O’Brian, 1999).

Due to these potentially erratic changes in temperature, the bridge deck and superstructure might deflect upwards or downwards due to compressive or tensile strains caused by a non-uniform heating of the bridge element throughout its depth (Brenner et al., 2011). When this happens, the stress generated (when different parts of the bridge element expand by different amounts) may exceed the strength of the material, causing cracks to form. This process of deflection, either upwards or downwards, is called ‘thermal bowing’ (Brenner et al., 2011).

2.3.3. Carbonation

Carbonation in concrete is caused by the penetration of atmospheric carbon dioxide into the concrete pore water, which then creates an acidic solution at a relative humidity of between 50% and 70% (Wang et al., 2010). When reinforcing bars are placed in concrete a thin protective layer of ferrous oxide is formed. This thin layer protects the reinforcing bars from exposure to oxygen and water which are the prime causes for rusting to begin. This layer can only be maintained at high pH values (greater than 12) (Wang et al., 2010). When the pH of concrete drops to a critical value (pH less than 7) it creates an acidic solution where the reinforcement becomes passive, causing initiation of corrosion and consequent damage (Alberto et al., 1997). If this is left unchecked, carbonation can also lead to spalling (Alberto et al., 1997).

2.3.4. Chloride-induced Corrosion

The destructive and unintentional attack of a metal is called corrosion. Corrosion is electrochemical in nature and a serious form of degradation of reinforced concrete. The corrosion of steel causes concrete deterioration in bridge decks. During the corrosion process, ferrous hydroxide and ferric hydroxide, are the two-major rust/corrosion products produced, and can cause considerable expansion (Wang et al., 2010). The typical product of corrosion, ferrous hydroxide, is four times in volume that of the consumed ferrite. This expansion generates internal stress, ultimately leading to cracking, delamination, and spalling (Wang et al., 2010).

Chlorides are the most common ions to destroy the thin layer of ferrous oxide formed when reinforcing bars are placed in concrete and which protects the bars from exposure to oxygen and water (Wang et al., 2010). When chlorides from the atmosphere, deicing salts, or any other outside source penetrate the concrete to the level of the steel, they accumulate on the steel reinforcement at a critical level and destroy the protective layer described in Section 2.3.3. (Wang et al., 2010). The effects of chloride-induced corrosion include cracking or spalling, rust staining, excessive deflection, and ultimate failure of structural members (Wang et al., 2010).

2.4. Climate Change

The Earth's changing climate is affecting America's infrastructure and human health and in many ways. Across the United States, extreme climate events are becoming more common with sudden temperature rises and shifting patterns of snow and precipitation. Following this set of changes, climate scientists are confident that the climate will not stay the same as before (EPA, 2015). The United States Environmental Protection Agency (EPA) has stated that this change in climate is due to increased heat collected by the Earth or a decrease in the amount of heat that is let out of the atmosphere. Heat exits the Earth as the Earth's surface is warmed by solar energy. This warmed Earth then radiates heat back into the atmosphere. Greenhouse gases in the atmosphere, such as water vapor, carbon dioxide, methane and nitrous oxide, allow the lower atmosphere to absorb the heat radiated from the Earth's surface and eventually trap heat within the atmosphere, thereby preventing the planet from becoming an icy sphere. These same gases, according to the EPA (2015), are the main cause for climate change when the quantities in the atmosphere change. Over the past century or so, the amounts of greenhouse gases within Earth's atmosphere have been increasing rapidly, mainly due to the burning of fossil fuels, industrial activities, and overuse of natural resources. As a result of all these factors, global temperatures have increased with increasing carbon dioxide levels.

This change in global temperatures is projected to increase the frequency and intensity of heat waves, which are likely to be more severe, and cause sea level rise that could amplify storms in coastal areas. Amplified storms in turn cause floods, damaging bridges and transportation infrastructure (NRC, 2008). It is expected that most transportation infrastructure being built now will last for 50 years or longer. Therefore, it is extremely important to understand how climate change might affect these investments in the future (NRC, 2008).

2.5. Condition of Oklahoma Bridges

According to the American Society of Civil Engineers (ASCE) 2013 Report Card for America’s Infrastructure, bridge conditions in the state of Oklahoma were rated D+, lower than the national average of C+ (ASCE, 2013). Oklahoma’s infrastructure is in need of immediate attention. Many years of continued deferred maintenance due to a lack of state funding led to the current situation of Oklahoma’s bridge and highway system problems (ODOT, 2015). From 1985 to 2005 transportation investments were flat and, as a result, the condition of the infrastructure experienced a decline that will take many years of committed, focused and dedicated resources to correct (ODOT, 2015). During the 20-year period, bridges deteriorated at a rate far beyond the available funding for repair.

The Oklahoma Section of ASCE and those from 37 other states work together in order to develop a state-specific report card to complement the national report card for America’s infrastructure (ASCE, 2013). The ASCE Oklahoma committee assessed data reaching as far back as 10 years and followed grading guidance developed by ASCE for the Report Card for Oklahoma’s Infrastructure. The seven fundamental grading components that were considered are (ASCE 2013):

- Capacity: a measure of how much reserve remains in the system
- Condition: a measure of ability of the system to perform as it was designed
- Funding: a measure of the past, current and predicted future investment
- Future Need: a measure of the projected demand and projected importance
- Operations and Maintenance: a measure of past, current and predicted future ability
- Public Safety: a measure of the danger posed by an ineffective system
- Resilience: a measure of the ability for a system to withstand occasional overloads

The Report Card utilizes a 10-point grading scale. The seven fundamental grading components were assigned a weighting factor by the committee and was graded for each infrastructure category (ASCE, 2013, p.3):

- 90-100 = A: Exceptionally Performing
- 80-89 = B: Satisfactorily Performing
- 70-79 = C: Marginally Performing
- 60-69 = D: Poorly Performing
- 59 or Below = F: Failing Infrastructure

This first-ever Report Card for Oklahoma’s Infrastructure gave the Oklahoma’s bridges a grade of D, lower than the national average. When the report was issued in 2013, approximately one in five bridges that Oklahoma motorists crossed each day were structurally deficient or deteriorating to some degree, and the state of Oklahoma was consistently rated as having the worst bridges in the nation (ASCE 2013). In 2010, Tulsa, Oklahoma was ranked #1 for having the highest percentage of structurally-deficient bridges for metropolitan areas with a population of 500,000 to 1 million people (ASCE, 2013). Tulsa had 27.5% or 783 bridges (ASCE, 2013) rated as structurally deficient in 2013.

ASCE specifies that the average age of bridges in the United States is 42 years old, while the average age of Oklahoma bridges is 44.6 years, and most bridges are only designed to last 50 years (ASCE, 2013). As of 2010, 10,922 of Oklahoma’s bridges were over 50 years old and Oklahoma City, Oklahoma in 2010 was ranked #1 for the highest percentage of structurally-deficient bridges for metropolitan areas with a population of 1 to 2 million people (ASCE, 2013).

Deficient bridges and poorly maintained transportation infrastructure will have a detrimental impact on Oklahoma’s commerce, job creation and economic growth. Most importantly, this condition could endanger the safety of the citizens. The ASCE reviews and rates bridges every 4 years (ASCE, 2013), with the help of volunteers from public agencies, private firms and nonprofit groups. ASCE may prepare a new report for the period 2013-2017, and it is hoped that this report might see some key improvements in Oklahoma’s grade following the continued efforts of ODOT.

2.6. ODOT’s Efforts in Improving Bridge Conditions

ODOT has accelerated bridge replacement through a focused and concentrated effort beginning in 2006, which has allowed the Department to replace or reconstruct 1,072 bridges in the last 10 years and has improved the bridges in Oklahoma since the ASCE report in 2013 (ODOT, 2015). A large number of bridge decks were effectively repaired by ODOT mainly using crack and surface sealers apart from a portfolio of other methods. These repairs were a part of the surface preservation program, which greatly slows down the deterioration process (ODOT, 2015). The primary objective of a surface and crack sealer is to prevent capillary action at the surface, thus preventing the penetration of water and chloride ions into the concrete deck (Gordon et al., 2011).

The bold and visionary plan of ODOT's former director and present secretary of transportation – Gary Ridley; was implemented by Oklahoma's Governor, Mary Fallin, to reduce the number of structurally-deficient bridges to near zero by the end of the decade (ASCE, 2013). Following the Governor's bridge improvement and turnpike modernization plan (Fallin, 2011); ODOT has been working hard to address bridge needs by increased funding (ASCE, 2013). Oklahoma's focus and progress is evident with the 2015 annual bridge inspection reports revealing that the 1042 structurally-deficient bridges recorded in 2001 were reduced to 372 in 2014 of the total recorded 6,812 bridges, as shown in Figure 2 (ODOT, 2015).

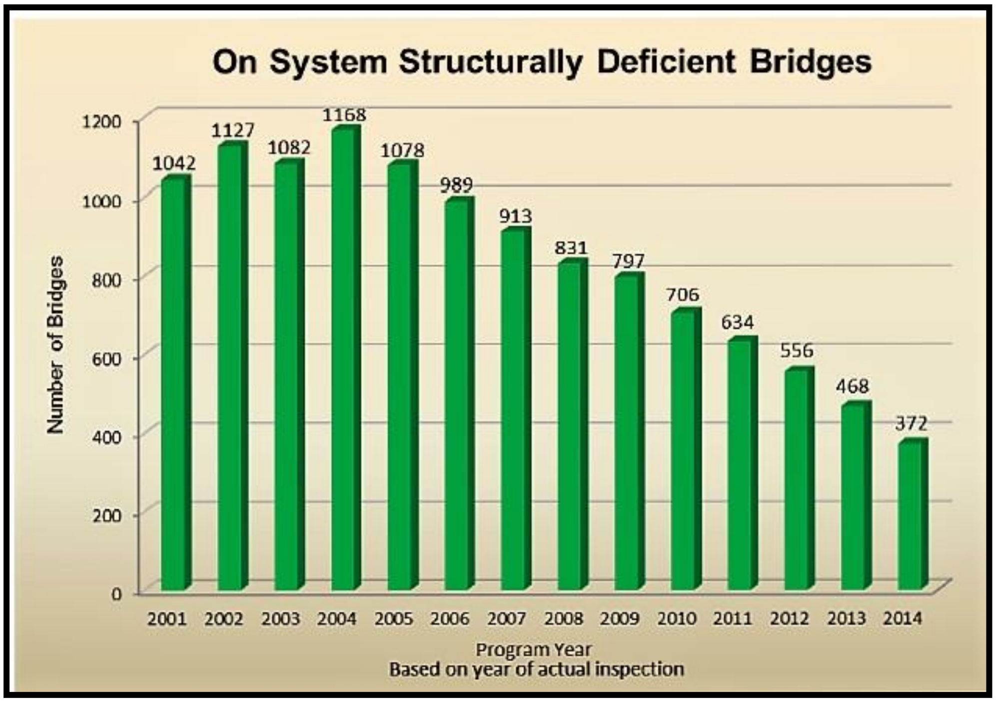


Figure 2. Structurally Deficient Bridges in Oklahoma (ODOT, 2015)

2.7. Previous Research Efforts

A number of previous research efforts have used National Bridge Inventory (NBI) data for identifying and modeling variables affecting bridge deterioration. A number of statistical and probabilistic methods have been utilized for identifying correlations and trends in the data. Significant research efforts have been conducted to evaluate and manage bridges based on NBI data or NBI type data using various techniques, such as numerical modeling, field testing, geographic information system (GIS) software, statistical analysis, probabilistic analysis, and artificial intelligence (Cesare et al., 1992; Madanat and Ibrahim, 1995; Morcous et al., 2002; Bolukbasi et al., 2004; Tapan and Aboutaha, 2008; Agrawal and Kawaguchi, 2009; Cheung et al., 2009; Elbehairy et al., 2009; Metzger and Huckelbridge, 2009).

Chase, Small, and Nutakor presented 'An In- Depth Analysis of the National Bridge Inventory Database Utilizing Data Mining, GIS and Advanced Statistical Methods' in 1999 (Chase et al., 1999). This paper facilitated a study of relationships between bridge behaviors and other factors, such as climate and geographical location. The relationships were identified by extracting the bridge condition information for functionally obsolete bridges, structurally deficient bridges, and those in need of maintenance using different data warehousing and mining techniques from NBI, then combining these data with climate information using GIS software (Chase et al., 1999). Using the expanded data sets from the combined NBI and GIS databases, three different regression analysis models (a linear model, a non-linear non-parametric model and a non-linear parametric model) were applied to map the relationship between bridge condition states (deck, superstructure, and substructure) and possible factors influencing deterioration (Chase et al., 1999). The variables included in this study were age, average daily traffic, precipitation, frequency of deicing, temperature range, freeze-thaw cycles, and type of bridge construction. As per this paper the generalized linear model gave the best prediction (Chase et al., 1999).

Mishalani and Madanat developed a bridge deterioration model with a stochastic approach and demonstrated the model using 1460 observations of bridges in NBI condition states of 7 and 8 taken from the 10-year period between 1974 and 1984 (Mishalani and Madanat, 2002). Structural types, highway class, traffic loading, age, and wearing surface types were the considered parameters. The effect of rehabilitation was eliminated from the data, but routine maintenance was not considered separately. The transition probability modeling method of state-based discrete-time was used for the model (Mishalani and Madanat, 2002). A Weibull distribution was used in the duration models for the two condition states and a 95% confidence interval was used in comparing variables. In this paper, mechanical processes due to abrasion and impact and chemical processes were found to be primary factors causing bridge deterioration, depending on the bridge rating (Mishalani and Madanat, 2002).

Research by Bolukbasi et al. published in 2004 estimated the future condition of highway bridge components from 2,601 Illinois bridges in the period of 1976–1998, using the NBI data (Bolukbasi et al., 2004). The bridge condition data was extracted and filtered by removing bridges for which reconstruction works were not recorded, to avoid erroneous future bridge condition predictions (Bolukbasi et al., 2004). Two methods were used to develop reasonable deterioration curves for the bridges. In method 1, the condition ratings adjustment was done on the basis of the notion that unless there is evidence of reconstruction or repair work, the condition rating cannot be greater than previous ratings, and in method 2, deterioration curves were constructed using data that represented the duration between consecutive inspections (Bolukbasi et al., 2004). These methods were applied to the rating data collected and bridge deterioration models were compared. Both methods showed that traffic volume has an important effect on bridge deterioration (Bolukbasi et al., 2004).

Research by Wu published in 2010 examined a range of NBI data for all states using exploratory data analysis tools to analyze the bridge data, using both GIS and MATLAB (a computing application) (Wu, 2010). Location, average daily traffic, structure length, deck width, structure type, ownership, maintenance responsibility, bridge design, environmental impacts, and critical bridges were the bridge parameters considered (Wu, 2010). The results of the study included information on patterns for types of bridge deficiency, load rating, design load, functional classification, bridge design, scour conditions, and fracture critical bridges in both time and space (Wu, 2010). The results were summarized in the form of statistics for each state and were intended to be useful to users, bridge owners, and design engineers involved in designing and maintaining bridges. The results in the research indicated differences in design loads over time. Some inconsistent spatial patterns in design load and load rating were identified. One specific finding was that bridges in the eastern United States were generally designed with lower design load standards (Wu, 2010). Type of deficiency exhibited significant patterns in spatial distribution. Wu points out that the study indicated additional knowledge could be gleaned from further study of the NBI database over time. Specifically studies related to effect of spatial distribution on condition rating, further investigation of patterns discovered, inclusion of additional data sets such as climate data, and identification of factors resulting in bridges being labeled as structurally deficient or functionally obsolete would be useful (Wu 2010).

Collective efforts to identify critical sources of bridge deterioration in North Dakota were made by Kim and Yoon in 2010. Their paper presented the performance of constructed bridges in cold regions through examining the bridges in North Dakota using a combined multiple regression and GIS technology (Kim and Yoon, 2010). These softwares were employed to evaluate and identify the critical sources affecting deterioration (Kim and Yoon, 2010). Physical, material, and environmental factors were examined with bridge data. The NBI data used for this study included 5,289 constructed bridges and 2,801 concrete deck slabs inspected during the year between 2006 and 2007 (Kim and Yoon, 2010). GIS software was used to visually assess the condition of bridges in North Dakota. Technical information including physical conditions, functional class, structural ratings, and longitude and latitude coordinates of individual bridges were collected. The bridge data for structurally deficient, open, and functionally obsolete bridges was linked to the precipitation, temperature, demographic population, lane use, and agriculture information obtained within the GIS model (Kim and Yoon, 2010). This linked data was used to further examine the factors influencing the bridge deterioration.

Kim and Yoon conducted an ordinary least-square multiple regression analysis to identify the critical sources of bridge deterioration by engaging the present condition of the bridges with contributing factors within a given period (Kim and Yoon, 2010). They also included information related to bridge maintenance and rehabilitation into the regression analysis, to examine their relationships with bridge deficiency. A correlation function called the Pearson's correlation was used to examine the mutual relationship of each of the above-mentioned variables (Kim and Yoon, 2010). The coefficient of correlation value typically measures the correlation on a scale with 1 indicating perfect positive correlation, 0 indicating no correlation at all, and negative 1 indicating perfect negative correlation (Kim and Yoon 2010). The alpha value (level of significance) of 0.05 was used, which means a 95% confidence level to support the correlation between two variables.

The condition evaluation of the bridge decks was done by using three categories, good rating from 7 to 9, fair rating from 5 to 6, and poor rating from 1 to 4 (Kim and Yoon 2010). According to their research the most critical bridges in North Dakota were girder-type bridges with steel members. The bridges comprised of prestressed concrete members and timbers included more functionally obsolete bridges than structurally deficient bridges (Kim and Yoon 2010). They concluded that corrosion and impact of heavy trucks were the primary source of deterioration for the steel bridges and the deck slabs (Kim and Yoon 2010). The possible sources of the corrosion as per their report were due the use of deicing salts and the contribution of rain and snow melting, including the effect of chloride. As a result of these, uniform corrosion was observed in a number of steel-plate girder bridges during their inspection (Kim and Yoon 2010). Their observations indicated that most of the truss bridges in North Dakota showed significant deterioration, so they recommended that truss bridges may not be an adequate structural system in cold regions such as North Dakota (Kim and Yoon 2010). As a conclusion, they identified that year built, followed by the volume of traffic, and the presence of water in structural systems were the most contributing parameters to bridge deterioration (Kim and Yoon 2010).

Tolliver and Lu (2011) conducted a case study analyzing bridge deterioration rates of the northern plains region. A regression model including five main variables: bridge material, bridge design, operating rating classification, average daily traffic, and the state where the bridge was located was analyzed over a 95-year period to study the effects of these variables (Tolliver and Lu, 2011). The effects were represented using indicator or dummy variables that shift the intercepts of the regression, creating many unique levels or categories (Tolliver and Lu, 2011).

A study by Lee published in 2012 examined the cause of bridge deterioration by analyzing NBI data. The bridge parameters considered in this study were traffic volume, structure type and deck protection systems, material type, and age (Lee, 2012). The results of the study indicated that bridge age, span length, average daily traffic, location, and highway system, in addition to other factors, might have an effect on structural deficiency (Lee, 2012).

A report by the Bridge Division of Texas DOT concentrated on NBI data for bridges in the state of Texas, focused on the change in the bridge conditions from 2004 to 2014 (Texas DOT, 2014). The results of this study indicated a growing number of bridges in the state, but a reduced percentage of structurally deficient bridges, and that the majority of funding for bridges was spent on bridge rehabilitation and repair (Texas DOT, 2014).

Nasrollahi and Washer statistically analyzed the NBI data of 4270 bridge superstructures in Oregon to estimate inspection intervals for constructed bridges

(Nasrollahi and Washer, 2015). Specifically, the time-in-condition rating (the time a bridge has a specific condition rating) for superstructure components was examined from NBI data using typical statistics. The data distribution for time-in-condition was assessed using the Anderson-Darling method. Normal, lognormal, exponential, Weibull, and gamma distributions were examined in this research. The Weibull distribution was found to provide the best overall representation of the data with the lognormal distribution also being competitive for lower condition ratings (i.e. 4 or 5), and the normal distribution provided a good fit for higher condition ratings (i.e. 8). The Weibull distribution was used to provide the most flexibility in estimating time to failure and the probability of deterioration was predicted using this distribution (Nasrollahi and Washer, 2015). Overall, it was determined that the time in a particular rating decreased as the rating decreased (Nasrollahi and Washer, 2015).

A paper by Kim and Queiroz examined a data set comprising 1,002,172 bridge decks and superstructures from inspection years 2010–2014, to assess the performance of bridge members in the United States (Kim and Queiroz, 2017). The condition ratings of bridge members (year-built, average daily traffic, deck conditions, and superstructure conditions) were extracted from the NBI, and the entire country was categorized into four different temperature-gradient service zones (Zone 1, Zone 2, Zone 3, and Zone 4) as per the American Association of State Highway Transportation Officials (AASHTO) Load and Resistance Factor Design (LRFD) Bridge Design Specifications (Kim and Queiroz, 2017). The performance of these members was examined statistically and probabilistically, using the NBI's nine-point condition rating scale in conjunction with the effect of traffic, temperature changes, and precipitation (Kim and Queiroz, 2017).

After all the data was organized, ‘Big Data’ analytics were used to establish trends in bridge performance (Kim and Queiroz, 2017). ‘Big Data’ uses software capable of determining scientific relationships between independent and dependent variables of interest, by examining massive data sets. Then data for all four zones were subjected to factorial analysis using a two-factor analysis of variance (ANOVA) test to examine statistical correlation of year-built with the condition ratings of bridge decks and superstructures. In ANOVA, an F statistic value was calculated for year-built vs deck and superstructure ratings, and compared with a critical value at a certain level of significance. A 95% significance level (alpha = 0.05) was employed in this study (Kim and Queiroz, 2017). If the F value was greater than 0.05, the effect of year-built was statistically significant on the condition rating of the bridge. At the end of this factorial analysis Kim and Queiroz implied that, to examine the performance of existing bridge members year-built was a crucial factor to be considered (Kim and Queiroz, 2017). They also determined that the type of structure played an important role on the performance of bridges in a particular area (Kim and Queiroz, 2017)

They concluded by making the following observations (Kim and Queiroz, 2017): 1) Zones 1 and 3 were subjected to higher traffic-induced distress than the bridges in Zones 2 and 4 due to increased fatigue cycles and possible overload, 2) Bridges constructed in Zones 1 and 4 experienced more temperature-induced deformations mainly due to average differences in maximum and minimum temperature cycles than those in Zones 2 and 3, 3) The amount of precipitation in Zone 1 was consistently low, with Zones 2 and 3 showing similar precipitation patterns, in contrast to the precipitation of Zone 4 which was significantly higher. This paper hypothesized that the ratings of the decks and superstructures exhibited a normal probability distribution, and performance uncertainty associated with the bridge members increased with an increase in service year, including a change in deterioration (Kim and Queiroz, 2017). Their probability-based analysis indicated that the bridge members in Zones 1 and 3 deteriorated more than the members in Zones 2 and 4, possibly due to higher traffic and thermal loadings. Also, the rate of deterioration of bridge decks was higher than that of bridge superstructures (Kim and Queiroz, 2017).

Summary

This literature review considered: 1) the factors that affect bridge deck and superstructure conditions, 2) important climatological variables, 3) the factors influencing fluctuations in climate, 4) Oklahoma ODOT's practices in improving bridge deck and superstructure conditions and its decision process for maintenance, 5) Previous research efforts using NBI data and deterioration models. Previous research shows that NBI bridge data can be used to identify trends in bridge behavior and deterioration over time. Climate variables, structure type, and location of the bridges may have effects on the deterioration of bridges over time and should be considered.

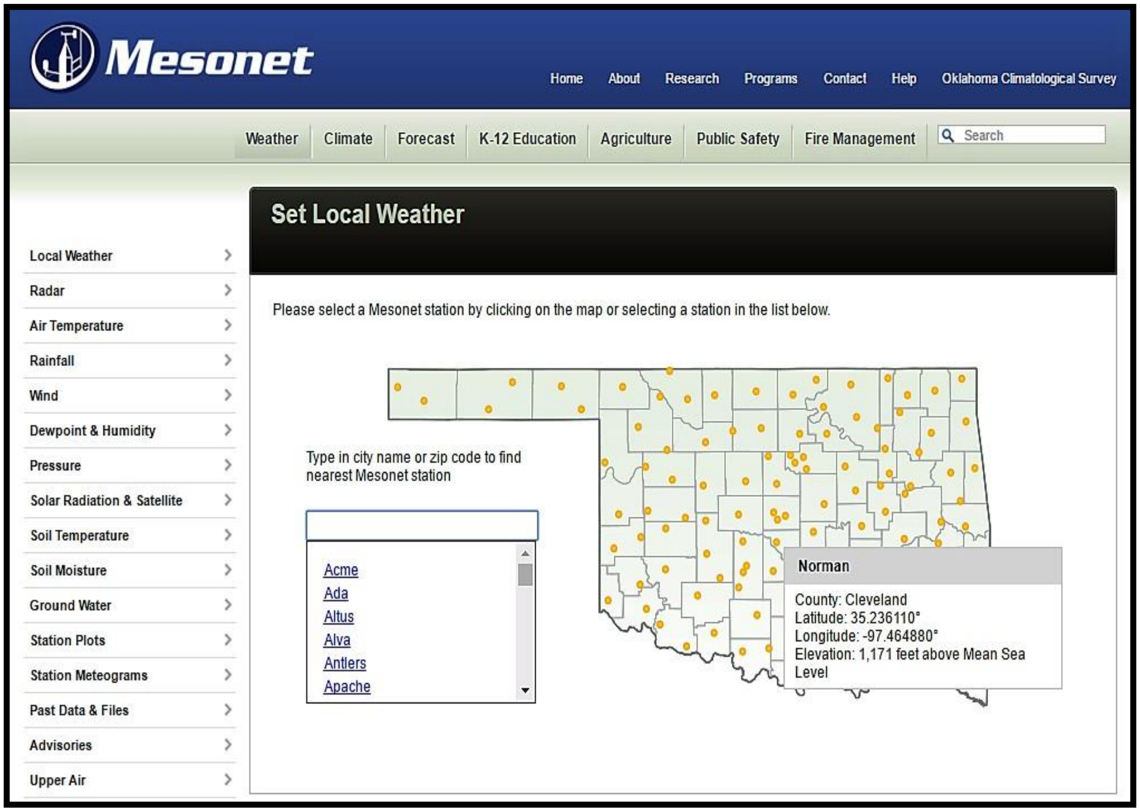
3. Research Methods and Approach

3.1. Collecting Climate and Bridge Data

Climate data related to the variables identified in the literature review (freeze-thaw cycles, rainfall, solar radiation, and temperature) were collected for the various regions of Oklahoma primarily using the Oklahoma Mesonet (McPherson et al., 2007; Brock et al., 1995). The Oklahoma Mesonet is a network of 120 automated environmental monitoring stations located on or near 10-meter (33 ft.) tall towers, designed to collect weather information (e.g., wind speed, rainfall, temperature) and transmit observations to the central facility every 5 minutes, 24 hours per day, every day of the year. The central facility is headquartered at the National Weather Center on the University of Oklahoma (OU) campus. The Mesonet stations cover each of Oklahoma's counties. The website hosts a comprehensive cluster of other useful information including weather updates, agriculture, forecast, public safety, and fire management.

3.1.1. Selection of Climate Stations

The process of filtering began with identifying climate stations representative of the different regions of Oklahoma, which was done by accessing the 'Local Weather' option from the Mesonet website as shown in Figure 3. The local weather option in the website is an effective tool to get a compact visual distribution of Mesonet climate stations over the entire state. The yellow dots within each county on the map in Figure 3 represent the climate stations. The locations of all stations in terms of latitude and longitude were collected for overlapping climate station with bridge locations. In the event of having more than one station in a county, the station having a larger number of bridges in close proximity, as described later in this section, was selected for data collection.



Please select a Mesonet station by clicking on the map or selecting a station in the list below.

Type in city name or zip code to find nearest Mesonet station

Norman

County: Cleveland
Latitude: 35.236110°
Longitude: -97.464880°
Elevation: 1,171 feet above Mean Sea Level

Figure 3. Mesonet Station Selection Chart (McPherson et al., 2007; Brock et al., 1995)

Maps of the ODOT Field Divisions and Mesonet Climate Divisions, shown in Figure 4 and Figure 5, were used along with the climate station locations to select climate stations representative of each of those regions, so that all the bridges in that region could be related to one climate station or two depending on the number available in each region.

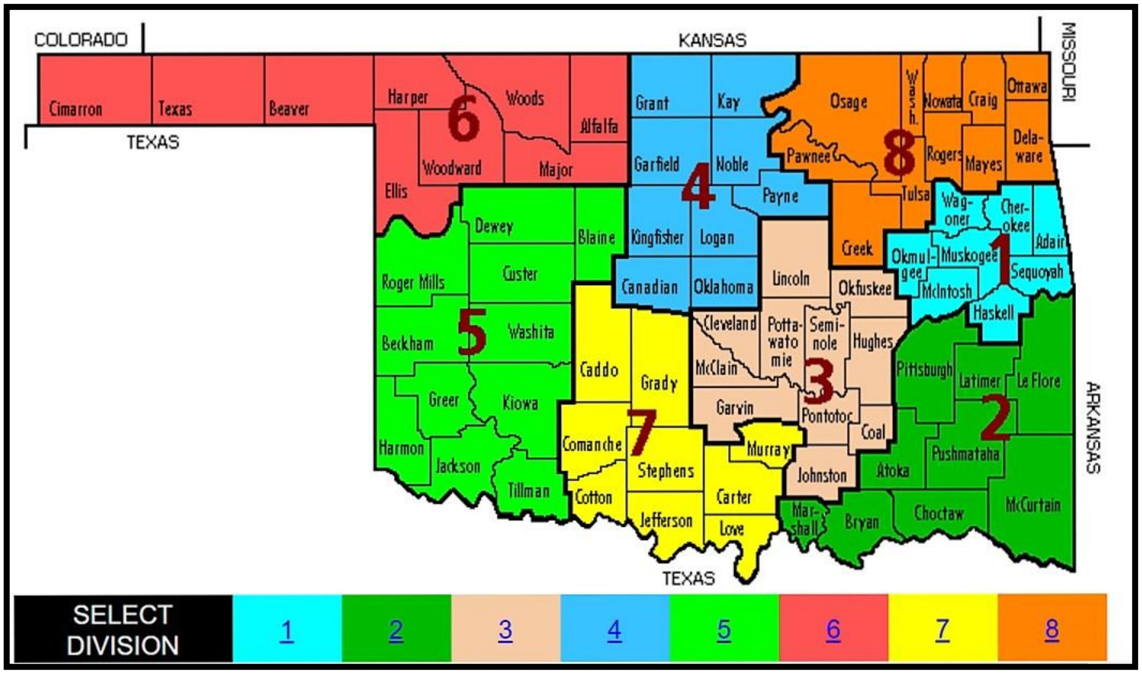
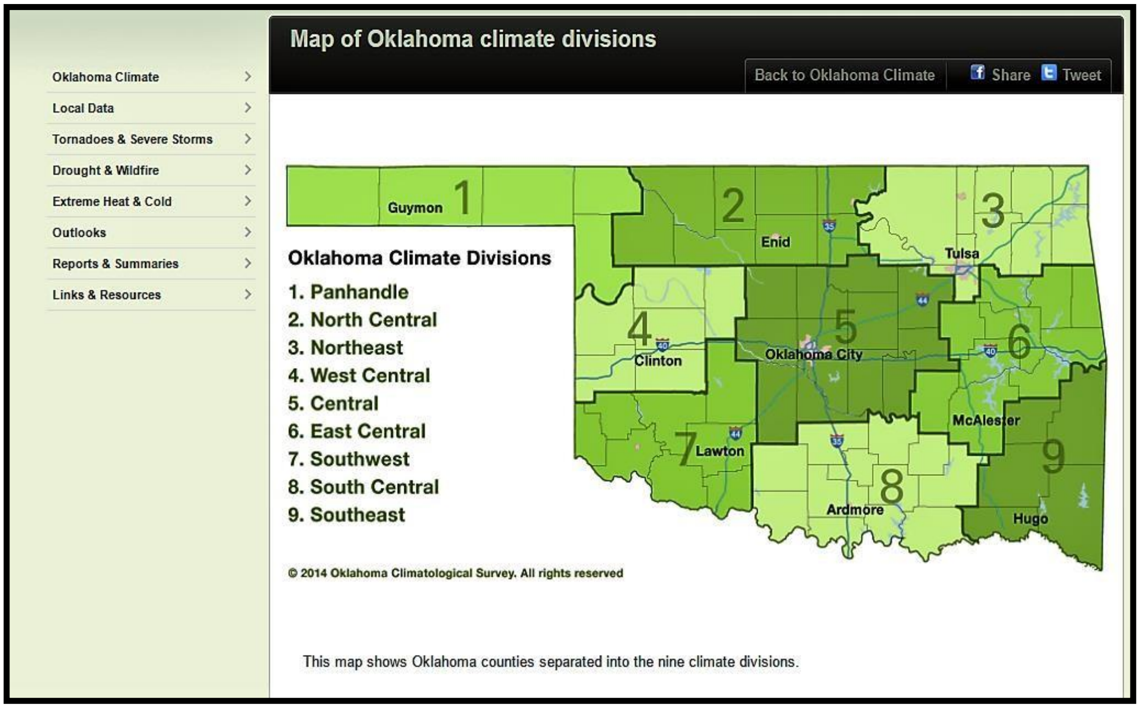


Figure 4. ODOT Field Division Map (ODOT, 2015)



Map of Oklahoma climate divisions

Oklahoma Climate Divisions

1. Panhandle
2. North Central
3. Northeast
4. West Central
5. Central
6. East Central
7. Southwest
8. South Central
9. Southeast

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This map shows Oklahoma counties separated into the nine climate divisions.

