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Methodologies for Evaluating the Importance of Highway Bridges

by

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Preface

The Multidisciplinary Center for Earthquake Engineering Research (MCEER) is a national center of excellence in advanced technology applications that is dedicated to the reduction of earthquake losses nationwide. Headquartered at the State University of New York at Buffalo, the Center was originally established by the National Science Foundation in 1986, as the National Center for Earthquake Engineering Research (NCEER).

Comprising a consortium of researchers from numerous disciplines and institutions throughout the United States, the Center's mission is to reduce earthquake losses through research and the application of advanced technologies that improve engineering, pre-earthquake planning and post-earthquake recovery strategies. Toward this end, the Center coordinates a nationwide program of multidisciplinary team research, education and outreach activities.

MCEER's research is conducted under the sponsorship of two major federal agencies, the National Science Foundation (NSF) and the Federal Highway Administration (FHWA), and the State of New York. Significant support is also derived from the Federal Emergency Management Agency (FEMA), other state governments, academic institutions, foreign governments and private industry.

The Center's FHWA-sponsored Highway Project develops retrofit and evaluation methodologies for existing bridges and other highway structures (including tunnels, retaining structures, slopes, culverts, and pavements), and improved seismic design criteria and procedures for bridges and other highway structures. Specifically, tasks are being conducted to:

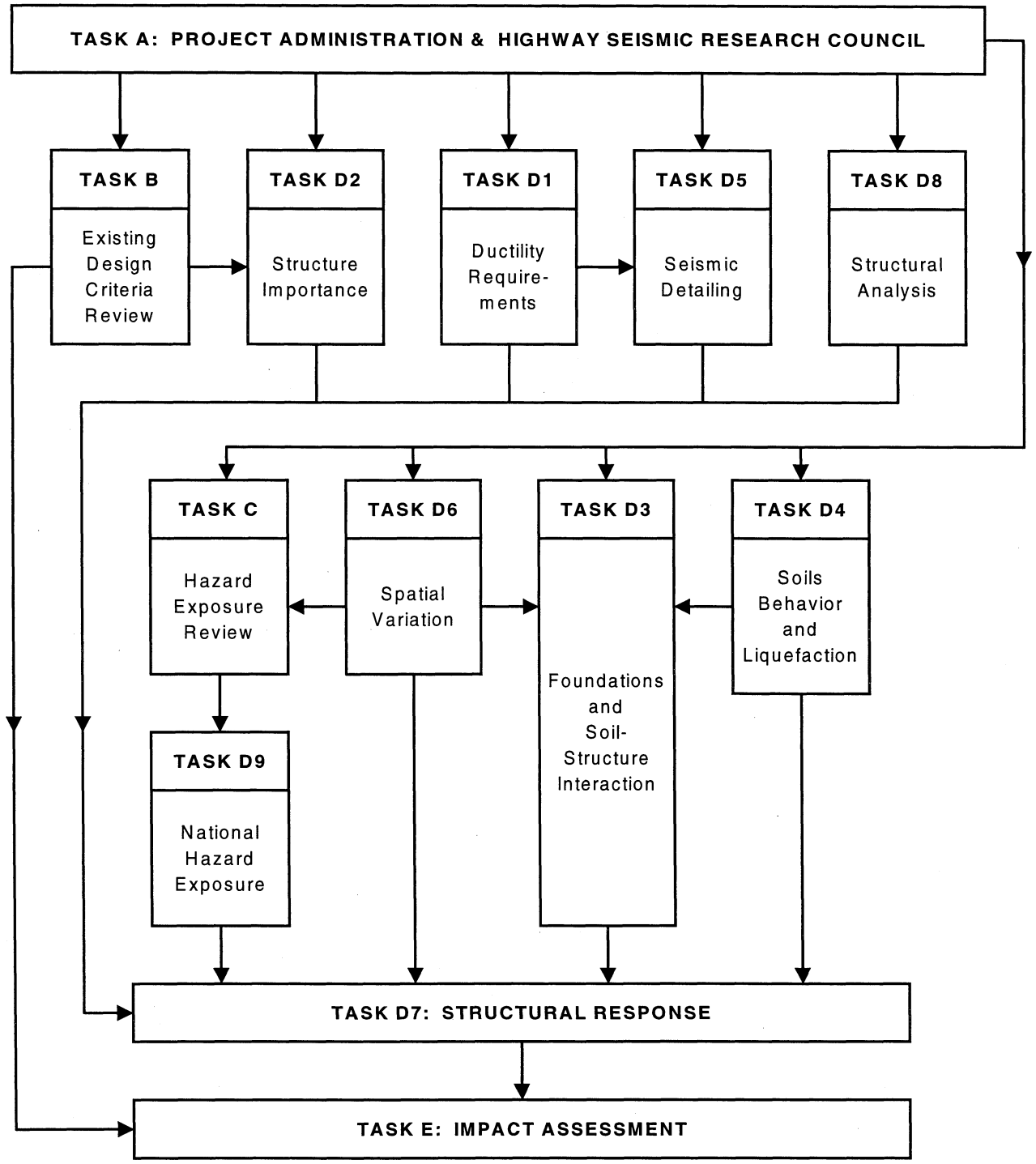
- assess the vulnerability of highway systems, structures and components
- develop concepts for retrofitting vulnerable highway structures and components;
- develop improved design and analysis methodologies for bridges, tunnels, and retaining structures, which include consideration of soil-structure interaction mechanisms and their influence on structural response;
- review and recommend improved seismic design and performance criteria for new highway structures.

Highway Project research focuses on two distinct areas: the development of improved design criteria and philosophies for new or future highway construction, and the development of improved analysis and retrofitting methodologies for existing highway systems and structures. The research discussed in this report is a result of work conducted under the new highway structures project, and was performed within Task 112-D-2, "Evaluation of Structure Importance" of that project as shown in the flowchart on the following page.

The overall objective of this task was to identify, assess and develop recommended improvements to existing methodologies for defining the importance of highway bridges. The report describes the work that was conducted leading to a simple bridge importance evaluation methodology developed by the authors. The 50 state transportation agencies were surveyed to identify how each state determines and classifies the importance of their bridges. Twelve importance methods were chosen from these replies for further investigation. Following a comparison of these methods, two were

selected for further evaluation: one from Illinois and the other from Montana. A recommended method, based on these two methods and additional refinements, was developed which works with a state's existing National Bridge Inventory (NBI) data and does not require the collection of new data. The method fills a need for states in low to moderate zones which need to develop or implement an importance method at little or no cost.

SEISMIC VULNERABILITY OF NEW HIGHWAY CONSTRUCTION
FHWA Contract DTFH61-92-C-00112



PREFACE

The objective of this report is to identify and assess existing methods for quantifying the importance of highway bridges. Several existing methods are compared and a preferred method is recommended for use in the design of new bridges and the retrofit of existing structures.

It is common practice to use importance, along with hazard exposure and structure vulnerability, to prioritize and specify minimum requirements for the retrofit of existing bridges. Similarly, hazard and importance are frequently used to specify minimum levels of analysis and design requirements for new bridges. But the importance of a bridge is a difficult attribute to quantify and although there have been many attempts to do so, there is little consensus about a preferred methodology. Generally these methods include traffic volume, detour length, the presence or absence of utilities and some form of functional classification (e.g. emergency route, interstate highway, defense route, and the like.) Few, if any, include network redundancy and socio-economic issues, both of which are even more difficult to quantify than the earlier set of attributes.

Nevertheless it is essential that an agreed definition of importance be developed particularly in view of the increasing number of owner-agencies who are establishing bridge retrofit programs. The prudent allocation of scarce resources to individual bridges is dependent on a rational methodology for assessing bridge importance.

This report therefore examines several of the most common methods and makes a comparative assessment of their relative work, first against each other and then against engineering judgment for two different inventories. Recommendations are made for a preferred method and modifications to existing AASHTO and FHWA provisions are suggested which indicate how this method might be included in these specifications.

In order to achieve this result, the difficult issues of network redundancy and socio-economic impacts have been set aside. (Whereas detour length has been included in this work, as a measure of network redundancy, it is not a reliable one since there is always the possibility that the identified detour is closed by the same earthquake.) These issues are the subject of another research task in the Highway Project at NCEER. Network redundancy is being explicitly modelled in a seismic risk assessment task and future expansions to this task will likely include economic factors. However, the routine application of this work, to the prioritization of retrofit projects for example, is still some years away. In the meantime the recommendations made in this report are expected to serve a useful purpose.

ABSTRACT

The location of a structure with respect to seismic hazards, its seismic vulnerability and its importance are factors which are used in determining what seismic design or seismic retrofit level a structure belongs in. This research evaluated methods for determining the importance of a structure and how to use this importance in seismic design and retrofitting specifications.

This report develops a method for determining the importance of a bridge. This importance ranking of a bridge is then used in proposed revisions to seismic bridge design and retrofitting specifications. Depending on the relative importance bridge ranking, design or retrofitting requirements will be increased or decreased (e.g. the higher the importance ranking, the greater the seismic design or retrofitting requirements). This report also provides for existing importance methods to be used with the seismic design and retrofitting specifications.

ACKNOWLEDGMENT

This research is through NCEER Project 112 which receives its funding from the FHWA.

The authors would like to thank Mr. Ayaz H. Malik of the New York State Department of Transportation (NYSDOT) and Mr. Hal Rogers of Pennsylvania Department of Transportation (PennDOT) for providing their state's bridge management data to us for our use.

We would also like to thank the many persons from the various government agencies who provided us with information and responded to our surveys.

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SECTION 1
INTRODUCTION

In the summer of 1993, the National Center for Earthquake Engineering Research (NCEER) initiated a research program with the goal of providing improved design and analysis procedures intended to minimize the seismic vulnerability of new highway infrastructure. The research is sponsored by the Federal Highway Administration (FHWA) of the U.S. Department of Transportation and consists of a series of studies, each focussed on the seismic design and analysis of particular highway system components and structural elements, and performed by researchers with expertise in that area of study.

The overall objective of Task 112-D-2 is to identify, assess and develop improvements to existing methodologies for defining structure importance, and to provide recommended definitions of importance and classification systems based on importance.

The location of a structure with respect to seismic hazards, its seismic vulnerability and its importance are factors which are used in determining the level to which a structure should be seismically designed or retrofitted. This research studied how to determine the importance of a structure and how to use this importance in seismic design and retrofitting specifications. This research envisions structural importance being used for preliminary ranking and screening for seismic retrofitting and as a design and/or retrofit parameter. Since seismic hazard and seismic vulnerability were not specific issues in this research, the structural importance information provided in this report could also be used to determine priorities for bridge issues unrelated to seismic activities.

A survey conducted under NCEER Highway Project Task 106-B(h) showed that nearly all states in high seismic risk areas had employed an importance ranking method. Therefore the most likely users of a importance method developed from this project would be those states which do not presently have an importance methodology in place or those which are still attempting to refine their procedures. This survey also indicated that twenty states, nearly all of them in low to moderate seismic risk zones, did not have an importance method. It is the researchers opinion that any system for determining importance must allow existing importance classification systems to be used. Further, any importance ranking method developed from this project must be cost effective and easy enough for those in low to moderate seismic risk areas to implement.

Figure 1-1 provides a general sequence of the major steps within this NCEER task from the review of the existing importance methods to the development of recommended specifications.

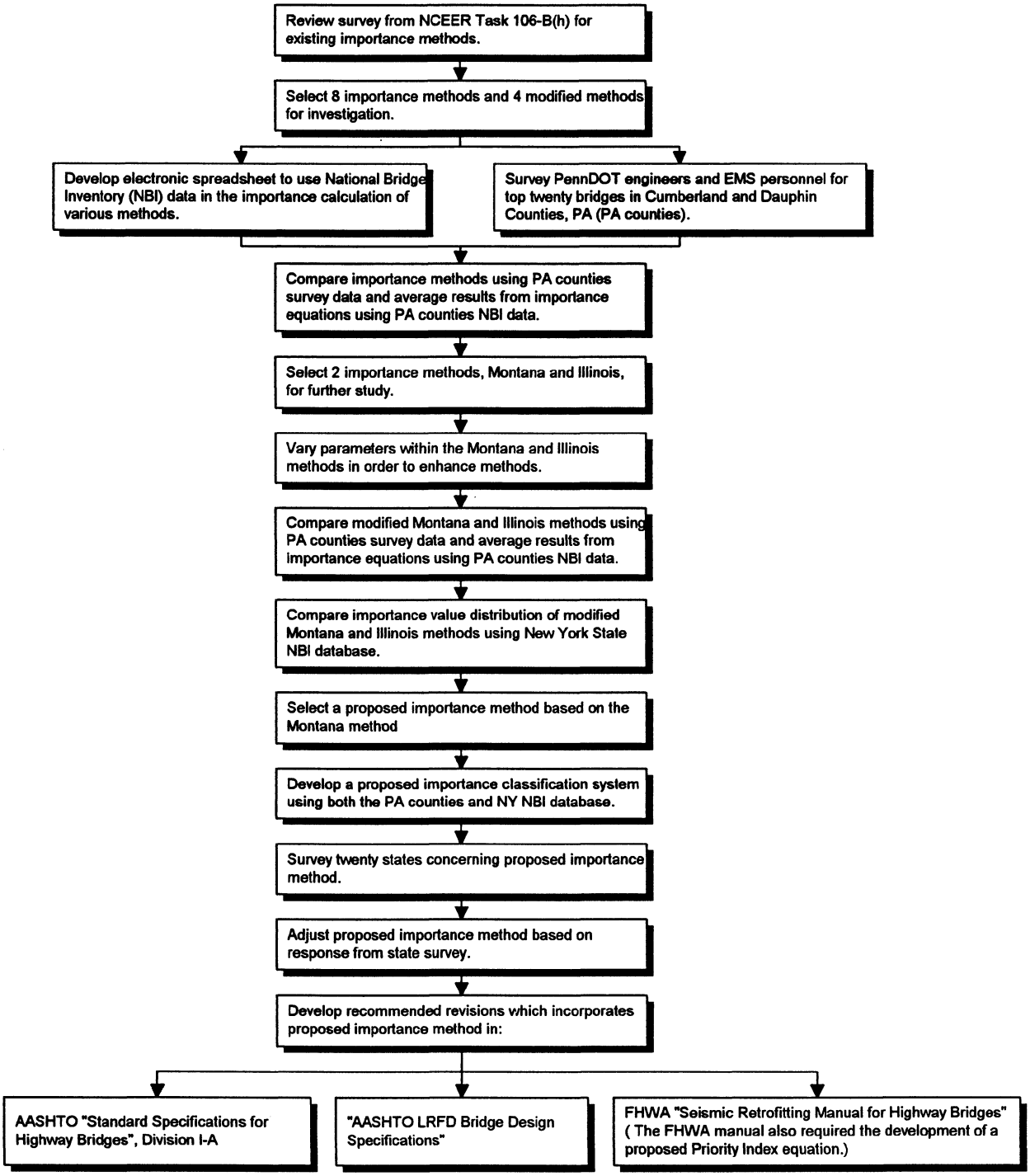


FIGURE 1-1 Sequence of Major Research Steps

SECTION 2
EVALUATION OF EXISTING IMPORTANCE METHODS

The investigation of defining structural importance was initiated with a survey via NCEER Highway Project Task 106-B(h) of the 50 states to identify how each state determines the importance of their bridges. Eight importance methods were chosen from the replies for investigation. In addition to those eight methods, four modified methods were also investigated resulting in a total of 12 methods. The investigation was based on information required in the National Bridge Inventory (NBI) records.

A definition list of terms used throughout this report is given below:

ADT:	Average Daily Traffic.
FADT:	Future Average Daily Traffic.
Bridge Length:	Total structure length as defined in FHWA-ED-89-044.
Critical Route:	The controlling route being considered if there is more than one route on or under the structure.
Carry:	Relating to the critical route on the structure being investigated.
Cross:	Relating to the critical route under the structure being investigated.
Bridge Rank:	A bridge's position in order of importance.
Rankings:	A list of bridges ranked in order of importance.

The equation and the definition of terms for each of the 12 methods are given in Appendix A. A general description of the highlights of each method is listed below:

- Babaei and Hawkins '91 (B&H): This method uses an ADT reference value of 30,000 and does not make a distinction among bridges with detour lengths greater than 16 km, (used by the Washington DOT).

- Modified Babaei and Hawkins: The reference ADT was adjusted from 30,000 to 6,000.

- Buckle '95: Includes a definition of a critical bridge as well as an equation to calculate the priority index, importance value, (used by the New York DOT). This investigation used only the equation.

- Modified Buckle '95: FADT was replaced by ADT.

- Caltrans: Importance calculations include a variable, leased air space, when considering the item being crossed by a structure. Leased air space is divided into two importance categories, residential/office and parking/storage. Since FHWA does not require this data to be collected in the NBIS, the lease air space variable was removed from this investigation. If the item crossed is not a waterway, road, or railroad, then it shall be categorized as other.

- Montana: This is a modification of the Babaei and Hawkins method. The terms

modified are the ADT reference value, detour length coefficient, utility considerations, and river crossing considerations. The reference value used in the Montana method is 6000 not 30,000 as in the Babaei and Hawkins method. This method considers five detour length categories as opposed to three. The coefficients for these categories are 0.7, 0.8, 0.9, 1.0 and 1.2, while Babaei and Hawkins uses 0.75, 0.8, and 1.0. The final modification is replacing the utility carried term with a river crossing term. The river crossing term is based on the structure length for structures crossing water.

- Nevada: This method includes a separate railroad consideration, most methods did not have this consideration. The importance of a railroad falls between primary and secondary routes according to this method. Therefore, this method places a higher importance ranking on bridges that carry or cross railroads than the other methods investigated. The Nevada method also included a maximum ADT value of 90,000. This maximum value was neglected in this investigation.

- South Carolina: This method calculates importance rating values as an integer. Minimums and maximum are applied to these values. This results in ratings ranging from of 0 to 10. Because of the integer ratings, bridges are divided into 11 importance rankings.

- Modified South Carolina: The maximum rating values were removed for this method.

- Missouri: This method bases the importance value on a spacing factor instead of the actual ADT value. This spacing factor is an estimate of the vehicle spacing based on the ADT. The spacing factor ranges from 0.2 to 2.0 based on the ADT. There are five categories of ADT each having a corresponding spacing coefficient. One category is for routes with an ADT of 50,000 to 100,000. The Missouri method makes no distinction between a route with an ADT of 50,000 than one with an ADT of 100,000. The other methods use the actual ADT value and therefore make a distinction between these routes.

- Modified Missouri: The Missouri method was modified by setting a maximum bridge length = 1610 m (5280 ft). This prevented structures with a total structure length larger than 1610 m from dominating the importance rankings.

- IDOT: This method considers the Illinois Earthquake Emergency Routes. Similarly to the leased air space in the Caltrans method, this data is not required by the FHWA. Therefore, the emergency route variable was removed from this investigation.

All states are currently required to inspect all public bridges greater than 6.0 meters biennially. The

Recording and Coding Guide for the Structure Inventory and Appraisal of the Nation's Bridges, FHWA-ED-89-044, describes the requirements of NBI records. The Guide describes the minimum amount of bridge data required by FHWA. However, a state may collect more data than required by the Guide but shall only report the required data to FHWA. This investigation used the information required by the Guide as a limit for the input. Therefore, all states already have and maintain the data required by the importance equations. A state can implement the proposed method without changing their database. In addition, all importance calculations can be performed without addition human input because there is no interpretation of input data necessary. The ranking process can be automated because there is no human input. However, some engineering judgement should still be used in the analysis of the importance results.

The general information required by each of the 12 methods is given in tables 2-1 and 2-2. Table 2-1 and table 2-2 pertains to data on the structure and under the structure, respectively.

TABLE 2-1 On the Structure Data Requirements

Method	FeatureCarried													
	Service Type	Route Type	Func. Class	L	W	# of Lanes	ADT	FADT	Detour Length	Util.	Fed. Fund.	Def. Des.	Nat. Net.	*Lease Space
B & H '91			X	X			X		X	X		X		
Mod. B & H '91			X	X			X		X	X		X		
Buckle'95			X					X	X	X				
Mod. Buckle'95			X				X		X	X				
Caltrans		X					X		X	X	X			X
Montana			X	X			X		X					
Nevada	X		X	X	X	X	X		X	X		X		
South Carolina		X		X	X		X		X			X	X	
Mod. South Carolina		X		X	X		X		X			X	X	
Missouri			X	X	X	X	X		X					
Mod. Missouri			X	X	X	X	X		X					
IDOT	X			X	X		X		X	X		X		

L = BridgeLength
W = BridgeWidth
Util.= Utilities
Def. Des. = DefenseHighwayDesignation
Nat. Net.= DesignatedNationalNetwork
* = Data not requiredin NBI records

TABLE 2-2 Under the Structure Data Requirements

Method	Feature Crossed							
	Service Type	Route Type	Func. Class	# of Lanes	ADT	Detour Length	Fed. Fund.	Def. Des.
B&H '91			X		X	X		X
Mod. B&H '91			X		X	X		X
Buckle '95								
Mod. Buckle '95								
Caltrans		X			X		X	
Montana	X		X		X	X		
Nevada	X		X	X	X	X		X
South Carolina	X	X						
Mod. South Carolina	X	X						
Missouri				X	X			
Mod. Missouri				X	X			
IDOT	X				X	X		X

New York State Department of Transportation (NYSDOT) provided a copy of their Bridge Management System (BMS) database which contained all the FHWA required structure inventory data for 19,740 bridges. The necessary data was imported into an Microsoft EXCEL Spreadsheet. A macro was written to calculate the importance rating for all 19,740 bridges using each of the 12 methods.

South Carolina and Modified South Carolina methods are based on two importance classifications (IC), I and II. A bridge is classified as IC=I, when the structure carries or crosses an interstate, defense highway, designated truck network, or access to a critical facility. All other bridges are classified as IC=II. The basic ratings are assigned an initial integer rating value of 1 or 6 for IC = II or I, respectively. Then integer values of -1 to 3 are added to the initial rating based on importance criteria, i.e. ADT, interchanges, deck area and item crossed. Maximum rating values of 5 and 10 are used for IC = II and IC =I, respectively. The IC = II limit insures that a bridge with an IC = II can not be ranked higher than an IC = I bridge. Based on the NYSDOT database calculations both integer rating methods were eliminated as possible methods, because this type of rating results in a large number of bridges with the same importance value. In the case of the South Carolina method, 2,193 of the 19,740 bridges were ranked as the most important bridge. While some engineering judgement is required to interpret the results from all the methods, deciding among 2,193 bridges would be too subjective.

The Modified South Carolina method was developed to decrease the amount of bridges ranked as the most important by eliminating the maximum rating values of 10 and 5 for IC=I and II, respectively. The highest calculated importance rating value was 13. This distributed the 2,193 bridges among 4 rankings. The redistribution among the four rankings values, i.e. 13, 12, 11, and 10, are 12, 281, 926, and 974 bridges, respectively. Although this method provided a better distribution of bridge importance than the South Carolina method, the results were very subjective when compared with the remaining 10 methods. It was felt that an effective importance method should be more discriminating and thereby limit the amount of interpretation required.

The NYSDOT database proved too large to be used as a comparison database for an initial investigation. With 19,740 bridges and 12 importance methods, conclusions could not be drawn for individual bridges. Comparisons of at least the top 500 ranked bridges would be required to establish importance value trends on bridge types. Therefore, the NYSDOT database was only used to examine the distribution of the importance values. It also provided a check for possible errors in the importance methods and/or the EXCEL macro when they were used with a large database.

Pennsylvania Department of Transportation (PennDOT) provided a copy of their Bridge Management System (BMS) database for Cumberland and Dauphin Counties. The PennDOT databases were used for further investigation because of their size, the diversity of bridges, and the researchers' familiarity with these counties.

Dauphin and Cumberland Counties are located in South Central Pennsylvania. Along with a third county, Perry County, this section is sometimes referred to as the Capitol Area Region. Both counties include industrial, residential, agricultural and forested land. Therefore, a wide variety of bridge crossings and traffic conditions exist within these counties. The population of Dauphin County is 246,338 and the largest city is Harrisburg, which is the state capitol, with a population of 54,238. The population of Cumberland County is 205,959 and the largest city is Carlisle with a population of 18,419. The average number of daily commuters in Dauphin and Cumberland County as per the 1990 census is 116,181 and 98,577, respectively. However, these figures are not reflective of the current traffic volumes due to the regional population increases in the last 8 years.

There are three interstate highways (I-83, I-81, and I-76), two rail services (Amtrak and Conrail), and numerous 4 lane routes and bypasses are located within these counties. Some critical importance issues to consider in these counties are Three Mile Island Nuclear Reactor, Naval Inventory Control Point (NAVICP)- Mechanicsburg, Defense Distribution Center (DDC), 7 hospitals, Susquehanna River, major truck terminals and I-81 access to Fort Indian Town Gap. Therefore, Dauphin and Cumberland County provided a wide range of importance issues to be analyzed.

I-83 extends north from Baltimore, Maryland to Harrisburg, Pennsylvania. Adjacent to Baltimore, I-83 connects with I-70, I-95, and I-695. At the Harrisburg end, I-83 connects with I-76 and I-81. I-81 is a north-south connector to I-80, I-78, and I-84. I-81 extends from Knoxville, Tennessee through New York and into Canada. This interstate is one of the major trucking routes between the Southern, Mid-Atlantic, and New England states. The Pennsylvania Turnpike, I-76, is an east-west connector which extends from Ohio to New Jersey. The major cities of Philadelphia and Pittsburgh are located along I-76 adjacent to the New Jersey and Ohio borders, respectively. Most major truck terminals in the Capitol Area Region are located in Carlisle at the intersection of I-81 and I-76. Philadelphia, Baltimore, and Washington D.C. can be reached using these interstates in 2 hours or less. New York City and Pittsburgh are approximately 4 hours away.

Using EXCEL, the 549 Cumberland County Bridges and 606 Dauphin County Bridges were rated for each method including the South Carolina methods, with the exception of the Modified Missouri method. The Modified Missouri method was not investigated because all the bridges in these counties had span lengths smaller than the maximum of 1610 m (5280'). Since the only difference between the two Missouri methods is the arbitrary setting of a maximum span length of 1610 m, both Missouri methods would give identical results. The South Carolina methods were used with the PennDOT database. However, as mentioned previously these techniques were not viable options. The South Carolina results were used only as a comparison.

The bridges were ranked for each county by each importance method. The top 3% of bridges identified by each method were plotted on county maps. In an ideal situation, all of the methods would rank the same 3% of bridges as the most important. However, this was not the case in this investigation. The bridges ranked most important by the each method were plotted to determine if a specific controlling importance issue could be the reason for the difference. Once the bridges are plotted on a map, trends to several controlling importance issues are detectable. The most noticeable trend is dependency upon traffic volume. This was shown by the plotted bridges being located upon several of the large interstates in these counties. Which interstate bridges depended on what other issue or issues the particular method being investigated considered important. Some importance issue trends noticed for the route on the bridge include; ADT, bridge length, rail traffic, and detour length. Some importance issue trends noticed for the route crossed by the bridge include; ADT, water crossings, and rail traffic. Once a trend for a method was noticed, several major importance issues for each method could be noted. This information was critical in later investigations when variations of the methods were made. The knowledge of major importance issues for a given method aided in determining what issue needed to be adjusted to obtain the desired results. In addition to the graphing, the results were compared to the following five rankings:

- An average ranking of all the methods for Dauphin County.
- An average ranking of all the methods for Cumberland County.
- The average results of a survey of PennDOT Engineers in Dauphin County.
- The average results of a survey of PennDOT Engineers in Cumberland County.
- The results of a survey of the Emergency Management System (EMS) of Dauphin County.

Cumberland County EMS was asked to participate, but did not respond to the survey.

The PennDOT survey involved the input of five state engineers working in both Dauphin and Cumberland Counties. The survey requested that the engineer list, in order, the twenty bridges which were the most important in their opinion. A copy of the survey letter is given in Appendix B.

The opinions of the five PennDOT engineers on the twenty most important structures in each county varied. The Cumberland and Dauphin County survey results are given in tables 2-3 and 2-4, respectively. Among the responses from the engineers, 49 different bridges were ranked in the top twenty for Cumberland County. Likewise, 45 different bridges were ranked in the top twenty for Dauphin County. Therefore, even the engineers familiar with these bridges have a wide variance in the concept of their structural importance. The five survey results for each county were averaged together to get an overall top twenty ranking.

TABLE 2-3 PennDOT Survey Responses for Cumberland County

Structural ID Number	Bridge Rank				
	Engineer 1	Engineer 2	Engineer 3	Engineer 4	Engineer 5
21001107400000			3		
21001107600000	5	8	7		2
21001108701474	10		8		4
21001108711456					5
21001108900000			9		
21001109800000	6		4		16
21001109810485					17
21001500601043	9				
21001501700000	7		6		
21001501700863	8				
21003403500025		11			
21007400202954		10			
21008103140410	11				
21008103540163				20	
21008103642258		19		13	
21008103901611				11	
21008103911674				12	
21008104400185	18	18	17		
21008104540557	17	17	16		
21008104601016				18	
21008104640250	16	16	15	9	
21008104641546				7	
21008104650367				10	
21008104651675				8	
21008104800066	15	15	14	5	
21008104810053				6	
21008104840101	14	14	13	3	
21008104850246				4	
21008104902459		13	12		
21008105100190	13	12	11	1	
21008105110135				2	
21008105140000	2		10		
21008105502205	3	1	5		6
21008105742141				17	
21008304041288		6	1	14	
21008304140000			2		
21008304160483					11
21011400601951	20			16	9
21017400400367			20		
21058100301760	12	3		15	8
21058100600203					14
21058101200000			18		
21064102401212		20			
21101001201023					18
21101001201163					19
21101500100878		4			7
21203500500000					12
21203500500133	1				13
21707699021516	4				15

TABLE 2-4 PennDOT Survey Responses for Dauphin County

Structural ID Number	Bridge Rank				
	Engineer 1	Engineer 2	Engineer 3	Engineer 4	Engineer 5
22001100100000					8
22002200500208	6	3	6	6	4
22002200900000					7
22002201501231					17
22002202310000		11			6
22002202901786				9	
22002202911867				10	9
22002204200000	9				
22003903300000		20			18
22008106520000	2	2	1	2	2
22008106601047		8	9		11
22008106811866		9			
22008106851552		10	10		
22008106940918			7		
22008107750790		17			
22008107852486		16			
22008304200000	1	1	2	1	1
22008304340000		5	11	14	
22008304340713		6	12		
22008304601012		7			
22008304611029				7	
22008304650343					12
22008304952447		12			
22008305011814			8		
22014700403231	19	15			16
22014703100842	20				
22022500540371		13			
22022501301860	17	14			15
22028300252054				8	13
22030000100964	12				
22030000710851	13	18			
22030001812288	16				
22032201700000	11	19		13	10
22044100802058	18				
22300901900601	7		4		
22301200300000	4		15	5	5
22301200800233			17	12	
22301400300190	8		16	11	19
22301600100000	3		5	4	3
22302200200250	14				
22303400100000			18		20
22707699024665	5	4	3	3	14
22707699024676			13		
22707699024709			14		
22801805000557	15			15	

The EMS survey involved the input of an emergency management specialist working in Dauphin County. The survey was similar to the PennDOT survey.

After all of the analytic methods listed above were examined, the method(s) that best corresponded to the above comparison rankings were chosen for possible modification. The methods were compared using average rankings which were determined in two ways. The average ranking for the methods is determined by averaging the rankings from all methods for the bridges ranked in the top 20 by the method being investigated. The average ranking for the surveys is determined by taking the average bridge rank from the method being investigated for the bridges ranked in the top 20 by a survey. A low average indicates that the bridges being investigated are ranked high in importance. Therefore, as the average ranking value decreases, the correlation between the comparison ranking and the method being examined increases. Tables of all of the comparison rankings are given in Appendix C.

A summary of these average rankings are given in table 2-5. The method with the lowest cumulative average indicates the best method because it ranks all bridges closest to the five comparison rankings. The examined methods were modified later in an attempt to provide results similar to the comparison rankings.