Figure 5. Mesonet Climate Divisions (McPherson et al., 2007; Brock et al., 1995)

Locating open bridges close to each climate station (within 50 miles) was one of the most important tasks to compare the effects of climate variables on bridge condition. The main sources used in this task were the National Bridge Inventory (NBI) (FHWA, 2017), Google Maps (Google, 2017), and other bridge data resources such as Bridge Hunter (Baughn, 2016) and Ugly Bridges (Baughn, 2016). The NBI is a database, compiled by the Federal Highway Administration (FHWA), having unified information about bridges in the United States including identification information, location, operational conditions, bridge types and specifications, and other bridge data including functional description and geometric data (Lubkin and Blades, 2016). Google Maps proved extremely useful when overlapping climate station and bridge locations by allowing both to be plotted on a single map. Ugly Bridges and Bridge Hunter are searchable versions of the NBI, giving detailed information about bridges in a more presentable way.

Oklahoma County is used as an example to show the procedure followed to find open bridges near a selected climate station. Finding open bridges near a climate station started with accessing the Bridge Hunter website and establishing a clear boundary for the station of interest. Figure 6 shows the Bridge Hunter boundary for Oklahoma County. The main purpose of the boundary was to avoid confusion with bridges from neighboring counties. Once the boundary was set, the Ugly Bridges filter for open bridges was used, and the website displayed the total number of open bridges for that county. Figure 7 shows the Ugly Bridges distribution of open bridges for Oklahoma County. The climate station location was entered into Google Maps using the latitude and longitude, which then sets up a pin point representing the location of the selected climate station. This location was then searched over Ugly Bridges by using the zoom function. If the climate station was located close to any school, creek, or any major landmark, it made the process less difficult. Once the exact location as shown by Google Maps was identified on Ugly Bridges and Bridge Hunter collectively, the number of open bridges within a 50-mile window surrounding that selected climate station was identified. The same process was repeated for all other climate stations. The stations selected for data collection are listed in Table 1 along with their location, the climate and ODOT divisions represented, and the number of bridges within 50 miles. Not all bridges in close proximity were identified during preliminary selection of the climate stations. Additional bridges were identified and used for data collection and statistical analysis of differences in bridge rating once the climate stations used for analysis were selected. The Oklahoma climate division labels used in Table 1 are defined in Table 2.

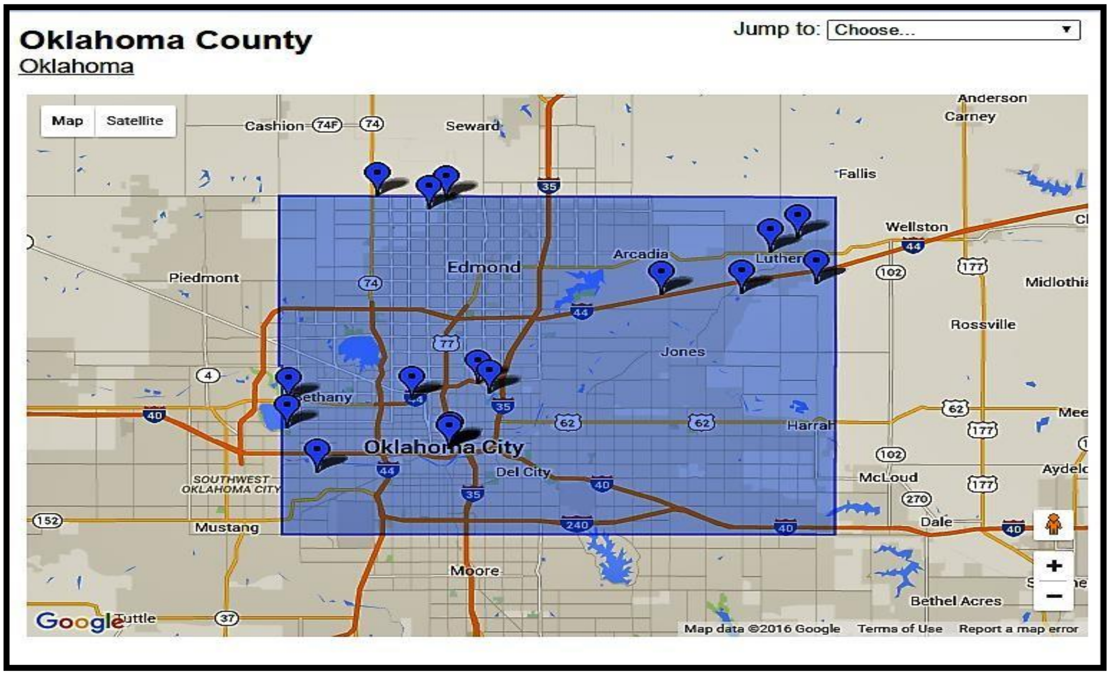


Figure 6. Oklahoma County Boundary (Baughn, 2016)

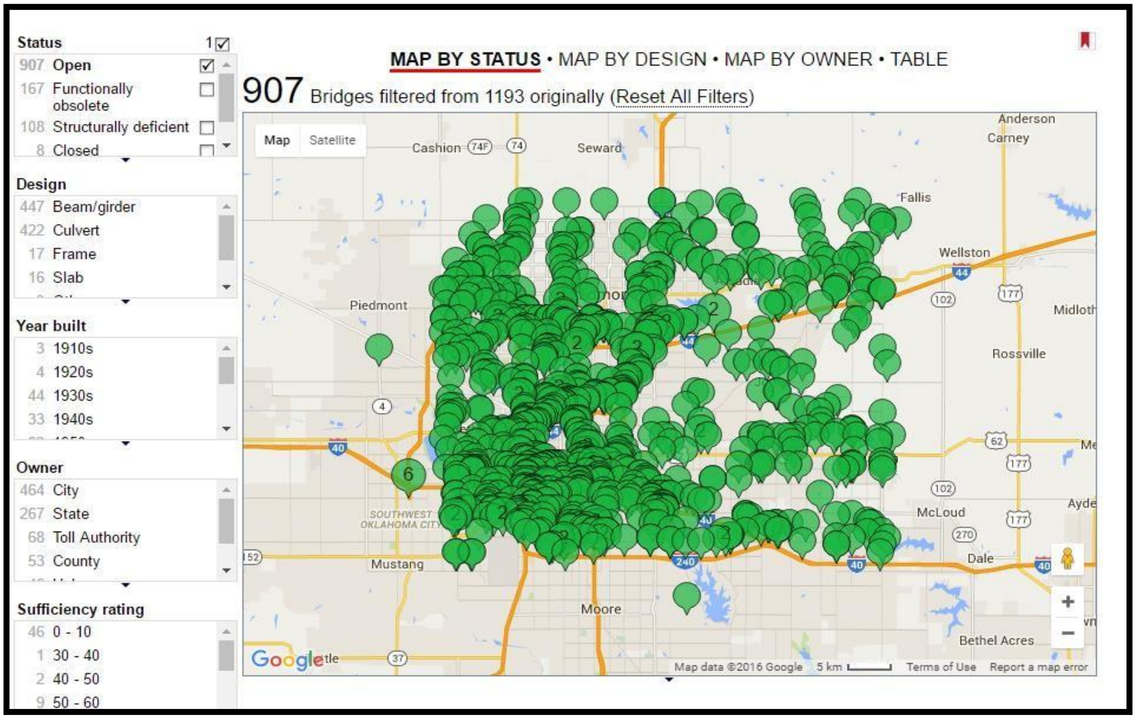


Figure 7. Total Open Bridges in Oklahoma County (Baughn, 2016)

Table 1. Mesonet Stations Selected for Data Collection

Climate Division	ODOT Division	Mesonet Station	Latitude	Longitude	Bridges <50 miles	
					Station Selection	Final for Analysis
EC – 6	1	Westville	36.011°	94.644°	7	10
SE – 9	2	Idabel	33.830°	94.880°	10	23
SE – 9	2	Wister	34.984°	94.687°	7	65
C – 5	3	Norman	35.236°	97.464°	7	29
C – 5	4	Stillwater	36.120°	97.095°	4	56
NC – 2	4	Breckinridge	36.412°	97.693°	3	30
WC – 4	5	Bessie	35.401°	99.058°	6	17
SW – 7	5	Tipton	34.439°	99.137°	6	4
PH – 1	6	Beaver	36.802°	100.530°	3	19
SC – 8	7	Burneyville	33.893°	97.269°	3	17
NE – 3	8	Copan	36.909°	95.885°	10	42
NE – 3	8	Inola	36.142°	95.450°	14	43

Table 2. Mesonet Climate Divisions

ID	Location
PH-1	Pan Handle
NC-2	North Central
NE-3	Northeast
WC-4	West Central
C-5	Central
EC-6	East Central
SW-7	Southwest
SC-8	South Central
SE-9	Southeast

3.1.2. Collection of Climate Data

Having selected the climate stations based number of bridges and distribution across the ODOT and climate regions, daily data for temperature, rainfall, humidity and solar radiation for the filtered climate stations were obtained from Oklahoma Mesonet for the date range of January 1, 1997 to December 31, 2015. These variables were selected for potential effects on bridge condition based on the results of the literature review. These data were sorted using Microsoft Excel to determine yearly freeze-thaw cycles for the stations listed in Table 1, based on the following criteria: maximum temperature greater than or equal to 32 °F, minimum temperature less than or equal to 25 °F, rainfall greater than or equal to 0.01 inches, and average humidity greater than or equal to 80%. These criteria were selected based on review of literature related to the effect of freeze-thaw cycles on structures (Section 2.3.1) and standard tests for examining freeze-thaw resistance in the laboratory. Table 3 shows an example of how a freeze-thaw cycle was determined based on the previously discussed criteria for the Norman Mesonet station in the year 2015.

Table 3. Example of Freeze-Thaw Cycles Filtering for Norman Station in 2015

February	**2015**		
Temperature, °F		Avg Humidity, %	Rainfall, inches
Max	Min		
46	22	85	0.05
35	21	80	0.01
42	20	89	0.05
Freeze-Thaw Cycles		**3**	
March	**2015**		
Temperature, °F		Avg Humidity, %	Rainfall, inches
Max	Min		
44	23	84	0.01
42	9	82	0.07
Freeze-Thaw Cycles		2	
December	**2015**		
Temperature °F		Avg Humidity, %	Rainfall, inches
Max	Min		
33	21	87	0.04
Freeze-Thaw Cycles		1	
All other months have - 0 Freeze-Thaw Cycles			
Total 2015 ---> 6 Freeze-thaw Cycles			

Temperature, rainfall, humidity and solar radiation data were collected and filtered on a monthly basis from the Oklahoma Mesonet website. The ‘Past Data and Files’ option navigates to a new window, displaying station monthly summaries as shown in Figure 8. The station monthly summaries were then accessed, which displays a new tab where month, year and station selection can be made, as shown in Figure 9. The selection for each required year, month and station was made and the page displayed comprehensive data for that selected range. An example for the Norman station is shown in Figure 10 for April 2015. Average values for each month were compiled for each station from these monthly summaries.

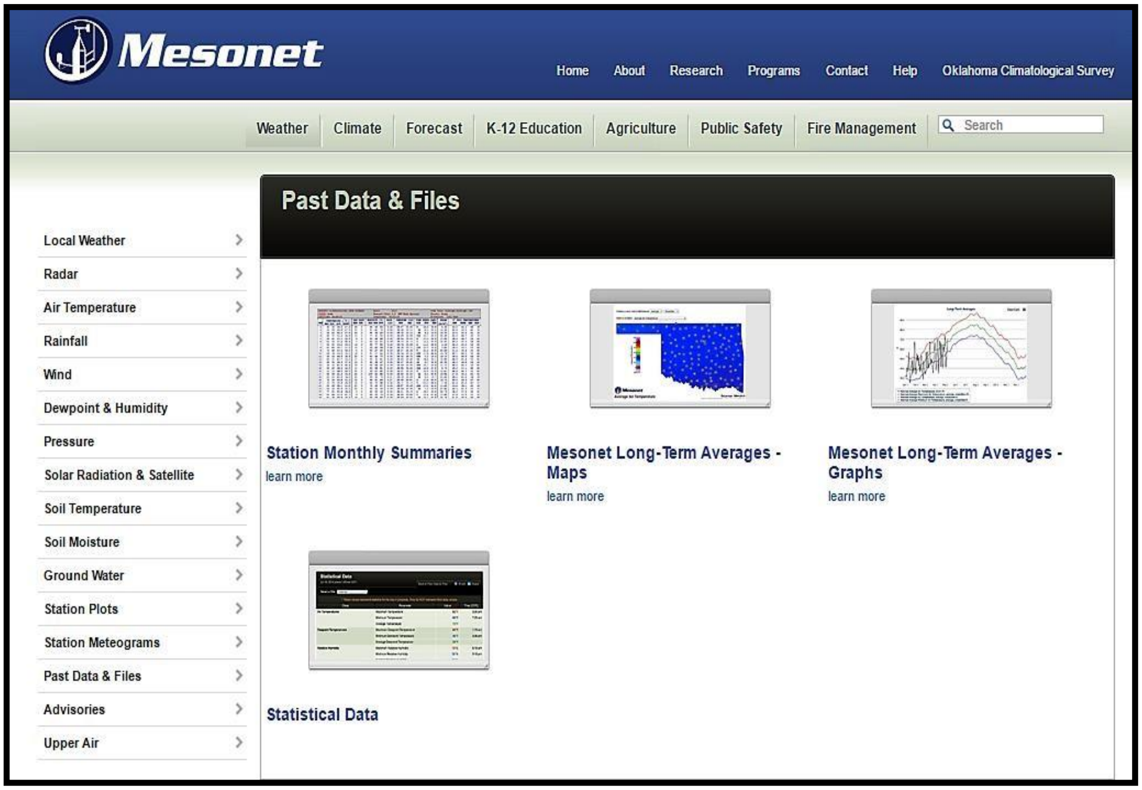
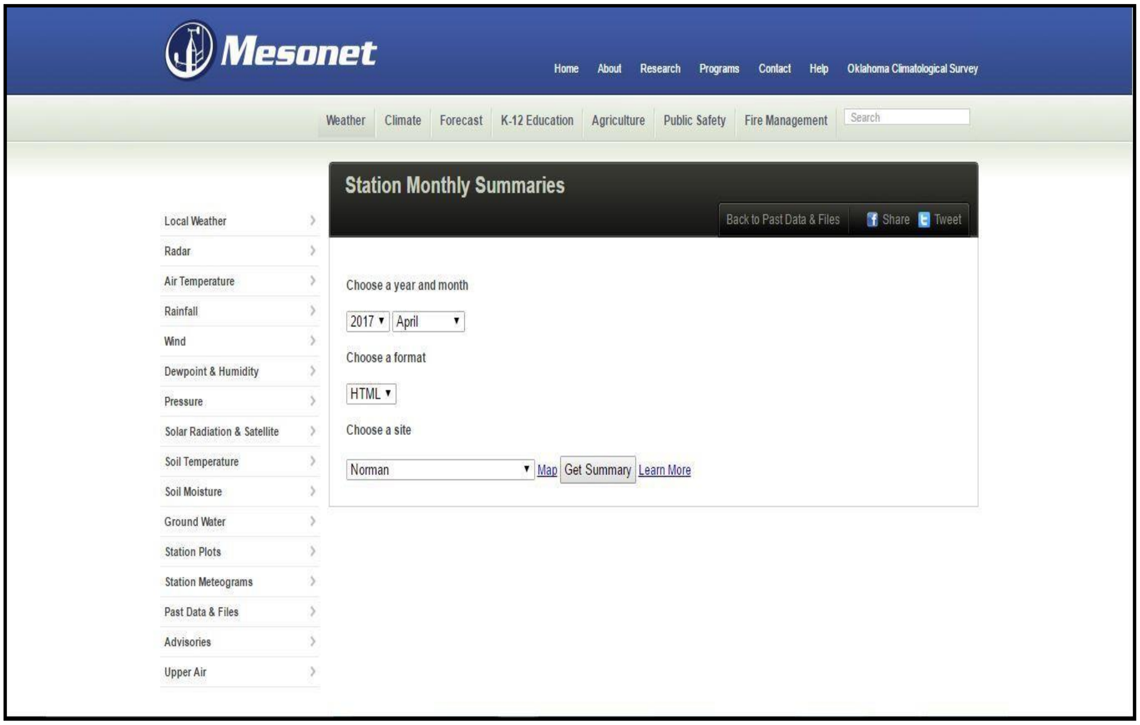


Figure 8. Oklahoma Mesonet Past Data and Files Tab (McPherson et al., 2007; Brock et al., 1995)



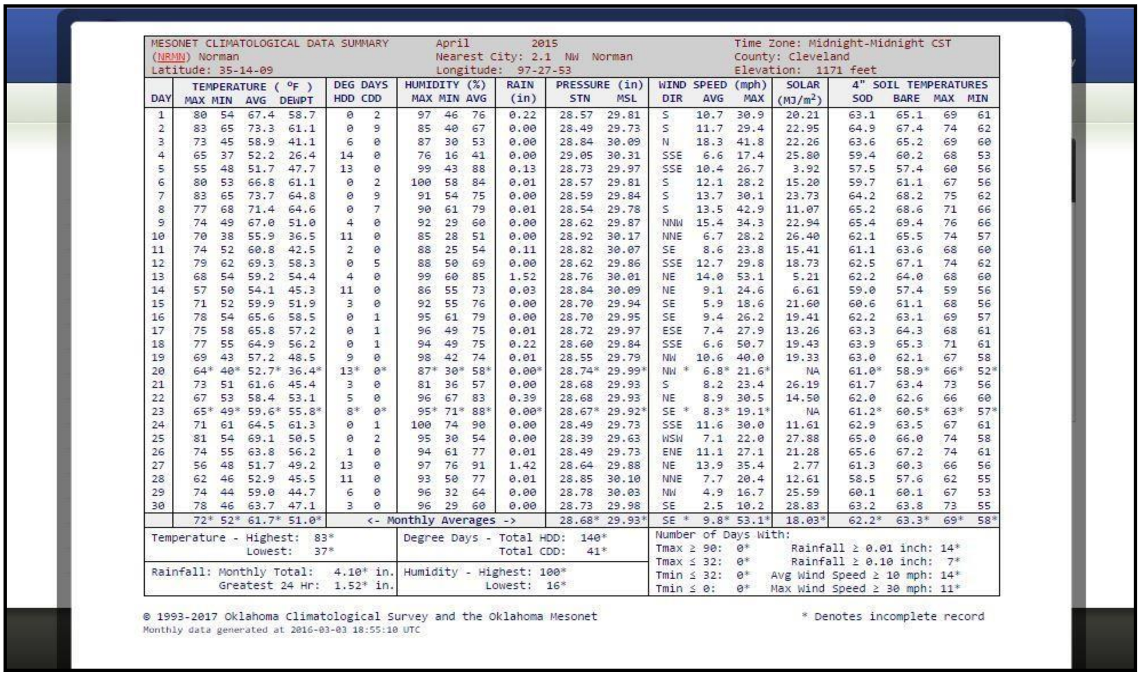
Station Monthly Summaries

Choose a year and month
2017 April

Choose a format
HTML

Choose a site
Norman

Figure 9. Station Monthly Summaries Home (McPherson et al., 2007; Brock et al., 1995)



MESONET CLIMATOLOGICAL DATA SUMMARY April 2015 Time Zone: Midnight-Midnight CST
(NRMN) Norman Nearest City: 2.1 NW Norman County: Cleveland
Latitude: 35-14-09 Longitude: 97-27-53 Elevation: 1171 feet

DAY	TEMPERATURE (°F) MAX	MIN	AVG	DEWPT	DEG DAYS HDD	CDD	HUMIDITY (%) MAX	MIN	AVG	RAIN (in)	PRESSURE (in) STN	MSL	WIND SPEED (mph) DIR	AVG	MAX	SOLAR (MJ/m²)	4" SOIL TEMPERATURES SOD	BARE	MAX	MIN
1	80	54	67.4	58.7	0	2	97	46	76	0.22	28.57	29.81	S	10.7	30.9	20.21	63.1	65.1	69	61
2	83	65	73.3	61.1	0	9	85	40	67	0.00	28.49	29.73	S	11.7	29.4	22.95	64.9	67.4	74	62
3	73	45	58.9	41.1	6	0	87	30	53	0.00	28.84	30.09	N	18.3	41.8	22.26	63.6	65.2	69	60
4	65	37	52.2	26.4	14	0	76	16	41	0.00	29.05	30.31	SSE	6.6	17.4	25.80	59.4	60.2	68	53
5	55	48	51.7	47.7	13	0	99	43	88	0.13	28.73	29.97	SSE	10.4	26.7	3.92	57.5	57.4	60	56
6	80	53	66.8	61.1	0	2	100	58	84	0.01	28.57	29.81	S	12.1	28.2	15.20	59.7	61.1	67	56
7	83	65	73.7	64.8	0	9	91	54	75	0.00	28.59	29.84	S	13.7	30.1	23.73	64.2	68.2	75	62
8	77	68	71.4	64.6	0	7	90	61	79	0.01	28.54	29.78	S	13.5	42.9	11.07	65.2	68.6	71	66
9	74	49	67.0	51.0	4	0	92	29	60	0.00	28.62	29.87	NNW	15.4	34.3	22.94	65.4	69.4	76	66
10	70	38	55.9	36.5	11	0	85	28	51	0.00	28.92	30.17	NNE	6.7	28.2	26.40	62.1	65.5	74	57
11	74	52	60.8	42.5	2	0	88	25	54	0.11	28.82	30.07	SE	8.6	23.8	15.41	61.1	63.6	68	60
12	79	62	69.3	58.3	0	5	88	50	69	0.00	28.62	29.86	SSE	12.7	29.8	18.73	62.5	67.1	74	62
13	68	54	59.2	54.4	4	0	99	60	85	1.52	28.76	30.01	NE	14.0	53.1	5.21	62.2	64.0	68	60
14	57	50	54.1	45.3	11	0	86	55	73	0.03	28.84	30.09	NE	9.1	24.6	6.61	59.0	57.4	59	56
15	71	52	59.9	51.9	3	0	92	55	76	0.00	28.70	29.94	SE	5.9	18.6	21.60	60.6	61.1	68	56
16	78	54	65.6	58.5	0	1	95	61	79	0.00	28.70	29.95	SE	9.4	26.2	19.41	62.2	63.1	69	57
17	75	58	65.8	57.2	0	1	96	49	75	0.01	28.72	29.97	ESE	7.4	27.9	13.26	63.3	64.3	68	61
18	77	55	64.9	56.2	0	1	94	49	75	0.22	28.60	29.84	SSE	6.6	50.7	19.43	63.9	65.3	71	61
19	69	43	57.2	48.5	9	0	98	42	74	0.01	28.55	29.79	NW	10.6	40.0	19.33	63.0	62.1	67	58
20	64*	40*	52.7*	36.4*	13*	0*	87*	30*	58*	0.00*	28.74*	29.99*	NW *	6.8*	21.6*	NA	61.0*	58.9*	66*	52*
21	73	51	61.6	45.4	3	0	81	36	57	0.00	28.68	29.93	S	8.2	23.4	26.19	61.7	63.4	73	56
22	67	53	58.4	53.1	5	0	96	67	83	0.39	28.68	29.93	NE	8.9	30.5	14.50	62.0	62.6	66	60
23	65*	49*	59.6*	55.8*	8*	0*	95*	71*	88*	0.00*	28.67*	29.92*	SE *	8.3*	19.1*	NA	61.2*	60.5*	63*	57*
24	71	61	64.5	61.3	0	1	100	74	90	0.00	28.49	29.73	SSE	11.6	30.0	11.61	62.9	63.5	67	61
25	81	54	69.1	50.5	0	2	95	30	54	0.00	28.39	29.63	WSW	7.1	22.0	27.88	65.0	66.0	74	58
26	74	55	63.8	56.2	1	0	94	61	77	0.01	28.49	29.73	ENE	11.1	27.1	21.28	65.6	67.2	74	61
27	56	48	51.7	49.2	13	0	97	76	91	1.42	28.64	29.88	NE	13.9	35.4	2.77	61.3	60.3	66	56
28	62	46	52.9	45.5	11	0	93	50	77	0.01	28.85	30.10	NNE	7.7	20.4	12.61	58.5	57.6	62	55
29	74	44	59.0	44.7	6	0	96	32	64	0.00	28.78	30.03	NW	4.9	16.7	25.59	60.1	60.1	67	53
30	78	46	63.7	47.1	3	0	96	29	60	0.00	28.73	29.98	SE	2.5	10.2	28.83	63.2	63.8	73	55
	72*	52*	61.7*	51.0*	<- Monthly Averages ->						28.68*	29.93*	SE *	9.8*	53.1*	18.03*	62.2*	63.3*	69*	58*

Temperature - Highest: 83*
Lowest: 37*

Degree Days - Total HDD: 140*
Total CDD: 41*

Rainfall: Monthly Total: 4.10* in.
Greatest 24 Hr: 1.52* in.

Humidity - Highest: 100*
Lowest: 16*

Number of Days With:
Tmax ≥ 90: 0* Rainfall ≥ 0.01 inch: 14*
Tmax ≤ 32: 0* Rainfall ≥ 0.10 inch: 7*
Tmin ≤ 32: 0* Avg Wind Speed ≥ 10 mph: 14*
Tmin ≤ 0: 0* Max Wind Speed ≥ 30 mph: 11*

© 1993-2017 Oklahoma Climatological Survey and the Oklahoma Mesonet
Monthly data generated at 2016-03-03 18:55:10 UTC

* Denotes incomplete record

Figure 10. Summary for Norman- April 2015 (McPherson et al., 2007; Brock et al., 1995)

Once the information for temperature, rainfall, solar radiation and humidity was collected for the 1997-2015 range, the data were arranged in Microsoft Excel for every selected station as: Average Yearly Temperature, Average Yearly Difference between Maximum and Minimum Temperature, Total Yearly Rainfall, Total Yearly Freeze -Thaw Cycles, and Total Yearly Solar Radiation.

3.1.3. Bridge Data

Comprehensive information for open bridges in close proximity (within an approximately 50-mile radius) to climate stations was gathered for the years from 1997 to 2015 from the NBI database in the form of ASCII files. Excel was then used to sort the bridge data to identify bridges that are within the targeted range of the filtered climate stations. The ASCII files provide a summary of data submitted annually to the FHWA by the states, federal agencies, and tribal governments for each bridge in accordance with the National Bridge Inspection Standards (NBIS) (Lubkin and Blades, 2016). The most important bridge information used for narrowing down bridge data included: structure number, county code, latitude, longitude, open-closed-posted, type of service, kind of material/design, type of design/construction, deck condition, superstructure condition, substructure condition (substructure data comparisons were also used since the data were available with deck and superstructure data), type of work proposed, deck structure type, wearing surface type, and average daily traffic.

The information relating to identifying specific variables was collected from 'The Recording and Coding Guide for the Structure Inventory and Appraisal of the Nation's Bridges' Guide (FHWA, 1995). This is a document published and maintained by the FHWA, which provides more thorough and detailed guidance in evaluating and coding specific bridge data. The items in the guide are expanded to provide detailed and explicit explanations for coding (FHWA, 1995). The collected ASCII bridge data files were imported into Excel and sorted using the variables discussed previously and coding information retrieved from the bridge guide as primary filters. The variables used for filtering are discussed in the following sections.

3.1.3.1 County Code

The NBI assigned the FIPS code (Federal Information Processing Standards) for all counties in Oklahoma. The county codes corresponding to the selected Mesonet stations are shown in Table 4. These codes were used to filter the bridge information to identify bridges located near each climate station.

Table 4. FIPS County Codes Corresponding to Selected Mesonet Stations

Station	**County**	**County Code**
Westville	Adair	1
Idabel	McCurtain	89
Wister	Leflore	79
Norman	Cleveland	27
Stillwater	Payne	119
Breckinridge	Garfield	47
Bessie	Washita	149
Tipton	Tillman	141
Beaver	Beaver	7
Burneyville	Love	85
Copan	Washington	147
Inola	Rogers	131

3.1.3.2. Latitude and Longitude

Trying to triangulate the exact location of a bridge close to a climate station based on latitude and longitude is difficult. Limit values were applied in Excel when filtering bridges based on location. A range of 1.0° was used for the filters, which corresponds to a distance of 69 miles. For example, from Table 1 the Wister climate station coordinates are Latitude = 36.011° and Longitude = 94.644°. So, to sort bridges located close to this location, the filter for Latitude was set for 36.000° to 37.000° and the filter for Longitude was set for 95.000° to 96.000° was used in Excel. This then returned the open bridges with these numbers and making bridge filtering relatively less cumbersome.

3.1.3.3. Open-Closed-Posted

This provides information about the actual operational status of a bridge structure. Since only open bridges were of interest to this study, ‘Code A’, corresponding to open bridges with no restrictions, was selected for sorting (FHWA, 1995).

3.1.3.4. Type of Service on Bridge

This indicates the type of service used on the bridge and the following codes were used in filtering the data (FHWA, 1995):

- Code 1 – For Highways
- Code 5 – For Highway Pedestrians

The remaining codes described in the guide are for buildings or plaza, railroads, highway railroad, pedestrian bicycle bridges, overpass structure at an interchange, third level (interchange), fourth level (interchange), and others, which were not of interest for this research.

3.1.3.5. Structure Type

This section is divided into two parts and is represented as Kind of material/design and Type of design/construction. Only concrete bridges were considered as they are the dominant bridge type in Oklahoma and in order to limit the number of variables involved. The following codes were used to filter the data to identify slab or stringer/multibeam/girder bridges (FHWA, 1995):

Kind of Material / Design

- Code 1 – Concrete
- Code 5 – Prestressed Concrete

Type of Design / Construction

- Code 1 – Slab
- Code 2 – Stringer/Multibeam or Girder

3.1.3.6. Deck, Superstructure and Substructure Condition

Since one of the primary objectives of this project involved evaluating effect of climate conditions on bridge condition, this section played a very important role in determining the results. Deck condition, superstructure condition, and substructure condition were represented as rating codes. The deck condition rating and superstructure rating describe physical condition of all traffic supporting structural members. The substructure rating deals with the physical conditions of piers, abutments, piles, fenders, footings and other components. However, all three factors are described using the following codes (FHWA, 1995):

- N – Not Applicable
- 9 – Excellent Condition

- 8- Very Good Condition
- 7 – Good Condition – some minor problems
- 6 – Satisfactory Condition – structural elements show minor deterioration
- 5 – Fair Condition – structural elements are sound but have minor losses and cracking
- 4 – Poor Condition – advanced section loss, deterioration, spalling or scour
- 3 – Serious Condition – loss of section, serious deterioration, spalling or scour
- 2 – Critical Condition – advanced deterioration of primary structural elements.
- 1 – Imminent Failure Condition – major deterioration, bridge is closed to traffic
- 0 – Failed Condition – out of service and beyond corrective action

Only rating codes 5-9 were considered because this research focused on open bridges in excellent to fair condition in order to evaluate effects on bridges where preventative measures would still be useful. The ratings 0-4 represent bridges in deteriorated condition and are closed to traffic.