TABLE 2-5 Average Results for the Comparison Rankings

Importance Method	Methods for Dauphin County	Methods for Cumberland County	PennDOT Survey for Dauphin County	PennDOT Survey for Cumberland County	EMS Survey for Dauphin County	Cumulative Average
B&H	86.7	72.0	79.3	105.5	133.3	95.4
Modified B&H	79.2	69.0	67.0	75.7	135.0	85.2
Buckle	46.6	114.0	96.0	91.5	182.9	106.2
Modified Buckle	48.0	115.6	99.5	104.1	184.9	110.4
Caltrans	58.4	59.4	77.5	96.3	171.4	92.6
Montana	78.3	66.8	56.7	55.6	118.5	75.2
Nevada	52.9	66.4	73.2	89.8	164.2	89.3
Missouri	66.5	80.5	66.8	77.9	150.1	88.3
IDOT	54.3	65.1	66.9	68.0	108.0	72.5
Note: B&H is an abbreviation for Babaei & Hawkins						

The three methods that compared best to the five comparison rankings were chosen for further analysis and/or modification. The three methods, in order of lowest cumulative average of the comparison rankings, were:

- IDOT Method

$I =$ 0.69*Vehicles Impacted + 0.15*Emergency Route + 0.10*Detour + 0.05*Defense Route + 0.01*Utilities

where:
"on" indicates the critical route on the bridge
"under" indicates the critical route under the bridge
Vehicles Impacted = $(ADT_{on}(Length_{bridge} + 72) + ADT_{under}(Deck\ width + 72))/1{,}546{,}400$
Emergency Route was not used in this equation.
Detour = $(ADT_{on}*detour\ length_{on})/161{,}000 + 0.39*(ADT_{under}*detour\ length_{under})/161{,}000 + 15*I_{NW} + 5*I_{RR}$
I_{NW} = 1 if bridge is over navigable water
I_{RR} = 1 if bridge is over railroad
Defense Route = 0.8 for priority route on bridge
= 0.2 for priority route under bridge
= 0.7 for secondary route on bridge
= 0.1 for secondary route under bridge
= 0 for non-defense route
Utilities = 1 if utilities on bridge

- Montana Method

$C =$ $[(RT_{carry})(DL_{carry}*N_{carry})] + 2/3(RT_{cross})(DL_{cross}*N_{cross})] + 0.34[(ADT_{carry}/6{,}000)(L)]^{0.25} + RV_{cross}$

where:
"carry" indicates the critical route on the bridge
"cross" indicates the critical route under the bridge
RT_{carry} = factor for the nature of the route
= 1.0; interstate route, principal artery, or confirmed emergency route
= 0.8; all other routes
DL_{carry} = factor representing criticality of detour length
= 1.20; When detour length > 155 km
= 1.00; When 80 ≤ detour length < 155 km
= 0.90; When 15 ≤ detour length < 80 km
= 0.80; When 5 ≤ detour length < 15 km
= 0.70; When detour length < 5 km
N_{carry} = factor representing criticality of detour due to traffic congestion
= $ADT_{carry}/6{,}000]^{0.25} >= 1$
ADT_{carry} = average daily traffic of the route
RT_{cross} = factor representing the nature of the route
= 1.0; interstate route, principal artery, railroads, or confirmed emergency route
= 0.8; all other routes
DL_{cross} = factor representing criticality of detour length
= 1.20; When detour length > 155 km
= 1.00; When 80 ≤ detour length < 155 km
= 0.90; When 15 ≤ detour length < 80 km

= 0.80; When 5 ≤ detour length < 15 km
= 0.70; When detour length < 5 km

N_{cross} = factor representing criticality of detour due to traffic congestion
= $ADT_{cross}/6{,}000]^{0.25} >= 1$

ADT_{cross} = average daily traffic

L = length of the bridge(m)

RV_{cross} = $3.28*10^{-3}$*L for river crossings

- Modified Babaei and Hawkins Method

$$C = [(RN_{carry})(DL_{carry}*N_{carry})] + [UT_{carry}] + (2/3)[(RN_{cross})(DL_{cross}*N_{cross})] + 0.34[(ADT_{carry}/6{,}000)(L)]^{0.25}$$

where:
"carry" indicates the critical route on the bridge
"cross" indicates the critical route under the bridge

RN_{carry} = factor for the nature of the route
= 1.0; interstate route, principal artery, or confirmed emergency route
= 0.8; all other routes

DL_{carry} = factor representing criticality of detour length
= 1.00; When detour length > 15 km
= 0.80; When 5 ≤ detour length < 15 km
= 0.75; When detour length < 5 km

N_{carry} = factor representing criticality of detour due to traffic congestion
= $ADT_{carry}/6{,}000]^{0.25} >= 1$

ADT_{carry} = average daily traffic of the route

UT_{carry} = factor representing utility lines
= 1; bridge carrying a confirmed essential utility line
= 0; all other bridges

RN_{cross} = factor representing the nature of the route
= 1.0; confirmed emergency route
= 0.8; all other routes
= 0.0; no route under the bridge

DL_{cross} = factor representing criticality of detour length
= 1.00; When detour length > 15 km
= 0.80; When 5 ≤ detour length < 15 km
= 0.75; When detour length < 5 km

N_{cross} = factor representing criticality of detour due to traffic congestion
= $ADT_{cross}/6{,}000]^{0.25} >= 1$

ADT_{cross} = average daily traffic

L = length of the bridge(m)

The Montana method is also a modification of the Babaei and Hawkins method. The Modified Babaei and Hawkins method uses a utility factor, 1 or 0, instead of the river crossing factor in the Montana method. Therefore, the results of the two methods were similar. As previously noted, in order to automate the importance screening, any data not required in the NBI records should be eliminated. While both New York and Pennsylvania keep utility data, it is not required. Therefore, a utility factor should not be included in the proposed importance equation. Thus,

methods which required a utility factor or comparable human input would have to be modified or eliminated. In this context, the Modified Babaei and Hawkins method was eliminated.

In summary, after a comparison of eight importance methods and four initial modified methods, two methods were selected for further evaluation through systematic variation of parameters.

SECTION 3
DEVELOPMENT OF PROPOSED IMPORTANCE METHOD

Several modifications were performed on both the Illinois Department of Transportation (IDOT) and Montana methods in an effort to increase the correlation of the methods to the five comparison rankings.

3.1 Modified IDOT

Twelve variations of the IDOT methods were investigated. These methods included changes to the ADT reference values, detour mile coefficients, rail traffic considerations and importance equation coefficients. The twelve variations are combinations of the adjustments listed below. Table 3-1 provides the adjustment combinations for each variation. The reasoning for those adjustments are described as follows:

- The emergency route factor was deleted. This was done because some states, like Pennsylvania and New York, do not keep this information in their BMS file. Also, defining an emergency route can be subjective.

- The emergency route factor was replaced partially by a rail traffic factor. The IDOT method gave little importance to railroad bridges. The IDOT method ranked railroad bridges much lower than the five comparison rankings. Therefore, it was decided to use part of the emergency route portion of the IDOT Importance as a railroad consideration.

- In the vehicle detour factor, the coefficient for the route under the bridge was increased while the navigable water coefficient was decreased. This was done to bring the maximum possible importance contribution from these items nearly equal i.e., the maximum ADT_{under} importance = water crossing importance. Responses from the survey of the 50 states indicate that there are two bases for importance rankings, loss of life and cost of replacement. Therefore, the maximum loss of life under the bridge was considered to be as important as the largest replacement costs. It was assumed that navigable waters are usually the largest bodies of water and therefore incur the largest replacement costs.

- The detour length for the route under the bridge was set at a constant of 1.6 kilometers, due to the fact that both New York and Pennsylvania do not keep this information in their database. In their opinion, this data is not necessary because the closing of a route under the bridge would be temporary and could be easily cleared. This modification works in conjunction with an increased "under" coefficient in the vehicle detour factor.

- The importance equation coefficients were modified to increase the importance of rural routes by decreasing the ADT effects and increasing the detour length effects. This revision was implemented in an attempt to increase the correlation with the EMS evaluation. EMS apparently rated bridge importance based on accessing rural areas.

- Average ADT and detour length reference values were investigated. Average values were investigated to allow each state to customize the importance equation. Every state has different typical traffic volumes and detour lengths. Therefore, an appropriate reference value for one state

may not be appropriate for another.

• The importance equation coefficient for defense routes was increased from 0.05 to 0.10. This was revised in part to account for deleting the emergency route factor.

TABLE 3-1 Variations of the IDOT Method

Variation	Coefficient					ADT Reference Value	Additional IDOT Equation Adjustments (see original IDOT equation on page 5)
	A	B	C	D	E		
MIDOT	0.70	0.14	0.10	0.01	0.05	161,000	Detour: Remove DL_{under} Detour: ADT_{under} coefficient from 0.39 to 5
M&M1	0.60	0.20	0.10	0.01	0.09	161,000	see MIDOT
M&M2	0.65	0.15	0.10	0.01	0.09	161,000	see MIDOT and Detour: I_{NW} coefficient from 15 to 20
M&M3	0.50	0.30	0.10	0.01	0.09	161,000	see MIDOT
M&M4	0.50	0.30	0.10	0.01	0.09	161,000	see MIDOT and Detour: I_{NW} coefficient from 15 to 5
M&M5	0.50	0.30	0.10	0.01	0.09	161,000	see M&M4 and Defense: Coefficients from 0.8, 0.2, 0.7, 0.1 and 0.0 to 1.0, 0.6, 0.9, 0.4 and 0.0, respectively
M&M6	0.50	0.30	0.10	0.01	0.09	161,000	see M&M4 and Defense: Coefficients from 0.8, 0.2, 0.7, 0.1 and 0.0 to 1.0, 0.4, 0.6, 0.3 and 0.0, respectively
M&M4a	0.50	0.30	0.10	0.01	0.09	80,500	see M&M4
M&M4b	0.50	0.30	0.10	0.01	0.09	241,500	see M&M4
M&M4c	0.50	0.30	0.10	0.01	0.09	Y	see M&M4 and Y = data average of (ADT_{carry} * DL_{carry})
M&M4d	0.50	0.30	0.10	0.01	0.09	Z	see M&M4 and Z = data average ADT_{carry} * data average DL_{carry}
M&M4e	0.50	0.30	0.10	0.01	0.09	2*Y	see M&M4
Modified Equation: I = A*Vehicles Impacted + B*Detour + C*Defense Route + D*Utilities + E*Rail							

These 12 variations were compared against each other using the same comparison ranking concepts that were described in section 2. A summary of the average rankings are given in table 3-2.

TABLE 3-2 Average Results for IDOT Variations

Variation	Methods for Dauphin County	Methods for Cumberland County	PennDOT Survey for Dauphin County	PennDOT Survey for Cumberland County	EMS Survey for Dauphin County	Cumulative Average	Standard Deviation
MIDOT	47.5	64.6	69.6	64.7	123.0	73.9	25.7
M&M1	47.0	70.8	70.7	151.8	127.0	93.4	39.3
M&M2	49.4	69.4	69.1	102.3	123.2	82.7	26.4
M&M3	56.2	73.9	154.7	245.4	146.5	135.3	67.3
M&M4	48.7	60.7	53.8	71.0	113.6	69.5	23.3
M&M5	51.4	62.8	58.6	72.1	119.0	72.8	24.0
M&M6	52.6	55.6	57.2	69.6	117.2	70.4	24.1
M&M4a	45.2	63.4	53.8	76.2	111.2	70.0	23.1
M&M4b	52.9	60.1	53.1	68.7	114.4	69.9	23.0
M&M4c	45.2	63.4	53.8	80.0	111.3	70.7	23.3
M&M4d	48.7	63.4	54.0	77.3	113.5	71.4	23.2
M&M4e	48.7	62.2	53.8	73.4	113.4	70.3	23.1

The M&M4c and M&M4d average reference values produced similar results to M&M4 for Dauphin County. The results for Cumberland County had a lower correlation than using a set ADT reference value of 161,000. Therefore, the concept of an average reference value was disregarded as an viable option in the IDOT variations.

Several of the variations obtained similar results. M&M5 and M&M6 used the M&M4 equation with variations of defense route coefficients. The defense route coefficients caused only minor differences in the results. However, none of them were improvements upon the M&M4 variation. The method with lowest cumulative average ranking and standard deviation for the five comparison rankings was M&M4 as shown in table 3-2. The M&M4 equation is given below:

M&M4 Equation:

$I = 0.5*\text{Vehicles Impacted} + 0.3*\text{Detour} + 0.1*\text{Defense Route} + 0.01*\text{Utilities} + 0.09*\text{Rail}$

where:
$\text{Detour} = (ADT_{on}*\text{detour length}_{on})/161{,}000 + 5*ADT_{under}/161{,}000 + 5*I_{NW} + 5*I_{RR}$
$I_{NW} = 1$ if bridge is over navigable water
$I_{RR} = 1$ if bridge is over railroad
Rail = 1 if bridge carries railroad
Other variables are the same as previously defined for the IDOT method.

3.2 Modified Montana

Seven variations of the Montana equations were investigated. These methods included adjustments to ADT reference values, bridge length reference values, rail traffic considerations and route importance values. The seven variations are combinations of the adjustments listed below. Table 3-3 provides the adjustment combinations for each variation. The reasoning for the adjustments mentioned above are described as follows:

- The Detour length$_{under}$ variable was replaced with a constant value of 0.9 because of a lack of data in the BMS files for this item. The value, 0.9, corresponds to a detour length of 15 to 80 kilometers in the original Montana method.

- The ADT reference values were changed to an average database ADT value to allow each state to customize the reference value to their traffic. The reference value of 6000 used in Montana does not compare with Washington's reference value of 30,000. Therefore, an appropriate reference value for one state may not be appropriate for another. The average database ADT, Ave ADT, is determined by taking the sum of all the controlling ADT values for the feature being carried by a structure, ADT_{carry}, and dividing by the number of bridges in the database. This adjustment sets $N_{carry} = 1$ for a bridge with a traffic volume equivalent to the average for that state.

- The N_{carry} equation was replaced by a constant value of 1 for bridges carrying rail traffic. This sets a railroad bridge equal to a highway bridge with an average ADT for the "carry" factor in the importance equation. Without this modification, the ADT of a railroad bridge is 0, which results in railroad bridges being ranked very low.

- The river crossing reference value was replaced by a value equal to the maximum bridge length in the specified database, L_{max}. Therefore, this portion of the equation can not exceed 1. This will increase the effects of the route on the bridge, thus increasing the importance of rural bridges and improving the correlation with the EMS survey. Rural routes in the test databases tended to be small river crossings. The structural importance of a rural route depends highly on the route it is carrying. Therefore, this adjustment tended to have a larger effect on the importance of rural routes.

- The route type coefficients were modified to increase correlation with EMS. The route coefficients were increased for routes on the bridge and decreased for routes under the bridge. This increased the importance of the route on the structure, which tended to have more of an affect on rural bridges.

TABLE 3-3 Variations of the Montana Method

Variation	ADT Reference Value	N_{carry} for railroads	River Crossing Reference	DL_{cross}	RT_{carry}	RT_{cross}
MNT1	Ave ADT	0.0	$3.28*10^{-3}$	0.9 for Railroads, 1.0 for all others	1.0, 0.8	1.0, 0.8
MNT2	Ave ADT	1.0	$3.28*10^{-3}$	0.9 for Railroads, 1.0 for all others	1.0, 0.8	1.0, 0.8
MNT3	Ave ADT	1.0	L_{max}	0.9 for Railroads, 1.0 for all others	1.0, 0.8	1.0, 0.8
MNT4	Ave ADT	1.0	L_{max}	0.9 for Railroads, 1.0 for all others	1.1, 0.9	1.0, 0.8
MNT5	Ave ADT	1.0	L_{max}	0.9 for all	1.1, 0.9	0.9, 0.8
MNT6	Ave ADT	1.0	L_{max}	0.9 for Railroads, 1.0 for all others	1.1, 0.9	0.9, 0.7
MNT7	1.25*Ave ADT	1.0	L_{max}	0.9 for Railroads, 1.0 for all others	1.1, 0.9	0.9, 0.8

The seven variations were compared against each other by the same comparison ranking concepts from section 2. A summary of the average rankings are given in table 3-4.

TABLE 3-4 Average Results for Montana Variations

Variation	Methods for Dauphin County	Methods for Cumberland County	PennDOT Survey for Dauphin County	PennDOT Survey for Cumberland County	EMS Survey for Dauphin County	Cumulative Average	Standard Deviation
MNT1	72.1	63.5	57.2	100.2	118.0	82.2	23.2
MNT2	72.1	54.9	47.2	55.0	121.7	70.2	27.0
MNT3	48.8	57.6	46.4	59.1	127.6	67.9	30.2
MNT4	44.5	51.7	45.8	59.0	127.2	65.6	31.2
MNT5	51.7	56.4	42.4	57.9	125.8	66.8	30.0
MNT6	51.7	62.1	45.3	58.0	124.1	68.2	28.5
MNT7	51.4	62.5	42.4	57.6	124.0	67.6	29.0

As shown in table 3-4, the three best methods were MNT4, MNT5 and MNT7. These three methods were chosen for further investigation because they had the lowest cumulative average and lower standard deviations. MNT4, MNT5 and MNT7 had different combinations of RT_{cross} coefficients. The "cross" factor of importance is not a major influencing factor in the Montana importance value.

In the MNT7 equation an ADT reference value of 1.25*Average ADT was used. The ADT reference value revision has more of an affect on bridges that do not receive a large portion of their importance value from ADT. Therefore, the most important structures were not affected with respect to rank due to the different reference value. However, the revised RT_{cross} coefficients did affect the distribution of the importance values. For the ADT and bridge length reference values, the average and maximum length, respectively, were used for both county databases. These adjustable reference values would allow each state to adjust these values to reflect their traffic and bridges. The maximum bridge length is the longest total structure in the database being ranked i.e. total distance from abutment to abutment not individual span length. This would help to prevent one state from getting an uneven distribution of importance values while another would get a more even distribution of values by using the same equation.