3.1.3.7. Type of Work Proposed

This section discusses the type of work proposed on the bridge structure to improve it to a point that it will provide the type of service needed. The codes used are as follows (FHWA, 1995):

- Code 31 – Replacement of bridge or other structure because of substandard load carrying capacity or substandard bridge roadway geometry
- Code 35 – Bridge rehabilitation because of general structure deterioration or inadequate strength

These codes are associated with bridges that have reached a level of deterioration requiring repair, which was of interest in this study.

3.1.3.8. Deck Structure Type

The Deck Structure Type indicates the type of deck system on the bridge. Since this project was concerned with concrete bridges, ‘Code 1’, which corresponds to cast-in place concrete, was selected for sorting (FHWA, 1995).

3.1.3.9. Wearing Surface/Protective System

The Type of Wearing Surface/Protective system indicates the covering for the bridge. The codes used in sorting the data for this item are as follows (FHWA, 1995):

- Code 1 – Monolithic Concrete
- Code 6 – Bituminous

‘Monolithic concrete’ and ‘Bituminous Concrete’ (asphalt) are the two most common types of wearing surfaces that would be affected by the climate variables considered in this study.

3.1.3.10. Average Daily Truck Traffic

Average Daily Truck Traffic shows the percentage of average daily traffic consisting of large semi-trucks. Vans, pickup trucks and other light trucks are not included in this category. Traffic volume significantly influences the level of deterioration of bridges. Since this research is concerned mainly about open bridges currently in use by traffic, this filter helps to sort out bridges accordingly. All data sets in this item were considered provided it was not left blank, which is done when average daily traffic is not greater than 100 (FHWA, 1995).

3.1.4. Summary of Task

Having applied all filters over the NBI bridge data, the structure number, deck rating, superstructure rating, and substructure rating for the years 1997-2015 were pulled out individually and were arranged into separate tables shown in Appendix B, with bridges corresponding to each Mesonet climate station arranged by ascending order of structure number. The filtering process reduced the number of bridges considered in this research from the total of 6800 state highway system bridges to the numbers considered for each climate shown in Table 1. Similarly, climate variable data (total freeze-thaw cycles, total solar radiation, total rainfall, average yearly temperature, and average difference between maximum and minimum temperature) corresponding to the Mesonet climate stations for each year from 1997-2015 were summarized and are shown in Appendix A.

3.2. Integrating Climate Data with NBI Data

3.2.1. Quantifying Change in Bridge Rating

The NBI bridge and climate data for each selected station were sorted and organized for the 19-year (1997-2015) time frame. The bridges having rating data for less than 10 years of the period of interest were not considered and information for these bridges is not included in Appendix B. The missing rating data is representative of bridges which were constructed very recently or discontinued during the period of interest. The change in bridge rating over a 10-year period was selected in order to have a metric for comparison. For example, the total number of bridges associated with the Norman Mesonet station for the bridge deck rating section was 29. Now, rating values are checked for each bridge and finally the average is calculated. If there are 22 bridges having 0 change in rating, 6 have 1 change, and 1 has 2 change the average bridge deck rating change = ((22*0) + (6*1) +(1*2)) /29 = 0.28. The same procedure was repeated for superstructure and substructure ratings changes for all the selected climate stations and the results for each station for bridge deck condition, superstructure condition and substructure condition were tabulated as shown in Table 5, and plotted as shown in Figures 11-13 to allow for comparison between regions. It was assumed that only a decrease in bridge rating was representative of deterioration and data indicating an increase in rating were not considered in order to eliminate the effects of major repairs. This did not take into account the effects of routine maintenance which may have kept the rating at a consistent level.

Table 5. Average Bridge Rating Changes

Station	**Deck Rating**	**Superstructure Rating**	**Substructure Rating**
Wister	0.15	0.17	0.13
Idabel	0.44	0.82	0.38
Copan	0.22	0.15	0.29
Inola	0.39	0.34	0.56
Norman	0.28	0.36	0.46
Stillwater	0.30	0.23	0.29
Tipton	0.75	0.75	0.75
Beaver	0.21	0.26	0.44
Bessie	0.33	0.59	0.66
Breckinridge	0.33	0.24	0.57
Burneyville	0.29	0.18	0.05
Westville	0.25	0.30	0.25

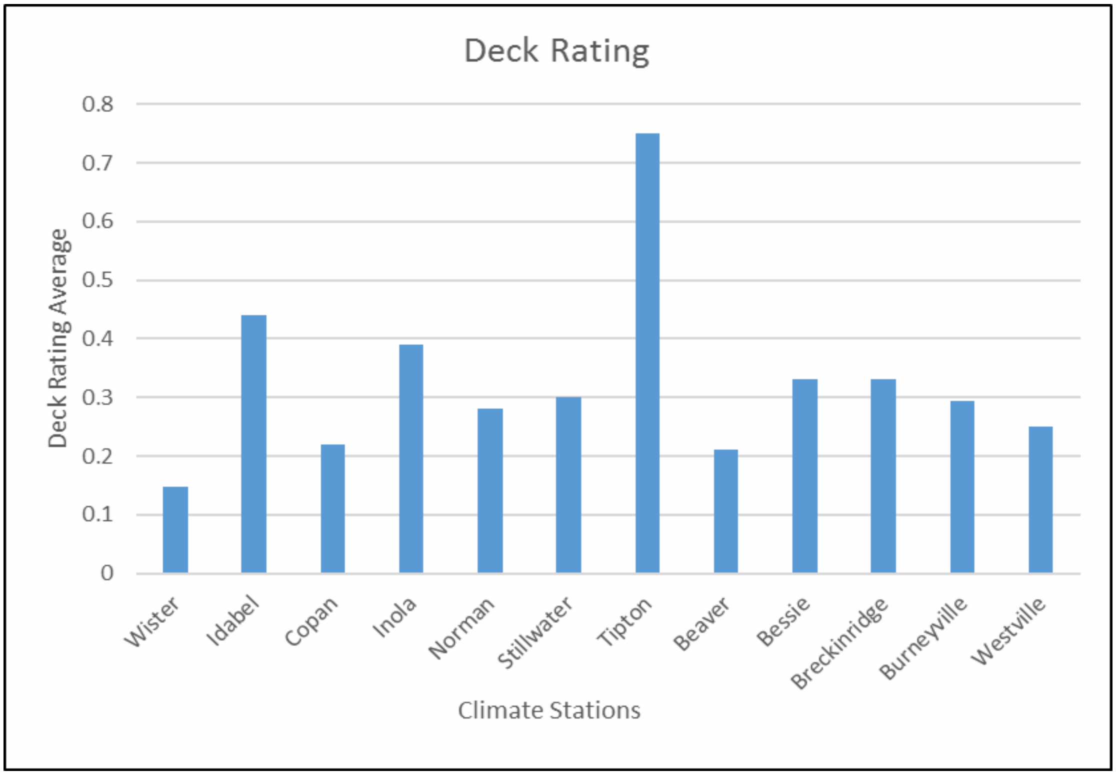


Figure 11. Average Deck Rating Change

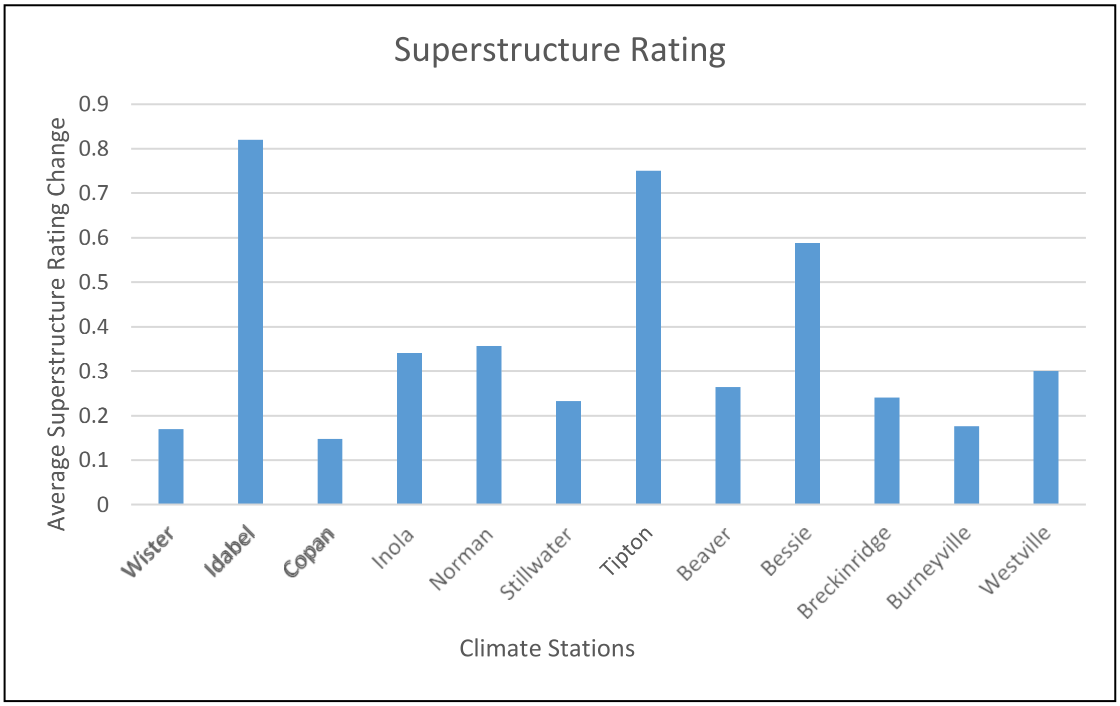


Figure 12. Average Superstructure Rating Change

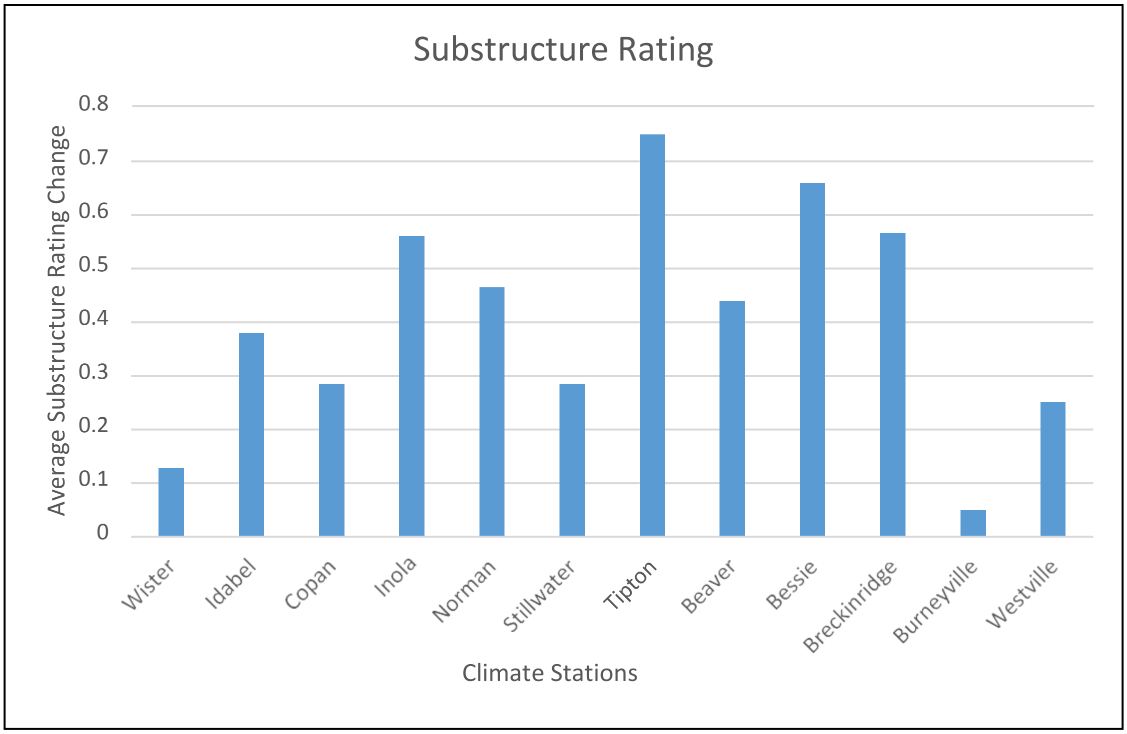


Figure 13. Average Substructure Rating Change

The average change in rating over time was also considered for multiple 10 year periods if additional data were available for each bridge in a station for all deck, superstructure and substructure ratings. Considering again Norman as the station of interest again for example, and a total of 19 years' data is available for any bridge, the data would be broken into two 10 year periods with one beginning at the initial data point and one ending at the last data point. If the first 10-year period is checked and if there is a change of 1 in rating, the average is calculated as 1/10= 0.1. Now, for the remaining 10-year period if there is a change of 2 in rating, the average is taken as 2/10= 0.2; the average for that particular bridge for the two 10-year periods is (0.1+0.2)/2 = 0.15. These average change calculations were repeated for all bridge ratings for each selected station, and were used for the final analyses.

3.2.2. Climate Data Analysis

The climate data (average temperature, average difference between maximum and minimum temperature, total yearly rainfall, total yearly freeze-thaw cycles, and total yearly solar radiation), as described in section 3.1.2, were plotted over time. These plots are shown in the respective sections in Chapter 4. Visible differences in the mean value for the time period considered were used to identify stations for more in depth statistical tests to determine whether the visible differences in the mean were statistically significant. This was done to produce representative values while reducing the required number of statistical tests.

3.2.3. Bridge and Climate Data Analysis

At least two station pairs representing visibly different curves and two station pairs representing visibly similar curves for each climate variable were selected for further analysis, and are shown in Table 6.

Table 6. Selected Climate Station Pairs for Analysis

Avg Yearly Temperature	Avg Diff in Max and Min Temperature	Total Rainfall	Total Freeze-Thaw Cycles	Total Solar Radiation
Inola-Burneyville	Westville-Beaver	Westville - Tipton	Copan-Tipton	Westville - Tipton
Westville-Tipton	Norman-Tipton	Norman-Idabel	Burneyville-Stillwater	Copan-Tipton
Norman-Bessie	Bessie-Inola	Bessie-Burneyville	Idabel-Wister	Wister- Inola
Copan-Breckinridge	Idabel-Stillwater	Wister-Copan	Burneyville-Norman	Burneyville-Breckinridge

The normalized bridge data for the 19-year period (described in section 3.2.1) and climate data for selected stations was subjected to statistical analysis using a ‘Student’s t-test' to identify possible correlations. This statistical test was used since it is appropriate for small sample sizes (smaller than 30) and can be used to identify differences in mean values for samples following a normal distribution. It was assumed that all variables examined in this research would follow a normal distribution. This was used as an initial starting point in the analysis of climate and bridge condition data. Some previous research has shown that a normal distribution provides a good representation of rating data for higher rating values (Nasrollahi and Washer, 2015) such as those considered in this research.

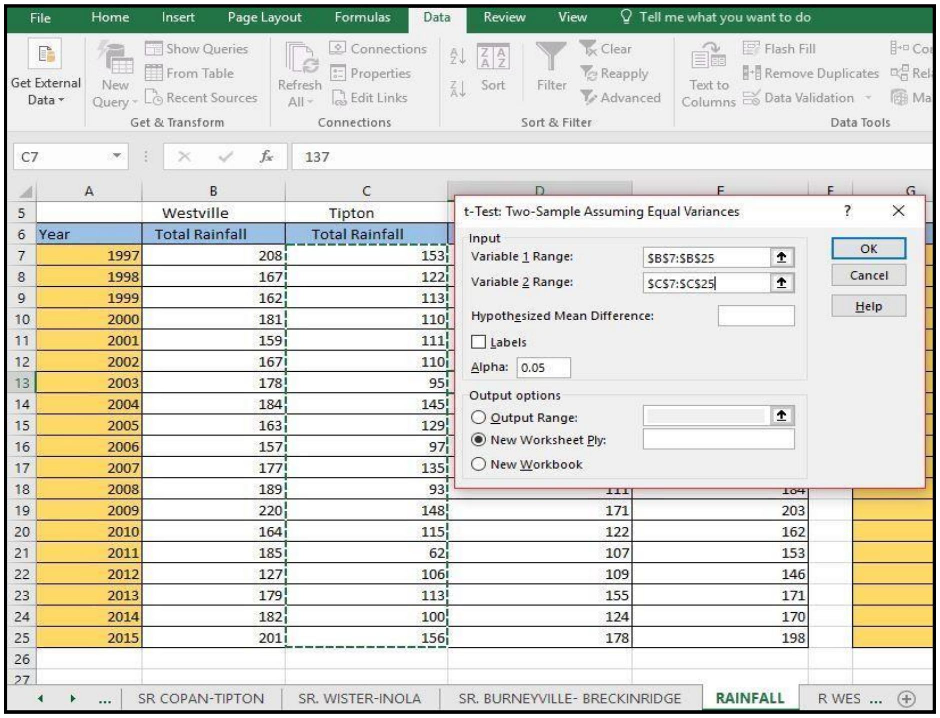
The t-test was developed by William Sealy Gosset under the pseudonym 'Student', hence the name. The t distribution in the t-test describes samples drawn from a full population described by a normal distribution. The t-distribution for each sample size is different, and the larger the sample, the more the distribution resembles a normal distribution. This analysis method performs a statistical hypothesis test based on the assumption of equality of the population means underlie each sample. Excel's 'Analysis Toolpak' was used to perform the analyses as it had all of the functions required for the selected analysis methods and was readily available. This tool calculates and displays the results for the given data and parameters using the appropriate statistical functions. More detail on the underlying statistical functions can be found in any statistics text (i.e. Chase and Bown, 1997). The Excel 'Analysis Toolpak' comes with many tools performing a variety of functions, and the tool used for this research was the 'Student's t-Test: Two-Sample Assuming Equal Variances' function.

This t-test form assumes that the two data sets came from distributions with the same variances. It is referred to as a homoscedastic t-test. This test was chosen as a reasonable starting point since the variables compared had similar sources of error and the population variance was unknown. This t-test can be used to determine whether the two samples are likely to have come from distributions with equal population means. A single tail significance level (alpha) of 0.05 (meaning a 95% confidence level to support the correlation between two variables) was selected for evaluating difference in the mean based on typical usage in previous research. Within Excel, the probability P (T<=t) was calculated and compared with the alpha value of 0.05. If the P value is less than 0.05 then there is a significant difference, and if the P value is greater than 0.05 there is not a significant difference.

To better explain, data from one selected pair of climate stations considering the climate variable of rainfall is shown in Table 7. Accessing the data analysis function in Excel opened a tab shown in Figure 14, and data from both stations (Westville and Tipton) were selected for analysis. The alpha value of 0.05 was selected before starting the analysis process. Excel then created a new worksheet as shown in Figure 15, the P (T<=t) value was checked and compared with the alpha value, and the results were tabulated as shown in Table 8. Table 8 includes the complete set of results from statistical tests for both different and similar curves for the rainfall variable. The same process was repeated for all climate variables. A comparison was then made for the normalized bridge ratings using the same station pairs as examined for differences in climate variables. Tables 9-11 show bridge deck, superstructure and substructure data analysis values for station pairs related to the rainfall variable, with each table including a complete set of tests for climate curves with both different and similar values.

Table 7. Example Station Data for Assessing Difference in Rainfall Variable

Year	Total Yearly Rainfall in Westville, inches	Total Yearly Rainfall in Tipton, inches
1997	208	153
1998	167	122
1999	162	113
2000	181	110
2001	159	111
2002	167	110
2003	178	95
2004	184	145
2005	163	129
2006	157	97
2007	177	135
2008	189	93
2009	220	148
2010	164	115
2011	185	62
2012	127	106
2013	179	113
2014	182	100
2015	201	156



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	A	B	C	D	E
5		Westville	Tipton		
6	Year	Total Rainfall	Total Rainfall		
7	1997	208	153		
8	1998	167	122		
9	1999	162	113		
10	2000	181	110		
11	2001	159	111		
12	2002	167	110		
13	2003	178	95		
14	2004	184	145		
15	2005	163	129		
16	2006	157	97		
17	2007	177	135		
18	2008	189	93		
19	2009	220	148	171	203
20	2010	164	115	122	162
21	2011	185	62	107	153
22	2012	127	106	109	146
23	2013	179	113	155	171
24	2014	182	100	124	170
25	2015	201	156	178	198

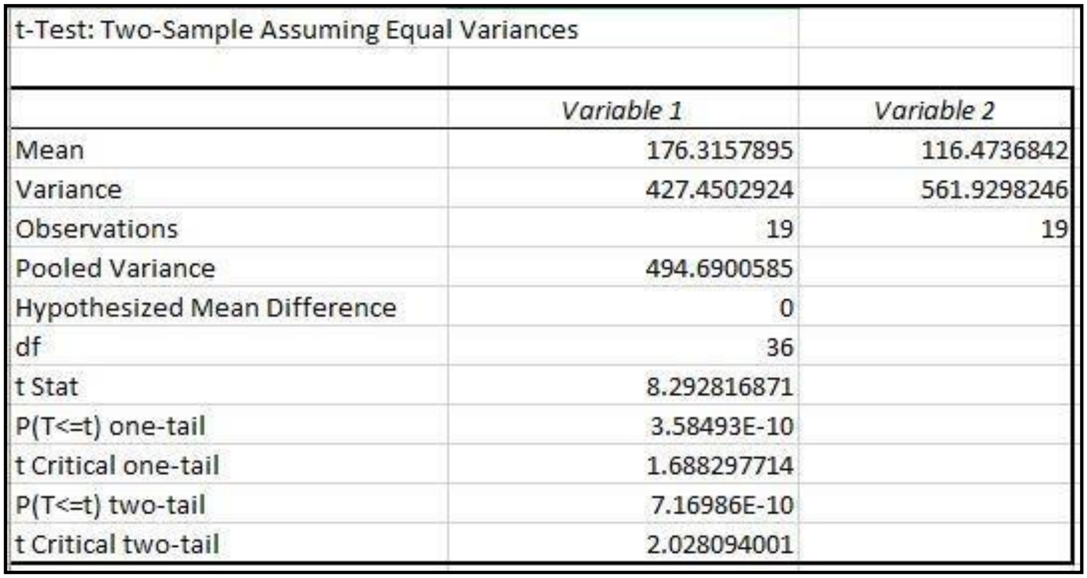
t-Test: Two-Sample Assuming Equal Variances

Input
Variable 1 Range: $B$7:$B$25
Variable 2 Range: $C$7:$C$25
Hypothesized Mean Difference:
☐ Labels
Alpha: 0.05

Output options
○ Output Range:
● New Worksheet Ply:
○ New Workbook

OK
Cancel
Help

Figure 14. Sample Worksheet for Rainfall Variable Data Analysis



t-Test: Two-Sample Assuming Equal Variances		
	Variable 1	*Variable 2*
Mean	176.3157895	116.4736842
Variance	427.4502924	561.9298246
Observations	19	19
Pooled Variance	494.6900585	
Hypothesized Mean Difference	0	
df	36	
t Stat	8.292816871	
P(T<=t) one-tail	3.58493E-10	
t Critical one-tail	1.688297714	
P(T<=t) two-tail	7.16986E-10	
t Critical two-tail	2.028094001	

Figure 15. Sample Output from t-Test Worksheet

Table 8. t-Test Results for Climate Comparison – Total Yearly Rainfall

Station Pair	**P (T<=t) values**	**Difference Yes/No**
Westville-Tipton	0.00003	Yes
Norman-Idabel	0.00043	Yes
Bessie-Burneyville	0.17669	No
Wister-Copan	0.02566	Yes

Table 9. t-Test Results for Deck Rating Reductions

Station Pair	**P (T<=t) values**	**Difference Yes/No**
Westville-Tipton	0.17422	No
Norman-Idabel	0.18289	No
Bessie-Burneyville	0.18619	No
Wister-Copan	0.43589	No

Table 10. t-Test Results for Superstructure Rating Reductions

Station Pair	**P (T<=t) values**	**Difference Yes/No**
Westville-Tipton	0.03289	Yes
Norman-Idabel	0.01793	Yes
Bessie-Burneyville	0.09432	No
Wister-Copan	0.15902	No

Table 11. t-Test Results for Substructure Rating Reductions

Station Pair	P (T<=t) values	Difference Yes/No
Westville-Tipton	0.00149	Yes
Norman-Idabel	0.02793	Yes
Bessie-Burneyville	0.13728	No
Wister-Copan	0.05574	No

Finally, the climate analysis results were compared with each of the bridge deck, superstructure, and substructure rating comparisons to find a possible correlation between rainfall and bridge rating data. This was done by matching 'Yes' (indicator of significant difference) results in a climate data set to 'Yes' results in a bridge rating data set. So, on comparing Table 8 and Table 9, it can be seen that the data does not support rainfall having an impact on deck rating change, because the deck ratings all have 'No' results (indicating no significant difference or a possible case of statistical similarity) even though two of the stations compared had significantly different rainfall. On comparing Table 8 and Table 10, and Table 8 and Table 11 it can be seen that station pairs Westville – Tipton and Norman – Idabel, have matching results. By this it can be said that rainfall may have an influence over superstructure and substructure rating changes. However, Wister – Copan did not exhibit differences in superstructure and substructure ratings even though they did have a difference in rainfall, which indicates that another factor may be involved. The same process was used for all other climate variables, results of which are discussed in Chapter 4.

4. Results

4.1. Student's t-Test for Average Temperature

The plots for average temperature versus time for all considered climate stations are shown in Figure 16. Climate stations with visible differences in average temperature selected for analysis of bridge rating differences are shown by square points and dashed lines while other stations are shown by circular points and solid lines. The t-test values for the station pairs selected from visible examination (listed in Table 6 of section 3.2.2) for the climate variable average temperature and the corresponding bridge data (deck rating, superstructure rating, and substructure rating) are shown in Tables 12-15.

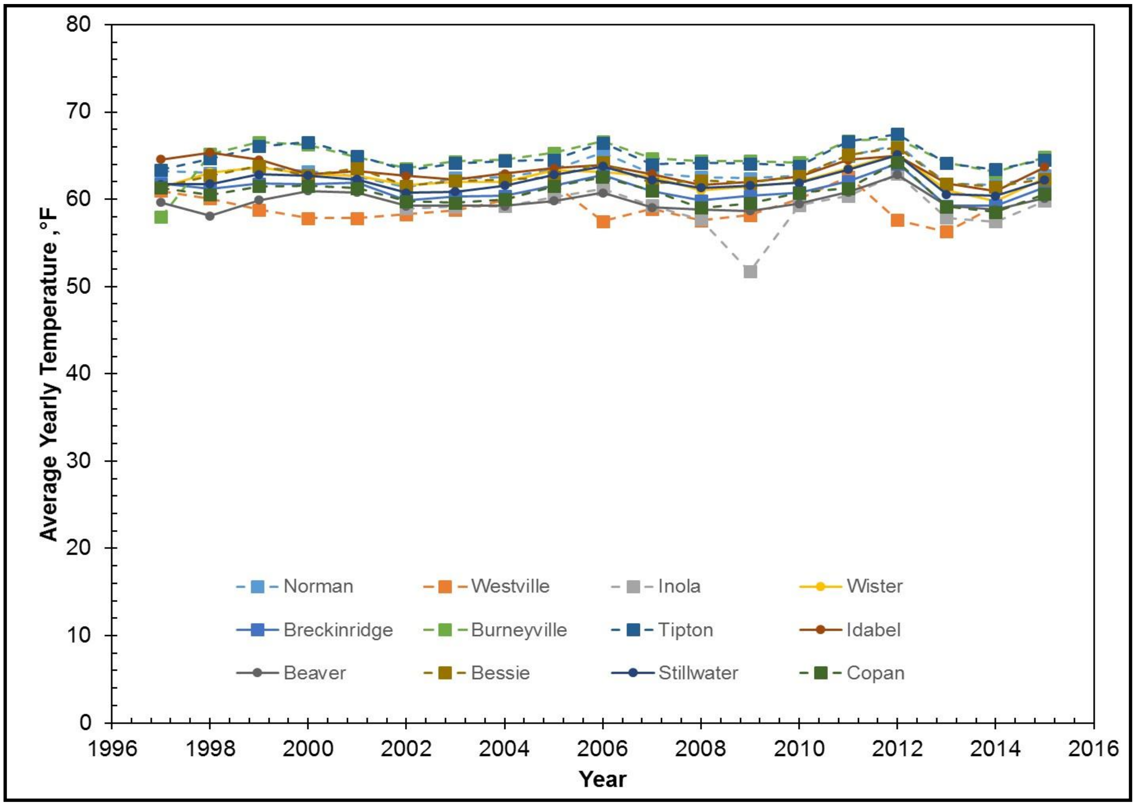


Figure 16. Average Yearly Temperature plotted over time

Table 12. t-Test Climate Analysis Results – Average Temperature

Station Pair	P (T<=t) values	Difference Yes/No
Inola-Burneyville	0.00147	Yes
Westville-Tipton	0.00562	Yes
Norman-Bessie	0.18997	No
Copan-Breckinridge	0.16364	No

Table 13. t-Test Results for Deck Rating Change – Average Temperature

Station Pair	P (T<=t) values	Difference Yes/No
Inola-Burneyville	0.20778	No
Westville-Tipton	0.17422	No
Norman-Bessie	0.08055	No
Copan-Breckinridge	0.01179	Yes

Table 14. t-Test Results for Superstructure Rating Change – Average Temperature

Station Pair	P (T<=t) values	Difference Yes/No
Inola-Burneyville	0.18785	No
Westville-Tipton	0.03289	Yes
Norman-Bessie	0.39249	No
Copan-Breckinridge	0.00404	Yes

Table 15. t-Test Results for Substructure Rating Change – Average Temperature

Station Pair	P (T<=t) values	Difference Yes/No
Inola-Burneyville	0.20436	No
Westville-Tipton	0.00149	Yes
Norman-Bessie	0.07271	No
Copan-Breckinridge	0.01867	Yes

The t-test climate analysis results shown in Table 12 were compared with the t-test results for each of the bridge deck, superstructure, and substructure rating changes, shown in Tables 13-15, to find a possible correlation between average temperature and bridge rating data. On comparing the results, it was observed that only one station pair, Westville – Tipton, showed a possible correlation (Yes-Yes). This can be seen in superstructure and substructure rating change comparison with climate results, shown in Tables 12, 14, and 15. The station pairs representative of no correlation (No-No) may be statistically identical.

Since there was no correlation with the bridge deck rating change and this climate variable has only one station pair matching, it was not clear whether average temperature may affect rating changes, but this does not seem likely based on the available information. Hence, this climate variable was not considered for further analysis.

4.2. Student's t-Test for Average Difference between Maximum and Minimum Temperature

The plots for average difference between maximum and minimum temperature versus time are shown in Figure 17 for all climate stations. Climate stations with visible differences selected for analysis of bridge rating differences are shown by square points and dashed lines while other stations are indicated by circular points and solid lines. No data were available for the Westville station after 2015. The t-test results for the station pairs identified from visible examination (listed in Table 6 of section 3.2.2) for the climate variable average difference between maximum and minimum temperature and the corresponding bridge data (deck rating, superstructure rating, and substructure rating) are shown in Tables 16-19.