The basic equation for all three variations is given below:

Equation for the Montana Variations, MNT4, MNT5 and MNT7:

$$C = [(RT_{carry})(DL_{carry}*N_{carry})] + 0.6(RT_{cross}*N_{cross}) + 0.34[(ADT_{carry}/\text{Ave ADT})(L)]^{0.25} + RV_{cross}$$

where:

Ave ADT = Average ADT_{carry} in the classification database

N_{carry} = $(ADT_{carry}/\text{Ave ADT})^{0.25}$ for MNT4
= $(ADT_{carry}/\text{Ave ADT})^{0.25}$ for MNT5
= $(ADT_{carry}/(1.25*\text{Ave ADT}))^{0.25}$ for MNT7
= 1 for bridges carrying railroads (MNT4, MNT5 and MNT7)

N_{cross} = $(ADT_{cross}/\text{Ave ADT})^{0.25}$ for MNT4
= $(ADT_{cross}/\text{Ave ADT})^{0.25}$ for MNT5
= $(ADT_{cross}/(1.25*\text{Ave ADT}))^{0.25}$ for MNT7

L_{max} = Maximum bridge length in the classification database

RV_{cross} = L/L_{max} for river crossings

RT_{carry} = 1.1 or 0.9

RT_{cross} = 1.0 or 0.8 for MNT4
= 0.9 or 0.8 for MNT5
= 0.9 or 0.8 for MNT7

Other variables are the same as previously defined for the Montana method

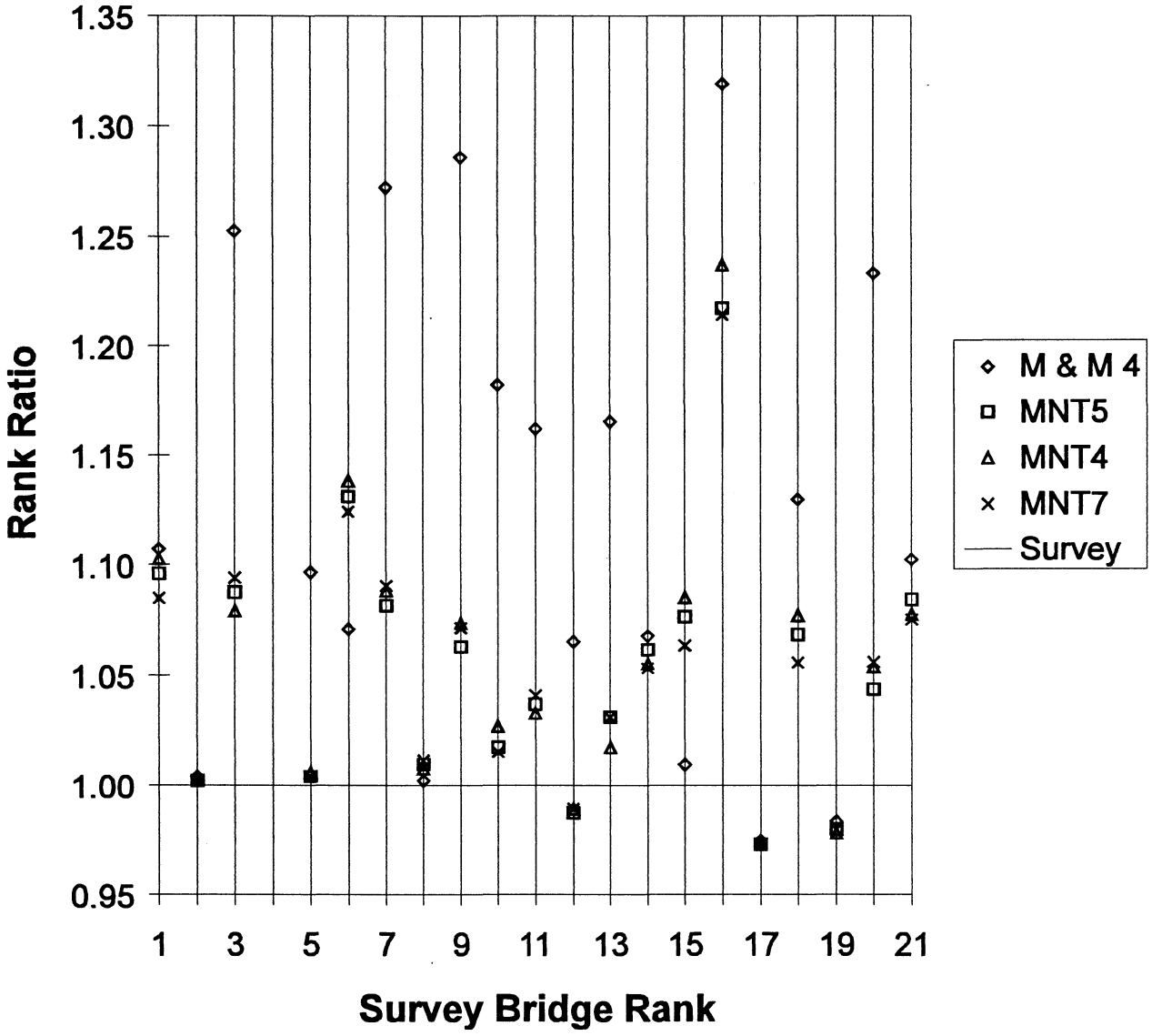
3.3 Comparison of M&M4, MNT4, MNT5 and MNT7

The revised modified IDOT and modified Montana methods, M&M4, MNT4, MNT5 and MNT7, were compared to each other in order to determine the recommended importance equation. The 20 or 21 bridge ranked most important by the surveys and their corresponding ranking by the modified methods were used as the final comparison. This comparison procedure was used throughout this investigation to aid in determining which parameter should be revised. Tables 3-5, 3-6, and 3-7 show the results of the M&M4, MNT4, MNT5, and MNT7 methods for Cumberland County PennDOT Survey, Dauphin County PennDOT Survey, and Dauphin County EMS Survey, respectively.

The rankings from tables 3-5, 3-6, and 3-7 were also graphed in figures 3-1, 3-2 and 3-3. The graphical comparison was based on a rank ratio, where the rank ratio relates the number of bridges ranked below a specific bridge by the survey to the number of bridges ranked below that bridge for a given importance method. The rank ratio equation is given in each of the figures 3-1, 3-2, and 3-3. A rank ratio greater than 1.0 means that a given importance method ranked the bridge lower than the survey. The ideal method would have a rank ratio of 1.0 for all bridges in the survey. A rank ratio was used because each importance rating method had a different range of importance values and each county had a different size database. The figures indicated graphically which bridge, if any, skewed the average results. If the results were skewed by one bridge, the method being investigated may be neglecting a controlling importance issue for that bridge.

TABLE 3-5 Cumberland County PennDOT Rankings

Structure ID Number	SURVEY RANK	M&M4 RANK	MNT5 RANK	MNT4 RANK	MNT7 RANK
21008105502205	1	54	49	52	44
21001107600000	2	4	3	3	3
21008105100190	3	113	47	43	50
21058100301760	4	288	484	484	484
21008304041288	5	53	7	8	7
21001108701474	6	42	69	72	66
21008104840101	7	123	48	51	52
21001109800000	8	9	13	12	14
21008104800066	9	129	41	46	45
21101500100878	10	93	19	24	18
21008105140000	11	86	30	28	32
21001501700000	12	45	5	6	6
21008104640250	13	89	29	22	29
21203500500133	14	48	45	42	41
21707699021516	15	20	53	57	47
21008105110135	16	145	111	118	110
21008304140000	17	3	2	2	2
21011400601951	18	79	52	56	46
21001107400000	19	10	8	7	8
21008104850246	20	120	42	47	48
21008104902459	21	70	62	59	58
Average Rank	-	77.3	58.0	59.0	57.6
Standard Deviation	-	63.6	98.7	98.9	98.7



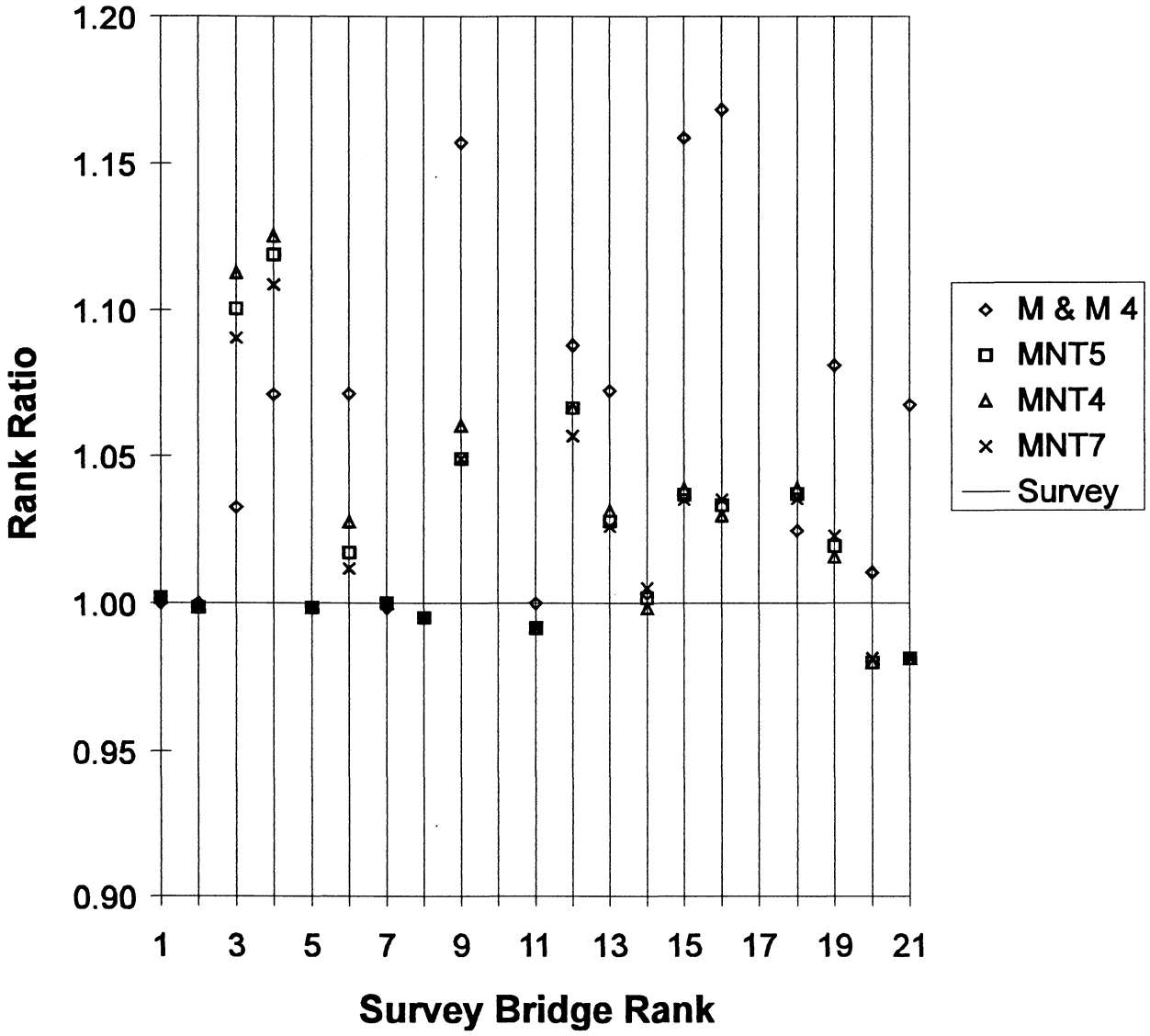
Rank Ratio = (# of bridges - Survey Rank)/(# of bridges - Method Rank)

Bridges not shown in graph				
Survey Rank	M&M4 ◇	MNT5 □	MNT4 △	MNT7 X
4	2.09	8.38	8.38	8.38

FIGURE 3-1 Comparison with PennDOT Survey for Cumberland County

TABLE 3-6 Dauphin County PennDOT Rankings

Structure ID Number	SURVEY RANK	M&M4 RANK	MNT5 RANK	MNT4 RANK	MNT7 RANK
22008304200000	1	1	2	2	2
22008106520000	2	2	1	1	1
22002200500208	3	22	58	64	53
22707699024665	4	44	68	71	63
22301600100000	5	4	4	4	4
22301200300000	6	46	16	22	13
22008106601047	7	6	7	7	7
22008304340000	8	5	5	5	5
22032201700000	9	90	37	43	37
22300901900601	10	196	253	260	223
22301400300190	11	11	6	6	6
22002202310000	12	60	49	49	44
22008304340713	13	53	29	31	28
22002202911867	14	16	15	13	17
22008106851552	15	96	36	37	35
22028300252054	16	101	35	33	36
22022501301860	17	198	226	228	227
22002200900000	18	32	39	40	38
22008106940918	19	63	30	28	32
22008304601012	20	26	8	8	9
22008304611029	21	58	10	10	10
Average Rank	-	53.8	44.5	45.8	42.4
Standard Deviation	-	55.5	66.1	67.5	61.8



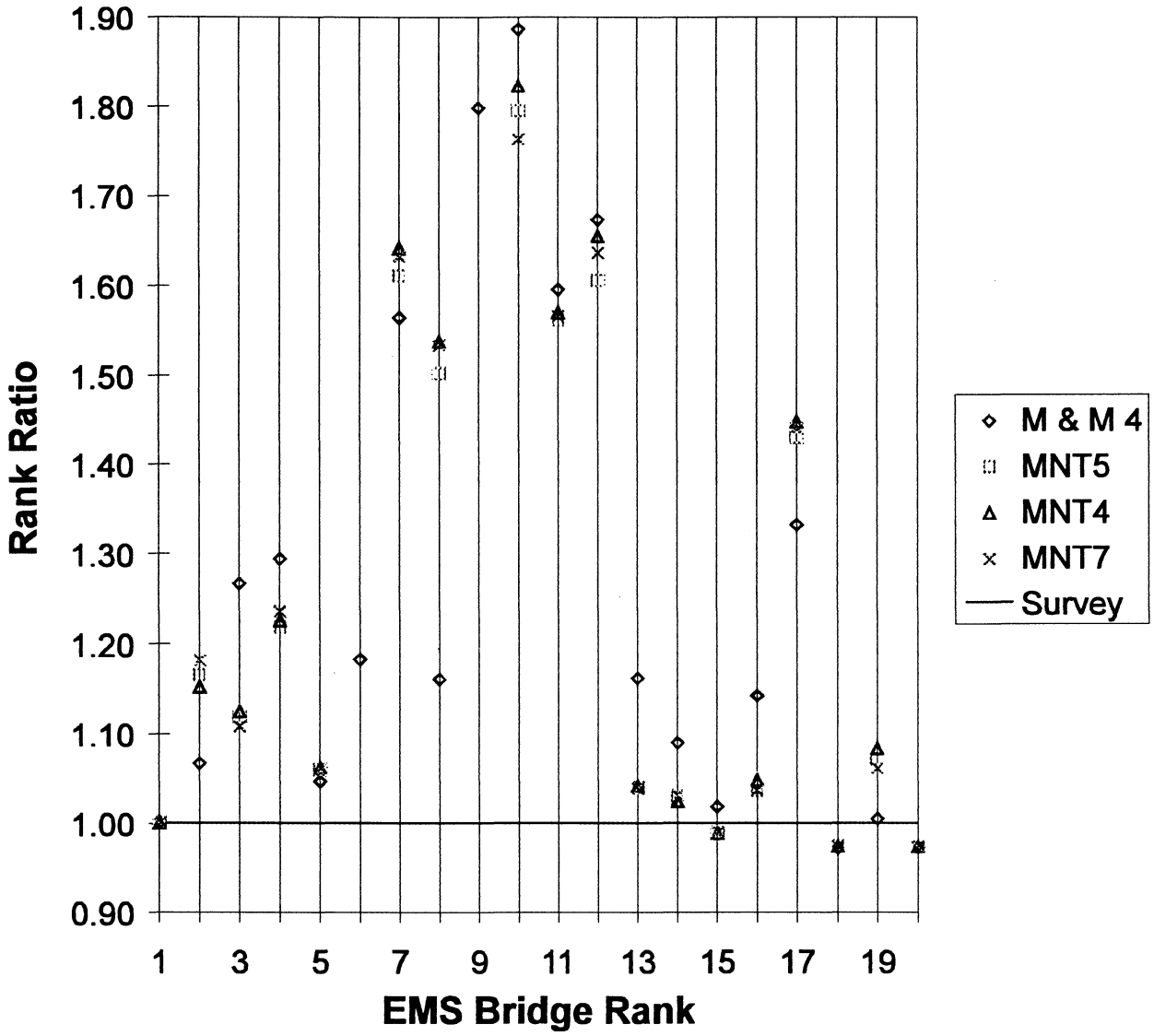
Rank Ratio = (# of bridges - Survey Rank)/(# of bridges - Method Rank)

Bridges not shown in graph				
Survey Rank	M&M4 ◇	MNT5 □	MNT4 △	MNT7 X
10	1.45	1.69	1.72	1.56
17	1.44	1.55	1.56	1.55

FIGURE 3-2 Comparison with PennDOT Survey for Dauphin County

TABLE 3-7 Dauphin County EMS Rankings

Structure ID Number	SURVEY RANK	M&M4 RANK	MNT5 RANK	MNT4 RANK	MNT7 RANK
22008106520000	1	2	1	1	1
22302100100000	2	40	88	82	95
22032200600000	3	130	67	70	62
22002201802643	4	141	112	115	119
22002200900000	5	32	39	40	38
22014700401898	6	99	321	323	323
22014702200000	7	223	234	241	239
22014703100842	8	91	208	217	216
22020900700000	9	274	315	317	316
22020901401722	10	290	274	279	268
22020902600000	11	233	225	227	226
22020903200000	12	251	236	247	243
22008106851552	13	96	36	37	35
22008106940918	14	63	30	28	32
22008304601012	15	26	8	8	9
22032201700000	16	90	37	43	37
22032202901298	17	164	194	199	197
22008304200000	18	1	2	2	2
22002200500208	19	22	58	64	53
22301600100000	20	4	4	4	4
Average Rank	-	113.6	124.5	127.2	125.8
Standard Deviation	-	93.5	110.2	112.0	111.2



Rank Ratio = (# of bridges - Survey Rank)/(# of bridges - Method Rank)

Bridges not shown in graph				
Survey Rank	M&M4 ◇	MNT5 □	MNT4 △	MNT7 X
6	N/A	2.11	2.12	2.12
9	N/A	2.05	2.07	2.06

FIGURE 3-3 Comparison with EMS Survey for Dauphin County

The initial investigation of tables 3-5, 3-6 and 3-7 and figures 3-1, 3-2 and 3-3 indicated the necessity for further investigation of several of the bridge rankings.

The Cumberland County PennDOT results, table 3-5 and figure 3-1, shows that none of the methods gave similar results for the bridge ranked fourth by the survey. Upon investigation of the database, it was discovered that the file for that bridge had not been updated since the completion of the highway. The bridge record had an ADT of zero but the PennDOT survey was based on the four lane highway being open to traffic. Therefore, any rankings based on this bridge's database information would rank the bridge far below its actual importance. This discovery reinforced the researchers' opinion that requesting more BMS data than currently required would increase the BMS work load for each state and be met with resistance.

The Dauphin County PennDOT results, table 3-6 and figure 3-2, shows that none of the methods gave similar results for the bridges ranked 10th and 17th by the survey. The bridge ranked 10th by PennDOT is a railroad bridge crossing a 2 lane highway. The bridge ranked 17th by PennDOT is a rural 2 lane, 15.5 m (51') bridge crossing a stream.

The Dauphin County EMS results, table 3-7 and figure 3-3, shows that none of the methods gave similar results for the bridges ranked 6th through 12th by the survey. These bridges are rural routes providing access to small towns. Several of the typical characteristics of these bridges are as follows:

- ADT < 8900
- 2 lane bridges
- Stream crossing
- Average bridge length of 29 m (95 ft)

While the variation of the methods made attempts to increase the importance of routes similar to the ones described above, further increasing the correlation with these routes was not possible without sacrificing the importance of highway and interstate bridges with high traffic volumes.

After further comparison of M&M4, MNT4, MNT5, and MNT7, two methods were selected for the final comparison. The M&M4 method was selected because it resulted in the best correlation with the EMS Survey and the lowest standard deviation in both PennDOT Surveys. In addition, M&M4 was retained because it was a variation of the IDOT method unlike the other three. Since it was not known if a Montana or IDOT variation was the best method for a statewide database, a minimum of one variation of each was included for further comparison. Both the MNT5 and MNT7 methods compared better with the PennDOT Surveys than the M&M4 Method. The results between the MNT5 and MNT7 were similar for the three final comparison rankings. However, the MNT5 equation was preferred because the ADT reference value was the average ADT value.

The M&M4 and MNT5 methods were then used with the NYSDOT database to investigate their functionality with a different and larger database. Before the NYSDOT database investigation began, it was discovered that the maximum bridge length and average ADT used in MNT5 may not be appropriate due to the large differences encountered in a large database. The maximum bridge length of 12 558 m (41,200') in that database was of particular concern considering the original Montana method used a reference value of 305 m (1000'). The maximum bridge length is defined in the National Bridge Inventory Database as the distance from abutment joint to abutment joint. This length can be substantial as seen in the NYSDOT database. Therefore, a third modified method, MNT5M, was used. This method investigated a maximum bridge length reference value of 1610 m (5280'). It was decided not to alter the ADT reference value at this time.

The distribution of importance values is based on the number of bridges in the importance value percentile obtained by using the following equation:

$$\text{Importance Value Percentile} = (\text{Actual Value} - \text{Value}_{min})/(\text{Value}_{max} - \text{Value}_{min})*100$$

where:

Actual Value = importance value being investigated

Value_{max} = maximum importance value calculated in the database

Value_{min} = minimum importance value calculated in the database

After ranking the database with the three methods, the distribution of importance values were graphed in figure 3-4. The results from the original Montana and IDOT methods were included in the plot as a comparison to the original importance value distribution. As discussed in section 2, an effective importance method would limit the amount of interpretation of the results. If the bridge importance values are distributed evenly, there are no large groupings of bridges that require interpretation of results. This becomes more crucial as the importance of the structures increase. Therefore, an ideal distribution of structural importance would be as the importance value percentile increases, the number of bridges would decrease. This results in the most distinction where structural importance has the greatest affect in the design and retrofitting specifications, among "critical" and "essential" bridges.

It was determined that MNT5 and MNT5M produced similar results. However, MNT5 gave results with a more even distribution of bridge importance (see figure 3-4). Therefore, a maximum bridge length reference value was deemed unnecessary. MNT5 also produced a more even distribution than M&M4.

Based on this portion of study, MNT5 provides one of the most accurate importance rankings when compared to the five comparison rankings while giving the best distribution of importance. Therefore, MNT5 was selected as the importance ranking method. MNT5 considers the following bridge management data:

Route Carried
- Route type
- ADT
- Average ADT of bridges in database
- Detour length
- Bridge length
- Maximum bridge length in database
- Rail traffic

Route Crossed
- Route type
- ADT
- Rail crossing
- Water crossing

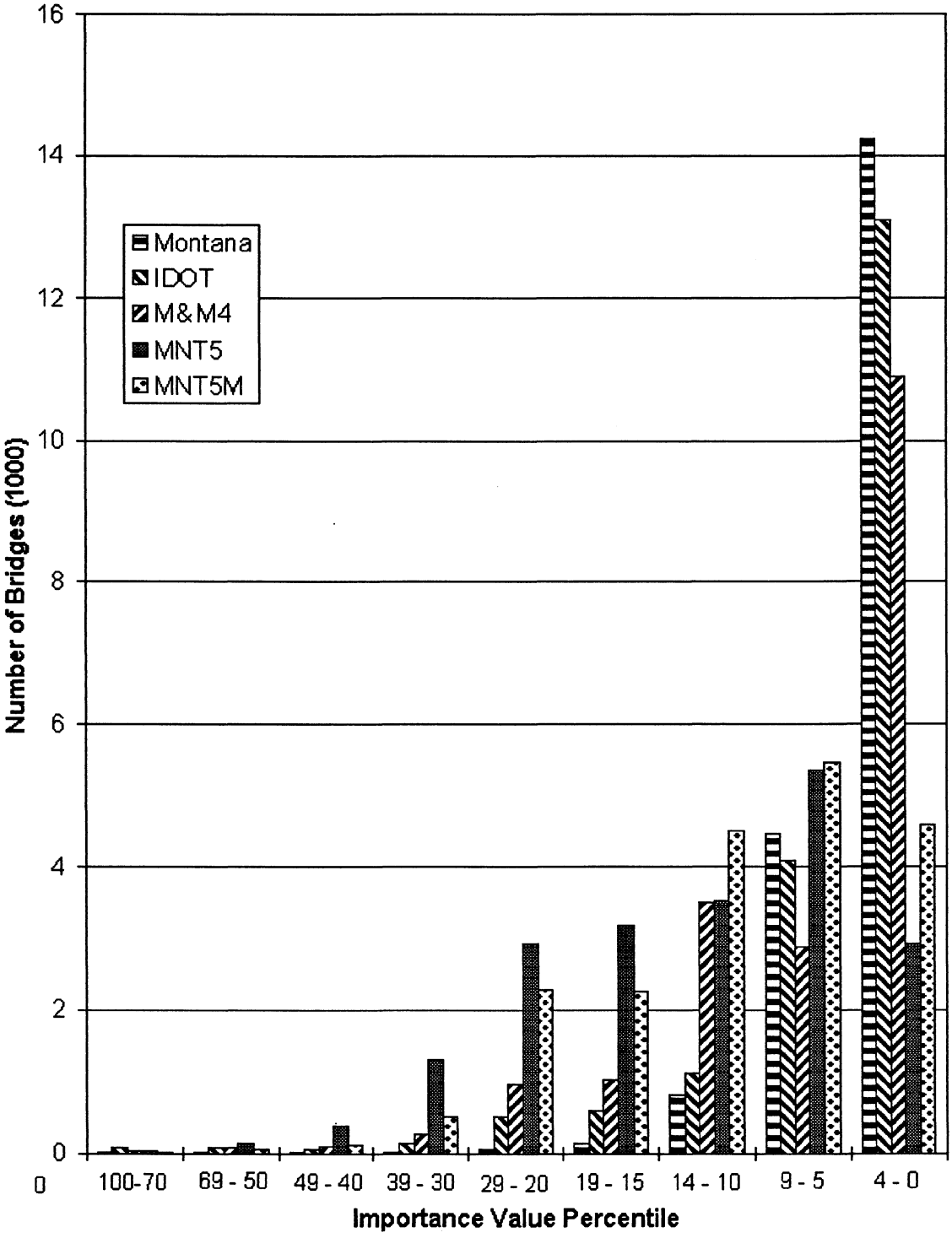


FIGURE 3-4 Distribution of NYSDOT Bridges by Importance Values

3.4 Importance Classification

Based on the analysis of the results discussed above, it is concluded that the MNT5 equation can then be used in the importance classification of bridges.

The next issue considered was the number of importance designations to be used in the in design specifications. The AASHTO "Standard Specification for Highway Bridges" currently uses two importance classifications, "essential" and "other". The "AASHTO LRFD Bridges Design Specification" uses three importance classifications, "critical", "essential", and "other". Further analysis of the PennDOT and NYSDOT BMS databases provided insight to this issue.

The MNT5 importance values versus the bridge rank percentile graphs for the Cumberland County, Dauphin County, and NYSDOT databases are shown in figures 3-5, 3-6, 3-7, respectively. The bridge rank percentile is based on the number of bridges with a lower importance ranking than the bridge being considered and can be obtained with the following equation:

Bridge Rank Percentile =
(total number of bridges - current bridge rank)/(total number of bridges)*100

If the importance value curves have significant extended changes in slope at specific rank percentiles, then that percentile may be interpreted as a change in the trend of bridge importance. These changes are considered as groups or classifications of bridges with similar structural importance.

Cumberland County importance values, shown in figure 3-5, have trend change points at approximately the 97th and 60th bridge rank percentiles. Dauphin County importance values, figure 3-6, have trend change points at approximately the 97th and 65th percentiles. NYSDOT importance values, figure 3-7, have trend change points at approximately the 95th and 70th percentile. All three databases showed three significant changes in the importance value trends. Therefore, the use of three bridge classifications, as used in the AASHTO LRFD Specification, corresponds better to these results. Most bridge classifications will be made using a state database instead of a county database. Therefore, more emphasis was placed on the NYSDOT results. Based solely on the NYSDOT results, the bridge importance classification divisions would be at the 95th and 70th bridge rank percentiles. The 95th percentile lower limit for "critical" bridges is considered acceptable because the lower limit for the smaller databases is the 97th percentile. However, the 70th percentile lower limit for "essential" bridges is too high when compared with the smaller databases. The smallest database, Cumberland County, has a limit of 60th percentile. The lower limit of 65th percentile for "essential" bridges is chosen because it is in agreement with the Dauphin County data and conservative when compared to the NYSDOT data.

In summary, three bridge importance classifications are indicated, designated herein following the LRFD terminology as "critical", "essential", and "other". The results of this study suggest that these classifications be divided by the 95th and 65th bridge rank percentiles.