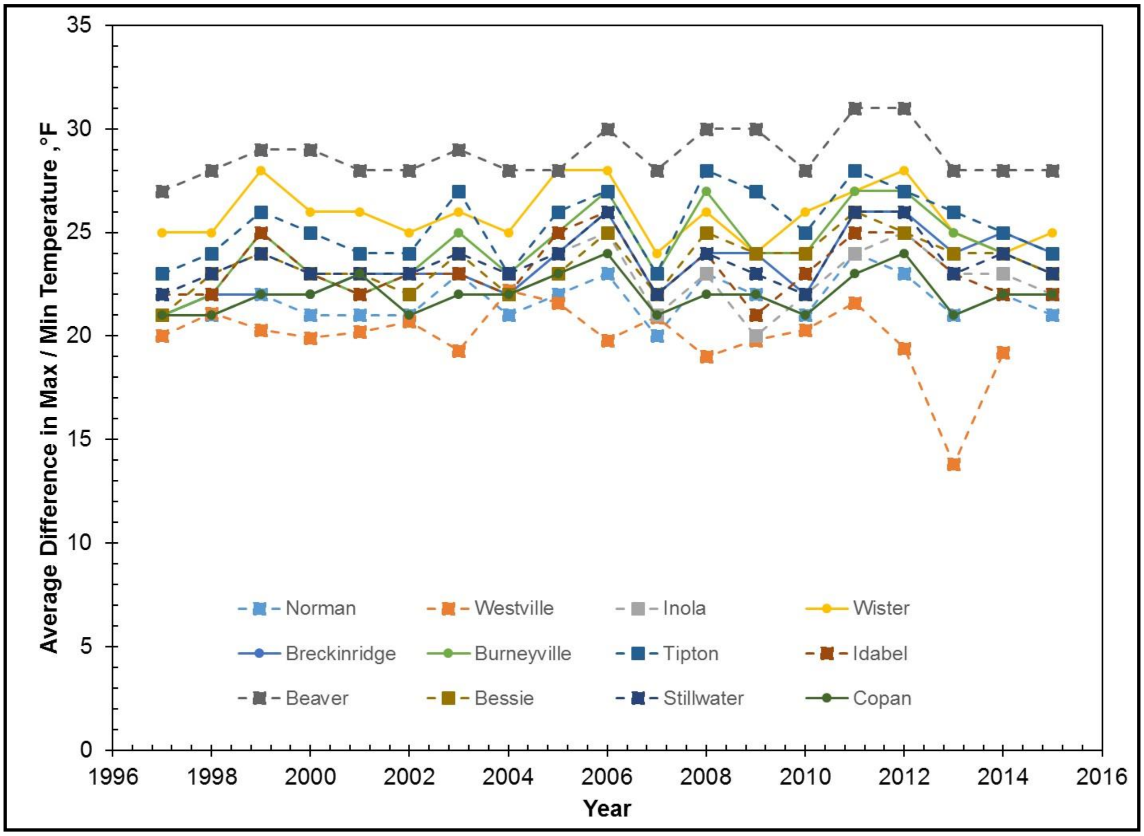


Figure 17. Average Difference in Max/Min Temperature over time

Table 16. t-Test Climate Analysis Results for Avg. Difference Max/Min Temperature

Station Pair	**P (T<=t) values**	**Difference Yes/No**
Westville-Beaver	0.00015	Yes
Norman-Tipton	0.00078	Yes
Bessie-Inola	0.08086	No
Idabel-Stillwater	0.17058	No

Table 17. t-Test Results for Deck Rating Change – Avg. Max/Min Temperature

Station Pair	**P (T<=t) values**	**Difference Yes/No**
Westville-Beaver	0.11056	No
Norman-Tipton	0.24083	No
Bessie-Inola	0.41070	No
Idabel-Stillwater	0.19522	No

Table 18. t-Test Results for Superstructure Rating Change – Avg. Max/Min Temperature

Station Pair	P (T<=t) values	Difference Yes/No
Westville-Beaver	0.02015	Yes
Norman-Tipton	0.06038	No
Bessie-Inola	0.37171	No
Idabel-Stillwater	0.21129	No

Table 19. t-Test Results for Substructure Rating Change – Avg. Max/Min Temperature

Station Pair	P (T<=t) values	Difference Yes/No
Westville-Beaver	0.02015	Yes
Norman-Tipton	0.06038	No
Bessie-Inola	0.37171	No
Idabel-Stillwater	0.21129	No

The t-test climate analysis results shown in Table 16 were compared with each of the bridge deck, superstructure, and substructure rating changes, shown in Tables 17-19, to find a possible correlation between average difference in maximum and minimum temperature and bridge rating data. On comparison, it was observed that only one station pair, Westville – Beaver, showed a possible correlation (Yes-Yes). This can be seen in superstructure and substructure rating change comparison with climate results, shown in Tables 16, 18 and 19. The station pairs representative of no correlation (No-No) may be statistically identical.

Since there was no correlation with the bridge deck rating change and this climate variable has only one station pair matching, it is unclear whether average difference in maximum and minimum temperature may affect rating changes, but this does not seem likely based on the available information. Hence, this climate variable was not considered for further analysis.

4.3. Student’s t-Test for Total Yearly Rainfall

The plots for total yearly rainfall versus time for all climate stations are shown in Figure 18. Climate stations with visible differences selected for analysis of bridge rating differences are shown by square points and dashed lines while other stations are indicated by circular points and solid lines. The t-test values for the station pairs identified from visible examination (listed in Table 6 of section 3.2.2) for the climate variable total yearly rainfall and the corresponding bridge data (deck rating, superstructure rating, and substructure rating) are shown in Tables 20-23.

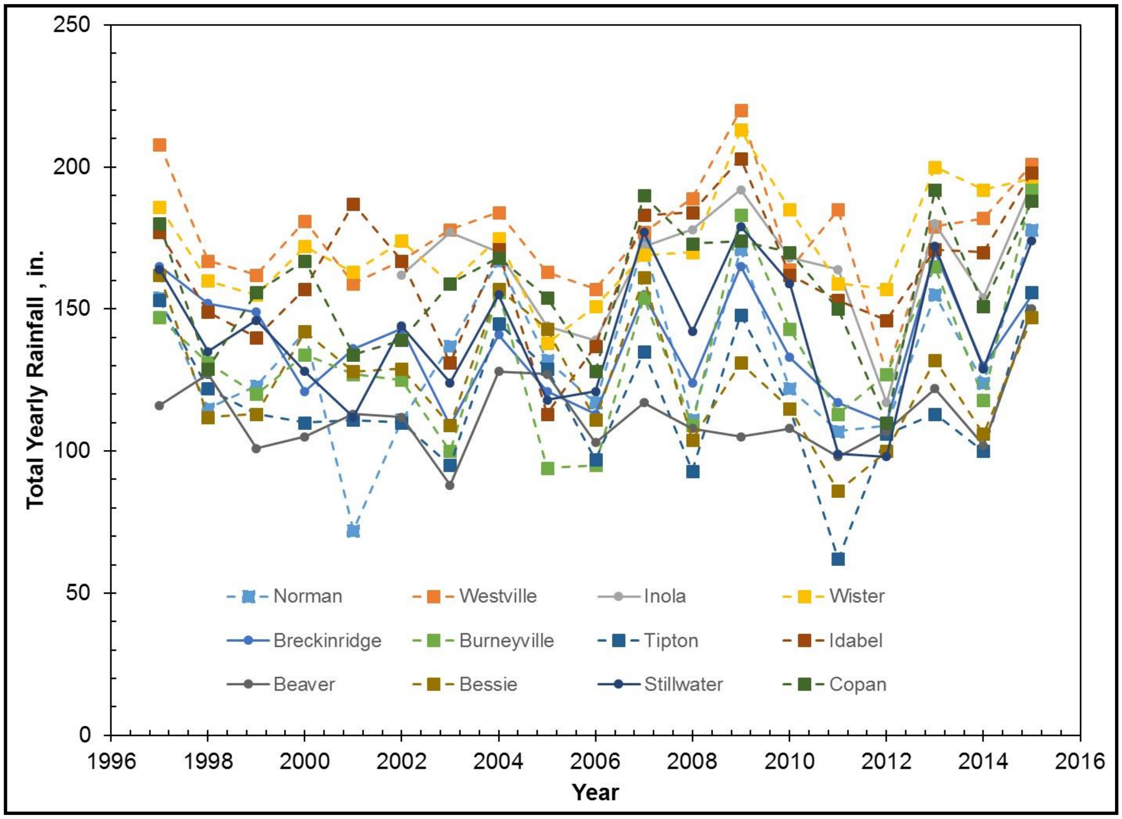


Figure 18. Total Yearly Rainfall over time

Table 20. t-Test Climate Analysis Results – Total Yearly Rainfall

Station Pair	P (T<=t) values	Difference Yes/No
Westville-Tipton	0.00035	Yes
Norman-Idabel	0.00043	Yes
Bessie-Burneyville	0.17669	No
Wister-Copan	0.02560	Yes

Table 21. t-Test Results for Deck Rating Change – Total Yearly Rainfall

Station Pair	P (T<=t) values	Difference Yes/No
Westville-Tipton	0.17422	No
Norman-Idabel	0.18289	No
Bessie-Burneyville	0.18619	No
Wister-Copan	0.43589	No

Table 22. t-Test Results for Superstructure Rating Change – Total Yearly Rainfall

Station Pair	P (T<=t) values	Difference Yes/No
Westville-Tipton	0.03289	Yes
Norman-Idabel	0.01793	Yes
Bessie-Burneyville	0.09432	No
Wister-Copan	0.15902	No

Table 23. t-Test Results for Substructure Rating Change – Total Yearly Rainfall

Station Pair	P (T<=t) values	Difference Yes/No
Westville-Tipton	0.00149	Yes
Norman-Idabel	0.02793	Yes
Bessie-Burneyville	0.13728	No
Wister-Copan	0.05574	No

The climate analysis results shown in Table 20 were compared with the t-test results for each of the bridge deck, superstructure, and substructure rating changes, shown in Tables 21-23, to find a possible correlation between total rainfall and bridge rating data. On comparison, it was observed that two station pairs, Westville – Tipton and

Norman – Idabel, showed a possible correlation (Yes-Yes). This can be seen in superstructure and substructure rating change comparisons with climate results, shown in Tables 20, 22, 23. The station pairs representative of no correlation (No-No) may be statistically identical.

Since there was no correlation with the bridge deck rating change, but this climate variable has two station pairs matching for superstructure and substructure, it may have an influence over bridge rating changes. Hence, this climate variable was considered for further analysis (section 4.6).

4.4. Student's t-Test for Total Yearly Freeze-Thaw Cycles

The plots for total yearly freeze-thaw cycles versus time for all climate stations are shown in Figure 19. Climate stations with visible differences selected for analysis of bridge rating differences are shown by square points and dashed lines while other stations are indicated by circular points and solid lines. The erratic nature of these curves indicates that a normal distribution may not be representative of the underlying data, potentially affecting the applicability of the t-test. The t-test values for the station pairs identified from visible examination (listed in Table 6 of section 3.2.2), for the climate variable total yearly freeze-thaw cycles and the corresponding bridge data (deck rating, superstructure rating, and substructure rating) are shown in Tables 25-27.

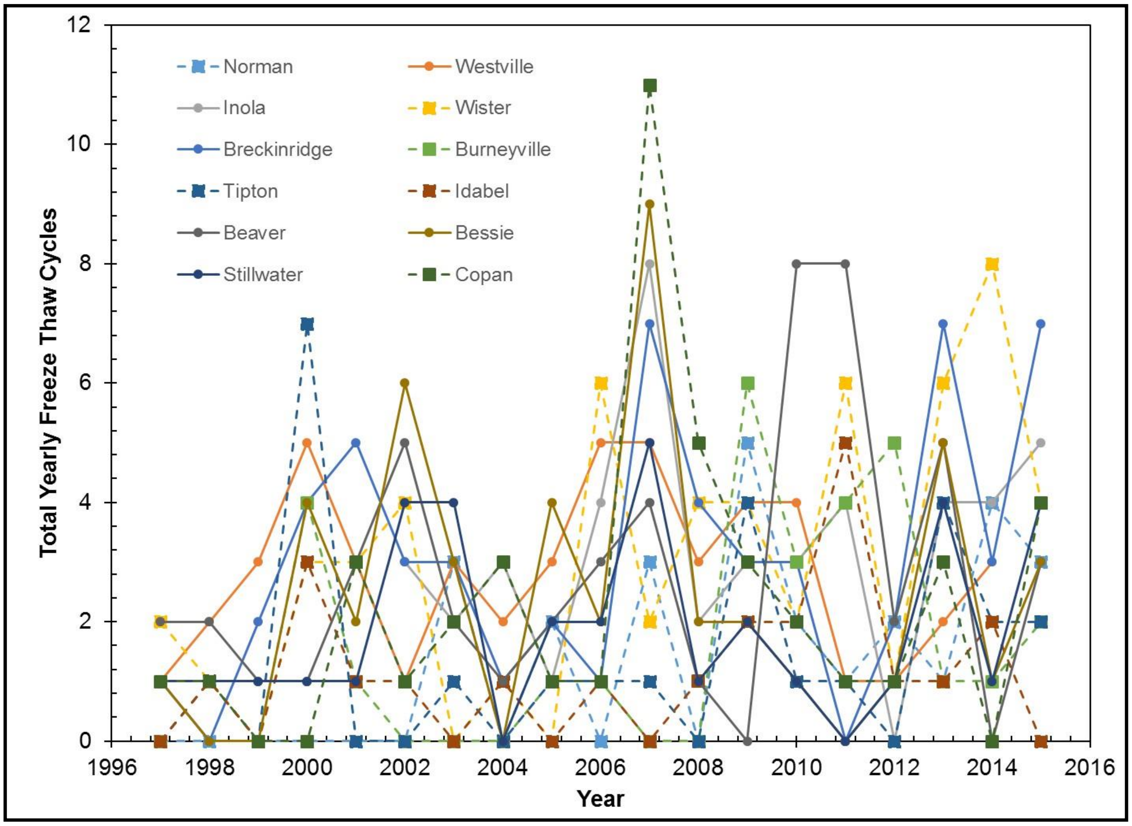


Figure 19. Total Yearly Freeze-Thaw Cycles for all stations over time

Table 24. t-Test Climate Analysis Results – Total Yearly Freeze-Thaw Cycles

Station Pair	P (T<=t) values	Difference Yes/No
Copan-Tipton	0.11024	No
Burneyville-Stillwater	0.28741	No
Idabel-Wister	0.00226	Yes
Burneyville-Norman	0.35697	No

Table 25. t-Test Results for Deck Rating Change – Total Yearly Freeze-Thaw Cycles

Station Pair	P (T<=t) values	Difference Yes/No
Copan-Tipton	0.04442	Yes
Burneyville-Stillwater	0.30857	No
Idabel-Wister	0.00392	Yes
Burneyville-Norman	0.26138	No

Table 26. t-Test Results for Superstructure Rating Change – Total Yearly Freeze-Thaw Cycles

Station Pair	P (T<=t) values	Difference Yes/No
Copan-Tipton	0.00071	Yes
Burneyville-Stillwater	0.19885	No
Idabel-Wister	0.00046	Yes
Burneyville-Norman	0.12675	No

Table 27. t-Test Results for Substructure Rating Change – Total Yearly Freeze-Thaw Cycles

Station Pair	P (T<=t) values	Difference Yes/No
Copan-Tipton	0.01134	Yes
Burneyville-Stillwater	0.01639	Yes
Idabel-Wister	0.23080	No
Burneyville-Norman	0.30865	No

The climate analysis results shown in Table 24 were compared with the t-test results for each of the bridge deck, superstructure, and substructure rating changes, shown in Tables 25-27, to find a possible correlation between total yearly freeze-thaw cycles and bridge rating data. On comparison, it was observed that two station pairs, Burneyville – Stillwater and Idabel – Wister, exhibited a possible correlation (Yes-Yes). The station pairs representative of no correlation (No-No) may be statistically identical. This can be seen in deck and superstructure rating comparisons with climate results shown in Tables 24, 25, and 26. There was no correlation with the substructure rating change, but since this climate variable had two station pairs matching with deck and substructure, it potentially has an influence on bridge rating changes. Hence, this climate variable was considered for further analysis (section 4.6).

4.5. Student’s t-Test for Total Yearly Solar Radiation

The plots for total yearly solar radiation versus time for all climate stations are shown in Figure 20. Climate stations with visible differences selected for analysis of bridge rating differences are shown by square points and dashed lines while other stations are indicated by circular points and solid lines. The t-test values for the station pairs identified from visible examination (listed in Table 6 of section 3.2.2) for the climate variable total yearly solar radiation and corresponding bridge data (deck rating, superstructure rating, and substructure rating) are shown in Tables 29-31.

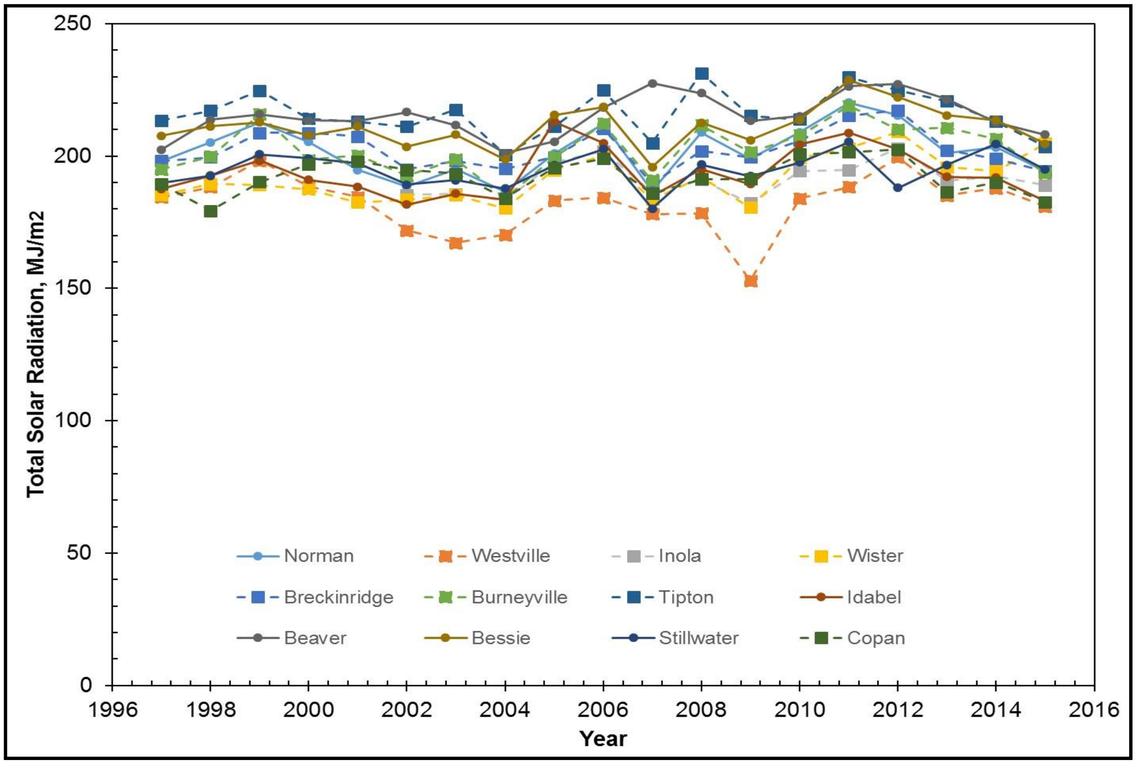


Figure 20. Total Yearly Solar Radiation over time

Table 28. t-Test Climate Analysis Results for Total Yearly Solar Radiation

Station Pair	P (T<=t) values	Difference Yes/No
Westville-Tipton	0.00314	Yes
Copan-Tipton	0.00812	Yes
Wister-Inola	0.44435	No
Burneyville-Breckinridge	0.48851	No

Table 29. t-Test Results for Deck Rating Change – Total Yearly Solar Radiation

Station Pair	P (T<=t) values	Difference Yes/No
Westville-Tipton	0.17422	No
Copan-Tipton	0.04442	Yes
Wister-Inola	0.00020	Yes
Burneyville-Breckinridge	0.50000	No

Table 30. t-Test Results for Superstructure Rating Change – Total Yearly Solar Radiation

Station Pair	P (T<=t) values	Difference Yes/No
Westville - Tipton	0.03289	Yes
Copan - Tipton	0.00710	Yes
Wister - Inola	0.16907	No
Burneyville - Breckinridge	0.50000	No

Table 31. t-Test Results for Substructure Rating Change – Total Yearly Solar Radiation

Station Pair	P (T<=t) values	Difference Yes/No
Westville - Tipton	0.00149	Yes
Copan-Tipton	0.01268	Yes
Wister- Inola	0.00016	Yes
Burneyville-Breckinridge	0.50000	No

The climate analysis results shown in Table 28 were compared with the t-test results for each of the bridge deck, superstructure, and substructure rating changes, shown in Tables 29-31, to find a possible correlation between total yearly solar radiation and bridge rating data. On comparison, it was observed that two station pairs, Copan – Tipton and Westville – Tipton, exhibited a potential correlation (Yes-Yes). The station pairs representative of no correlation (No-No) may be statistically identical. This can be seen in deck, superstructure, and substructure rating change comparisons with climate results, shown in Tables 28-31. Since two station pairs with statistically different values of total solar radiations also exhibited statistically different changes in bridge rating, total solar radiation may have an influence over bridge rating changes. Hence, this climate variable was considered for further analysis (section 4.6).

4.6. Climate Comparison with Additional Stations

Based on comparisons of bridge condition rating changes for stations with significantly different climate conditions, it was found that total yearly freeze-thaw cycles, total yearly rainfall, and total yearly solar radiation may have an influence over changes in bridge ratings over time. Additional station pairs were added to the examination of difference in rating changes related to freeze-thaw cycles, rainfall, and solar radiation data to get a better understanding of the correlations identified in sections 4.3, 4.4, and 4.5. The additional station pairs included in the analysis are shown in Table 32. These station pairs were added to the graphs for these climate variables previously shown in Figures 18, 19, and 20. The updated plots are shown in Figures 21-23.

Table 32. Additional Climate Station Pairs for t-Test Analysis

Yearly Rainfall	**Yearly Freeze-Thaw Cycles**	**Yearly Solar Radiation**
Beaver-Tipton	Breckinridge-Stillwater	Bessie-Idabel
Idabel-Copan	Beaver-Idabel	Wister-Copan

4.6.1. Total Yearly Rainfall with Additional Stations

The plots for total yearly rainfall versus time for all selected climate stations are shown in Figure 21 with the climate stations chosen for additional data analysis shown by triangular points and dash lines. All other stations are indicated by circular points and solid lines. The t-test values for the station pairs listed in Table 32 for the climate variable total yearly rainfall and the corresponding bridge data (deck rating, superstructure rating, and substructure rating) are shown in Tables 33-36.

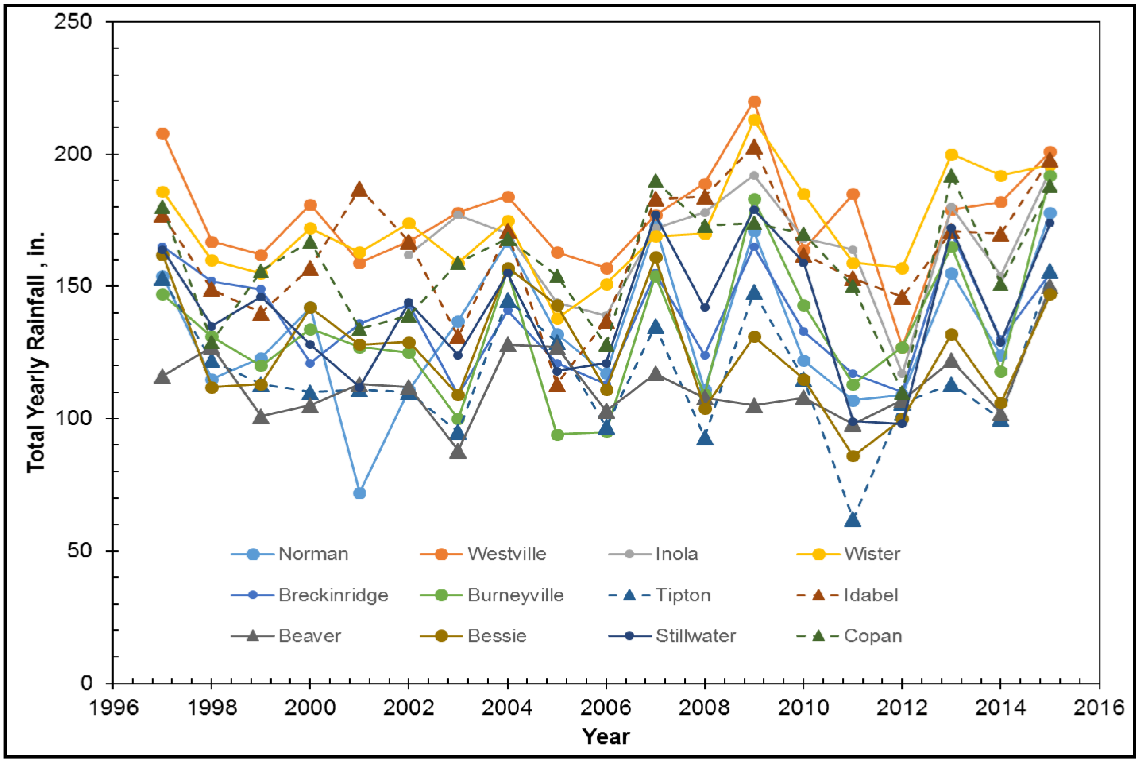


Figure 21. Total Yearly Rainfall with Additional Station Pairs over Time

Table 33. t-Test Results for Climate Comparison – Total Yearly Rainfall

Station Pair	P (T<=t) values	Difference Yes/No
Beaver-Tipton	0.26517	No
Idabel-Copan	0.27383	No

Table 34. t-Test Results for Deck Rating Change – Total Yearly Rainfall

Station Pair	P (T<=t) values	Difference Yes/No
Beaver-Tipton	0.18619	No
Idabel-Copan	0.43589	No

Table 35. t-Test Results for Superstructure Rating Change – Total Yearly Rainfall

Station Pair	P (T<=t) values	Difference Yes/No
Beaver-Tipton	0.09432	No
Idabel-Copan	0.15902	No

Table 36. t-Test Results for Substructure Rating Change – Total Yearly Rainfall

Station Pair	P (T<=t) values	Difference Yes/No
Beaver-Tipton	0.13728	No
Idabel-Copan	0.05574	No

The climate analysis results shown in Table 33 were compared with the t-test results for each of the bridge deck, superstructure, and substructure rating change, shown in Tables 34-36 to find a possible correlation between total yearly rainfall and bridge rating change data. On comparison, it was observed that neither of the additional station pairs showed a potential correlation (both No-No). However, neither of these station pairs exhibited a difference in climate condition over time so no additional inference can be drawn beyond that of section 4.3. Based on those results, it can be said that rainfall may have an influence over superstructure and substructure ratings. However, Wister – Copan exhibited a difference in rainfall over time, but did not exhibit differences in bridge ratings, while station pairs Westville – Tipton and Norman – Idabel exhibited differences in superstructure and substructure ratings, but did not exhibit differences in deck ratings. These results indicate that other factors may also be involved.

4.6.2. Total Yearly Freeze-Thaw Cycles with Additional Stations

The plots for total yearly freeze-thaw cycles versus time for all selected climate stations are shown in Figure 22 with the climate stations chosen for additional data analysis shown by triangular points and dash lines. The t-test values for the station pairs listed in Table 32 for the climate variable total yearly freeze-thaw cycles and the corresponding bridge data (deck rating, superstructure rating, and substructure rating) are shown in Tables 37-40.

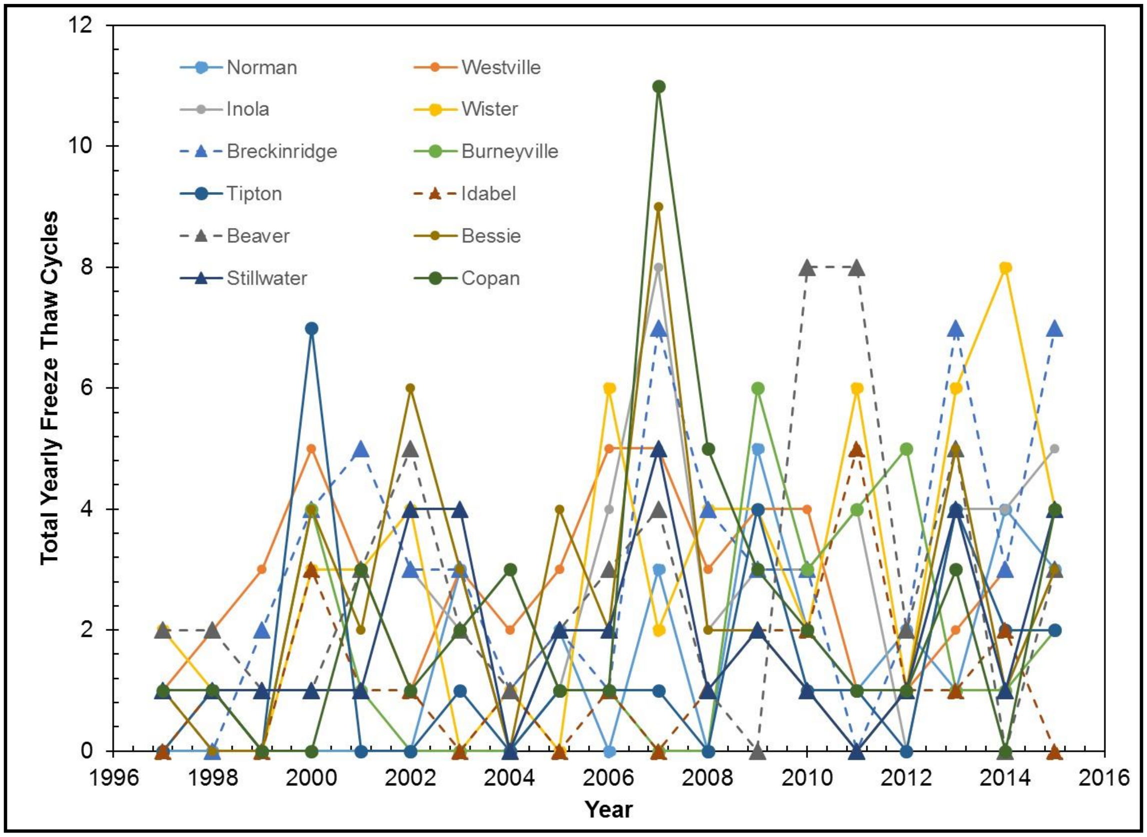


Figure 22. Total Yearly Freeze-Thaw Cycles with Additional Station Pairs over Time

Table 37. t-Test Climate Analysis Results for Total Yearly Freeze-Thaw Cycles

Station Pair	P (T<=t) values	Difference Yes/No
Breckinridge-Stillwater	0.03360	Yes
Beaver-Idabel	0.00536	Yes

Table 38. t-Test Results for Deck Rating Change – Total Yearly Freeze-Thaw Cycles

Station Pair	P (T<=t) values	Difference Yes/No
Breckinridge-Stillwater	0.36868	No
Beaver-Idabel	0.30857	No

Table 39. t-Test for Superstructure Rating Change – Total Yearly Freeze-Thaw Cycles

Station Pair	P (T<=t) values	Difference Yes/No
Breckinridge-Stillwater	0.00014	Yes
Beaver-Idabel	0.19885	No

Table 40. t-Test for Substructure Rating Change – Total Yearly Freeze-Thaw Cycles

Station Pair	P (T<=t) values	Difference Yes/No
Breckinridge - Stillwater	0.27570	No
Beaver - Idabel	0.01639	Yes

The climate analysis results shown in Table 37 were compared with the t-test results for each of the bridge deck, superstructure, and substructure rating changes, shown in Tables 38-40 to find a possible correlation between total yearly freeze-thaw cycles and bridge rating change data. On comparison, it was observed that the Breckinridge – Stillwater station pair showed a correlation (Yes-Yes) for change in Superstructure rating and the Beaver – Idabel station pair showed a correlation (Yes-Yes) for change in substructure rating.

By combining the results from the additional stations with the results presented in section 4.4, it can be said that freeze-thaw cycles may have an influence over deck, superstructure, and substructure ratings. However, Idabel – Wister did not exhibit differences in substructure ratings, Breckinridge – Stillwater did not exhibit differences in deck and substructure ratings, and Beaver –Idabel did not exhibit differences in deck and superstructure ratings, which indicates that other factors may also be involved.

4.6.3. Total Yearly Solar Radiation

The plots for total yearly rainfall versus time for all selected climate stations (are shown in Figures 23, with the climate stations chosen for additional data analysis shown by triangular points and dash lines. The t-test values for the additional station pairs listed in Table 32, for the climate variable total yearly solar radiation and corresponding bridge data (deck rating, superstructure rating, and substructure rating) are shown in Tables 41-44.

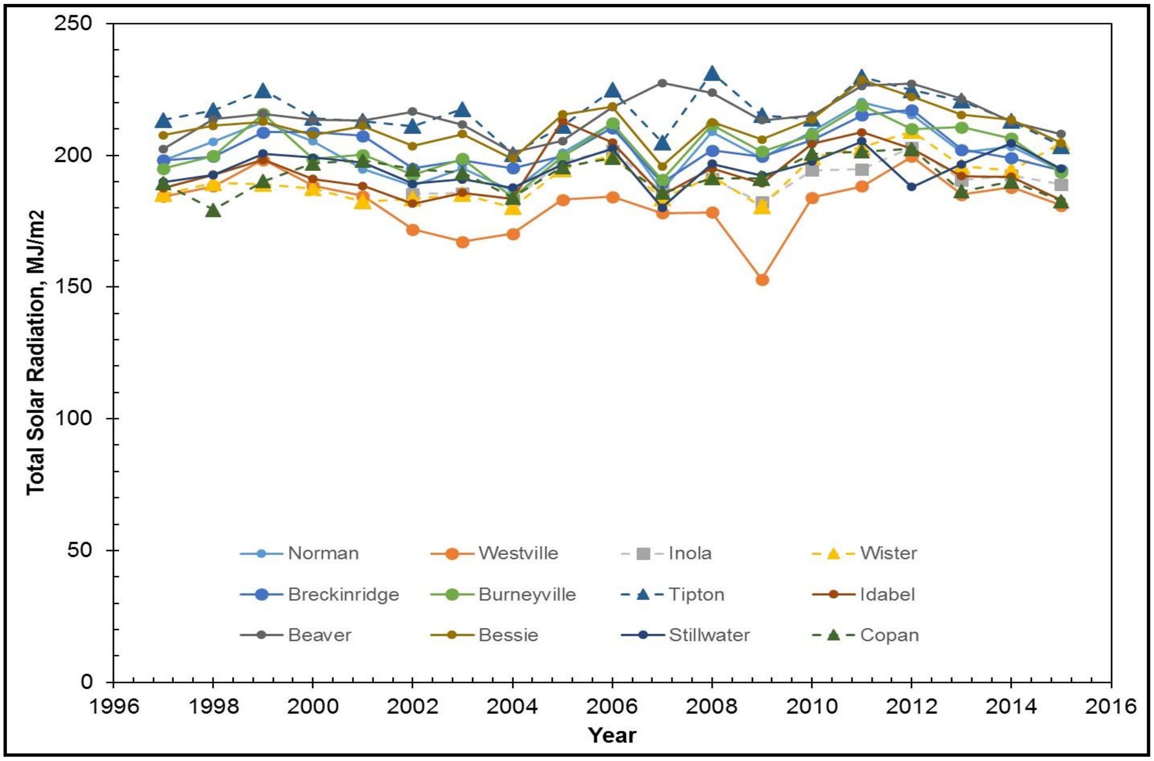


Figure 23. Total Yearly Solar Radiation with Additional Station Pairs over Time

Table 41. t-Test Climate Analysis Results for Total Yearly Solar Radiation

Station Pair	P (T<=t) values	Difference Yes/No
Bessie-Idabel	1.6531E-07	Yes
Wister-Copan	0.39824	No

Table 42. t-Test Results for Deck Rating Change – Total Yearly Solar Radiation

Station Pair	P (T<=t) values	Difference Yes/No
Bessie-Idabel	0.43589	No
Wister-Copan	0.33585	No

Table 43. t-Test Results for Superstructure Rating Change – Total Yearly Solar Radiation

Station Pair	P (T<=t) values	Difference Yes/No
Bessie-Idabel	0.048950	Yes
Wister-Copan	0.15902	No

Table 44. t-Test for Substructure Rating Change – Total Yearly Solar Radiation

Station Pair	P (T<=t) values	Difference Yes/No
Bessie-Idabel	0.055746	No
Wister-Copan	0.001870	Yes

The climate analysis results shown in Table 41 were compared with the t-test results for each of the bridge deck, superstructure, and substructure rating changes, shown in Tables 42-44, to find a possible correlation between total yearly solar radiation and bridge rating data. On comparison, it was observed that the Copan – Tipton station pair showed a potential correlation (Yes-Yes) for change in deck and superstructure ratings and the Bessie – Idabel station pair showed a potential correlation (Yes-Yes) for change in superstructure ratings. By combining these results with those from section 4.5, it can be said that solar radiation may have an influence over deck, superstructure and substructure rating change. However, station pair Westville – Tipton did not exhibit differences related to deck ratings, station pair Bessie – Idabel did not exhibit differences related to deck and substructure ratings, and station pair Wister – Copan did not exhibit differences related to deck and superstructure ratings, which indicates that other factors may also be involved.

5. Summary, Conclusions and Recommendations

The work described in this thesis consisted of a study into potential relationships between the climate variables of average temperature, average difference between minimum and maximum temperature, total yearly rainfall, total yearly freeze-thaw cycles, and total yearly solar radiation and bridge ratings in Oklahoma. Climate data used in this study were collected from the Oklahoma Mesonet and bridge data were collected from the National Bridge Inventory (NBI). Pairs of climate stations were chosen based on differences in climate variables over time, and change in bridge deck, superstructure, and substructure ratings over time for bridges located within approximately 50 miles of each station were compared to identify possible correlations in the data. The Student's t-test was used to evaluate potential relationships between the stations.

The results presented in Chapter 4 indicate that stations Tipton, Copan, Idabel and Wister show differences for all three considered climate variables (freeze-thaw cycles, rainfall and solar radiation) for the period of time examined. The locations of these stations are shown in Figure 24. Differences in these climate variables can be considered as a long-term risk issue if changes in the climate occur over time or a short-term risk issue in terms of extreme weather events. Bridges in the regions having potential high impacts from each of the climate variables may need extra care and treatment.

Figure 24. Climate Stations showing differences in climate behaviors

Based on the analysis of results discussed in Chapter 4, the conclusions shown in Table 45 were made. The table is representative of the final list of climate stations and associated climate variables of freeze-thaw cycles, rainfall, and solar radiation, which may to some extent affect the condition of any of the three bridge ratings (deck, superstructure and substructure) for each station.

For each of the climate stations in Table 45, the climate variables may cause a difference in bridge deterioration behavior. These variables may increase the risk of bridge deterioration in the long-term. These results can help inform asset management and regular inspection of bridges in these regions to avoid any negative impacts. This helps improve ODOT’s ability to predict and assess the vulnerability and resilience of the critical bridge infrastructure. Also, quantifying the risk of probable bridge deterioration in these regions, under the influence of changing climate has the potential to benefit other infrastructure services such as water, power and telecommunications.

Table 45. Summary of Potential Effects of Climate Factors on Bridge Ratings near Climate Stations

Station	**Freeze-thaw Cycles**	**Rainfall**	**Solar Radiation**
Copan	May not Affect	Deck and Superstructure	Substructure
Wister	Superstructure	Deck and Superstructure	Substructure
Idabel	Superstructure	Superstructure and Substructure	Superstructure and Substructure
Stillwater	Superstructure	May not Affect	May not Affect
Beaver	Substructure	May not Affect	May not Affect
Tipton	May not Affect	Superstructure and Substructure	Deck, Superstructure and Substructure
Westville	May not Affect	Superstructure and Substructure	Superstructure and Substructure
Norman	May not Affect	Superstructure and Substructure	May not Affect
Breckinridge	Superstructure	May not Affect	May not Affect
Bessie	May not Affect	May not Affect	Superstructure and Substructure

Climate change is an important global challenge to be addressed in the coming years. Most of Oklahoma’s bridges, which are designed to be operational for 50 years, are more likely to experience the impact before their intended lifespan. Knowledge of potential impacts of future climatic conditions is essential to aid transportation departments in managing the structural health of both existing and planned bridge infrastructures. This thesis presented an initial attempt to evaluate the potential significance of the anticipated impact of climate change to bridge deck and superstructure deterioration, and provided good initial correlative analysis linking multiple climate factors. Additional statistical analyses considering time-dependent effects should be considered to provide better evaluation of the potential impacts of climate change on bridges.

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Appendix A - Climate Variables for all Climate Stations

Table A.1. Wister Climate Variable Data

Year	Total Rainfall (in.)	Total Solar Radiation (MJ/m^2)	Avg Diff Max & Min Temp (°F)	Avg yearly Temp (°F)	Total Freeze-thaw Cycles
1997	186	185.24	25	61.4	2
1998	160	189.55	25	63.08	1
1999	155	189.16	28	63.68	0
2000	172	187.52	26	62.9	3
2001	163	182.57	26	62.68	3
2002	174	183.61	25	61.63	4
2003	159	185.26	26	61.95	0
2004	175	180.28	25	62	1
2005	138	194.71	28	63.27	0
2006	151	200.05	28	63.09	6
2007	169	183.59	24	62.63	2
2008	170	192.03	26	61	4
2009	213	180.62	24	61.45	4
2010	185	199.24	26	61.95	2
2011	159	202.97	27	63.59	6
2012	157	209.16	28	65.18	1
2013	200	195.79	25	61.04	6
2014	192	194.39	24	59.77	8
2015	196	204.82	25	62.45	4

Table A.2. Idabel Climate Variable Data

Year	Total Rainfall (in.)	Total Solar Radiation (MJ/m2)	Avg Diff/Max &Min Temp (°F)	Avg yearly Temp (°F)	Total Freeze-thaw Cycles
1997	177	187.58	22	64.56	0
1998	149	192.65	22	65.37	1
1999	140	198.3	25	64.5	0
2000	157	191.01	23	62.87	3
2001	187	188.36	22	63.2	1
2002	167	181.64	23	62.66	1
2003	131	185.85	23	62.266	0
2004	171	183.45	22	62.95	1
2005	113	213.05	25	63.54	0
2006	137	204.94	26	63.91	1
2007	183	185.01	22	62.91	0
2008	184	195.06	24	61.62	1
2009	203	189.39	21	61.95	2
2010	162	204.35	23	62.62	2
2011	153	208.76	25	64.5	5
2012	146	202.42	25	65	1
2013	171	192.18	23	61.79	1
2014	170	191.85	22	60.91	2
2015	198	182.86	22	63.7	0

Table A.3. Copan Climate Variable Data

Year	Total Rainfall (in.)	Total Solar Radiation (MJ/m2)	Avg Diff/Max &Min Temp (°F)	Avg yearly Temp (°F)	Total Freeze-thaw Cycles
1997	180	189.42	21	61.3	1
1998	129	179.34	21	60.5	1
1999	156	190.19	22	61.5	0
2000	167	196.99	22	61.54	0
2001	134	197.98	23	61.27	3
2002	139	194.72	21	59.77	1
2003	159	193.31	22	59.59	2
2004	168	184.05	22	60	3
2005	154	195.55	23	61.5	1
2006	128	199.04	24	62.5	1
2007	190	185.82	21	61	11
2008	173	191.36	22	59	5
2009	174	191.37	22	59.54	3
2010	170	200.65	21	60.72	2
2011	150	201.5	23	61.27	1
2012	110	202.5	24	64.27	1
2013	192	186.34	21	59.13	3
2014	151	190.13	22	58.54	0
2015	188	182.66	22	60.59	4

Table A.4. Inola Climate Variable Data

Year	Total Rainfall (in.)	Total Solar Radiation (MJ/m2)	Avg Diff/Max &Min Temp (°F)	Avg yearly Temp (°F)	Total Freeze-thaw Cycles
1997	N/A	N/A	N/A	N/A	N/A
1998	N/A	N/A	N/A	N/A	N/A
1999	N/A	N/A	N/A	N/A	N/A
2000	N/A	N/A	N/A	N/A	N/A
2001	N/A	N/A	N/A	N/A	N/A
2002	162	185.37	23	58.95	3
2003	177	185.63	23	59.16	2
2004	170	183.16	22	59.2	3
2005	144	197.52	24	60.25	1
2006	139	201.84	25	61.16	4
2007	172	186.16	21	59.29	8
2008	178	191.08	23	57.7	2
2009	192	182.19	20	51.7	3
2010	168	194.35	22	59.33	3
2011	164	194.8	24	60.37	4
2012	117	203	25	62.87	0
2013	180	190.62	23	57.87	4
2014	154	192.35	23	57.45	4
2015	194	189	22	59.83	5

Table A.5. Norman Climate Variable Data

Year	Total Rainfall (in.)	Total Solar Radiation (MJ/m2)	Avg Diff/Max &Min Temp (°F)	Avg yearly Temp (°F)	Total Freeze-thaw Cycles
1997	154	198.03	21	63.25	0
1998	115	205.21	21	63.04	0
1999	123	212.72	22	63.68	0
2000	142	205.29	21	63.22	0
2001	72	194.79	21	62.59	0
2002	111	188.49	21	61.36	0
2003	137	195.16	23	62.45	3
2004	167	186.67	21	62.5	0
2005	132	200.99	22	63.4	2
2006	117	212.07	23	65.36	0
2007	173	186.71	20	63	3
2008	111	208.88	23	62.54	0
2009	171	198.83	22	62.4	5
2010	122	209.03	21	62.68	2
2011	107	220.26	24	64.95	1
2012	109	215.39	23	66.18	2
2013	155	201.16	21	61.77	1
2014	124	203.21	22	61.63	4
2015	178	194.29	21	62.72	3

Table A.6. Stillwater Climate Variable Data

Year	**Total Rainfall (in.)**	**Total Solar Radiation (MJ/m2)**	**Avg Diff/Max &Min Temp (°F)**	**Avg yearly Temp (°F)**	**Total Freeze-thaw Cycles**
1997	164	190	22	61.7	1
1998	135	192.55	23	61.75	1
1999	146	200.71	24	62.86	1
2000	128	199.2	23	62.72	1
2001	112	197.4	23	62.27	1
2002	144	189.28	23	60.72	4
2003	124	190.85	24	60.86	4
2004	155	187.71	23	61.59	0
2005	118	196.53	24	62.81	2
2006	121	202.62	26	63.77	2
2007	177	180.13	22	62.22	5
2008	142	196.8	24	61.31	1
2009	179	192.42	23	61.59	2
2010	159	197.59	22	61.9	1
2011	99	205.39	26	63.4	0
2012	98	188.03	26	65.09	1
2013	172	196.66	23	60.54	4
2014	129	204.59	24	60.4	1
2015	174	194.91	23	62.18	4

Table A.7. Tipton Climate Variable Data

Year	Total Rainfall (in.)	Total Solar Radiation (MJ/m2)	Avg Diff/Max &Min Temp (°F)	Avg yearly Temp (°F)	Total Freeze-thaw Cycles
1997	153	213.43	23	63.36	0
1998	122	217.21	24	64.66	1
1999	113	224.68	26	66.04	0
2000	110	213.95	25	66.54	7
2001	111	213.04	24	64.95	0
2002	110	211.08	24	63.31	0
2003	95	217.63	27	64.13	1
2004	145	200.53	23	64.4	0
2005	129	211.18	26	64.54	1
2006	97	224.86	27	66.45	1
2007	135	204.9	23	64	1
2008	93	231.34	28	64.18	0
2009	148	215.24	27	64.09	4
2010	115	213.92	25	63.81	1
2011	62	229.82	28	66.63	1
2012	106	224.68	27	67.45	0
2013	113	220.7	26	64.13	4
2014	100	213.1	25	63.4	2
2015	156	203.55	24	64.54	2

Table A.8. Beaver Climate Variable Data

Year	Total Rainfall (in.)	Total Solar Radiation (MJ/m2)	Avg Diff/Max &Min Temp (°F)	Avg yearly Temp (°F)	Total Freeze-thaw Cycles
1997	116	202.51	27	59.65	2
1998	127	213.77	28	58.08	2
1999	101	215.79	29	59.9	1
2000	105	213.49	29	60.95	1
2001	113	213.26	28	60.77	3
2002	112	216.62	28	59.22	5
2003	88	211.7	29	59.27	2
2004	128	201.09	28	59.22	1
2005	127	205.44	28	59.81	2
2006	103	218.3	30	60.72	3
2007	117	227.42	28	59.04	4
2008	108	223.75	30	58.81	1
2009	105	213.3	30	58.68	0
2010	108	215.14	28	59.5	8
2011	98	226.32	31	60.81	8
2012	107	227.18	31	62.81	2
2013	122	221.48	28	59.22	5
2014	102	212.65	28	58.86	0
2015	150	208.14	28	60.13	3

Table A.9. Bessie Climate Variable Data

Year	Total Rainfall (in.)	Total Solar Radiation (MJ/m2)	Avg Diff/Max &Min Temp (°F)	Avg yearly Temp (°F)	Total Freeze-thaw Cycles
1997	162	207.61	21	61.36	1
1998	112	211.32	23	62.7	0
1999	113	212.71	24	63.81	0
2000	142	207.84	23	62.7	4
2001	128	211.16	23	63.54	2
2002	129	203.49	22	61.54	6
2003	109	208.04	24	62.09	3
2004	157	198.8	22	62.22	0
2005	143	215.5	23	62.54	4
2006	111	218.6	25	64.272	2
2007	161	195.84	22	61.81	9
2008	104	212.67	25	62.13	2
2009	131	205.98	24	61.9	2
2010	115	213.73	24	62.68	1
2011	86	228.74	26	65.09	0
2012	100	222.32	25	65.95	1
2013	132	215.36	24	61.77	5
2014	106	213.58	24	61.45	1
2015	147	204.6	23	62.31	3

Table A.10. Breckinridge Climate Variable Data

Year	Total Rainfall (in.)	Total Solar Radiation (MJ/m2)	Avg Diff/Max &Min Temp (°F)	Avg yearly Temp (°F)	Total Freeze-thaw Cycles
1997	165	198.15	21	61.8	1
1998	152	199.55	22	61.2	0
1999	149	208.81	22	61.81	2
2000	121	208.74	22	61.72	4
2001	136	207.45	23	61.9	5
2002	143	195.08	23	59.86	3
2003	109	198.12	23	60.36	3
2004	141	195.18	22	60.4	1
2005	121	199.65	24	61.59	2
2006	113	210.49	26	62.77	1
2007	155	189.72	22	60.95	7
2008	124	201.93	24	59.86	4
2009	165	199.5	24	60.4	3
2010	133	205.87	22	60.77	3
2011	117	215.2	26	62.04	0
2012	110	217.36	26	64.09	2
2013	170	202.16	24	59.22	7
2014	130	198.97	25	59.27	3
2015	155	194.35	24	61.4	7

Table A.11. Burneyville Climate Variable Data

Year	Total Rainfall (in.)	Total Solar Radiation (MJ/m2)	Avg Diff/Max &Min Temp (°F)	Avg yearly Temp (°F)	Total Freeze-thaw Cycles
1997	147	194.96	21	57.95	0
1998	131	199.81	22	65.2	1
1999	120	215.84	25	66.54	0
2000	134	198.53	23	66.22	4
2001	127	200.28	22	64.77	1
2002	125	192.56	23	63.54	0
2003	100	198.69	25	64.36	0
2004	156	184.03	23	64.5	0
2005	94	199.5	25	65.31	1
2006	95	212.17	27	66.63	1
2007	154	190.79	23	64.68	0
2008	109	211.68	27	64.4	0
2009	183	201.53	24	64.4	6
2010	143	207.8	24	64.22	3
2011	113	218.89	27	66.72	4
2012	127	210.07	27	66.95	5
2013	165	210.68	25	64.18	1
2014	118	206.48	24	63.13	1
2015	192	193.49	23	64.81	2

Table A.12. Westville Climate Variable Data

Year	Total Rainfall (in.)	Total Solar Radiation (MJ/m2)	Avg Diff/Max &Min Temp (°F)	Avg yearly Temp (°F)	Total Freeze-thaw Cycles
1997	208	184.43	N/A	N/A	2
1998	167	188.26	20	60.95	1
1999	162	198.35	21.1	60.08	2
2000	181	188.4	20.3	58.81	3
2001	159	184.6	19.9	57.82	5
2002	167	171.87	20.2	57.82	3
2003	178	167.17	20.7	58.25	1
2004	184	170.25	19.3	58.75	3
2005	163	183.21	22.2	59.84	2
2006	157	184.28	21.6	61.73	3
2007	177	178.05	19.8	57.48	5
2008	189	178.37	20.9	58.87	5
2009	220	152.98	19	57.57	3
2010	164	183.96	19.8	58.2	4
2011	185	188.22	20.3	60.01	4
2012	127	199.55	21.6	62.6	1
2013	179	185.11	19.4	57.62	1
2014	182	187.85	13.8	56.3	2
2015	201	180.96	19.2	59.25	3

Appendix B - Bridge Ratings for all Climate Stations

Note: - indicates that no data was available for that bridge during that year.

Table B.1. Wister Station Deck Ratings

Bridge #	**97**	**98**	**99**	**00**	**01**	**02**	**03**	**04**	**05**	**06**	**07**	**08**	**09**	**10**	**11**	**12**	**13**	**14**	**15**	**Avg**
2.76E+12	-	-	-	-	-	7	7	7	7	7	7	7	7	7	7	7	7	7	7	0
5.092E+13	-	6	6	6	6	6	6	6	6	6	-	6	6	6	6	6	6	6	6	0
5.479E+13	-	-	-	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	0
5.49E+13	-	-	-	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	0
6.03E+13	-	6	6	-	6	6	6	6	6	6	-	6	6	6	6	-	-	-	-	0
6.102E+13	-	-	-	-	-	5	5	5	5	5	-	5	5	5	5	-	-	-	-	0
6.485E+13	6	6	6	7	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	0
6.495E+13	5	7	7	5	7	7	7	7	7	7	7	7	7	7	7	8	8	8	8	0.1
6.503E+13	6	5	5	7	5	5	5	5	5	5	-	-	-	-	-	-	-	-	-	0
7.65E+13	-	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	0
9.371E+13	-	-	-	-	-	6	6	6	6	6	6	6	6	6	5	5	5	6	6	0.1
1.0728E+14	-	-	-	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	0
1.297E+14	-	-	-	-	-	6	6	6	6	6	6	6	6	6	6	6	6	6	6	0
1.6067E+14	-	-	-	6	6	6	6	7	7	7	7	7	7	7	5	5	5	5	5	0.1
1.6168E+14	-	-	-	-	-	-	-	6	6	6	6	6	6	6	6	6	6	6	6	0
1.9068E+14	-	-	-	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	0
1.9089E+14	-	-	-	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	0
1.9218E+14	-	-	-	7	7	7	7	7	7	7	7	7	7	7	8	8	8	8	7	0.1
1.9225E+14	-	-	-	-	-	-	7	7	7	7	7	7	7	7	7	7	7	7	7	0
1.9226E+14	-	-	-	-	-	-	7	7	7	7	7	7	7	7	7	7	7	7	7	0
1.9231E+14	-	-	-	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	0

Bridge #	**97**	**98**	**99**	**00**	**01**	**02**	**03**	**04**	**05**	**06**	**07**	**08**	**09**	**10**	**11**	**12**	**13**	**14**	**15**	**Avg**
1.9236E+14	-	-	-	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	0
1.9242E+14	-	-	-	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	0
1.9251E+14	-	-	-	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	0
1.9252E+14	-	-	-	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	0
1.9265E+14	7	-	-	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	0
1.9266E+14	-	7	7	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	0
1.9814E+14	-	-	-	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	0
1.9976E+14	-	-	-	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	6	0
2.0311E+14	7	7	7	-	-	-	-	7	7	7	-	7	7	7	7	7	7	7	7	0
2.0852E+14	7	7	7	8	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	0
2.1596E+14	-	7	7	8	7	7	7	7	7	7	7	7	7	7	7	-	-	-	-	0
2.2408E+14	-	7	7	7	7	7	7	6	6	6	6	6	6	6	6	6	6	6	6	0.1
2.2824E+14	7	-	-	8	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	0
2.2943E+14	-	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	0
2.2945E+14	-	-	-	8	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	0
2.3182E+14	-	-	-	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	0
2.3183E+14	7	-	-	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	0
2.3184E+14	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	0
2.3187E+14	-	7	7	7	7	7	7	6	6	6	6	6	6	6	6	6	6	6	6	0.1
2.3352E+14	-	-	-	8	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	0
2.337E+14	7	-	-	-	-	-	7	7	7	7	7	7	7	7	7	7	7	7	7	0
2.3711E+14	-	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	0
2.4412E+14	-	-	-	-	-	-	-	7	7	7	7	7	7	7	7	7	7	7	7	0
2.4558E+14	-	-	-	6	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	0
2.5495E+14	-	-	-	-	-	-	7	7	7	7	7	7	7	7	7	7	7	7	7	0
2.5657E+14	-	-	-	-	-	-	-	7	7	7	7	7	7	7	7	7	7	7	7	0

Bridge #	97	98	99	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	Avg
2.5658E+14	-	-	-	-	-	-	-	7	7	7	7	7	7	7	7	7	7	7	7	0
2.5659E+14	-	-	-	-	-	-	-	7	7	7	7	7	7	7	7	7	7	7	7	0
2.566E+14	-	-	-	-	-	-	-	7	7	7	7	7	7	7	7	7	7	7	7	0
2.5733E+14	-	-	-	8	9	7	7	7	7	7	7	7	7	7	7	-	-	-	-	0
2.6392E+14	-	-	-	-	-	-	-	7	7	7	7	7	7	7	7	7	7	7	7	0
2.6394E+14	-	-	-	-	-	-	-	7	7	7	7	7	7	7	7	7	7	7	7	0
2.7041E+14	-	-	-	-	-	-	-	-	-	8	8	8	8	8	8	8	8	8	8	0

Table B.2. Wister Superstructure Ratings

Bridge #	97	98	99	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	Avg
2.76E+12	-	-	-	-	-	8	8	8	8	8	8	8	8	8	8	8	8	8	8	0
5.092E+13	-	7	7	7	7	7	7	7	7	7	-	7	7	7	7	7	7	7	7	0
5.479E+13	-	-	-	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	0
5.49E+13	-	-	-	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	0
6.03E+13	-	7	7	-	7	7	7	7	7	7	-	7	7	7	7	-	-	-	-	0
6.102E+13	-	-	-	-	-	6	6	6	6	6	-	6	6	6	6	-	-	-	-	0
6.485E+13	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	6	6	6	6	0.1
6.495E+13	5	8	8	9	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	0.2
6.503E+13	6	5	5	5	5	5	5	5	5	5	-	-	-	-	-	-	-	-	-	0
6.517E+13	-	6	6	6	6	6	6	6	6	6	-	-	-	-	-	-	-	-	-	0
7.65E+13	-	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	0
9.371E+13	-	-	-	-	-	6	6	6	6	6	6	6	6	6	5	5	5	6	6	0.1
9.487E+13	-	8	8	9	8	8	8	8	8	8	-	-	-	-	-	-	-	-	-	0
1.0728E+14	-	-	-	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	0
1.127E+14	-	-	-	-	-	8	8	8	8	8	8	8	8	8	8	8	8	8	8	0
1.297E+14	-	-	-	-	-	7	7	7	7	7	7	7	7	7	7	6	6	6	6	0.1
1.6067E+14	-	-	-	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	7	0
1.6168E+14	-	-	-	-	-	-	-	8	8	8	8	8	8	8	8	8	8	8	7	0

Bridge #	97	98	99	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	Avg
1.9068E+14	-	-	-	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	7	0
1.9089E+14	-	-	-	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	0
1.9218E+14	-	-	-	8	8	8	8	8	8	8	8	8	8	8	7	7	7	7	7	0.1
1.9225E+14	-	-	-	-	-	-	8	8	8	8	8	8	8	8	8	8	8	8	7	0
1.9226E+14	-	-	-	-	-	-	8	8	8	8	8	8	8	8	8	8	8	8	7	0
1.9231E+14	-	-	-	8	8	8	8	8	8	8	8	8	8	8	7	7	7	7	7	0.1
1.9236E+14	-	-	-	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	7	0
1.9242E+14	-	-	-	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	0
1.9251E+14	-	-	-	8	8	8	8	8	8	8	8	8	8	8	5	5	5	5	5	0.1
1.9252E+14	-	-	-	8	8	8	8	8	8	8	8	8	8	8	6	6	6	6	6	0.1
1.9265E+14	9	-	-	8	8	8	8	8	8	8	8	8	8	8	7	7	7	7	7	0.1
1.9266E+14	-	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	7	0
1.9814E+14	-	-	-	9	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	0
1.9969E+14	-	-	-	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	7	0
1.9976E+14	-	-	-	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	7	0
2.0311E+14	9	8	8	-	-	-	-	8	8	8	-	8	8	8	8	8	8	8	8	0
2.0852E+14	9	8	8	9	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	0
2.1596E+14	-	8	8	9	8	8	8	8	8	8	8	8	8	8	8	-	-	-	-	0
2.1706E+14	9	-	-	9	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	0
2.2369E+14	-	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	0
2.2392E+14	9	-	-	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	0
2.2408E+14	-	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	7	7	7	0.1
2.2824E+14	9	-	-	9	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	0
2.2943E+14	-	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	0
2.2945E+14	-	-	-	9	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	0
2.3182E+14	-	-	-	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	0
2.3183E+14	9	-	-	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	0
2.3184E+14	9	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	0
2.3187E+14	-	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	0
2.3343E+14	-	-	-	9	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	0

Bridge #	**97**	**98**	**99**	**00**	**01**	**02**	**03**	**04**	**05**	**06**	**07**	**08**	**09**	**10**	**11**	**12**	**13**	**14**	**15**	**Avg**
2.3352E+14	-	-	-	9	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	0
2.337E+14	9	-	-	-	-	-	8	8	8	8	8	8	8	8	8	8	8	8	8	0
2.3711E+14	-	9	9	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	0
2.4412E+14	-	-	-	-	-	-	-	8	8	8	8	8	8	8	8	8	8	8	8	0
2.4558E+14	-	-	-	9	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	0
2.5495E+14	-	-	-	-	-	-	8	8	8	8	8	8	8	8	8	8	8	8	8	0
2.5657E+14	-	-	-	-	-	-	-	8	8	8	8	8	8	8	8	8	8	8	8	0
2.5658E+14	-	-	-	-	-	-	-	8	8	8	8	8	8	8	8	8	8	8	8	0
2.5659E+14	-	-	-	-	-	-	-	8	8	8	8	8	8	8	8	8	8	8	8	0
2.566E+14	-	-	-	-	-	-	-	8	8	8	8	8	8	8	8	8	8	8	8	0
2.5733E+14	-	-	-	8	9	7	7	7	7	7	7	7	7	7	5	-	-	-	-	0.1
2.6392E+14	-	-	-	-	-	-	-	8	8	8	8	8	8	8	8	8	8	8	8	0
2.6393E+14	-	-	-	-	-	-	-	8	8	8	8	8	8	8	8	8	8	8	8	0
2.6394E+14	-	-	-	-	-	-	-	8	8	8	8	8	8	8	8	8	8	8	8	0
2.6539E+14	-	-	-	-	-	-	-	8	8	8	8	8	8	8	8	8	8	8	8	0
2.654E+14	-	-	-	-	-	-	-	8	8	8	8	8	8	8	8	8	8	8	8	0
2.7041E+14	-	-	-	-	-	-	-	-	-	8	8	8	8	8	8	8	8	8	8	0

Table B.3. Wister Substructure

Bridge #	**97**	**98**	**99**	**00**	**01**	**02**	**03**	**04**	**05**	**06**	**07**	**08**	**09**	**10**	**11**	**12**	**13**	**14**	**15**	**Avg**
2.76E+12	-	-	-	-	-	7	7	7	7	7	7	7	7	7	7	7	7	7	7	0
5.092E+13	-	6	6	6	6	6	6	6	6	6	-	6	6	6	6	7	7	7	7	0.1
5.479E+13	-	-	-	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	0
5.49E+13	-	-	-	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	0
6.03E+13	-	5	5	-	5	5	5	5	5	5	-	6	6	6	6	-	-	-	-	0.1
6.102E+13	-	-	-	-	-	6	6	6	6	6	-	6	6	6	6	-	-	-	-	0
6.485E+13	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	0
6.495E+13	5	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	0
6.503E+13	5	6	6	5	6	6	6	6	6	6	-	-	-	-	-	-	-	-	-	0
6.517E+13	-	5	5	5	5	5	5	5	5	5	-	-	-	-	-	-	-	-	-	0
7.65E+13	-	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	0
9.371E+13	-	-	-	-	-	5	5	5	5	5	5	5	5	5	5	5	5	5	5	0
9.487E+13	-	7	7	7	7	7	7	7	7	7	-	-	-	-	-	-	-	-	-	0
1.0728E+14	-	-	-	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	0
1.297E+14	-	-	-	-	-	6	6	6	6	6	6	6	6	6	6	5	5	5	5	0.1
1.6067E+14	-	-	-	7	7	7	7	7	7	7	7	7	7	7	8	8	8	8	7	0.1
1.6168E+14	-	-	-	-	-	-	-	7	7	7	7	7	7	7	7	7	7	7	7	0
1.9068E+14	-	-	-	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	0
1.9089E+14	-	-	-	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	0
1.9218E+14	-	-	-	7	7	7	7	7	7	7	7	7	7	7	6	6	6	6	6	0.1
1.9225E+14	-	-	-	-	-	-	7	7	7	7	7	7	7	7	7	7	7	7	7	0
1.9226E+14	-	-	-	-	-	-	7	7	7	7	7	7	7	7	7	7	7	7	7	0
1.923E+14	-	-	-	7	7	7	7	7	7	7	7	7	7	7	6	6	6	6	6	0.1
1.9236E+14	-	-	-	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	0
1.9242E+14	-	-	-	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	0