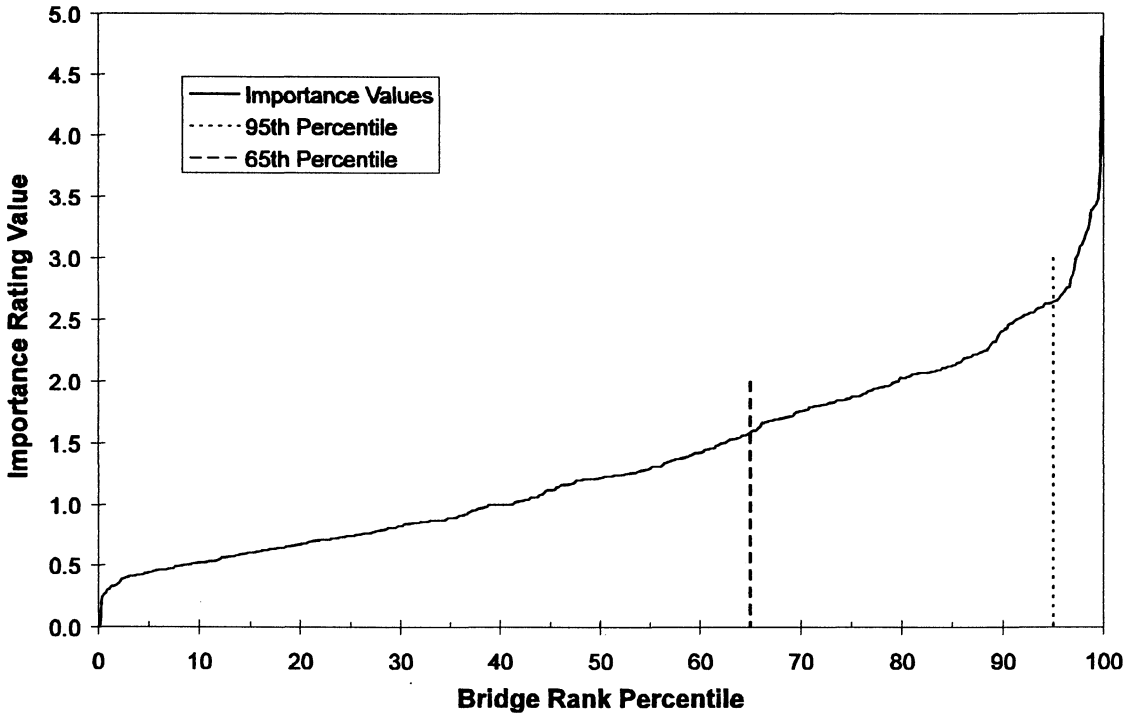


FIGURE 3-5 Cumberland County Importance Value Distribution

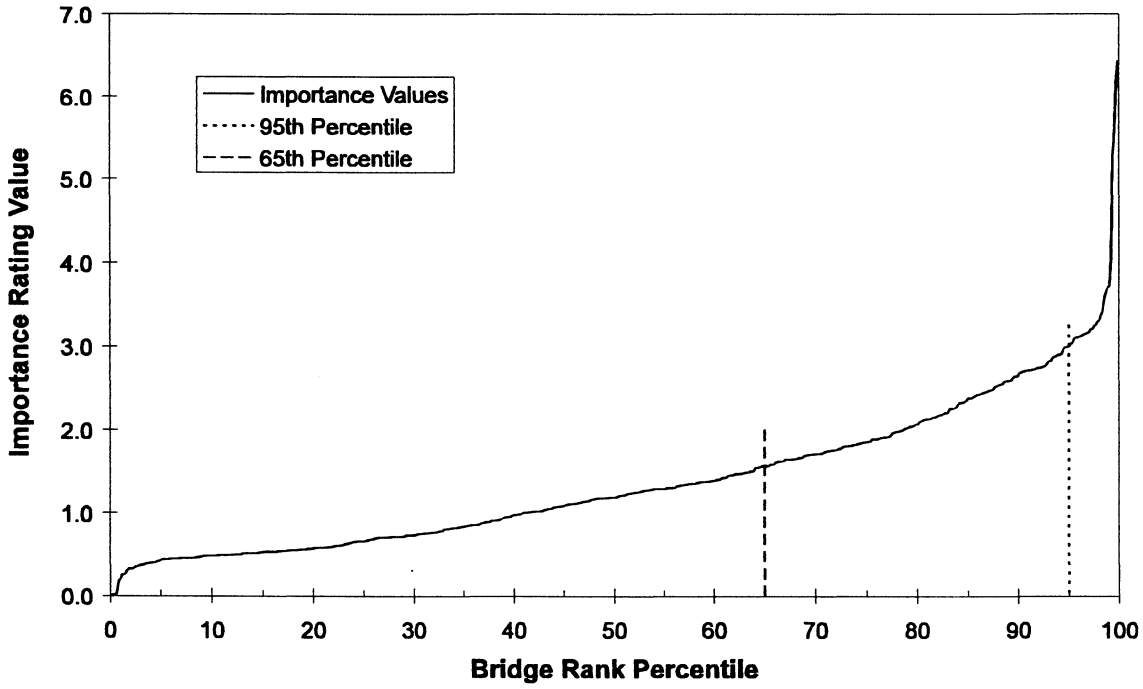


FIGURE 3-6 Dauphin County Importance Value Distribution

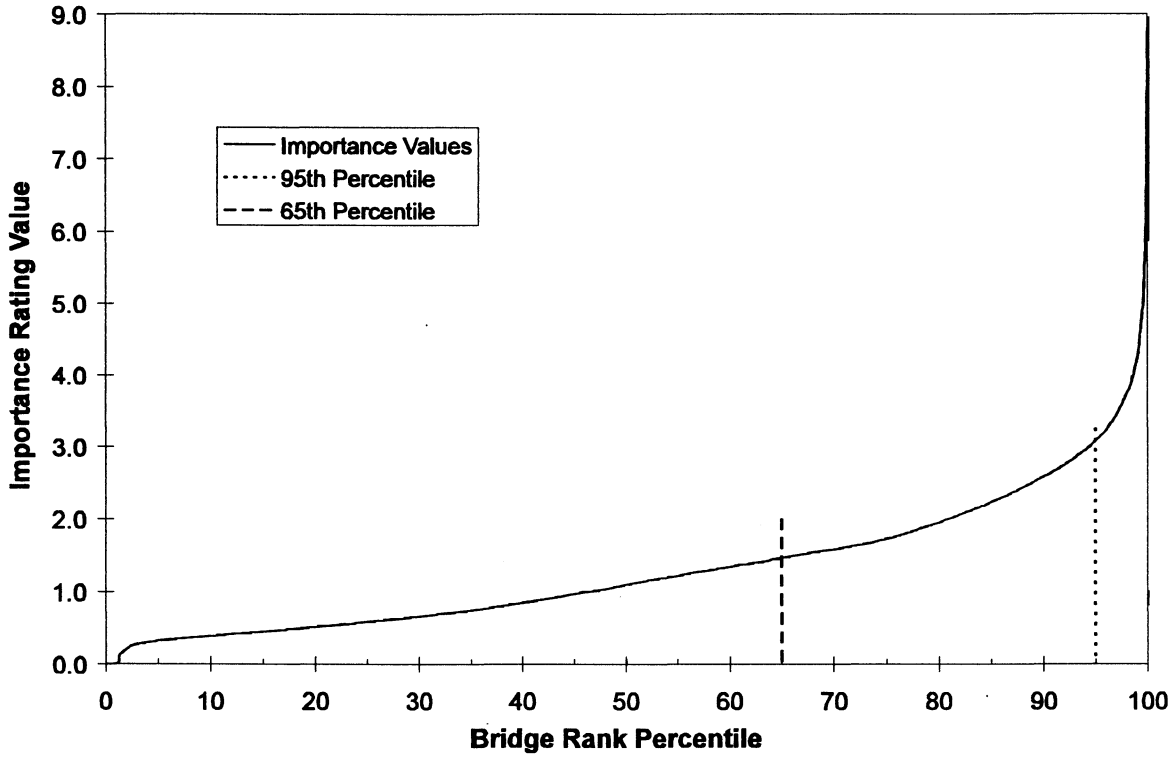


FIGURE 3-7 NYSDOT Importance Value Distribution

SECTION 4
REVIEW OF PROPOSED IMPORTANCE METHOD BY SELECTED STATES

Based on comments received from the NCEER Highway Project advisory committee in 1996, a survey on the recommended importance equation, MNT5, was sent to twenty states and one city. The survey included the following major items:

- Explanation of research task objectives,
- Questions regarding what method the agency currently uses to determine importance (if any),
- Questions regarding this task's proposed importance method,
- EXCEL spreadsheet macro to calculate the importance ranking using bridge management data.

A copy of the survey letter is provided in Appendix D. Table 4-1 provides a list of the states and city that were surveyed and their responses. New York City was included in the survey due to it large traffic volumes and number of bridges. However, New York City did not respond to the survey.

In general, the states responded positively to the MNT5 proposal. Based on the state comments, MNT5 was further modified and renamed MNT5R. The major state concerns are described and the corresponding equation modifications are discussed below.

Some of the comments from the states conflicted with one another as might be expected. For example, consider those received on the river crossing factor. Montana stated that river crossings were not making a large enough contribution to bridge importance. Their rationale was that construction costs for river crossings are much higher. Therefore, these bridges should be considered more important. Washington stated that the possibility of loss of life on a waterway was much less than on a roadway below the structure during a damaging earthquake. Therefore, the roadway crossing should be considered more important. Based on these conflicting responses, the MNT5 equation was not revised. The river crossing issue was considered a compromise between the two importance issues, cost of replacement and loss of life.

Montana and Alaska stated that the spread of the importance values, C, was not large enough. The equation was not modified based on these comments because this was believed to be more of a cosmetic issue. In the case of NYSDOT, the database contains 19,740 bridges. The distribution of the importance values are shown in figure 3-7. The bridges classified as "critical" and "essential" have a larger distribution of importance values. Importance will play a larger factor in the retrofitting or design scheme for "critical" and "essential" bridges. The importance values for "other" bridges are closer together. However, "other" bridges should not be retrofitted based solely upon importance. These structures will tend to be controlled by seismic vulnerability, retrofitting costs, and rehabilitation scheduling, none of which were considered in this task. Therefore, the smaller difference in the importance values is not significant. If a state believes that a larger spread is necessary, it could increase all of the RT values or use a percentage of C_{max}. The values, as presented, are giving relative importance and exact numbers are not as critical.

TABLE 4-1 Summary of Survey Responses

Agency	Yes	No	Comments
Alaska	X		Ran macro and completed survey forms.
Arizona		X	
California		X	Called and asked questions, but never received a response.
Connecticut	X		Completed survey forms, but did not run macro. No plans for changing current method of ranking bridges.
Hawaii		X	
Idaho		X	
Illinois	X		Completed survey forms, but did not run macro. No plans for changing current method of ranking bridges.
Iowa	X		Seismic Cat. A; therefore seismic retrofits not applicable
Kentucky		X	
Missouri		X	
Montana	X		Ran macro and completed survey forms.
Nevada		X	
New York - City		X	Called and asked questions, but never received a response.
New York - State	X		Completed survey forms, but did not run macro. No plans for changing current method of ranking bridges.
Oregon	X		Completed survey forms, but did not run macro. No plans for changing current method of ranking bridges.
Pennsylvania		X	
South Carolina	X		Ran macro and completed survey forms.
Tennessee		X	
Utah		X	
Washington	X		Ran macro and completed survey forms.
Wyoming	X		Ran macro and completed survey forms.

No = did not return the survey

Most of the states responded that the addition of railway considerations was an important factor in the importance issue. Some of the states had previously based railway bridge importance on ADT = 0. However, South Carolina and Wyoming stated that too much emphasis was being placed on

the railroads. In response to the railway concerns, the coefficients RT_{carry} and N_{carry} were revised to 0.9 and 0.8, respectively. This results in a 72% reduction in the "carry" factor of MNT5 for bridges carrying railways. Therefore the final recommended equation, MNT5R, is as follows:

C = bridge importance value
$= [RT_{carry}(DL_{carry}*N_{carry})] + 0.6(RT_{cross}*N_{cross}) + 0.34[(ADT_{carry}/\text{Ave ADT})L]^{0.25} + RV_{cross}$

where:
"carry" indicates the critical route on the bridge;
"cross" indicates the critical route under the bridge;
RT_{carry} = Factor for nature of route:
= 1.1 for Interstate Route or Principal Artery,
= 0.9 for all other routes and railroad bridges;

DL_{carry} = Factor representing criticality of detour length:
= 1.2 for Detour Lengths > 155 km,
= 1.0 for 80 km < Detour Lengths ≤ 155 km,
= 0.9 for 15 km < Detour Lengths ≤ 80 km,
= 0.8 for 5 km < Detour Lengths ≤ 15 km,
= 0.7 for Detour Lengths ≤ 5 km,
= 1.0 for bridges carrying railroads;
N_{carry} = Factor representing criticality of traffic congestion:
$= (ADT_{carry}/\text{Ave ADT})^{0.25}$,
= 0.8 for bridges carrying railroads;
ADT_{carry}= Average Daily Traffic on the bridge;
L = Bridge length(m);
RT_{cross} = Factor for nature of route:
= 0.8 for all routes and structures,
= 0.0 for no route or structure under the bridge;
N_{cross} = Factor representing criticality of traffic congestion:
$= (ADT_{cross}/\text{Ave ADT})^{0.25}$;
RV_{cross} = Ratio of bridge length to longest bridge in the database:
$= L/L_{max}$;
Ave ADT= Average ADT_{carry} in the classification database;
L_{max} = Maximum bridge length(m) in the classification database.

Illinois and Washington disagreed with the omission of the emergency route. As mentioned previously, the test databases from New York and Pennsylvania do not have this information. Therefore, it is suggested that if a state has this data, that state could increase C by 10% for a specified emergency route. This modification is included as commentary in the draft proposals of the specifications in order to allow individual states with specified emergency routes some freedom in adjusting the importance they want to assign to their emergency routes (see section 5). An example of a modified importance equation would be as follows:

$$C = ER *\{[(RT_{carry})(DL_{carry}*N_{carry})] + 0.6(RT_{cross}*N_{cross}) + 0.34[(ADT_{carry}/\text{Ave ADT})(L)]^{0.25} + RV_{cross}\}$$

where:

ER = 1.1 for confirmed emergency route
1.0 for others
Other variables are defined in the MNT5R method given above.

As shown in table 4-1, several of the responses from the states indicated that they were satisfied with their current method for evaluating importance and were unlikely to change. However, the recommended method will still be of value to agencies that have not finalized their bridge seismic screening and evaluation process.

SECTION 5
PROPOSED IMPORTANCE METHOD IN DESIGN AND RETROFIT SPECIFICATIONS

In section 3, a bridge importance classification system was proposed based on data from the NBI database. After evaluating comments received from several states, refinements to the proposed importance classification system were developed as documented in section 4. This section provides recommendations for implementing the proposed importance classification system into seismic design and retrofitting specifications. This implementation is based on inserting the proposed importance classification system into the specifications without changing the basic seismic design philosophies within each of the specifications.

5.1 The AASHTO "Standard Specifications for Highway Bridges", Division I-A

5.1.1 Abstract

The current AASHTO "Standard Specifications for Highway Bridges", Division I-A (from hence forth this specification will be referred to as Division I-A) provides for an Importance Classification with two categories:

- essential bridges and
- other bridges.

The commentary to Division I-A suggests items which should be considered when determining the classification. However, the Division I-A does not provide a method to formally categorize a bridge.

Section 3.4 suggests that an Importance Classification with three categories as given in the "AASHTO LRFD Bridge Design Specifications" should be used:

- critical bridges,
- essential bridges and
- other bridges.

In addition to the change from two to three Importance Classification categories, a method to determine the bridge classification category is included in the recommended revision. The recommended Importance Classifications are based on the bridge importance rank percentile.

In the determination of the Seismic Performance Category (SPC) the Division I-A specification only makes a distinction between "essential" and "other" bridges in regions with an acceleration coefficient, A, greater than 0.29. In order to make a distinction between the three proposed categories in Division I-A with respect to SPC, a classification coefficient, I_C, is assigned to each of the Importance Classification categories. The classification coefficients were developed such that the new minimum design requirements would not be less than previous requirements. The product, $A*I_C$, is then compared to the previous limits for the acceleration coefficient, A. A maximum limit is placed on this product for "other" bridges to insure that the minimum seismic design requirements are not increased from the current Division I-A requirements for "other" bridges.

5.1.2 Recommended Specification Revision

The bold text given below is the suggested revision of Division I-A Sections 3.3 and 3.4 in SI units; Appendix E provides the suggested revision of Division I-A Sections 3.3 and 3.4 in customary U.S. units.

3.3 IMPORTANCE CLASSIFICATION

An Importance Classification (I_C) shall be assigned for all bridges for the purpose of determining the Seismic Performance Category (SPC) in Article 3.4 as follows:

I_C = 1.2 for "critical" bridges: those bridges which are required to remain functional for all traffic after an earthquake of the same magnitude as the design earthquake and provide at least a minimum level of functionality for emergency vehicles or for security/defense purposes immediately after a large earthquake, e.g., 2500 year return period event.

I_C = 1.1 for "essential" bridges: those bridges which are required to provide at least a minimum level of functionality for emergency vehicles or for security/defense purposes after an earthquake of the same magnitude as the design earthquake.

I_C = 1.0 for "other" bridges: all other bridges

The Importance Classification shall include Social/Survival and Security/Defense considerations. If the recommended classification method is used, these requirements shall be considered to be fulfilled. Factors such as socioeconomic or emergency route considerations may also be considered as deemed appropriate by the owner. A methodology for including emergency routes in the determination of structural importance is described in the commentary. Additional owner specified socioeconomic factors can be implemented similar to emergency routes or by the use of additional or modified RT_{carry} and/or RT_{cross} factors. The addition and/or modification of "RT" factors is preferred for socioeconomic factors because it will increase only the importance contribution of the route being considered. The emergency route method given in the commentary increases the contribution of all importance considerations as apposed to only the route being considered i.e., route carried, route crossed, river crossing, etc.

If the owner has a method to classify bridges as "critical", "essential" or "other" bridges, it may be used in lieu of the provisions specified herein. However, if the owner does not have an importance classification system in place, bridges may be classified using the following equation which is based on data from the National Bridge Inventory (NBI) Database:

C = Bridge importance value

$$= [RT_{carry}(DL_{carry}*N_{carry})] + 0.6(RT_{cross}*N_{cross}) + 0.34[(ADT_{carry}/\text{Ave ADT})L]^{0.25} +$$

RV_{cross}

where:

"carry" indicates the critical route on the bridge;

"cross" indicates the critical route under the bridge;

RT_{carry} = Factor for nature of route:
= 1.1 for Interstate Route or Principal Artery,
= 0.9 for all other routes and for railroad bridges;

DL_{carry} = Factor representing criticality of detour length:
= 1.2 for Detour Lengths > 155 km,
= 1.0 for 80 km < Detour Lengths ≤ 155 km,
= 0.9 for 15 km < Detour Lengths ≤ 80 km,
= 0.8 for 5 km < Detour Lengths ≤ 15 km,
= 0.7 for Detour Lengths ≤ 5 km,
= 1.0 for bridges carrying railroads;

N_{carry} = Factor representing criticality of traffic congestion:
= $(ADT_{carry}/\text{Ave ADT})^{0.25}$,
= 0.8 for bridges carrying railroads;

ADT_{carry} = Average Daily Traffic on the bridge;

L = Bridge length(m);

RT_{cross} = Factor for nature of route:
= 0.8 for all routes,
= 0.0 for no route under the bridge;

N_{cross} = Factor representing criticality of traffic congestion:
= $(ADT_{cross}/\text{Ave ADT})^{0.25}$;

RV_{cross} = Ratio of bridge length to longest bridge in the database:
= L/L_{max};

Ave ADT = Average ADT_{carry} in the classification database;

L_{max} = Maximum bridge length(m) in the classification database.

All bridges shall be ranked in order of importance, with the maximum importance value (C_{max}) being the most critical bridge in the classification database. After the bridges are ranked in order of importance, the bridge rank percentile shall be determined. Bridge

rank percentile is the percentage of bridges ranked lower than the bridge being considered and can be obtained by using the following equation:

Bridge Rank Percentile = (total number of bridges - current bridge rank)/(total number of bridges)*100

These rank percentiles shall be used to determine the Importance Classifications:

"critical" bridges are those bridges in the 95th percentile or higher,

"essential" bridges are those bridges ranked in or above the 65th but below the 95th percentile,

"other" bridges are those bridges ranked below the 65th percentile.

DIVISION I-A COMMENTARY: C3.3

The importance rankings for the complete database are required for this importance classification method. Once the importance rankings have been developed, they may be used without recalculating them as long as the NBI Records are not revised. The Engineer shall then only be required to calculate the Importance Value, C, for new structures and determine their Importance Classification in the established rankings. For a new structure, an estimated ADT at the time of opening should be used in the calculation of the importance value, not the design ADT which is usually taken as a projected 20-year ADT. A projected ADT would not be comparable to existing structures with an established ADT and therefore skews the results towards all new structures having higher importance rankings.

If a state has confirmed emergency routes, the importance value, C, could be increased by 10% for that route. This is not included in the design specifications in order to allow individual states with specified emergency routes some freedom in adjusting the importance they want to assign to their emergency routes. An example of a modified importance equation would be as follows:

$$C = ER * \{[(RT_{carry})(DL_{carry} * N_{carry})] + 0.6(RT_{cross} * N_{cross}) + 0.34[(ADT_{carry}/Ave\ ADT)(L)]^{0.25} + RV_{cross}\}$$

where:

ER = 1.1 for confirmed emergency route
1.0 for others

If an owner has a method to rank bridges for seismic importance but does not have a method to assign the "critical", "essential", and "other" classifications, the bridge rank percentiles in the design specification may be used with the existing seismic importance

rankings to determine the Importance Classifications.

3.4 SEISMIC PERFORMANCE CATEGORIES

Each bridge shall be assigned to one of four Seismic Performance Categories (SPC), A through D, based on the Acceleration Coefficient, A, and the Importance Classification (I_C), as shown in Table 3.4. Minimum analysis and design requirements are governed by the SPC.

The product of the Acceleration Coefficient, A, and the Importance Classification, I_C, is only used to determine the SPC of a structure. The actual Acceleration Coefficient, A, shall be used in all other calculations.