Bridge #	97	98	99	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	Avg
1.9251E+14	-	-	-	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	0
1.9252E+14	-	-	-	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	0
1.9265E+14	7	-	-	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	0
1.9266E+14	-	7	7	7	7	7	7	7	7	7	7	7	7	7	6	6	6	6	6	0.1
1.9814E+14	-	-	-	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	0
1.9976E+14	-	-	-	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	0
2.0311E+14	7	7	7	-	-	-	-	7	7	7	-	7	7	7	7	7	7	7	7	0
2.0852E+14	7	7	7	7	7	7	7	6	6	6	6	6	6	7	7	7	7	7	7	0.1
2.1596E+14	-	7	7	7	7	7	7	5	5	7	7	7	7	7	7	-	-	-	-	0.1
2.1706E+14	7	-	-	7	7	7	7	7	7	7	7	7	7	7	7	8	8	8	8	0.1
2.2369E+14	-	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	0
2.2408E+14	-	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	0
2.2943E+14	-	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	0
2.2945E+14	-	-	-	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	0
2.3182E+14	-	-	-	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	0
2.3183E+14	7	-	-	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	0
2.3184E+14	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	0
2.3187E+14	-	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	0
2.337E+14	7	-	-	-	-	-	7	7	7	7	7	7	7	7	7	7	7	7	7	0
2.3711E+14	-	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	0
2.4412E+14	-	-	-	-	-	-	-	7	7	7	7	7	7	7	7	7	7	7	7	0
2.4558E+14	-	-	-	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	0
2.5495E+14	-	-	-	-	-	-	7	7	7	7	7	7	7	7	7	7	7	7	7	0
2.5657E+14	-	-	-	-	-	-	-	7	7	7	7	7	7	7	7	7	7	7	7	0
2.5658E+14	-	-	-	-	-	-	-	7	7	7	7	7	7	7	7	7	7	7	7	0
2.5659E+14	-	-	-	-	-	-	-	7	7	7	7	7	7	7	7	7	7	7	7	0

Bridge #	**97**	**98**	**99**	**00**	**01**	**02**	**03**	**04**	**05**	**06**	**07**	**08**	**09**	**10**	**11**	**12**	**13**	**14**	**15**	**Avg**
2.566E+14	-	-	-	-	-	-	-	7	7	7	7	7	7	7	7	7	7	7	7	0
2.5733E+14	-	-	-	8	9	7	7	7	7	7	7	7	7	5	5	-	-	-	-	0.1
2.6394E+14	-	-	-	-	-	-	-	7	7	7	7	7	7	7	7	7	7	7	7	0
2.7041E+14	-	-	-	-	-	-	-	-	-	8	8	8	8	8	8	8	8	8	8	0

Table B.4. Idabel Deck Ratings

Bridge #	**97**	**98**	**99**	**00**	**01**	**02**	**03**	**04**	**05**	**06**	**07**	**08**	**09**	**10**	**11**	**12**	**13**	**14**	**15**	**Avg**
1.341E+13	6	7	7	6	6	6	6	6	6	6	-	-	-	-	-	-	-	-	-	0.1
3.841E+13	5	5	5	5	5	5	5	5	5	5	-	-	-	-	-	-	-	-	-	0
9.812E+13	-	-	-	6	6	6	6	6	6	6	6	6	6	6	6	6	-	-	-	0
1.0851E+14	-	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	-	7	7	0
1.092E+14	-	-	-	7	7	7	6	6	6	6	6	6	6	6	6	6	-	6	6	0.1
1.0959E+14	-	-	-	7	7	7	6	6	6	6	6	6	6	6	6	6	-	5	5	0.2
1.0962E+14	-	-	-	6	6	6	6	6	6	6	6	6	6	6	6	6	-	6	6	0
1.11E+14	-	-	-	7	6	6	6	6	6	6	6	6	6	6	6	5	-	-	-	0.2
1.1104E+14	-	-	-	7	6	6	7	7	7	7	7	7	7	7	7	7	-	7	7	0
1.7537E+14	-	-	-	7	7	7	7	7	7	7	7	7	7	7	7	7	-	7	7	0
1.8785E+14	7	7	7	7	6	6	6	6	6	6	6	6	6	6	6	6	-	6	6	0.1
1.925E+14	-	-	-	7	7	7	7	7	7	7	7	7	7	6	6	6	-	6	6	0.1
1.9255E+14	-	-	-	7	6	6	6	6	6	6	6	6	6	6	6	6	6	5	5	0.2
1.9269E+14	-	-	-	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	0
1.9802E+14	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	6	7	7	0
2.0297E+14	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	0
2.3314E+14	-	-	-	7	7	7	7	7	7	7	7	7	7	6	6	7	6	7	7	0
2.4772E+14	-	-	-	-	-	7	7	7	7	7	7	7	7	7	7	7	6	7	7	0
2.4773E+14	-	-	-	-	-	7	7	7	7	7	7	7	7	7	7	7	7	7	7	0

Bridge #	97	98	99	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	Avg
2.5343E+14	-	-	-	7	9	7	7	7	7	7	7	7	7	7	7	7	5	7	7	0
2.5344E+14	-	-	-	7	9	7	7	7	7	7	7	7	7	7	7	7	7	7	7	0
2.5363E+14	-	-	-	7	7	7	7	7	7	7	7	7	7	7	7	7	8	7	7	0
2.6672E+14	-	-	-	-	-	-	-	7	7	7	7	7	7	7	7	7	6	7	7	0

Table B.5. Idabel Superstructure Ratings

Bridge #	97	98	99	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	Avg
1.341E+13	6	7	7	6	6	6	6	6	6	6	-	-	-	-	-	-	-	-	-	0
3.841E+13	6	6	6	6	6	6	6	6	6	6	-	-	-	-	-	-	-	-	-	0
9.812E+13	-	-	-	7	7	7	7	7	7	7	7	7	7	6	7	7	6	-	-	0.1
1.092E+14	-	-	-	7	7	7	6	6	6	6	6	6	6	6	6	6	6	6	6	0.1
1.0953E+14	-	-	-	7	7	7	7	7	7	7	7	7	7	6	7	5	7	5	5	0.2
1.0957E+14	-	-	-	7	5	5	5	6	6	6	6	6	6	6	6	5	7	5	5	0.6
1.0959E+14	-	-	-	7	7	7	7	7	7	7	7	7	7	6	7	6	6	5	5	0.2
1.0962E+14	-	-	-	7	7	7	7	7	7	7	7	7	7	6	7	5	6	5	5	0.2
1.11E+14	-	-	-	7	7	7	7	7	7	7	7	7	7	6	7	6	5	-	-	0.1
1.1104E+14	-	-	-	7	7	7	7	7	7	7	7	7	7	7	7	6	7	6	6	0.1
1.2609E+14	-	-	-	7	7	7	7	7	7	7	7	7	7	6	7	5	7	6	6	0.2
1.7537E+14	-	-	-	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	0
1.8785E+14	9	8	8	9	5	5	5	5	5	5	5	5	5	6	5	5	6	5	5	0.1
1.925E+14	-	-	-	9	8	8	8	8	8	8	8	8	8	6	7	7	6	7	7	0.1
1.9257E+14	-	-	-	9	8	8	8	8	8	8	8	8	8	6	8	8	6	7	7	0.1
2.0297E+14	7	7	7	7	7	7	7	7	7	6	6	6	6	7	6	6	7	7	7	0.1

Table B.6. Idabel Substructure Ratings

Bridge #	97	98	99	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	Avg
1.341E+13	5	6	6	5	6	6	6	6	6	6	-	-	-	-	-	-	-	-	-	0
3.841E+13	7	7	7	7	7	7	7	7	7	7	-	-	-	-	-	-	-	-	-	0
9.812E+13	-	-	-	7	7	7	7	7	7	7	7	7	7	7	7	7	7	-	-	0
1.0851E+14	-	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	8	7	7	0
1.0959E+14	-	-	-	7	7	7	7	7	7	7	7	7	7	7	7	7	6	5	5	0.1
1.11E+14	-	-	-	7	7	7	7	7	7	7	7	7	7	7	7	7	6	-	-	0
1.1104E+14	-	-	-	7	7	7	7	7	7	7	7	7	7	7	7	7	6	7	7	0
1.2609E+14	-	-	-	7	7	7	7	7	7	7	7	6	6	6	6	7	5	7	7	0.1
1.3503E+14	-	-	-	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	0
1.7537E+14	-	-	-	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	0
1.8785E+14	7	7	7	7	5	5	5	6	6	6	7	7	7	7	6	6	5	6	6	0.1
1.925E+14	-	-	-	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	0
1.9255E+14	-	-	-	7	7	7	7	7	7	7	7	7	7	7	7	7	8	7	7	0
1.9257E+14	-	-	-	7	7	7	7	7	7	7	7	6	6	6	6	6	8	5	5	0.2
1.9269E+14	-	-	-	8	7	7	7	7	7	7	7	7	7	7	7	7	8	7	7	0
1.9802E+14	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	8	7	7	0
2.0297E+14	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	6	7	7	0
2.1951E+14	7	7	7	6	7	7	7	7	7	7	7	7	7	7	7	7	6	7	7	0
2.3314E+14	-	-	-	7	7	7	7	7	7	7	7	7	7	7	7	7	8	7	7	0
2.4772E+14	-	-	-	-	-	7	7	7	7	7	7	7	7	7	7	7	8	7	7	0
2.4773E+14	-	-	-	-	-	7	7	6	6	7	7	7	7	6	6	6	8	6	6	0.1

Table B.7. Copan Deck Ratings

Bridge #	**97**	**98**	**99**	**00**	**01**	**02**	**03**	**04**	**05**	**06**	**07**	**08**	**09**	**10**	**11**	**12**	**13**	**14**	**15**	**Avg**
7.36E+13	5	5	5	6	5	5	5	5	5	5	5	5	5	5	5	7	5	5	5	0
7.384E+13	5	7	7	7	7	-	-	-	-	-	-	-	-	7	7	-	7	7	7	0
1.0092E+14	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	0
1.2798E+14	6	6	6	6	6	6	5	5	5	5	5	5	5	5	5	5	5	-	-	0.1
1.875E+14	7	7	7	7	7	7	7	7	7	7	7	7	7	-	-	-	-	-	-	0
1.9462E+14	7	7	7	8	7	7	7	7	7	7	7	7	7	-	-	-	-	-	-	0
1.9464E+14	6	6	6	7	6	6	6	6	6	6	6	6	6	-	-	-	-	-	-	0
1.9613E+14	7	7	7	8	7	7	7	7	7	7	7	7	7	-	-	-	-	-	-	0
1.9623E+14	7	7	7	8	7	7	7	7	7	7	7	7	7	-	-	-	-	-	-	0
1.963E+14	7	7	7	7	7	7	7	7	7	7	7	7	7	-	-	-	-	-	-	0
1.9796E+14	6	7	7	7	7	7	7	7	7	7	7	7	7	-	-	-	-	-	-	0
1.9944E+14	7	7	7	7	7	7	7	7	7	7	7	7	7	-	-	-	-	-	-	0
2.0271E+14	7	7	7	8	7	7	7	7	7	7	7	7	7	-	-	-	-	-	-	0
2.0544E+14	7	7	7	8	7	7	7	7	7	7	7	7	7	-	-	-	-	-	-	0
2.0572E+14	7	7	7	7	7	7	7	7	7	7	7	7	7	-	-	-	-	-	-	0
2.1108E+14	7	7	7	7	7	7	7	7	7	7	7	7	7	-	-	-	-	-	-	0
2.1109E+14	6	5	5	7	5	5	5	6	6	6	6	6	6	-	-	-	-	-	-	0.1
2.1121E+14	8	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	0
2.1125E+14	8	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	0
2.13E+14	7	7	7	8	7	7	7	7	7	7	7	7	7	-	-	-	-	-	-	0
2.1347E+14	6	7	7	7	7	7	7	7	7	7	7	7	7	-	-	-	-	-	-	0
2.1354E+14	-	-	-	7	7	7	7	7	7	7	7	7	7	7	7	6	6	6	6	0.1
2.1718E+14	-	-	-	7	7	7	7	7	7	7	7	7	7	7	7	6	6	6	6	0.1
2.2346E+14	-	-	-	7	7	7	7	7	7	7	7	7	7	7	7	7	8	7	7	0
2.2366E+14	-	-	-	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	0

Bridge #	**97**	**98**	**99**	**00**	**01**	**02**	**03**	**04**	**05**	**06**	**07**	**08**	**09**	**10**	**11**	**12**	**13**	**14**	**15**	**Avg**
2.2367E+14	-	-	-	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	0
2.2603E+14	7	7	7	8	7	7	7	7	7	7	7	7	7	-	-	-	-	-	-	0
2.2617E+14	7	7	7	8	7	7	7	7	7	7	7	7	7	-	-	-	-	-	-	0
2.2849E+14	-	-	-	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	0
2.2882E+14	7	7	7	8	7	7	7	7	7	7	7	7	7	-	-	-	-	-	-	0
2.3389E+14	8	7	7	8	7	7	7	7	7	7	7	7	7	-	-	-	-	-	-	0
2.339E+14	7	7	7	8	7	7	7	7	7	7	7	7	7	-	-	-	-	-	-	0
2.3418E+14	7	7	7	8	7	7	7	7	7	7	7	7	7	-	-	-	-	-	-	0
2.3419E+14	7	7	7	8	7	7	7	7	7	7	7	7	7	-	-	-	-	-	-	0
2.388E+14	9	7	7	7	7	7	7	7	7	7	7	7	7	-	-	-	-	7	7	0
2.4597E+14	-	7	7	-	7	7	7	7	7	7	7	7	7	-	-	-	-	-	-	0
2.5069E+14	-	7	7	8	7	7	7	7	7	7	7	7	7	-	-	-	-	-	-	0
2.5123E+14	-	7	-	8	7	7	7	7	7	7	7	7	7	-	-	-	-	-	-	0
2.5496E+14	-	-	-	-	-	-	-	-	-	8	8	8	8	8	8	8	8	8	8	0
2.5497E+14	-	-	-	-	-	-	-	-	8	8	8	8	8	8	8	8	8	8	8	0
2.7157E+14	-	-	-	-	-	-	-	-	9	9	9	9	9	8	8	8	8	8	8	0.1

Table B.8. Copan Superstructure Ratings

Bridge #	**97**	**98**	**99**	**00**	**01**	**02**	**03**	**04**	**05**	**06**	**07**	**08**	**09**	**10**	**11**	**12**	**13**	**14**	**15**	**Avg**
7.36E+13	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	6	6	0.1
7.384E+13	6	7	7	7	7	-	-	-	-	-	-	-	-	7	7	-	7	7	7	0
1.0092E+14	6	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	0
1.2798E+14	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	-	-	0
1.875E+14	9	8	8	9	8	8	8	8	8	8	8	8	8	-	-	-	-	-	-	0
1.9462E+14	9	8	8	9	8	8	8	8	8	8	8	8	8	-	-	-	-	-	-	0
1.9464E+14	9	8	8	9	8	8	8	8	8	8	8	8	8	-	-	-	-	-	-	0
1.9613E+14	9	8	8	9	8	8	8	8	8	8	8	8	8	-	-	-	-	-	-	0
1.9623E+14	9	8	8	9	8	8	8	8	8	8	8	8	8	-	-	-	-	-	-	0
1.963E+14	9	8	8	9	8	8	8	8	8	8	8	8	8	-	-	-	-	-	-	0
1.9796E+14	9	8	8	9	8	8	8	8	8	8	8	8	8	-	-	-	-	-	-	0
1.9944E+14	7	7	7	7	7	7	7	7	7	7	7	7	7	-	-	-	-	-	-	0
2.0271E+14	9	8	8	9	8	8	8	8	8	8	8	8	8	-	-	-	-	-	-	0
2.0544E+14	9	8	8	9	8	8	8	8	8	8	8	8	8	-	-	-	-	-	-	0
2.0568E+14	-	-	-	9	8	8	8	8	8	8	8	8	8	8	8	7	7	6	6	0.2
2.0572E+14	9	8	8	9	8	8	8	8	8	8	8	8	8	-	-	-	-	-	-	0
2.1108E+14	9	8	8	9	8	8	8	8	8	8	8	8	8	-	-	-	-	-	-	0
2.1109E+14	9	8	8	9	8	8	8	8	8	8	8	8	8	-	-	-	-	-	-	0
2.1121E+14	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	0
2.1125E+14	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	0
2.13E+14	9	8	8	9	8	8	8	8	8	8	8	8	8	-	-	-	-	-	-	0
2.1347E+14	9	8	8	9	8	8	8	8	8	8	8	8	8	-	-	-	-	-	-	0
2.1354E+14	-	-	-	9	8	8	8	8	8	8	8	8	8	8	8	6	6	6	6	0.1
2.1718E+14	-	-	-	9	8	8	8	8	8	8	8	8	7	7	7	6	6	6	6	0.1
2.2286E+14	9	8	8	9	8	8	8	8	8	8	8	8	8	-	-	-	8	-	-	0

Bridge #	**97**	**98**	**99**	**00**	**01**	**02**	**03**	**04**	**05**	**06**	**07**	**08**	**09**	**10**	**11**	**12**	**13**	**14**	**15**	**Avg**
2.2345E+14	-	-	-	9	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	0
2.2346E+14	-	-	-	9	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	0
2.2361E+14	-	-	-	9	8	8	8	8	8	8	8	8	8	8	8	8	-	8	8	0
2.2366E+14	-	-	-	9	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	0
2.2367E+14	-	-	-	9	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	0
2.2603E+14	9	8	8	9	8	8	8	8	8	8	8	8	8	-	-	-	-	-	-	0
2.2617E+14	9	8	8	9	8	8	8	8	8	8	8	8	8	-	-	-	-	-	-	0
2.2849E+14	-	-	-	9	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	0
2.2882E+14	9	8	8	9	8	8	8	8	8	8	8	8	8	-	-	-	-	-	-	0
2.338E+14	9	8	8	9	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	0
2.3389E+14	8	8	8	9	8	8	8	8	8	8	8	8	8	-	-	-	-	-	-	0
2.339E+14	9	8	8	9	8	8	8	8	8	8	8	8	8	-	-	-	-	-	-	0
2.3418E+14	9	8	8	9	8	8	8	8	8	8	8	8	8	-	-	-	-	-	-	0
2.3419E+14	9	8	8	9	8	8	8	8	8	8	8	8	8	-	-	-	-	-	-	0
2.388E+14	9	8	8	8	8	8	8	8	8	8	8	8	8	-	-	-	-	8	8	0
2.4469E+14	-	-	-	5	9	8	8	8	8	8	8	8	8	-	-	-	-	-	-	0
2.4597E+14	-	7	7	-	7	7	7	7	7	7	7	7	7	-	-	-	-	-	-	0
2.5069E+14	-	9	9	9	8	8	8	8	8	8	8	8	8	-	-	-	-	-	-	0
2.5123E+14	-	9	-	9	8	8	8	8	8	8	8	8	8	-	-	-	-	-	-	0
2.5496E+14	-	-	-	-	-	-	-	-	-	8	8	8	8	8	8	8	8	8	8	0
2.5497E+14	-	-	-	-	-	-	-	-	8	8	8	8	8	8	8	8	8	8	8	0
2.7157E+14	-	-	-	-	-	-	-	-	9	9	9	9	9	9	9	9	9	9	9	0

Table B.9. Copan Substructure Ratings

Bridge #	**97**	**98**	**99**	**00**	**01**	**02**	**03**	**04**	**05**	**06**	**07**	**08**	**09**	**10**	**11**	**12**	**13**	**14**	**15**	**Avg**
7.36E+13	6	6	6	5	6	5	5	5	5	5	5	5	5	5	5	8	5	5	5	0.2
1.0092E+14	8	8	8	8	8	8	8	8	8	8	8	8	8	6	6	5	5	5	5	0.2
1.875E+14	7	7	7	7	7	7	7	7	7	7	7	7	7	-	-	-	-	-	-	0
1.9462E+14	7	7	7	7	7	7	7	7	7	7	7	7	7	-	-	-	-	-	-	0
1.9464E+14	7	7	7	7	7	7	7	7	7	7	7	7	7	-	-	-	-	-	-	0
1.9613E+14	7	7	7	7	7	7	7	7	7	7	7	7	7	-	-	-	-	-	-	0
1.9623E+14	7	7	7	7	7	7	7	7	7	7	7	7	7	-	-	-	-	-	-	0
1.963E+14	7	7	7	7	7	7	7	7	7	7	7	7	7	-	-	-	-	-	-	0
1.9796E+14	7	7	7	7	7	7	7	7	7	7	7	7	7	-	-	-	-	-	-	0
1.9944E+14	7	7	7	7	7	7	7	7	7	7	7	7	7	-	-	-	-	-	-	0
2.0271E+14	7	7	7	7	7	7	7	7	7	7	7	7	7	-	-	-	-	-	-	0
2.0544E+14	7	7	7	7	7	7	7	7	7	7	7	7	7	-	-	-	-	-	-	0
2.0568E+14	-	-	-	7	7	7	7	7	7	7	7	7	8	8	8	7	7	7	7	0.1
2.0572E+14	7	7	7	7	7	7	7	7	7	6	6	6	6	-	-	-	-	-	-	0.1
2.1108E+14	7	7	7	7	7	7	7	7	7	7	7	7	7	-	-	-	-	-	-	0
2.1109E+14	7	7	7	7	7	7	7	7	7	7	7	7	7	-	-	-	-	-	-	0
2.1121E+14	8	7	7	7	7	7	7	7	6	6	6	6	6	6	5	5	5	5	5	0.2
2.1125E+14	8	7	7	7	7	7	7	7	6	6	6	6	6	6	5	5	5	5	5	0
2.13E+14	7	7	7	7	7	7	7	7	7	7	7	7	7	-	-	-	-	-	-	0
2.1347E+14	7	7	7	7	7	7	7	7	7	7	7	7	7	-	-	-	-	-	-	0
2.1354E+14	-	-	-	7	7	7	7	7	7	7	7	7	7	7	7	6	6	5	5	0.2
2.1718E+14	-	-	-	7	7	7	7	7	7	7	7	7	7	7	7	6	6	6	6	0
2.2286E+14	7	7	7	7	7	7	7	7	7	7	7	7	7	-	-	-	6	-	-	0
2.2345E+14	-	-	-	7	7	7	7	7	7	8	8	7	7	7	7	6	8	6	6	0.2
2.2366E+14	-	-	-	7	7	7	7	7	7	7	7	7	7	7	7	7	7	6	6	0.1

Bridge #	97	98	99	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	Avg
2.2603E+14	7	7	7	7	7	7	7	7	7	7	7	7	7	-	-	-	-	-	-	0
2.2617E+14	7	7	7	7	7	7	7	7	7	7	7	7	7	-	-	-	-	-	-	0
2.2882E+14	7	7	7	7	7	7	7	7	7	7	7	7	7	-	-	-	-	-	-	0
2.338E+14	7	7	7	7	7	7	7	7	7	7	7	7	7	7	5	5	5	7	7	0.1
2.3389E+14	8	7	7	7	7	7	7	7	7	7	7	7	7	-	-	-	-	-	-	0
2.339E+14	7	7	7	7	7	7	7	7	7	7	7	7	7	-	-	-	-	-	-	0
2.3418E+14	7	7	7	7	7	7	7	7	7	7	7	7	7	-	-	-	-	-	-	0
2.3419E+14	7	7	7	7	7	7	7	7	7	7	7	7	7	-	-	-	-	-	-	0
2.388E+14	9	7	7	7	7	7	7	7	7	7	7	7	7	-	-	-	-	5	5	0.1
2.4469E+14	-	-	-	5	9	7	7	7	7	7	7	7	7	-	-	-	-	-	-	0
2.4597E+14	-	7	7	-	7	7	7	7	7	7	7	7	7	-	-	-	-	-	-	0
2.4985E+14	-	-	7	-	-	7	7	7	7	7	7	7	7	-	-	-	-	-	-	0
2.5069E+14	-	7	7	7	7	7	7	7	7	7	7	7	7	-	-	-	-	-	-	0
2.5123E+14	-	7	-	7	7	7	7	7	7	7	7	7	7	-	-	-	-	-	-	0
2.5496E+14	-	-	-	-	-	-	-	-	-	8	8	8	8	8	8	8	8	8	8	0
2.5497E+14	-	-	-	-	-	-	-	-	8	8	8	8	8	8	8	8	8	7	7	0.1
2.7157E+14	-	-	-	-	-	-	-	-	9	9	9	9	9	9	9	9	9	9	9	0

Table B.10. Inola Deck Ratings

Bridge #	**97**	**98**	**99**	**00**	**01**	**02**	**03**	**04**	**05**	**06**	**07**	**08**	**09**	**10**	**11**	**12**	**13**	**14**	**15**	**Avg**
1.586E+13	-	-	-	6	6	6	6	6	6	6	6	6	-	-	-	-	-	-	-	0
2.117E+13	5	5	5	5	5	-	-	-	-	-	-	-	-	-	-	5	5	-	-	0
2.847E+13	-	7	7	7	7	7	7	6	6	6	-	-	-	6	6	6	6	-	-	0.1
2.848E+13	-	6	6	6	7	7	7	7	7	7	7	7	7	7	7	7	7	-	-	0
8.109E+13	7	-	-	-	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	0
9.715E+13	7	7	7	7	7	7	7	7	7	7	-	-	-	7	7	7	7	-	-	0
1.071E+14	5	5	5	5	5	5	5	5	5	-	-	-	-	5	5	5	5	5	5	0
1.4116E+14	-	-	-	-	-	-	-	-	7	7	7	7	7	7	-	7	7	7	7	0
1.8278E+14	-	-	-	6	6	6	5	5	-	5	-	-	-	-	-	9	9	9	8	0.2
1.8768E+14	-	-	-	7	6	6	6	6	5	-	5	5	5	5	-	5	5	5	5	0.2
1.8782E+14	-	-	-	7	6	6	6	6	6	6	6	6	6	6	-	6	6	6	5	0.2
1.8787E+14	-	-	-	5	5	5	5	5	5	5	5	5	5	5	-	5	5	5	5	0
1.906E+14	-	-	-	7	7	7	7	7	7	7	7	7	7	7	-	7	7	7	7	0
1.9101E+14	-	-	-	7	6	6	6	6	5	5	-	-	6	6	-	-	5	5	5	0.2
1.9102E+14	7	7	7	7	7	6	6	6	6	6	6	6	6	6	-	6	6	6	6	0
1.921E+14	7	7	7	7	7	7	7	7	7	7	7	7	7	7	-	7	7	7	7	0
1.9785E+14	7	7	7	7	7	7	7	7	7	7	7	7	7	7	-	7	7	7	7	0
2.-275E+14	7	7	7	7	7	7	7	7	7	7	7	7	7	7	-	7	7	7	7	0
2.1-22E+14	-	-	-	7	7	7	7	7	7	7	7	7	7	7	-	7	7	7	7	0
2.1078E+14	8	8	8	7	7	7	7	7	7	7	7	7	7	7	-	7	7	7	7	0.1
2.1961E+14	8	8	8	8	7	7	7	7	7	7	7	7	7	7	-	7	7	7	7	0.1
2.2025E+14	8	7	7	8	7	7	7	7	7	7	7	7	7	7	-	7	7	7	7	0.1
2.3672E+14	7	7	7	7	7	7	7	7	7	7	7	7	7	7	-	7	7	7	7	0
2.3673E+14	-	-	-	7	7	7	7	7	7	7	7	7	7	7	-	7	7	7	7	0
2.4913E+14	-	-	-	-	-	-	-	7	7	7	7	7	7	7	-	7	7	7	7	0

Bridge #	97	98	99	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	Avg
2.5246E+14	-	-	-	9	7	7	7	7	8	8	8	8	8	8	-	7	7	7	7	0.1
2.5249E+14	-	-	-	-	-	-	-	-	8	8	8	8	8	8	-	8	8	8	8	0
2.525E+14	-	-	-	9	7	7	7	7	8	8	8	8	8	8	-	7	7	7	7	0.1
2.5251E+14	-	-	-	-	-	-	-	-	8	8	8	8	8	8	-	7	7	7	7	0.1
2.5252E+14	-	-	-	-	-	-	-	-	8	8	8	8	8	8	-	8	8	8	8	0
2.5254E+14	-	-	-	-	-	-	-	-	8	8	8	8	8	8	-	7	7	7	7	0.1
2.5255E+14	-	-	-	-	-	-	-	-	8	8	8	8	8	8	-	7	7	7	7	0.1
2.5375E+14	-	-	-	-	9	7	7	7	7	7	7	7	7	7	-	7	7	7	7	0
2.5525E+14	-	-	-	-	-	-	-	7	7	7	7	7	7	7	-	7	7	7	7	0
2.5676E+14	-	-	-	-	-	-	8	8	8	8	8	8	8	8	-	8	8	8	8	0
2.6074E+14	-	-	-	-	-	-	-	-	-	7	7	7	7	7	7	7	7	7	7	0
2.6518E+14	-	-	-	-	-	-	-	7	7	7	7	7	7	7	-	7	7	7	7	0
2.711E+14	-	-	-	-	-	-	-	7	8	8	8	8	8	8	-	7	7	7	7	0.1
2.7111E+14	-	-	-	-	-	-	-	7	7	7	8	8	7	7	-	7	7	7	7	0.1
2.7112E+14	-	-	-	-	-	-	-	7	8	8	8	8	8	8	-	8	8	8	8	0
2.7142E+14	-	-	-	-	-	-	-	-	-	9	9	9	8	8	-	8	8	8	8	0.1
2.7143E+14	-	-	-	-	-	-	-	-	-	9	9	9	8	8	-	8	8	8	8	0.1
2.7379E+14	-	-	-	-	-	-	-	7	7	7	7	7	7	7	-	7	7	7	7	0

Table B.11. Inola Superstructure Ratings

Bridge #	**97**	**98**	**99**	**00**	**01**	**02**	**03**	**04**	**05**	**06**	**07**	**08**	**09**	**10**	**11**	**12**	**13**	**14**	**15**	**Avg**
1.586E+13	-	-	-	7	7	7	5	5	5	5	5	5	-	-	-	-	-	-	-	0.1
2.847E+13	-	5	5	5	7	7	7	5	5	5	-	-	-	5	5	5	5	-	-	0.1
2.848E+13	-	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	-	-	0
8.109E+13	7	-	-	-	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	0
9.715E+13	7	7	7	7	7	7	7	7	7	7	-	-	-	7	7	7	7	-	-	0
1.071E+14	6	6	6	6	7	7	7	7	7	-	-	-	-	7	7	7	7	7	7	0.1
1.3686E+14	-	-	-	7	6	6	6	6	6	6	6	6	-	-	-	-	-	-	-	0
1.4116E+14	-	-	-	-	-	-	-	-	8	8	8	8	8	8	-	8	8	8	8	0
1.8278E+14	-	-	-	9	8	8	7	7	-	8	-	-	-	-	-	7	8	8	8	0.1
1.8768E+14	-	-	-	9	8	8	8	8	8	-	8	8	8	8	-	8	8	8	8	0
1.8782E+14	-	-	-	9	8	8	8	8	8	8	8	8	8	8	-	8	8	8	8	0
1.8787E+14	-	-	-	9	6	6	6	6	6	6	6	6	6	5	-	5	5	5	5	0.2
1.906E+14	-	-	-	9	8	8	8	8	7	7	7	7	6	6	-	6	6	6	6	0.2
1.9101E+14	-	-	-	9	8	8	8	8	8	8	-	-	8	8	-	-	8	8	8	0
1.9102E+14	7	7	7	9	8	8	8	8	7	7	7	7	7	7	-	7	7	7	7	0.2
1.9785E+14	9	8	8	7	7	7	7	7	7	7	7	7	7	7	-	7	7	7	7	0.1
2.0275E+14	7	8	8	8	8	8	8	8	8	8	8	8	8	8	-	8	8	8	8	0
2.1022E+14	-	-	-	8	8	8	8	8	8	8	8	8	8	8	-	8	8	8	8	0
2.1-78E+14	8	8	8	8	8	8	8	8	8	8	8	8	8	8	-	8	8	8	8	0
2.2025E+14	8	8	8	7	8	8	8	8	8	8	8	8	8	8	-	8	8	8	8	0
2.3672E+14	9	8	8	8	8	8	8	8	8	8	8	8	8	8	-	8	8	8	8	0
2.3673E+14	-	-	-	8	8	8	8	8	8	8	8	8	8	8	-	8	8	8	8	0
2.4589E+14	-	-	-	9	8	8	8	8	8	8	8	8	8	8	-	8	8	8	8	0
2.4913E+14	-	-	-	-	-	-	-	8	8	8	8	8	8	8	-	8	8	8	8	0
2.5246E+14	-	-	-	9	8	8	8	8	8	8	8	8	8	8	-	8	8	8	8	0