TABLE 3.4 Seismic Performance Category (SPC)

SPC	Range of I_CA
*A	$I_CA \leq 0.09$
B	$0.09 < I_CA \leq 0.19$
C	$0.19 < I_CA \leq 0.29$
**D	$0.29 < I_CA$
* For "critical" bridges (I_C = 1.2), $I_CA > 0.09$ ** For "other" bridges (I_C = 1.0), $I_CA \leq 0.29$	

DIVISION I-A COMMENTARY: C3.4

The product I_CA has a maximum value of 0.29 for "other" bridges. This maximum value is used to prevent an "other" bridge from being assigned to SPC D. This corresponds to the requirements of the AASHTO Sixteenth Edition of the Standard Specification of Highway Bridges, Division I-A.

The product I_CA has a minimum value of 0.09 for "critical" bridges. This minimum value is used to prevent a "critical" bridge from being assigned to SPC A.

5.2 "AASHTO LRFD Bridge Design Specifications"

5.2.1 Abstract

The "AASHTO LRFD Bridge Design Specifications" (from hence forth, this specification will be

referred to as LRFD) provides for an Importance Classification with three categories:

- critical bridges,
- essential bridges and
- other bridges.

The LRFD Specification suggests items which should be considered when determining the classification. However, the specification does not provide a method to categorize a bridge. The proposed LRFD revision, given in the next subsection, has a recommended method for categorizing bridges. The recommended Importance Classifications are based on the bridge's importance rank percentile.

The specification specifies a response modification factor, R, based on the Importance Classification. Therefore, the design applications of the Importance Classifications are already included in the specifications.

5.2.2 Recommended Specification Revision

The bold text given below is the suggested revision to LRFD Sections 3.10.3, C3.10.3 and 4.7.4.3.1 for SI units; Appendix F provides the suggested revision of LRFD Sections 3.10.3 and C3.10.3 in customary U.S. units. If these articles are adopted, new definitions and references must be added to the notation and reference lists in LRFD Section 3.

3.10.3 Importance Categories

For the purpose of Article 3.10, the Owner shall classify bridges into one of three importance categories taken as:

- **critical bridges,**
- **essential bridges, or**
- **other bridges.**

The basis of classification shall include social/survival and security/defense requirements. Use of Equation 1 shall be considered as satisfying these requirements. Additional socioeconomic or emergency route considerations as deemed appropriate by the owner may be included in establishing Importance Classifications.

C3.10.3

"Essential" bridges are generally those that should, as a minimum, be open to emergency vehicles and for security/defense purposes immediately after the design earthquake, i.e., a 475-year return period event. However, some bridges must remain open to all traffic after the design earthquake and be usable by emergency vehicles and for security/defense purposes immediately after a large earthquake, e.g., a 2,500-year return period event. These should be regarded as "critical" bridges.

The addition and/or modification of "RT" factors is preferred for socioeconomic factors because it will increase only the importance contribution of the route being considered. The emergency route method given below increases the contribution of all importance considerations as apposed to only the route being considered i.e., route

Additional owner specified socioeconomic factors may also be implemented similar to emergency routes or by the use of additional or modified RT_{carry} and/or RT_{cross} factors. When classifying a bridge, consideration should be given to possible future changes in conditions and requirements.

Other owner approved methods to classify bridges as "critical", "essential" or "other" bridges may be used. Where such owner approved methods do not exist, importance classifications may be determined as specified herein based on data from the National Bridge Inventory (NBI) Records:

C = bridge importance value

$$=[RT_{carry}(DL_{carry}N_{carry})]+0.6(RT_{carry}N_{cross}) +0.34\left[\left(\frac{ADT_{carry}}{AveADT}\right)L\right]^{0.25}+RV_{cross} \quad (3.10.3\text{-}1)$$

where:

"carry" indicates the critical route on the bridge;

"cross" indicates the critical route under the bridge;

RT_{carry} = Factor for nature of route:
- = 1.1 for Interstate Route or Principal Artery,
- = 0.9 for all other routes including railroads;

DL_{carry} = Factor representing criticality of detour length:
- = 1.2 for Detour Lengths > 155 km,
- = 1.0 for 80 km < Detour Lengths ≤ 155 km,
- = 0.9 for 15 km < Detour Lengths

carried, route crossed, river crossing, etc.

If a state has confirmed emergency routes, the importance value, C, could be increased by 10% for that route. This is not included in the design specifications in order to allow individual states with specified emergency routes some freedom in adjusting the importance they want to assign to their emergency routes. An example of a modified importance equation is:

C = bridge importance value

$$=ER[[RT_{carry}(DL_{carry}N_{carry})]+0.6(RT_{carry}N_{cross}) +0.34\left[\left(\frac{ADT_{carry}}{AveADT}\right)L\right]^{0.25}+RV_{cross}] \quad (C3.10.3\text{-}1)$$

where:

ER = 1.1 for confirmed emergency route
1.0 for others

≤ 80 km,
= 0.8 for 5 km < Detour Lengths ≤ 15 km,
= 0.7 for Detour Lengths ≤ 5 km,
= 1.0 for bridges carrying railroads;

N_{carry} = Factor representing criticality of traffic congestion:
= $(ADT_{carry}/Ave\ ADT)^{0.25}$,
= 0.8 for bridges carrying railroads;

ADT_{carry} = Average Daily Traffic on the bridge;

L = Bridge length(m);

RT_{cross} = Factor for nature of route:
= 0.8 for all routes,
= 0.0 for no route under the bridge;

N_{cross} = Factor representing criticality of traffic congestion:
= $(ADT_{cross}/Ave\ ADT)^{0.25}$;

RV_{cross} = Ratio of bridge length to longest bridge in the database:
= L/L_{max};

Ave ADT= Average ADT_{carry} in the classification database;

L_{max} = Maximum bridge length(m) in the classification database.

All of the bridges shall be ranked in order of importance, with the maximum importance value (C_{max}) being the most critical bridge in the classification database. After the bridges are ranked in order of importance, the bridge rank percentile shall be determined as:

Bridge Rank Percentile =
= (total number of bridges - current bridge rank)/(total number of

The importance rankings for the complete database are required for this importance classification method to be used. Once the importance rankings for the complete database have been developed, they may be used without recalculating them as long as the NBI Records are not revised. The Engineer shall then only be required to calculate the Importance Value, C, for new structures and determine their

bridges)*100 (3.10.3-2)

These rank percentiles shall be used to determine the Importance Classifications:

"critical" bridges are those bridges in the 95th percentile or higher,

"essential" bridges are those bridges ranked in or above the 65th but below the 95th percentile,

"other" bridges are those bridges ranked below the 65th percentile.

4.7.4.3.1 Selection of Method (insert before Table 1)

When determining the minimum analysis requirements from Table 1, the bridge importance categories as defined in Article 3.10.3 shall be used.

Importance Classification in the established rankings. For a new structure, an estimated ADT at the time of opening should be used in the calculation of the importance value, not the design ADT which is usually taken as a projected 20-year ADT. A projected ADT would not be comparable to existing structures with an established ADT and therefore skews the results towards all new structures having higher importance rankings.

Bridge rank percentile is the percentage of bridges ranked lower than the bridge being considered. If an owner has a method to rank bridges for seismic importance but does not have a method to assign the importance classifications, the bridge rank percentiles may be used with the existing seismic importance rankings to determine the importance classifications.

5.3 The FHWA "Seismic Retrofitting Manual for Highway Bridges"

5.3.1 Abstract

Like Division I-A, the current FHWA "Seismic Retrofitting Manual for Highway Bridges" (from hence forth referred to as Seismic Retrofitting Manual) provides for a Importance Classification which has two categories:

- essential bridges and
- standard bridges.

However, the Seismic Retrofitting Manual uses this classification to determine the Seismic Performance Category (SPC) differently than does Division I-A. This is because Division I-A made no allowance for the structure importance for bridges with acceleration coefficients less than 0.29. The recommended revision to Division I-A as presented in section 5.1.2 includes three categories, i.e. "critical", "essential", and "other", and makes a distinction between them. The recommended revisions for the Seismic Retrofitting Manual will include the same three importance categories.

However, the SPC will be determined similarly to the way the Seismic Retrofitting Manual currently requires. The only distinction with regards to SPC between the current Seismic Retrofitting Manual and the recommended revision is the addition of "critical" classification. As proposed, "critical" bridges will be required to be retrofitted to the "essential" bridges. Thus at this time, the "critical" classification is more of a consistency revision to correspond to the use of three classifications in the "AASHTO LRFD Bridge Design Specifications" and the recommended revisions to the AASHTO "Standard Specification for Highway Bridges, Division I-A". The distinctions between retrofitting requirements for "critical" and "essential" bridges can be revised as future research deems necessary.

The Seismic Retrofitting Manual recommends the use of a Priority Index which is a function of importance, structural vulnerability and seismicity, but this manual does not specify how that functionality should be established. Based on the proposed importance equation, it is anticipated that there will be a wide distribution of importance values. The use of a summation equation to combine importance, structural vulnerability and seismicity into a composite index, "Priority Index", would cause the structure importance to have a large affect on this index. Therefore, importance coefficients were developed so the Priority Index could be the product of importance, structural vulnerability and seismicity coefficients. Numerous importance coefficients to be used in the Priority Index product were investigated using the NYSDOT database (see table 5-1). The coefficients considered were:

- C1 - classification coefficients,
  "critical", "essential", and "other", $C_{if} = I_C = 1.2, 1.1, 1.0$, respectively;
- C2 - linear function of importance rank, C_{if} = (# of bridges - rank) / # of bridges;
- C3 - linear function of the importance values, $C_{if} = C_i$;
- C4 - exponential function of the importance value, $C_{if} = C_i^{0.5}$;
- C4a - exponential function of the importance value, $C_{if} = C_i^{0.25}$;
- C5 - percentage of importance value, $C_{if} = C_i^{0.5}/(C_{max}-C_{min})^{0.5}$;
- C5a - percentage of importance value, $C_{if} = C_i^{0.5}/(C_{max}-C_{min})^{0.5} \geq 0.5$;
- C5b - percentage of importance value, $C_{if} = C_i^{0.25}/(C_{max}-C_{min})^{0.25}$;
- C5c - percentage of importance value, $C_{if} = C_i^{0.25}/(C_{max}-C_{min})^{0.25} \geq 0.5$;
- C6 - percentage of importance rank, C_{if} = (# of bridges - rank)$^{0.5}$/(# of bridges)$^{0.5}$;
- C6a - percentage of importance rank, C_{if} = (# of bridges - rank)$^{0.5}$/(# of bridges)$^{0.5} \geq 0.5$;
- C6b - percentage of importance rank, C_{if} = (# of bridges - rank)$^{0.25}$/(# of bridges)$^{0.25}$;
- C6c - percentage of importance rank, C_{if} = (# of bridges - rank)$^{0.25}$/(# of bridges)$^{0.25} \geq 0.5$;

  where:
  I_C is the importance classification coefficient in the proposed revision of Division I-A
  C is the importance value in the proposed revision of Division I-A

TABLE 5-1 Importance Coefficients

Importance Coefficient	Coefficient Data			
	max	min	Ave	Std. Dev
C1	1.20	1.00	1.040	0.058
C2	1.00	0.00	0.500	0.289
C3	8.77	0.00	1.297	0.927
C4	2.96	0.00	1.069	0.392
C4a	1.72	0.00	1.014	0.204
C5	1.00	0.00	0.361	0.132
C5a	1.00	0.50	0.512	0.040
C5b	1.00	0.00	0.589	0.118
C5c	1.00	0.50	0.603	0.093
C6	1.00	0.00	0.667	0.236
C6a	1.00	0.00	0.800	0.163
C6b	1.00	0.50	0.806	0.148
C6c	1.00	0.50	0.708	0.172

The importance coefficients, C1, C2, C3, C4, and C4a, had a large variation in values. Coefficients with a large variation in value would cause structural importance to dominate the Priority Index and therefore, these coefficients were not selected. A minimum coefficient limit of 0.50 was selected to prevent highly vulnerable structures with low importance from being neglected. The importance coefficients, C5, C5b, C6, and C6b, were not considered for final recommendation because they did not have a minimum value. The C6a and C6c coefficients had an average value close to the median value. An average coefficient close to the median value would not allow a significant distinction among the three importance classifications so these coefficients were disregarded. The C5a coefficient had an average value only 2% greater than the minimum coefficient. This would result in very minor distinctions among all bridges with the exception of "critical" bridges. The C5c coefficient had an average value 20% greater than the minimum. This would allow some distinction among "other" bridges while giving greater importance to "critical" and "essential" bridges. Therefore, the final recommended importance coefficient is the C5c coefficient.

5.3.2 Recommended Manual Revision

The bold text given below the is suggested revision to the FHWA "Seismic Retrofitting Manual for Highway Bridges", Publication No. FHWA-RD-94-052 (May 1995), sections 1.5 and 2.3.2. Since these sections do not have units of measure contained within them it, both the metric and customary U.S.

units versions would be identical.

1.5 BRIDGE CLASSIFICATION

Before seismic retrofitting can be undertaken for a group of bridges, they must first be classified according to their Seismic Performance Category (SPC). As noted in section 1.3, the SPC is determined by a combination of seismic hazard and structure importance.

Seismic hazard is reflected in the Acceleration Coefficient (A) values that are assigned to all locations covered by the AASHTO Specifications. When multiplied by the acceleration due to gravity (g), the product (A*g) represents the likely peak horizontal ground acceleration that will occur due to an earthquake sometime within a 475-year period. More rigorously, this acceleration has a 10 percent probability of being exceeded within a 50-year time frame.

Bridge importance is not so readily quantified. The determination of the Importance Classification of a bridge is necessarily subjective and consideration should be given to societal/survival and security/defense requirements.

The societal/survival evaluation addresses a number of socio-economical needs and includes, for example, the need for access for emergency relief and recovery operations immediately following an earthquake.

Security/defense requirements may be evaluated using the 1973 Federal-aid Highway Act, which required that a plan for defense highways be developed by each State. The defense highway network provides connecting routes to military installations, industries and resources not covered by the Federal-aid primary routes.

Three Importance Classifications are specified: "critical", "essential", and "other". These classifications are defined in the AASHTO "Standard Specifications for Highway Bridges", Division I-A, section 3.3. If the owner has a method to classify bridges as "critical", "essential", or "other" bridges, it may be used in lieu of the provisions referenced herein. However, if the owner does not have an importance classification system in place, a recommended method is given in Division I-A, section 3.3. If the classifications are determined as specified in Division I-A, the societal/survival and security/defense requirements can be considered fulfilled.

Based on the above considerations for seismic hazard and importance, four Seismic Importance Categories are defined as shown in table 1.

Table 1. Seismic performance category.

Acceleration Coefficient	Importance Classification		
	Critical	Essential	Other
$A \leq 0.09$	B	B	A
$0.09 < A \leq 0.19$	C	C	B
$0.19 < A \leq 0.29$	C	C	C
$0.29 < A$	D	D	C

The bridge SPC is assigned differently from AASHTO Specifications for new design. In view of the high cost of retrofitting, it is important to be able to distinguish between "critical" or "essential" and "other" structures; this is especially so in low-to-moderate seismic zones. Such a distinction also enables a more rational allowance to be made for the nature of the seismic hazard in the Central and Eastern United States where the maximum credible earthquake is expected to be significantly larger than the "design" earthquake (475-year event). This implies that if a "critical" bridge in the East is to remain fully operational following a large earthquake, it will need to be retrofitted to a standard higher than that required by the specification for new construction. This observation is reflected in the SPC assignment for "critical" and "essential" bridges in table 1.

2.3.2 CALCULATION OF PRIORITY INDEX

Once a rank has been calculated for each bridge based on equation 2-2, the bridges may be listed in numerical order of decreasing rank. This order is then modified to include such factors as bridge importance, network redundancy, nonseismic deficiencies, remaining useful life and any other factor deemed necessary by the owner.

Guidance on assigning importance is given in Division I-A and some discussion of network redundancy and nonseismic rehabilitation was provided in section 1.6 (and figures 4 and 5) under the Heading, "Preliminary Screening". If a bridge is part of a highly redundant highway network with alternative bridges or routes, the likelihood that these alternate facilities may also be damaged must be considered. If, for example, an overpass can be bypassed by using the on- and off-ramps, then a relatively convenient detour may be nearby, provided these access ramps remain operational. If, on the otherhand, the structure in question is a critical river crossing, the nearest detour may be kilometers away, but the possibility of it also being damaged may not be so great. Nevertheless, the higher priority should be given to the river crossing because of lack of alternate routes. In general, it is difficult to develop a single number by which to scale the seismic rank (equation 2-2) to obtain the priority index. However, unless the owner is willing to reorder the rank to

include the importance issue by some subjective means using a combination of engineering and societal judgement, then some type of numerical equation is necessary to determine the priority index. With a large number of bridges, even a simplistic numerical equation will be of great benefit in determining the priority index. Therefore, if the owner implements the importance method from Division I-A to calculate the Priority Index (P), the following method should be used:

$$P = R * C_{if}$$

where:

R = bridge rank (section 2.3.1)

$$C_{if} = \frac{C_i^{0.25}}{(C_{max} - C_{min})^{0.25}} \geq 0.50$$

C_i = importance value for the bridge being considered (Division I-A)

C_{max} = maximum importance value in the classification database

C_{min} = minimum importance value in the classification database

If the owner does not implement the importance method from Division I-A, a similar equation could be used.