Bridge #	**97**	**98**	**99**	**00**	**01**	**02**	**03**	**04**	**05**	**06**	**07**	**08**	**09**	**10**	**11**	**12**	**13**	**14**	**15**	**Avg**
2.5249E+14	-	-	-	-	-	-	-	-	8	8	8	8	8	8	-	8	8	8	8	0
2.525E+14	-	-	-	9	8	8	8	8	8	8	8	8	8	8	-	8	8	8	8	0
2.5251E+14	-	-	-	-	-	-	-	-	8	8	8	8	8	8	-	8	8	8	8	0
2.5252E+14	-	-	-	-	-	-	-	-	8	8	8	8	8	8	-	8	8	8	8	0
2.5254E+14	-	-	-	-	-	-	-	-	8	8	8	8	8	8	-	8	8	8	8	0
2.5255E+14	-	-	-	-	-	-	-	-	8	8	8	8	8	8	-	8	8	8	8	0
2.5375E+14	-	-	-	-	9	8	8	8	8	8	8	8	8	8	-	8	8	8	8	0
2.5525E+14	-	-	-	-	-	-	-	8	8	8	8	8	8	8	-	8	8	8	8	0
2.563E+14	-	-	-	-	-	8	8	8	8	8	8	8	8	8	-	8	8	8	8	0
2.5631E+14	-	-	-	-	-	8	8	8	8	8	8	8	8	8	-	8	8	8	8	0
2.5676E+14	-	-	-	-	-	-	8	8	8	8	8	8	8	8	-	8	8	8	8	0
2.6074E+14	-	-	-	-	-	-	-	-	-	8	8	8	8	8	8	8	8	8	8	0
2.6518E+14	-	-	-	-	-	-	-	8	8	8	8	8	8	8	-	8	8	8	8	0
2.6856E+14	-	-	-	-	-	-	-	-	8	8	8	8	8	8	-	8	8	8	8	0
2.711E+14	-	-	-	-	-	-	-	8	8	8	8	8	8	8	-	8	8	8	8	0
2.7111E+14	-	-	-	-	-	-	-	8	8	8	8	8	8	8	-	8	8	8	8	0
2.7112E+14	-	-	-	-	-	-	-	8	8	8	8	8	8	8	-	7	7	7	7	0.1
2.7379E+14	-	-	-	-	-	-	-	8	8	8	8	8	8	8	-	8	8	8	8	0

Table B.12. Inola Substructure Ratings

Bridge #	**97**	**98**	**99**	**00**	**01**	**02**	**03**	**04**	**05**	**06**	**07**	**08**	**09**	**10**	**11**	**12**	**13**	**14**	**15**	**Avg**
1.586E+13	-	-	-	7	7	7	6	6	6	6	6	6	-	-	-	-	-	-	-	0.1
2.848E+13	-	6	6	6	6	6	6	6	6	6	6	6	6	6	6	5	5	-	-	0.1
8.109E+13	6	-	-	-	8	8	8	8	8	8	8	8	8	6	6	5	5	5	5	0.2
9.715E+13	7	8	8	8	7	7	7	8	8	8	-	-	-	8	8	5	5	-	-	0.2
1.071E+14	6	6	6	6	6	6	6	6	6	-	-	-	-	6	6	5	5	5	5	0.1
1.3686E+14	-	-	-	6	6	6	6	6	5	5	5	5	-	-	-	-	-	-	-	0.1
1.4116E+14	-	-	-	-	-	-	-	-	7	7	7	7	7	7	-	7	7	7	7	0
1.8278E+14	-	-	-	7	7	7	7	7	-	7	-	-	-	-	-	7	7	7	7	0
1.8768E+14	-	-	-	9	6	7	7	7	7	-	7	7	7	7	-	7	7	7	7	0
1.8782E+14	-	-	-	8	7	7	6	6	6	6	6	6	6	6	-	5	5	5	5	0.2
1.8787E+14	-	-	-	6	6	6	5	5	5	7	7	7	7	5	-	5	5	5	5	0.2
1.906E+14	-	-	-	7	7	7	6	6	6	6	6	6	5	5	-	5	6	6	5	0.2
1.9101E+14	-	-	-	9	6	6	5	5	5	5	-	-	6	6	-	-	7	7	6	0.3
1.921E+14	7	7	7	7	7	7	7	7	7	7	7	7	7	5	-	5	5	5	5	0.1
1.9785E+14	7	7	7	7	7	7	7	7	7	7	7	7	7	7	-	7	7	7	7	0
2.0275E+14	7	6	6	7	7	7	7	7	7	7	7	7	7	7	-	7	7	7	7	0
2.1022E+14	-	-	-	6	6	6	6	6	6	6	6	6	6	6	-	5	5	5	5	0.1
2.1078E+14	8	8	8	7	7	7	7	7	7	7	7	7	7	7	-	7	7	7	7	0.1
2.1961E+14	8	8	8	8	7	7	7	6	6	6	6	6	6	6	-	6	6	6	6	0.1
2.2-25E+14	8	7	7	8	7	7	7	7	7	7	7	7	7	7	-	7	7	7	7	0.1
2.3672E+14	7	7	7	7	7	7	7	7	7	7	7	7	7	7	-	7	7	7	7	0
2.3673E+14	-	-	-	7	7	7	7	7	7	7	7	7	7	7	-	7	7	7	7	0
2.4913E+14	-	-	-	-	-	-	-	7	7	7	7	7	7	7	-	7	7	7	7	0
2.5246E+14	-	-	-	9	7	7	7	7	8	8	8	8	8	8	-	7	7	7	7	0.3
2.5249E+14	-	-	-	-	-	-	-	-	8	8	8	8	7	7	-	7	7	7	6	0.2

Bridge #	**97**	**98**	**99**	**00**	**01**	**02**	**03**	**04**	**05**	**06**	**07**	**08**	**09**	**10**	**11**	**12**	**13**	**14**	**15**	**Avg**
2.525E+14	-	-	-	9	7	7	7	7	8	8	8	8	7	7	-	7	7	7	7	0.1
2.5251E+14	-	-	-	-	-	-	-	-	8	8	8	8	8	8	-	7	7	7	6	0.2
2.5252E+14	-	-	-	-	-	-	-	-	8	8	8	8	8	8	-	7	7	7	6	0.2
2.5254E+14	-	-	-	-	-	-	-	-	8	8	8	8	8	8	-	8	8	8	8	0
2.5255E+14	-	-	-	-	-	-	-	-	8	8	8	8	8	8	-	8	8	8	8	0
2.5375E+14	-	-	-	-	9	7	7	7	7	7	7	7	7	7	-	7	7	7	7	0
2.5525E+14	-	-	-	-	-	-	-	7	7	7	7	7	7	7	-	7	7	7	7	0
2.563E+14	-	-	-	-	-	7	7	7	8	8	8	8	8	8	-	8	7	7	7	0.2
2.5631E+14	-	-	-	-	-	7	7	7	8	8	8	8	7	7	-	7	8	8	8	0.2
2.5676E+14	-	-	-	-	-	-	8	8	8	8	8	8	8	8	-	8	8	8	8	0
2.6074E+14	-	-	-	-	-	-	-	-	-	7	7	7	7	7	7	7	7	7	7	0
2.6518E+14	-	-	-	-	-	-	-	7	7	7	7	7	7	7	-	7	7	7	7	0
2.6856E+14	-	-	-	-	-	-	-	-	7	7	8	8	8	8	-	8	8	8	8	0.1
2.711E+14	-	-	-	-	-	-	-	7	8	8	8	8	8	8	-	8	8	8	8	0
2.7112E+14	-	-	-	-	-	-	-	7	8	8	8	8	8	8	-	8	8	8	8	0
2.7379E+14	-	-	-	-	-	-	-	7	7	7	7	7	7	7	-	7	7	7	7	0

Table B.13. Norman Deck Ratings

Bridge #	**97**	**98**	**99**	**00**	**01**	**02**	**03**	**04**	**05**	**06**	**07**	**08**	**09**	**10**	**11**	**12**	**13**	**14**	**15**	**Avg**
2.96E+12	7	7	7	8	7	7	7	7	7	7	7	-	-	-	-	-	-	-	-	0
6.203E+13	7	7	7	8	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	0
1.6744E+14	-	-	-	6	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	0
1.9348E+14	7	7	7	8	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	0
1.9451E+14	7	7	7	8	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	0
2.0794E+14	7	7	7	8	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	0
2.0801E+14	7	7	7	8	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	0
2.1052E+14	7	7	7	8	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	0
2.2039E+14	7	7	7	6	7	7	7	7	7	7	7	7	7	7	7	6	6	6	6	0.1
2.208E+14	7	7	7	6	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	0
2.2254E+14	7	7	7	8	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	0
2.2283E+14	7	7	7	8	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	0
2.23E+14	7	7	7	8	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	0
2.2313E+14	7	7	7	8	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	0
2.2323E+14	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	0
2.2324E+14	7	7	7	8	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	0
2.2567E+14	7	7	7	-	7	6	6	7	7	7	7	7	7	7	7	7	7	7	7	0.1
2.2569E+14	7	7	7	8	7	7	7	6	6	6	6	7	7	7	7	7	7	7	7	0.2
2.2628E+14	7	7	7	8	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	0
2.2642E+14	7	6	7	8	7	6	6	7	7	7	7	7	7	7	7	7	7	7	7	0.1
2.2833E+14	6	7	6	6	6	7	7	6	6	6	6	6	6	6	6	6	6	6	6	0.1
2.3372E+14	7	7	7	8	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	0
2.3373E+14	7	7	7	8	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	0
2.4463E+14	-	-	-	-	-	-	-	7	7	7	7	7	7	7	7	7	7	7	7	0
2.4635E+14	9	7	7	9	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	0

Bridge #	97	98	99	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	Avg
2.4822E+14	-	-	-	-	-	-	-	-	-	7	7	7	7	7	7	7	7	7	7	0
2.5821E+14	-	-	-	-	-	7	-	-	9	9	9	9	9	9	9	8	8	8	8	0.1
2.6098E+14	-	-	-	-	-	-	7	7	7	7	7	7	7	7	7	7	7	7	7	0
2.7229E+14	-	-	-	-	-	-	-	-	9	9	9	9	9	9	9	8	8	8	8	0.1

Table B.14. Norman Superstructure Ratings

Bridge #	97	98	99	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	Avg
2.96E+12	9	8	8	9	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	0.1
6.203E+13	9	8	8	9	8	8	8	8	8	8	8	7	7	7	7	7	7	7	7	0
1.6744E+14	-	-	-	7	7	5	5	5	5	5	5	7	7	7	7	7	7	7	7	0.2
1.9348E+14	7	7	7	7	7	7	7	7	7	6	6	7	7	7	7	7	7	7	7	0.2
1.9451E+14	9	8	8	9	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	0
2.0794E+14	9	8	8	9	8	8	8	8	8	8	8	8	8	7	7	6	6	6	6	0.2
2.0801E+14	9	8	8	9	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	0
2.1052E+14	8	7	7	7	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	0.1
2.2039E+14	7	7	7	9	8	8	8	8	8	8	8	8	8	8	8	7	7	7	5	0.2
2.208E+14	9	8	8	9	8	8	8	8	8	8	8	8	8	7	7	7	7	7	7	0.1
2.2254E+14	9	8	8	9	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	0.1
2.2283E+14	9	8	8	9	8	8	8	8	8	8	8	8	8	8	8	7	7	7	7	0.1
2.23E+14	9	8	8	9	8	8	8	8	8	8	8	8	8	7	7	7	7	7	7	0.1
2.2313E+14	9	8	8	9	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	0
2.2323E+14	9	8	8	9	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	0
2.2324E+14	9	8	8	-	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	0
2.2567E+14	9	8	8	9	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	0
2.2569E+14	9	8	8	9	8	8	8	8	8	8	8	8	8	7	7	7	7	7	7	0.1
2.2628E+14	9	8	8	9	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	0

Bridge #	97	98	99	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	Avg
2.2642E+14	9	8	8	9	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	0
2.2833E+14	9	8	8	9	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	0
2.3372E+14	9	8	8	9	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	0
2.3373E+14	7	7	7	8	7	7	7	8	8	8	8	8	8	8	8	8	8	8	8	0
2.4463E+14	-	9	9	9	9	8	8	8	8	8	8	8	8	8	8	8	8	8	8	0.1
2.4635E+14	-	-	-	-	-	8	8	8	8	8	8	8	8	8	8	8	8	8	8	0

Table B.15. Norman Substructure Ratings

Bridge #	97	98	99	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	Avg
2.96E+12	7	7	7	7	7	7	7	7	7	7	7	-	-	-	-	-	-	-	-	0
6.203E+13	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	0
1.6744E+14	-	-	-	6	6	6	6	5	5	5	5	5	5	-	-	-	-	-	-	0.1
1.9348E+14	7	7	7	7	7	7	7	6	6	6	6	6	6	6	6	6	6	6	6	0.1
1.9451E+14	7	7	7	7	7	7	7	7	7	7	7	7	7	6	6	5	5	5	5	0.1
2.0794E+14	6	6	6	6	7	7	7	7	7	7	7	7	7	7	7	-	-	6	6	0.2
2.0801E+14	7	7	7	7	7	6	6	6	6	6	6	6	6	5	5	5	5	7	7	0.2
2.1052E+14	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	0
2.2039E+14	8	7	7	8	7	7	7	7	7	7	7	7	7	7	7	6	6	6	6	0.1
2.208E+14	8	7	7	8	7	7	7	7	7	7	7	7	7	7	7	6	6	6	6	0.1
2.2283E+14	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	0
2.2291E+14	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	0
2.23E+14	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	5	5	5	5	0.1
2.2313E+14	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	0
2.2323E+14	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	0
2.2567E+14	7	7	7	-	7	7	7	6	6	6	6	6	6	6	6	6	6	6	6	0.1
2.2569E+14	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	0

Bridge #	97	98	99	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	Avg
2.2586E+14	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	0
2.2628E+14	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	5	5	7	7	0.1
2.2642E+14	7	7	7	7	7	5	5	7	7	7	7	7	7	7	7	7	7	7	7	0.1
2.2833E+14	7	7	7	6	5	7	7	5	5	5	5	5	5	6	6	6	6	6	6	0.2
2.3372E+14	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	0
2.3373E+14	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	0
2.4463E+14	-	-	-	-	-	-	-	7	7	7	7	7	7	7	7	7	7	5	5	0.1
2.5147E+14	-	9	9	8	9	7	7	7	7	7	7	6	6	6	6	6	6	7	7	0.1
2.5221E+14	-	-	-	-	-	7	7	7	7	7	7	7	7	7	7	7	7	7	7	0
2.5821E+14	-	-	-	-	-	7	-	-	9	9	9	9	9	9	9	8	8	8	8	0.1
2.6098E+14	-	-	-	-	-	-	7	7	7	7	7	7	7	7	7	7	7	7	7	0

Table B.16. Stillwater Deck Ratings

Bridge #	97	98	99	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	Avg
7.049E+13	-	-	-	-	-	7	7	7	7	7	7	7	7	7	7	7	7	7	7	0
1.0135E+14	6	-	6	-	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	0
1.698E+14	-	-	-	7	7	7	7	6	6	6	6	6	6	6	6	6	6	6	6	0.1
1.8476E+14	-	-	-	7	7	7	7	7	-	7	7	7	7	7	7	7	7	7	7	0
1.8478E+14	-	-	-	7	7	7	7	7	-	7	7	7	7	7	7	7	7	7	7	0
1.8497E+14	-	-	-	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	0
1.8503E+14	-	-	-	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	0
1.8506E+14	-	-	-	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	0
1.851E+14	-	-	-	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	0
1.8513E+14	-	-	-	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	0
1.8524E+14	-	-	-	-	-	7	7	7	7	7	7	7	7	7	7	7	7	7	7	0
1.8538E+14	-	-	-	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	0

Bridge #	**97**	**98**	**99**	**00**	**01**	**02**	**03**	**04**	**05**	**06**	**07**	**08**	**09**	**10**	**11**	**12**	**13**	**14**	**15**	**Avg**
1.8539E+14	-	-	-	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	0
1.854E+14	-	-	-	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	0
1.8541E+14	-	-	-	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	0
1.8542E+14	-	-	-	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	0
1.8544E+14	-	-	-	-	-	7	7	7	7	7	7	7	7	7	7	7	7	7	7	0
1.8565E+14	-	-	-	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	0
1.857E+14	-	-	-	-	-	7	7	7	7	7	7	7	7	7	7	7	7	7	7	0
1.9049E+14	-	-	-	7	5	5	5	-	-	-	-	5	5	5	5	5	5	5	5	0.1
1.9063E+14	-	-	-	6	7	7	6	6	6	6	6	6	6	6	6	6	6	6	6	0.1
1.9077E+14	-	-	-	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	0
2.0252E+14	7	-	7	7	7	7	6	6	6	6	7	7	7	7	7	7	7	7	7	0.1
2.0291E+14	-	-	-	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	0
2.032E+14	-	-	-	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	0
2.05E+14	-	-	-	-	-	-	-	7	7	7	7	7	7	7	7	7	7	7	7	0
2.0812E+14	7	-	5	5	5	5	5	5	5	5	5	5	5	6	6	7	7	7	7	0.2
2.1645E+14	7	-	7	7	7	7	7	5	5	5	5	5	5	5	5	5	5	5	5	0.1
2.2013E+14	-	-	-	8	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	0
2.2094E+14	-	-	-	6	6	6	6	6	7	7	7	7	7	7	7	7	7	7	7	0.1
2.2102E+14	-	-	-	8	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	0
2.2103E+14	-	-	-	8	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	0
2.2414E+14	7	-	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	0
2.2802E+14	7	-	6	6	6	6	6	6	6	6	6	6	6	7	7	7	7	7	7	0.1
2.3371E+14	7	-	-	-	7	-	-	7	7	7	8	8	8	8	8	7	7	7	7	0.1
2.354E+14	7	-	7	7	7	7	6	6	6	6	7	7	7	7	7	7	7	7	7	0.1
2.3593E+14	7	-	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	0
2.3877E+14	7	-	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	0

Bridge #	97	98	99	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	Avg
2.4659E+14	-	-	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	0
2.4662E+14	-	-	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	0
2.4676E+14	-	-	-	6	6	6	6	6	6	6	6	6	6	7	7	7	7	7	7	0.1
2.5154E+14	-	-	-	-	-	-	7	7	8	8	8	8	8	8	8	7	7	7	7	0.1
2.5609E+14	-	-	-	-	-	7	7	7	7	7	7	7	7	7	7	7	7	7	7	0
2.6054E+14	-	-	-	-	-	-	-	7	7	7	7	7	7	7	7	7	7	7	7	0
2.679E+14	-	-	-	-	-	-	-	-	8	8	8	8	8	8	8	8	8	8	8	0
2.7319E+14	-	-	-	-	-	-	-	-	9	9	8	8	8	8	8	8	8	8	8	0.1

Table B.17. Stillwater Superstructure Ratings

Bridge #	97	98	99	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	Avg
7.049E+13	-	-	-	-	-	7	7	7	7	7	7	7	7	7	7	7	7	7	7	0
1.0135E+14	7	7	7	-	7	7	7	7	6	6	6	6	6	6	6	6	6	6	6	0.1
1.6408E+14	7	7	7	6	6	6	6	6	6	6	6	5	5	5	6	6	6	6	6	0.2
1.698E+14	-	-	-	9	8	8	8	5	5	8	8	8	8	8	8	8	8	8	8	0
1.8476E+14	-	-	-	9	8	8	8	8	-	8	8	8	8	8	8	8	7	7	7	0.2
1.8478E+14	-	-	-	9	8	8	8	8	-	8	8	8	7	7	7	7	7	7	7	0.2
1.8482E+14	-	-	-	9	8	8	8	8	-	7	7	7	7	7	7	7	7	7	7	0.2
1.8497E+14	-	-	-	8	8	8	8	8	8	8	8	8	8	8	7	7	7	7	7	0.1
1.8503E+14	-	-	-	9	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	0.1
1.8506E+14	-	-	-	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	0
1.851E+14	-	-	-	9	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	0
1.8513E+14	-	-	-	9	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	0
1.8524E+14	-	-	-	-	-	8	8	8	8	8	8	8	8	8	8	8	8	8	8	0
1.8538E+14	-	-	-	9	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	0
1.8539E+14	-	-	-	9	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	0

Bridge #	97	98	99	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	Avg
1.854E+14	-	-	-	9	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	0
1.8541E+14	-	-	-	9	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	0
1.8542E+14	-	-	-	9	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	0
1.8544E+14	-	-	-	-	-	8	8	8	8	8	8	8	8	8	8	8	8	8	8	0
1.8565E+14	-	-	-	9	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	0
1.857E+14	-	-	-	-	-	8	8	8	8	8	8	8	8	8	8	8	8	8	8	0
1.9049E+14	-	-	-	9	8	8	8	-	-	-	-	6	6	6	6	6	6	6	6	0.1
1.9063E+14	-	-	-	9	8	8	8	8	9	9	7	7	7	7	7	7	7	7	7	0.1
1.9077E+14	-	-	-	9	8	8	8	8	8	8	8	8	8	8	8	8	7	7	7	0.2
2.0252E+14	9	8	8	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	0
2.0291E+14	-	-	-	9	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	0
2.032E+14	-	-	-	9	8	8	8	8	8	8	8	8	8	8	8	8	8	7	7	0.1
2.05E+14	-	-	-	-	-	-	-	8	8	8	8	8	8	8	8	8	8	8	8	0
2.0812E+14	7	7	7	7	7	6	6	6	6	6	6	6	6	6	6	6	6	6	6	0.1
2.1645E+14	7	7	7	7	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	0.1
2.2013E+14	-	-	-	9	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	0
2.2094E+14	-	-	-	9	8	8	7	7	8	8	8	8	8	8	8	8	8	8	8	0.2
2.2102E+14	-	-	-	9	8	8	8	8	8	7	7	7	7	7	7	7	7	7	7	0.2
2.2103E+14	-	-	-	9	8	8	8	8	8	7	7	7	7	7	7	7	7	7	7	0.2
2.2414E+14	9	8	8	9	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	0.1
2.2802E+14	9	8	8	9	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	0.1
2.2898E+14	9	8	8	9	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	0.1
2.3371E+14	9	-	-	-	8	-	-	8	8	8	8	8	8	8	8	8	8	8	8	0
2.354E+14	9	8	8	9	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	0.1
2.3593E+14	9	8	8	9	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	0.1
2.3877E+14	9	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	0

Bridge #	97	98	99	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	Avg
2.4116E+14	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	0
2.4408E+14	-	-	-	-	-	8	8	8	8	8	8	8	8	8	8	8	8	8	8	0
2.4634E+14	-	-	-	-	-	8	8	8	8	8	8	8	8	8	8	8	8	8	8	0
2.4659E+14	-	9	9	9	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	0.1
2.4662E+14	-	9	9	9	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	0
2.4676E+14	-	-	-	9	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	0
2.5154E+14	-	-	-	-	-	-	8	8	8	8	8	8	8	8	8	8	8	8	8	0
2.5551E+14	-	-	-	-	-	8	8	8	8	8	8	8	8	8	8	8	8	8	8	0
2.5609E+14	-	-	-	-	-	8	8	8	8	8	8	8	8	8	8	8	8	8	8	0
2.5688E+14	-	-	-	-	-	-	8	8	8	8	8	8	8	8	8	8	8	8	8	0
2.6054E+14	-	-	-	-	-	-	-	8	8	8	8	8	8	8	8	8	8	8	8	0
2.6215E+14	-	-	-	-	-	-	-	8	8	8	8	8	8	8	8	8	8	8	8	0
2.6216E+14	-	-	-	-	-	-	-	8	8	8	8	8	8	8	8	8	8	8	8	0
2.679E+14	-	-	-	-	-	-	-	-	8	8	8	8	8	8	8	8	8	8	8	0
2.7319E+14	-	-	-	-	-	-	-	-	9	9	8	8	8	8	8	8	8	8	8	0.1

Table B.18. Stillwater Substructure Ratings

Bridge #	**97**	**98**	**99**	**00**	**01**	**02**	**03**	**04**	**05**	**06**	**07**	**08**	**09**	**10**	**11**	**12**	**13**	**14**	**15**	**Avg**
7.049E+13	-	-	-	-	-	8	8	8	8	8	8	8	8	8	8	8	8	7	7	0.1
1.0135E+14	7	7	7	-	5	5	5	5	6	6	6	6	6	6	6	5	5	5	5	0.2
1.6408E+14	7	5	5	5	6	6	6	6	6	6	6	5	5	5	6	6	6	6	6	0.2
1.698E+14	-	-	-	7	7	7	7	7	7	5	5	5	5	5	5	5	5	5	5	0.1
1.8476E+14	-	-	-	7	7	7	7	7	-	7	7	7	7	7	7	7	7	7	7	0
1.8478E+14	-	-	-	7	7	7	7	7	-	7	7	7	7	7	7	7	7	7	7	0
1.8482E+14	-	-	-	7	7	7	7	7	-	7	7	7	7	7	7	7	7	7	7	0
1.8497E+14	-	-	-	7	7	7	6	6	6	6	6	6	6	6	6	6	6	6	6	0.1
1.8503E+14	-	-	-	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	0
1.8506E+14	-	-	-	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	0
1.851E+14	-	-	-	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	0
1.8513E+14	-	-	-	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	0
1.8524E+14	-	-	-	-	-	7	7	7	7	7	7	7	7	7	7	7	7	7	7	0
1.8538E+14	-	-	-	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	0
1.8539E+14	-	-	-	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	0
1.854E+14	-	-	-	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	0
1.8541E+14	-	-	-	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	0
1.8542E+14	-	-	-	7	6	6	6	6	7	7	7	7	7	7	7	7	7	7	7	0.1
1.8544E+14	-	-	-	-	-	6	6	6	6	6	6	6	6	6	6	6	6	6	7	0
1.8565E+14	-	-	-	7	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	0
1.857E+14	-	-	-	-	-	6	6	6	6	6	6	6	6	6	6	6	6	6	6	0
1.9049E+14	-	-	-	9	7	7	7	-	-	-	-	6	6	6	6	6	6	6	6	0.1
1.9063E+14	-	-	-	7	6	6	6	6	7	7	7	7	7	7	7	7	7	7	7	0.1
1.9077E+14	-	-	-	7	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	0
2.0252E+14	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	0

Bridge #	**97**	**98**	**99**	**00**	**01**	**02**	**03**	**04**	**05**	**06**	**07**	**08**	**09**	**10**	**11**	**12**	**13**	**14**	**15**	**Avg**
2.0291E+14	-	-	-	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	0
2.032E+14	-	-	-	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	0
2.0812E+14	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	0
2.1645E+14	8	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	5	5	0.1
2.2013E+14	-	-	-	7	7	6	6	7	7	7	7	7	7	7	7	7	7	7	7	0.1
2.2094E+14	-	-	-	6	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	0
2.2102E+14	-	-	-	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	0
2.2103E+14	-	-	-	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	0
2.2414E+14	7	7	7	7	7	7	7	7	6	6	7	7	7	7	7	7	7	7	7	0.1
2.2802E+14	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	0
2.3371E+14	7	-	-	-	7	-	-	7	7	7	8	8	8	8	8	7	7	7	7	0.1
2.354E+14	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	0
2.4659E+14	-	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	0
2.4662E+14	-	7	7	7	7	7	7	7	7	5	5	5	5	5	5	5	5	5	5	0.1
2.4676E+14	-	-	-	7	7	7	7	7	7	7	7	7	7	7	5	5	5	5	5	0.1
2.5154E+14	-	-	-	-	-	-	7	7	8	8	8	8	8	8	8	8	8	8	8	0
2.6215E+14	-	-	-	-	-	-	-	7	7	7	8	8	8	8	8	7	7	7	7	0.1
2.679E+14	-	-	-	-	-	-	-	-	8	8	8	8	8	8	8	8	8	8	8	0
2.7319E+14	-	-	-	-	-	-	-	-	9	9	8	8	8	8	8	8	8	8	8	0.1

Table B.19. Tipton Deck Ratings

Bridge #	**97**	**98**	**99**	**00**	**01**	**02**	**03**	**04**	**05**	**06**	**07**	**08**	**09**	**10**	**11**	**12**	**13**	**14**	**15**	**Avg**
1.9212E+14	-	-	-	5	5	5	5	7	7	7	7	7	7	6	6	6	6	6	-	0.2
2.2293E+14	-	-	-	6	-	-	7	7	7	7	7	6	6	6	6	6	6	6	-	0
2.2576E+14	-	-	-	6	-	-	7	7	7	7	7	6	6	6	6	6	6	6	-	0
2.2733E+14	-	-	-	7	-	-	7	7	7	7	7	7	7	7	7	7	7	7	-	0

Table B.20. Tipton Superstructure Ratings

Bridge #	**97**	**98**	**99**	**00**	**01**	**02**	**03**	**04**	**05**	**06**	**07**	**08**	**09**	**10**	**11**	**12**	**13**	**14**	**15**	**Avg**
1.9212E+14	-	-	-	6	6	6	6	7	7	7	7	7	7	6	6	6	6	6	-	0.1
2.2293E+14	-	-	-	6	-	-	7	7	7	7	7	7	7	7	7	7	7	7	-	0
2.2576E+14	-	-	-	7	-	-	7	7	7	7	7	6	6	5	5	6	6	6	-	0.2
2.2733E+14	-	-	-	7	-	-	7	7	7	7	7	7	7	7	7	6	6	6	-	0.1

Table B.21. Tipton Substructure Ratings

Bridge #	**97**	**98**	**99**	**00**	**01**	**02**	**03**	**04**	**05**	**06**	**07**	**08**	**09**	**10**	**11**	**12**	**13**	**14**	**15**	**Avg**
1.9212E+14	-	-	-	5	6	6	6	7	7	7	7	6	6	5	5	5	5	5	-	0.2
2.2293E+14	-	-	-	7	-	-	6	7	7	7	7	7	7	5	5	6	6	6	-	0.2
2.2576E+14	-	-	-	7	-	-	6	7	7	7	7	6	6	5	5	6	6	6	-	0.1
2.2733E+14	-	-	-	6	-	-	6	6	6	6	6	6	6	6	6	6	6	6	-	0

Table B.22. Beaver Deck Ratings

Bridge #	**97**	**98**	**99**	**00**	**01**	**02**	**03**	**04**	**05**	**06**	**07**	**08**	**09**	**10**	**11**	**12**	**13**	**14**	**15**	**Avg**
4.488E+13	-	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	0
4.526E+13	-	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	0
1.7452E+14	5	-	-	-	-	7	7	7	6	6	6	6	6	6	-	-	-	-	-	0.1
1.7892E+14	5	6	6	6	6	6	6	6	-	5	-	5	5	5	5	5	5	5	-	0.1
2.0546E+14	7	7	7	7	-	7	7	7	6	7	7	-	-	-	-	-	-	-	-	0
2.1359E+14	-	-	-	6	6	6	6	6	6	6	6	6	6	6	-	6	6	6	6	0
2.1636E+14	-	-	-	6	-	6	6	6	6	6	6	6	6	6	-	6	6	6	6	0
2.1637E+14	-	-	-	6	6	6	6	6	6	6	6	6	6	6	-	6	6	6	6	0
2.17E+14	-	-	-	6	6	6	6	6	6	6	6	6	6	6	-	6	6	6	6	0
2.172E+14	-	-	-	6	6	6	6	6	6	6	6	6	6	6	-	6	6	6	6	0
2.1987E+14	-	-	-	6	6	6	6	6	6	6	6	6	6	6	-	6	6	6	6	0
2.2042E+14	-	-	-	5	5	5	5	5	5	5	5	5	5	5	-	5	5	6	6	0.1
2.2049E+14	-	-	-	6	6	6	6	6	6	6	6	6	6	6	-	6	6	6	6	0
2.205E+14	-	-	-	6	-	6	6	6	6	6	6	6	6	6	-	5	5	6	6	0.1
2.2076E+14	-	-	-	6	6	6	6	6	6	7	7	6	6	6	-	6	6	6	6	0.1
2.2106E+14	-	-	-	6	6	5	5	5	5	5	5	5	5	5	-	5	5	5	5	0.1
2.3972E+14	7	7	-	-	7	-	-	7	7	7	7	-	-	-	7	7	7	7	7	0
2.4398E+14	-	-	-	7	7	6	6	6	6	6	6	6	6	6	-	6	6	6	6	0.1
2.5275E+14	-	-	-	7	-	7	7	7	7	7	7	-	-	7	-	7	7	7	7	0

Table B.23. Beaver Superstructure Ratings

Bridge #	**97**	**98**	**99**	**00**	**01**	**02**	**03**	**04**	**05**	**06**	**07**	**08**	**09**	**10**	**11**	**12**	**13**	**14**	**15**	**Avg**
4.488E+13	-	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	0
4.526E+13	-	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	0
1.7452E+14	5	-	-	-	-	7	7	7	7	7	7	7	7	7	-	-	-	-	-	0
1.7892E+14	5	5	5	5	5	5	5	5	-	5	-	5	5	5	5	5	5	5	-	0
2.0546E+14	7	7	7	7	-	7	7	7	7	7	7	-	-	-	-	-	-	-	-	0
2.1359E+14	-	-	-	7	7	7	7	7	7	7	7	7	7	7	-	7	7	7	7	0
2.1636E+14	-	-	-	8	-	8	8	8	8	8	8	8	8	7	-	7	7	7	7	0.1
2.1637E+14	-	-	-	8	8	8	8	8	8	8	8	8	8	8	-	8	8	8	8	0
2.17E+14	-	-	-	9	8	8	8	8	8	8	8	8	8	8	-	8	8	8	8	0
2.172E+14	-	-	-	8	8	8	8	8	8	8	8	8	8	8	-	8	8	8	8	0
2.1987E+14	-	-	-	9	8	8	8	8	8	8	8	8	8	8	-	8	8	8	8	0
2.2042E+14	-	-	-	9	8	8	8	8	8	8	8	8	8	8	-	8	8	8	8	0
2.2049E+14	-	-	-	9	8	8	8	8	8	8	8	8	8	8	-	8	8	8	8	0
2.205E+14	-	-	-	9	-	8	8	8	8	8	8	8	8	8	-	8	8	8	8	0
2.2076E+14	-	-	-	7	7	7	7	7	7	7	7	7	7	7	-	7	7	7	7	0
2.2106E+14	-	-	-	9	8	8	8	8	8	8	8	8	8	8	-	8	8	8	8	0
2.3972E+14	7	7	-	-	7	-	-	7	7	7	7	-	-	-	7	7	7	7	7	0
2.4398E+14	-	-	-	9	8	8	8	8	8	8	8	8	8	8	-	8	8	8	8	0
2.5275E+14	-	-	-	9	-	8	8	8	8	8	8	-	-	8	-	8	8	8	8	0

Table B.24. Beaver Substructure Ratings

Bridge #	**97**	**98**	**99**	**00**	**01**	**02**	**03**	**04**	**05**	**06**	**07**	**08**	**09**	**10**	**11**	**12**	**13**	**14**	**15**	**Avg**
4.488E+13	-	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	0
4.526E+13	-	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	0
1.7452E+14	5	-	-	-	-	7	7	7	7	6	6	6	6	6	-	-	-	-	-	0.1
1.7892E+14	5	7	7	7	7	7	7	7	-	6	-	6	6	6	6	6	6	6	-	0.1
2.0546E+14	7	6	6	7	-	6	6	6	7	6	6	-	-	-	-	-	-	-	-	0.1
2.1359E+14	-	-	-	7	7	7	7	6	6	6	6	7	7	7	-	7	7	7	7	0.1
2.1636E+14	-	-	-	6	-	6	6	6	6	6	6	7	7	7	-	7	7	7	7	0
2.1637E+14	-	-	-	7	7	7	7	6	6	6	6	7	7	7	-	7	7	7	7	0.1
2.17E+14	-	-	-	7	7	7	7	7	7	7	7	7	7	7	-	7	7	7	7	0
2.172E+14	-	-	-	7	7	7	7	6	6	6	6	7	7	7	-	7	7	7	7	0.1
2.1987E+14	-	-	-	7	7	7	7	7	7	7	7	7	7	7	-	7	7	7	7	0
2.2042E+14	-	-	-	7	7	7	7	7	7	7	7	7	7	7	-	7	7	7	7	0
2.2049E+14	-	-	-	7	7	7	7	7	7	7	7	7	7	7	-	7	7	7	7	0
2.2076E+14	-	-	-	7	7	7	7	7	7	7	7	7	7	7	-	7	7	7	7	0
2.2106E+14	-	-	-	7	7	7	7	7	7	7	7	7	7	7	-	7	7	7	7	0
2.3972E+14	8	7	-	-	7	-	-	7	7	6	6	-	-	-	6	6	6	6	7	0.1
2.4398E+14	-	-	-	7	7	7	7	7	7	7	7	7	7	7	-	7	7	7	7	0
2.5275E+14	-	-	-	7	-	7	7	7	7	7	7	-	-	7	-	7	7	7	7	0

Table B.25. Bessie Deck Ratings

Bridge #	**97**	**98**	**99**	**00**	**01**	**02**	**03**	**04**	**05**	**06**	**07**	**08**	**09**	**10**	**11**	**12**	**13**	**14**	**15**	**Avg**
3.852E+13	-	-	-	-	-	-	-	-	6	6	6	6	6	6	6	6	6	6	6	0
6.68E+13	-	-	-	-	-	-	-	-	-	6	6	6	6	6	6	6	6	6	6	0
6.77E+13	-	-	-	-	-	-	-	-	-	6	6	6	6	6	6	6	6	6	6	0
7.515E+13	-	6	6	-	6	7	7	7	7	7	7	7	7	7	7	7	7	7	7	0.1
7.524E+13	-	-	-	-	-	7	7	7	7	7	7	7	7	6	6	6	6	6	6	0.1
1.2408E+14	-	-	-	5	5	5	5	5	6	6	6	6	7	7	-	-	-	-	-	0.2
1.5526E+14	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	0
1.8087E+14	-	-	-	7	7	7	6	6	7	7	7	7	-	-	-	7	7	7	7	0.1
1.9222E+14	-	-	-	7	7	7	7	7	7	7	7	7	-	-	-	7	7	7	7	0
1.9262E+14	-	-	-	7	7	7	6	6	7	7	7	7	-	-	-	7	7	7	7	0.1
1.9271E+14	-	-	-	7	7	7	6	6	7	7	7	7	-	-	-	7	7	7	7	0.1
2.0212E+14	7	7	7	7	7	7	7	7	7	7	7	8	8	8	-	-	-	-	-	0.1
2.0492E+14	7	7	7	7	7	7	7	7	7	-	-	8	-	-	-	-	-	-	-	0
2.081E+14	-	-	-	7	7	7	7	7	-	7	7	7	-	-	-	7	7	7	7	0
2.1048E+14	7	7	7	7	7	7	7	7	7	-	-	-	-	-	-	-	-	-	-	0

Table B.26. Bessie Superstructure Ratings

Bridge #	**97**	**98**	**99**	**00**	**01**	**02**	**03**	**04**	**05**	**06**	**07**	**08**	**09**	**10**	**11**	**12**	**13**	**14**	**15**	**Avg**
3.852E+13	-	-	-	-	-	-	-	-	6	6	6	6	5	5	5	5	5	5	5	0.1
6.68E+13	-	-	-	-	-	-	-	-	-	6	6	6	6	6	6	6	6	6	6	0
6.77E+13	-	-	-	-	-	-	-	-	-	7	7	7	7	7	7	7	7	6	6	0.1
7.524E+13	-	-	-	-	-	7	7	7	7	7	7	7	7	6	6	6	6	6	6	0.1
1.2461E+14	-	-	-	6	6	6	6	6	6	6	6	-	7	7	6	6	6	6	6	0
1.2802E+14	-	-	-	6	6	6	6	6	7	7	7	7	7	7	7	5	5	5	5	0.2
1.2811E+14	-	-	-	6	6	6	6	6	7	7	7	7	7	7	7	7	6	6	6	0.2
1.5526E+14	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	0
1.8087E+14	-	-	-	7	8	8	8	8	8	8	7	7	-	-	-	7	7	7	7	0.1
1.9222E+14	-	-	-	9	8	8	8	8	7	7	7	7	-	-	-	6	6	6	6	0.2
1.9262E+14	-	-	-	9	8	8	8	8	7	7	7	7	-	-	-	7	7	7	7	0.1
1.9271E+14	-	-	-	7	8	8	8	8	7	7	7	7	-	-	-	7	7	7	7	0.1
1.9359E+14	9	8	8	9	8	8	8	8	8	-	-	-	-	-	-	-	-	-	-	0
2.0212E+14	9	8	8	9	8	8	8	8	8	8	8	8	8	8	-	-	-	-	-	0
2.0492E+14	9	8	8	9	8	8	8	8	8	-	-	8	-	-	-	-	-	-	-	0
2.0495E+14	9	8	8	9	8	8	8	8	8	8	8	-	8	8	-	8	8	8	8	0
2.081E+14	-	-	-	9	8	8	8	8	-	8	8	8	-	-	-	8	8	8	8	0

Table B.27. Bessie Substructure Ratings

Bridge #	**97**	**98**	**99**	**00**	**01**	**02**	**03**	**04**	**05**	**06**	**07**	**08**	**09**	**10**	**11**	**12**	**13**	**14**	**15**	**Avg**
3.852E+13	-	-	-	-	-	-	-	-	6	6	6	6	6	6	6	6	6	6	6	0
6.68E+13	-	-	-	-	-	-	-	-	-	5	5	6	6	6	6	6	6	6	6	0.1
1.2461E+14	-	-	-	6	6	6	6	6	6	6	5	-	5	5	5	5	5	5	5	0.1
1.2802E+14	-	-	-	6	6	6	6	6	7	7	6	6	6	6	6	5	5	5	5	0.2
1.2811E+14	-	-	-	5	6	6	6	6	6	6	6	6	6	6	5	5	5	5	5	0.1
1.5526E+14	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	0
1.8087E+14	-	-	-	6	6	6	6	6	7	7	6	6	-	-	-	5	5	5	5	0.2
1.9222E+14	-	-	-	6	6	6	6	6	7	7	6	6	-	-	-	6	6	6	6	0.1
1.9262E+14	-	-	-	6	6	6	6	6	7	7	6	6	-	-	-	5	5	5	5	0.2
1.9271E+14	-	-	-	6	6	6	6	6	6	6	6	6	-	-	-	5	5	5	5	0.1
2.0212E+14	7	7	7	7	7	7	7	7	7	7	7	8	8	5	-	-	-	-	-	0.1
2.0492E+14	7	7	7	7	7	7	7	7	7	-	-	8	-	-	-	-	-	-	-	0

Table B.28. Breckinridge Deck Ratings

Bridge #	**97**	**98**	**99**	**00**	**01**	**02**	**03**	**04**	**05**	**06**	**07**	**08**	**09**	**10**	**11**	**12**	**13**	**14**	**15**	**Avg**
2.382E+13	7	7	7	-	7	-	7	7	7	7	-	7	7	7	7	-	-	-	-	0
1.0024E+14	7	7	7	7	7	7	7	7	7	-	-	-	7	7	7	7	7	7	7	0
1.0172E+14	-	7	7	7	7	7	6	6	6	6	6	6	6	6	-	-	-	-	-	0.1
1.0308E+14	-	7	7	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	0.1
1.2541E+14	-	-	-	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	0
1.5135E+14	-	-	-	-	-	-	-	5	5	5	5	5	5	5	-	5	5	5	5	0
1.5363E+14	5	5	5	6	5	5	5	5	5	5	5	5	5	5	-	5	5	5	5	0
1.6597E+14	5	5	5	7	5	5	5	-	-	-	-	-	-	-	-	-	-	5	5	0
1.6718E+14	7	7	7	5	5	-	5	5	-	-	5	5	5	5	5	5	5	5	5	0.1
1.6958E+14	-	-	-	-	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	0
1.6972E+14	-	-	-	-	6	6	6	6	6	-	6	6	6	6	6	6	6	6	6	0
1.7267E+14	7	6	6	6	6	6	6	6	6	6	6	6	6	6	-	6	6	6	6	0
1.8489E+14	-	-	-	-	6	6	6	6	6	6	6	6	6	6	-	6	6	6	6	0
1.9045E+14	-	-	-	-	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	0
1.9059E+14	-	-	-	-	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	0
1.9081E+14	7	6	6	6	6	6	6	6	6	-	-	-	-	-	-	6	6	6	6	0
1.9085E+14	-	-	-	-	6	6	6	6	6	6	6	6	6	6	-	6	6	6	6	0
1.9216E+14	-	-	-	-	7	7	6	6	6	6	6	6	6	6	6	6	6	5	5	0.2
1.9239E+14	-	-	-	-	7	7	7	7	7	7	7	7	7	7	-	7	7	7	7	0
1.9256E+14	-	-	-	-	7	7	7	7	7	7	7	7	7	7	-	7	7	7	7	0
2.0527E+14	7	7	7	6	6	6	6	6	6	6	-	-	-	-	-	6	6	6	6	0.1
2.0538E+14	7	6	6	6	6	6	5	5	5	-	-	-	-	-	5	5	5	5	5	0.1
2.1313E+14	7	6	6	6	5	5	5	5	5	-	-	-	-	-	-	5	5	5	5	0.1
2.1327E+14	-	-	6	-	7	7	7	7	7	7	7	7	7	7	-	7	7	7	7	0
2.1339E+14	-	-	-	-	7	7	7	7	7	7	7	7	7	7	-	7	7	7	7	0

Bridge #	**97**	**98**	**99**	**00**	**01**	**02**	**03**	**04**	**05**	**06**	**07**	**08**	**09**	**10**	**11**	**12**	**13**	**14**	**15**	**Avg**
2.2616E+14	7	-	-	-	6	-	-	7	7	7	-	-	-	-	7	7	7	7	7	0
2.3027E+14	-	-	-	-	7	7	7	7	7	7	7	7	7	7	-	7	7	7	7	0
2.3404E+14	7	-	-	-	7	-	-	7	6	6	-	-	-	-	-	6	6	6	6	0.1
2.3756E+14	6	6	-	6	6	-	6	5	5	5	5	5	5	5	5	5	5	5	5	0.1
2.3872E+14	7	7	7	7	7	7	6	6	6	6	6	6	6	6	6	6	6	6	6	0.1

Table B.29. Breckinridge Superstructure Ratings

Bridge #	**97**	**98**	**99**	**00**	**01**	**02**	**03**	**04**	**05**	**06**	**07**	**08**	**09**	**10**	**11**	**12**	**13**	**14**	**15**	**Avg**
1.0024E+14	7	7	7	7	7	7	7	7	7	-	-	-	7	7	7	7	7	7	7	0
1.0172E+14	-	7	7	7	7	7	7	7	7	7	7	7	7	7	-	-	-	-	-	0
1.0308E+14	-	7	7	7	7	7	7	6	6	6	6	6	6	6	6	6	6	6	6	0.1
1.2541E+14	-	-	-	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	0
1.3643E+14	9	8	8	9	8	8	8	-	-	-	-	-	-	8	-	8	8	8	8	0.1
1.5135E+14	-	-	-	-	-	-	-	7	7	7	7	7	7	7	-	7	7	7	7	0
1.5363E+14	6	5	5	6	5	5	5	8	8	8	8	8	8	8	-	8	8	7	7	0.2
1.6718E+14	7	7	7	7	7	-	7	7	-	-	6	6	5	5	5	5	5	5	5	0.2
1.6972E+14	-	-	-	-	6	6	6	6	6	-	6	6	6	6	6	6	6	6	6	0
1.7267E+14	9	8	8	8	6	6	6	5	7	7	7	7	7	7	-	7	7	7	7	0.2
1.8489E+14	-	-	-	-	8	8	8	8	8	8	8	8	8	8	-	8	8	8	8	0
1.9045E+14	-	-	-	-	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	0
1.9059E+14	-	-	-	-	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	0
1.9081E+14	8	8	8	9	8	8	8	8	8	-	-	-	-	-	-	8	8	8	8	0
1.9085E+14	-	-	-	-	8	8	8	8	8	8	8	8	8	8	-	7	7	7	7	0.1
1.9216E+14	-	-	-	-	7	7	6	6	6	6	6	6	6	6	6	6	6	6	6	0.1
1.9239E+14	-	-	-	-	8	8	8	8	8	8	8	7	7	7	-	7	7	7	7	0.1
1.9256E+14	-	-	-	-	8	8	8	8	8	7	7	7	7	7	-	7	7	7	7	0.1

Bridge #	97	98	99	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	Avg
1.9344E+14	-	-	-	-	8	8	8	8	8	8	8	8	8	8	-	8	8	8	6	0
2.0527E+14	9	8	8	9	8	8	8	8	8	8	-	-	-	-	-	8	8	8	7	0
2.0538E+14	7	7	7	7	7	7	7	7	7	-	-	-	-	-	7	7	7	7	7	0
2.1313E+14	9	8	8	9	8	8	8	8	8	-	-	-	-	-	-	8	8	8	8	0
2.1327E+14	-	-	5	-	8	8	8	8	8	8	8	8	8	8	-	8	8	8	8	0
2.1339E+14	-	-	-	-	8	8	8	8	8	8	8	8	8	8	-	8	8	8	8	0
2.2616E+14	7	-	-	-	7	-	-	7	7	7	-	-	-	-	7	7	7	7	7	0
2.3027E+14	-	-	-	-	8	8	8	8	8	8	8	8	8	8	-	8	8	8	8	0
2.3404E+14	9	-	-	-	8	-	-	8	8	8	-	-	-	-	-	8	8	8	8	0
2.3756E+14	5	5	-	5	5	-	5	5	5	5	5	5	5	5	5	5	5	5	5	0
2.3872E+14	9	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	0

Table B.30. Breckinridge Substructure Ratings

Bridge #	97	98	99	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	Avg
2.382E+13	5	6	6	-	6	-	6	7	7	7	-	7	7	6	6	-	-	-	-	0.1
1.0024E+14	7	7	7	7	7	7	7	7	7	-	-	-	7	7	7	7	7	7	7	0
1.0172E+14	-	7	7	7	7	7	7	7	7	7	7	7	7	7	-	-	-	-	-	0
1.0308E+14	-	6	6	5	6	6	6	6	6	6	6	6	5	5	5	5	5	5	5	0.1
1.2541E+14	-	-	-	7	7	7	7	7	7	7	5	5	5	5	5	5	5	5	5	0.1
1.3642E+14	7	7	7	6	7	6	6	-	-	-	-	-	-	6	-	7	7	7	7	0.2
1.3643E+14	7	7	7	6	7	7	7	-	-	-	-	-	-	6	-	5	5	5	5	0.2
1.5135E+14	-	-	-	-	-	-	-	6	6	6	6	6	6	6	-	5	5	5	5	0.1
1.5363E+14	5	6	6	5	6	6	6	6	6	6	6	6	6	6	-	5	5	5	5	0.2
1.6597E+14	7	6	6	7	6	6	6	-	-	-	-	-	-	-	-	-	-	5	5	0.1
1.6718E+14	7	7	7	7	6	-	6	6	-	-	6	6	5	5	5	5	5	5	5	0.2
1.6958E+14	-	-	-	-	6	6	6	6	6	5	5	5	5	5	5	5	5	5	5	0.1

Bridge #	**97**	**98**	**99**	**00**	**01**	**02**	**03**	**04**	**05**	**06**	**07**	**08**	**09**	**10**	**11**	**12**	**13**	**14**	**15**	**Avg**
1.6972E+14	-	-	-	-	6	6	6	6	6	-	5	5	5	5	5	5	5	5	5	0.1
1.7267E+14	7	7	7	7	7	7	7	7	7	7	7	7	7	7	-	7	7	7	7	0
1.8489E+14	-	-	-	-	7	7	7	7	7	7	7	7	7	7	-	7	7	7	7	0
1.9045E+14	-	-	-	-	7	7	6	6	6	5	5	5	5	5	5	5	5	5	5	0.1
1.9059E+14	-	-	-	-	6	6	6	6	6	5	5	5	5	5	5	5	5	5	5	0.1
1.9081E+14	8	7	7	7	7	7	7	7	7	-	-	-	-	-	-	7	7	7	7	0
1.9085E+14	-	-	-	-	7	7	7	7	7	7	7	7	7	7	-	6	6	6	6	0.1
1.9216E+14	-	-	-	-	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	0
1.9239E+14	-	-	-	-	7	7	7	7	7	7	7	6	6	6	-	6	6	6	6	0.1
1.9256E+14	-	-	-	-	7	7	7	7	7	7	7	7	7	7	-	7	7	7	7	0
1.9344E+14	-	-	-	-	7	7	7	7	7	7	7	7	7	7	-	7	7	7	7	0
2.0527E+14	7	7	7	7	7	7	7	7	7	7	-	-	-	-	-	7	7	7	6	0
2.0538E+14	7	7	7	7	6	6	6	6	6	-	-	-	-	-	6	6	6	6	6	0.1
2.1313E+14	7	6	6	6	5	5	5	5	5	-	-	-	-	-	-	5	5	5	5	0.1
2.2616E+14	7	-	-	-	7	-	-	7	7	7	-	-	-	-	7	7	7	7	7	0
2.3027E+14	-	-	-	-	7	7	7	7	7	7	7	7	7	7	-	7	7	7	7	0
2.3404E+14	7	-	-	-	7	-	-	7	7	7	-	-	-	-	-	7	7	7	7	0
2.3756E+14	5	6	-	6	6	-	6	6	6	6	6	6	6	6	6	5	5	5	5	0.1

Table B.31. Burneyville Deck Ratings

Bridge #	**97**	**98**	**99**	**00**	**01**	**02**	**03**	**04**	**05**	**06**	**07**	**08**	**09**	**10**	**11**	**12**	**13**	**14**	**15**	**Avg**
1.0916E+14	6	7	7	7	7	7	7	7	7	7	-	-	-	-	-	-	5	-	-	0.1
2.0753E+14	6	7	7	7	7	7	7	7	7	7	7	7	7	7	-	-	-	-	-	0
2.0757E+14	7	7	7	7	7	7	7	7	7	7	7	7	7	7	-	7	-	7	7	0
2.104E+14	6	7	7	7	7	7	7	7	7	7	7	7	7	7	-	7	7	7	7	0
2.1507E+14	7	7	7	7	7	7	7	7	7	7	7	7	7	7	-	7	6	7	7	0
2.1976E+14	6	7	7	7	7	7	7	7	7	7	7	7	7	7	-	7	7	7	7	0
2.2319E+14	7	7	7	7	7	7	7	7	7	7	7	7	7	7	-	7	7	7	7	0
2.2579E+14	7	7	7	7	7	7	7	7	7	7	7	7	7	7	-	7	7	7	7	0
2.2599E+14	7	7	7	7	7	7	7	7	7	7	7	7	7	7	-	7	7	7	7	0
2.2829E+14	7	7	7	7	7	7	7	7	7	7	7	7	7	7	-	7	7	7	7	0
2.4191E+14	7	9	9	9	7	7	7	7	7	7	7	7	7	7	-	7	7	7	7	0.2
2.4299E+14	-	-	-	-	-	7	7	7	7	7	7	7	7	7	-	7	7	7	7	0
2.4523E+14	7	6	6	6	7	7	7	7	7	7	7	7	7	7	-	7	7	7	7	0
2.5036E+14	-	-	-	-	-	-	-	7	7	7	7	7	7	7	-	7	7	7	7	0
2.6456E+14	-	-	-	-	-	-	-	-	7	7	7	7	7	7	-	7	7	7	7	0
2.6457E+14	-	-	-	-	-	-	-	-	7	7	7	7	7	7	-	7	7	7	7	0
2.7077E+14	-	-	-	-	-	-	-	7	7	7	7	7	7	7	-	7	7	7	7	0

Table B.32. Burneyville Superstructure Ratings

Bridge #	**97**	**98**	**99**	**00**	**01**	**02**	**03**	**04**	**05**	**06**	**07**	**08**	**09**	**10**	**11**	**12**	**13**	**14**	**15**	**Avg**
1.0916E+14	6	7	7	7	7	7	7	7	7	7	-	-	-	-	-	-	-	-	-	0
2.0753E+14	9	8	8	8	8	8	8	8	8	8	8	8	8	8	-	-	-	-	-	0
2.0757E+14	9	8	8	8	8	8	8	8	8	8	8	8	8	8	-	8	7	8	8	0
2.104E+14	9	8	8	8	8	8	8	8	8	7	7	7	7	7	-	7	7	7	7	0.1
2.1507E+14	9	8	8	8	8	8	8	8	8	7	7	7	7	7	-	7	7	7	7	0.1
2.1976E+14	9	8	8	8	8	8	8	8	8	8	8	8	8	8	-	8	7	8	8	0
2.2319E+14	9	8	8	8	8	8	8	8	8	8	8	8	8	8	-	8	7	8	8	0
2.2579E+14	9	8	8	8	8	8	8	8	8	7	7	7	7	7	-	7	7	7	7	0.1
2.2599E+14	9	8	8	8	8	8	8	8	8	8	8	8	8	8	-	8	7	8	8	0
2.2829E+14	9	8	8	8	8	8	8	8	8	8	8	8	8	8	-	8	7	8	8	0
2.4191E+14	9	9	9	9	8	8	8	8	8	8	8	8	8	8	-	8	7	8	8	0
2.4299E+14	-	-	-	-	-	8	8	8	8	8	8	8	8	8	-	8	7	8	8	0
2.4523E+14	9	9	9	9	8	8	8	8	8	8	8	8	8	8	-	8	7	8	8	0
2.5036E+14	-	-	-	-	-	-	-	8	8	8	8	8	8	8	-	8	7	8	8	0
2.6456E+14	-	-	-	-	-	-	-	-	8	8	8	8	8	8	-	8	7	8	8	0
2.6457E+14	-	-	-	-	-	-	-	-	8	8	8	8	8	8	-	8	7	8	8	0
2.7077E+14	-	-	-	-	-	-	-	8	8	8	8	8	8	8	-	8	7	8	8	0

Table B.33. Burneyville Substructure Ratings

Bridge #	**97**	**98**	**99**	**00**	**01**	**02**	**03**	**04**	**05**	**06**	**07**	**08**	**09**	**10**	**11**	**12**	**13**	**14**	**15**	**Avg**
6.214E+13	5	5	5	5	5	8	8	8	8	7	7	7	7	7	7	7	7	7	7	0.2
1.0916E+14	6	6	6	6	6	6	6	6	6	5	-	-	-	-	-	-	-	-	-	0
2.0753E+14	7	7	7	7	7	7	7	7	7	5	5	5	5	5	-	-	-	-	-	0.1
2.0757E+14	7	7	7	7	7	7	7	7	7	7	7	7	7	7	-	7	8	7	7	0
2.104E+14	7	7	7	7	7	7	7	7	7	7	7	7	6	6	-	6	7	6	6	0.1
2.1976E+14	7	7	7	7	7	7	7	7	7	7	7	7	7	7	-	7	8	7	7	0
2.2319E+14	7	7	7	7	7	7	7	7	7	7	7	7	7	7	-	7	8	7	7	0
2.2579E+14	7	7	7	7	7	7	7	7	7	7	7	7	7	7	-	7	7	7	7	0
2.2599E+14	7	7	7	7	7	7	7	7	7	7	7	7	7	7	-	7	8	7	7	0
2.2829E+14	7	7	7	7	7	7	7	7	7	7	7	7	7	7	-	7	8	7	7	0
2.4191E+14	7	7	7	7	7	7	7	7	7	7	7	7	7	7	-	7	8	7	7	0
2.4299E+14	-	-	-	-	-	7	7	7	7	7	7	7	7	7	-	7	8	7	7	0
2.4523E+14	7	7	7	7	7	7	7	7	7	7	7	7	7	7	-	7	8	7	7	0
2.5-36E+14	-	-	-	-	-	-	-	7	7	7	7	7	7	7	-	7	8	7	7	0
2.6456E+14	-	-	-	-	-	-	-	-	7	7	7	7	7	7	-	7	8	7	7	0
2.6457E+14	-	-	-	-	-	-	-	-	7	7	7	7	7	7	-	7	8	7	7	0
2.7077E+14	-	-	-	-	-	-	-	7	7	7	7	7	7	7	-	7	8	7	7	0

Table B.34. Westville Deck Ratings

Bridge #	**97**	**98**	**99**	**00**	**01**	**02**	**03**	**04**	**05**	**06**	**07**	**08**	**09**	**10**	**11**	**12**	**13**	**14**	**15**	**Avg**
4.634E+13	-	-	-	6	-	-	-	-	-	6	-	6	6	6	6	6	6	6	6	0
6.635E+13	-	-	6	6	6	-	6	6	6	6	-	6	6	6	6	-	-	6	6	0
1.0051E+14	7	7	6	6	6	-	-	-	-	6	-	-	-	-	-	6	6	6	6	0.1
1.2835E+14	-	-	-	6	5	5	5	5	-	-	5	5	5	5	5	5	5	5	5	0
1.3086E+14	-	-	-	5	5	5	5	5	-	-	-	-	5	5	5	5	5	5	5	0
2.2605E+14	7	7	7	7	7	7	7	7	7	7	7	7	7	7	-	7	7	7	7	0
2.4787E+14	-	-	-	-	-	-	7	7	7	7	7	7	7	7	-	7	7	-	-	0
2.4789E+14	-	-	-	-	-	7	7	7	7	7	7	7	7	7	-	7	7	7	7	0

Table B.35. Westville Superstructure Ratings

Bridge #	**97**	**98**	**99**	**00**	**01**	**02**	**03**	**04**	**05**	**06**	**07**	**08**	**09**	**10**	**11**	**12**	**13**	**14**	**15**	**Avg**
4.634E+13	-	6	-	6	-	-	-	-	-	6	-	6	6	6	6	6	6	6	6	0
6.635E+13	-	6	6	6	6	-	6	6	6	6	-	6	6	6	6	-	-	6	6	0
6.636E+13	-	7	7	7	7	6	6	6	6	6	-	-	-	-	-	-	-	-	-	0.1
1.0051E+14	7	6	6	6	6	-	-	-	-	6	-	-	-	-	-	6	6	6	6	0
1.2835E+14	-	-	-	7	7	7	6	6	-	-	6	6	6	6	6	6	6	6	6	0.1
1.3086E+14	-	-	-	5	6	6	6	6	-	-	-	-	6	6	6	6	6	6	6	0
2.2605E+14	9	8	8	8	8	8	8	8	8	8	8	8	8	8	-	8	8	8	8	0
2.4787E+14	-	-	-	-	-	-	8	8	8	8	8	8	8	8	-	8	8	-	-	0
2.4789E+14	-	-	-	-	-	8	8	8	8	8	8	8	8	8	-	8	8	7	7	0.1
2.6059E+14	-	-	-	-	-	-	-	8	8	8	8	8	8	8	-	8	8	8	8	0

Table B.36. Westville Substructure Ratings

Bridge #	**97**	**98**	**99**	**00**	**01**	**02**	**03**	**04**	**05**	**06**	**07**	**08**	**09**	**10**	**11**	**12**	**13**	**14**	**15**	**Avg**
6.635E+13	-	5	5	5	5	-	5	5	5	5	-	5	5	5	5	-	-	5	5	0
6.636E+13	-	5	5	5	5	5	5	5	5	5	-	-	-	-	-	-	-	-	-	0
1.0051E+14	8	5	5	5	5	-	-	-	-	5	-	-	-	-	-	5	5	5	5	0
1.2835E+14	-	-	-	5	5	5	5	5	-	-	5	5	5	5	5	5	5	5	5	0
1.3086E+14	-	-	-	7	6	6	6	6	-	-	-	-	6	6	6	6	6	6	6	0
2.2605E+14	7	7	7	7	7	7	7	7	7	7	7	7	7	7	-	7	7	7	7	0
2.4787E+14	-	-	-	-	-	-	7	7	7	7	7	7	7	7	-	7	7	-	-	0
2.4789E+14	-	-	-	-	-	7	7	7	7	7	7	7	7	7	-	7	7	7	7	0