SECTION 6
CONCLUSIONS AND RECOMMENDATIONS

The three major results of this project are:

- Development of an importance ranking method which is based on existing NBI data.
- Development of suggested revisions to the AASHTO "Standard Specification for Highway Bridges", Division I-A, "AASHTO LRFD Bridge Design Specifications" and the FHWA "Seismic Retrofitting Manual for Highway Bridges" to specifically include importance in seismic design procedures.
- Allowance for existing importance ranking methods to be used with the suggested revisions to the specifications given above.

The Importance method developed from this study is simplistic in nature when compared with the research done by others which use a network approach and Geographic Information System (GIS) data. However, the method from this report works with the state's existing NBI data and does not require the collection of new data. During this research, several data entry errors and omissions were discovered in the test databases. Rapid growth in ADT and bridge rehabilitations makes maintaining the NBI Records difficult. The requirement of additional data would only increase the cost of maintaining bridge inventory records.

The method proposed herein fills a need for states in low and moderate seismic zones to develop an importance ranking method with minimal effort or cost. When GIS based network analysis become readily available and cost effective, engineers can then implement more advanced systems for determining importance rankings.

SECTION 7
REFERENCES

AASHTO (1996), Standard Specification for Highway Bridges, Sixteenth Edition, Washington, D.C.

AASHTO (1994), AASHTO LRFD Bridge Design Specifications, First Edition, Washington, D.C.

FHWA (1995), Seismic Retrofitting Manual for Highway Bridges, Publication No. FHWA-RD-94-052

APPENDIX A
EXISTING IMPORTANCE METHODS

The importance methods provided in this appendix are given in customary U.S. Units.

Babaei and Hawkins '91: Washington DOT

CRITICALITY FACTOR, C

$$C = [(RN_{carry})(DL_{carry} X N_{carry})] + [UT_{carry}] + (2/3)[(RN_{cross})(DL_{cross} X N_{cross})] + (1/4)[(ADT_{carry}/30,000)(L)]^{0.25}$$

RN_{carry} = factor for the nature of the route

RN_{carry} = 1.0; interstate route, principal artery, or confirmed emergency route
= 0.8; all other routes

DL_{carry} = factor representing criticality of detour length
= 1.00; When detour length > 10 mi
= 0.80; When detour length is 3 to 10 mi
= 0.75; When detour length < 3 mi

N_{carry} = factor representing criticality of detour due to traffic congestion
= $ADT_{carry}/30,000]0.25 >=1$

ADT_{carry} = average daily traffic of the route

UT_{carry} = factor representing utility lines
= 1; bridge carrying a confirmed essential utility line
= 0; all other bridges

RN_{cross} = factor representing the nature of the route
= 1.0; confirmed emergency route
= 0.8; all other routes
= 0.0; no route under the bridge

DL_{cross} = factor representing criticality of detour length

= 1.00; when detour length > 10 miles
= 0.80; when detour length is 3 to 10 miles
= 0.75; when detour length < 3 mi

N_{cross} = factor representing criticality of detour due to traffic congestion
= $ADT_{cross}/30{,}000]^{0.25} >= 1$

ADT_{cross} = average daily traffic

L = length of the bridge in ft.

Modified Babaei and Hawkins: Adjust reference ADT from 30,000 to 6,000

CRITICALITY FACTOR, C

$$C = [(RN_{carry})(DL_{carry} X N_{carry})] + [UT_{carry}] + (2/3)[(RN_{cross})(DL_{cross} X N_{cross})] + (1/4)[(ADT_{carry}/6{,}000)(L)]^{0.25}$$

RN_{carry} = factor for the nature of the route
RN_{carry} = 1.0; interstate route, principal artery, or confirmed emergency route
= 0.8; all other routes
DL_{carry} = factor representing criticality of detour length
= 1.00; When detour length > 10 mi
= 0.80; When detour length is 3 to 10 mi
= 0.75; When detour length < 3 mi
N_{carry} = factor representing criticality of detour due to traffic congestion
= $ADT_{carry}/6{,}000]^{0.25} >= 1$
ADT_{carry} = average daily traffic of the route
UT_{carry} = factor representing utility lines
= 1; bridge carrying a confirmed essential utility line
= 0; all other bridges
RN_{cross} = factor representing the nature of the route
= 1.0; confirmed emergency route
= 0.8; all other routes
= 0.0; no route under the bridge
DL_{cross} = factor representing criticality of detour length
= 1.00; when detour length > 10 miles
= 0.80; when detour length is 3 to 10 miles
= 0.75; when detour length < 3 mi
N_{cross} = factor representing criticality of detour due to traffic congestion
= $ADT_{cross}/6{,}000]^{0.25} >= 1$

ADT_{cross} = average daily traffic
L = length of the bridge in ft.

Buckle '95; New York DOT

Please note that for comparison studies, only the equation was used.

A bridge is defined as "critical" if any one of the following conditions exist:

1. Bridge is designated as a critical facility
2. Bridge carries a defense highway
3. Bridge is located on the national network for trucks
4. The index (i) is greater than or equal to 2.5

Where:

$$I = 1 + \frac{FADT}{15{,}000} + \frac{N}{10} + \frac{DL}{20} + \frac{FC}{2}$$

FADT = future average daily traffic
N = number of utilities carried
DL = detour length (miles)
FC = functional classification

Modified Buckle '95: Replace FADT with ADT

$$I = 1 + \frac{ADT}{15{,}000} + \frac{N}{10} + \frac{DL}{20} + \frac{FC}{2}$$

ADT = average daily traffic
N = number of utilities carried
DL = detour length (miles)
FC = functional classification

Caltrans Method

Impact = .28 * (Value from a curve based on ADT on the structure)
+.12 * (Value from a curve based on ADT under or over the structure)
+.14 * (Value from a line normalized to 100 miles based on detour length)
+.15 * (Leased Air Space Residential, Office; 1 = present, 0 = else)
+.07 * (Leased Air Space Parking, Storage; 1 = present, 0 = else)
+.07 * (Route Type on Bridge;
1.0 = interstate, 0.8 = US, State route or street, 0.7 = RR, 0.5 = federal funded County route or city street, 0.2 = nonfederal funded County route or city street, 0.0 = federal land, State land, other)

+.07 * (Facility Crossed; use categories from route type on bridge)
+.10 * (Critical Utility; 1 = present, 0 = else)

Montana

$$C = [(RT_{carry})(DL_{carry}*N_{carry})] + (2/3)[(RT_{cross})(DL_{cross}*N_{cross})] + (1/4)[(ADT_{carry}/6{,}000)(L)]^{0.25} + RV_{cross}$$

where:

$N_i = (ADT_i/6000)^{0.25}$
DL_i = Detour Length Coefficient
RV_{cross} = L/1000 for river crossings
RT_{carry} = 1.0 or 0.8
RT_{cross} = 1.0 or 0.8

Nevada

I = RT + T + Det + Ut + Def + RR

Type of route, RT :

The sum of RT for the routes on and under the bridge
Interstate, RT = 3 Primary Route, RT = 2
Secondary route, RT = 1 Others, RT = 0
Urban Routes are classified as primary or secondary

Traffic count, T :

Sum of the value of T for routes on and under the bridge

$$T = \frac{\sqrt{ADT}}{100}\left[1 + \frac{\sqrt{(LW)(N)}}{300}\right]$$

where:
ADT $\leq$ 90,000
LW = bridge length for route on the bridge
and bridge width for route under the bridge
N = number of lanes on or under the bridge

Detour length, Det:

One tenth of the sum of the detour for both routes on and under the bridge. Det $\leq$ 2

Utilities on the bridge, Ut :

1.0 if utilities exist on the bridge, otherwise = 0.0

Defense classification, Def :

1.0 if the route on or under the bridge is designated as part of the strategic Highway Network, otherwise = 0

Rail roads :

1.5 if railroad exists on or under the bridge, otherwise = 0.0

South Carolina

Importance Rating, IR:

All bridges will be classified as IC = II except in the following cases where the bridges will be classified as IC = I:

(a) Bridges on or passing over an interstate highway
(b) Bridges on designated truck network or defense highway
(c) Bridges necessary to provide access to emergency services, power plants and water treatment plants.

Bridges classified as IC = I, will have an initial value of IR = 6. This value will be increased or decreased based on the factors below, but will not be taken less than 6 or greater than 10:

1.	Bridge over water	+1
2.	Bridge carries interstate	+1
3.	Bridge over interstate	+1
4.	Interchange allows traffic to bypass bridge	-1
5.	5000 < ADT < 10,000	+1
6.	10,000 < ADT < 20,000	+2
7.	ADT > 20,000	+3
8.	Bridge deck surface area > 12,000 SF	+1

Bridges classified as IC = II, will have an initial value of IR = 0. This value will be increased or decreased based on the factors below, but will not be taken less than 0 or greater than 5:

1.	Bridge over water	+1
2.	50 < ADT < 200	+1
3.	200 < ADT < 500	+2
4.	ADT > 500	+3
5.	Detour length > 10 miles	+1

Modified South Carolina

For the South Carolina method given above, deleted the maximum values of 10 and 5 placed on IC=I and IC=II, respectively.

Missouri

Importance factor $=[(3+l_1) \times n_1 \times SF_1 + (3+l_2) \times n_2 \times SF_2] \times P + RC + Det$

where:

l_1, l_2 : Length of bridge and length along intersecting roadway under the bridge, respectively. Both are in 100 ft.

n_1, n_2 : Number of lanes on and under the bridge, respectively.

SF_1, SF_2: Spacing factor based on ADT on and under the bridge, respectively. Values of SF are calculated based on the ADT as follows:

ADT	Vehicle spacing	SF
< 5,000	500 ft.	0.20
5,000 - 20,000	300 ft.	0.33
20,000 - 50,000	200 ft.	0.50
50,000 - 100,000	100 ft.	1.00
> 100,000	50 ft.	2.00

P : Route priority factor = 1.2 for priority 1 routes
1.0 for priority 2 routes

RC : Route continuity factor =
2.0 for bridges needed for completing a route, otherwise = 0.0. RC is ignored in the preliminary screening and will be considered only in the final screening.

Det : Detour length factor = 1.0 for detour length $\geq$ 5 miles, otherwise = 0

Modified Missouri

For the Missouri method given above, set the maximum bridge length = 5280'.

IDOT

I = 0.69*Vehicles Impacted + 0.15*Emergency Route + 0.10*Detour + 0.05*Defense Route + 0.01*Utilities

where:
Vehicles Impacted = $(ADT_{on}(Length_{bridge} + 236) + ADT_{under}(Deck\ width + 236))/5{,}068{,}800$
Emergency Route was not used in this equation.
Detour = $(ADT_{on}*detour\ length_{on})/100{,}000 + 0.39*(ADT_{under}*detour\ length_{under})/100{,}000 + 15*I_{NW} + 5*I_{RR}$
I_{NW} = 1 if bridge is over navigable water
I_{RR} = 1 if bridge is over railroad
Defense Route = 0.8 for priority route on bridge
= 0.2 for priority route under bridge
= 0.7 for secondary route on bridge
= 0.1 for secondary route under bridge
= 0 for non-defense route
Utilities = 1 if utilities on bridge

APPENDIX B

PENNDOT IMPORTANCE SURVEY

July 2, 1996

Mr. John Rautzahn, P. E., Assistant District Engineer, Design
Pennsylvania Department of Transportation
Engineering District 8-0
2140 Herr Street
Harrisburg, Pennsylvania 17103-2699

RE: NCEER HIGHWAY PROJECT, DTFH61-92-C-00112 JN1525
Evaluation of Structure Importance
Bridge Importance in Dauphin and Cumberland Counties

Dear Mr. Rautzahn:

Modjeski and Masters, Inc. has been working on a seismic research project which is investigating the importance rating for bridges. This project is with the National Center for Earthquake Engineering Research. In prioritization of bridges for seismic retrofits, importance is one factor in the prioritization equation (see attached copy of flowchart from the Seismic Retrofit Manual).

Modjeski and Masters, Inc. has been reviewing 12 importance equations developed by individuals and States. Most of these equations are designed to work with data from bridge management systems (BMS). Mr. Hal Rogers, an Assistant Chief Bridge Engineer with PennDOT, has provided us with BMS data for Dauphin and Cumberland Counties in order to review these equations.

We are asking if several of the District 8-0 employees could list what, in their opinion, are the top 20 most important State or local bridges in Dauphin and Cumberland Counties (each County separately). The lists supplied by your employees would then be compared with results which were obtained from the importance equations. Mr. Rogers informed me of his conversation with you on Friday, June 28, 1996. Mr. Rogers indicated your willingness to help with this study. Mr. Rogers also stated that you had discussed allowing County Managers, traffic personnel, maintenance personnel, bridge personnel or whoever else you believe is appropriate complete the forms.

In our definition of "importance", the most important bridges would be ones which if they were out of service would cause the most disruption to the community and/or public service. In our definition of "importance", a bridge's need of repair or replacement is not a rating factor (i.e. we are not looking for the maintenance or replacement priority list).

We would appreciation obtaining these lists from your employees by July 18, 1996, so that we can incorporate them into our ongoing study. In order to expedite the process, we expect the forms to be filled out by hand (i.e. not typed). After we have processed these lists, we can setup a

meeting to discuss our comparison of your results and our equations. At the end of the project, we will provide you with a copy of the final report.

Enclosed are eight sets of list forms and instructions for your employees, if you need more let us know.

If you have any questions, please call me or Mr. Andrew L. Thomas.

Thank you for your time and consideration on this matter.

Very truly yours,

SCOTT R. ESHENAUR,
Associate

SRE:rsb

encl.
as

cc: Mr. Hal Rogers, PennDOT, Central Office (w/encl)

INSTRUCTIONS FOR COMPLETING FORMS

Modjeski and Masters, Inc. has been working on a seismic research project which is investigating the importance rating for bridges. This project is with the National Center for Earthquake Engineering Research. In prioritization of bridges for seismic retrofits, importance is one factor in the prioritization equation.

Modjeski and Masters, Inc. has been reviewing 12 importance equations developed by individuals and states. Most of these equations are designed to work with data from bridge management systems(BMS).

We are asking that you list what in your opinion are the top twenty most important state or local bridges in Dauphin and Cumberland Counties (each county separately, see attached sheets). If possible, please rank these top twenty bridges with number one being the most important and number twenty being the least important of the top twenty. These lists will then be compared with results which were obtained from the importance equations.

In our definition of Importance, the most important bridges would be ones which if they were out of service would cause the most disruption to the community and/or public services. In our definition of Importance, a bridge's need of repair or replacement is not a rating factor (i.e. we are not looking for the maintenance or replacement priority list.).

We would appreciation obtaining these lists from you by July 18, 1996 so that we can incorporate them into our on going study. In order to expedite the process, we expect the forms to be fill out by hand (i.e. not typed). Please return the completed lists in the attached stamped envelope.

If you have any questions concerning these lists, please call Mr. Andy Thomas or Mr. Scott Eshenaur of Modjeski and Masters at 717-790-9565.

Thank you for your time and consideration on this matter.

PennDOT SURVEY

Most Important State or Local Bridges in Dauphin County

Unit:_____ Title:_____ Name(optional):_____

Rank	Name of Bridge or Route Carried	State or Local	Feature Crossed (Route, river, RR, etc)	Township (if known)	Reason of Importance *
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					
11					
12					
13					
14					
15					
16					
17					
18					
19					
20					

* The reasons for bridge importance ranking is helpful but not required. The reverse side may be used for any additional comments.

Note: Forms may be handwritten.

APPENDIX C
COMPARISON RESULTS

Babaei and Hawkins Results for Dauphin County												
B&H RANK	Structure ID Number	Mod B&H RANK	Buckle RANK	Mod Buckle RANK	Caltrans RANK	Montana RANK	Nevada RANK	SC RANK	Mod SC RANK	Missouri RANK	IDOT RANK	
1	22008304200000	1	4	1	1	2	1	51	16	1	1	
2	22301600100000	2	22	60	8	3	15	106	72	5	4	
3	22008106520000	3	23	16	17	1	3	16	4	2	2	
4	22008304203326	4	3	2	4	4	2	52	17	3	3	
5	22301400300190	5	159	172	19	5	18	352	352	15	8	
6	22301200300000	7	177	135	68	8	203	348	348	11	9	
7	22002200500208	12	142	140	74	19	107	2	83	93	20	
8	22301200100000	10	186	198	97	12	226	347	347	32	27	
9	22032201700000	9	88	120	59	30	198	98	70	47	31	
10	22301200800233	11	231	277	34	6	40	349	349	38	19	
11	22002204200000	8	94	103	2	28	9	14	34	26	54	
12	22302200200250	13	133	157	37	39	79	451	451	53	103	
13	22008304300800	15	396	408	9	54	26	53	100	6	44	
14	22707699024676	21	81	81	16	69	21	113	75	62	108	
15	22301701102199	16	232	251	11	52	39	107	117	48	106	
16	22008304340000	6	1	3	3	9	4	54	50	4	5	
17	22300900101034	18	125	128	26	50	126	446	446	92	134	
18	22003900201278	17	183	212	25	53	84	405	405	61	144	
19	22300700600000	22	284	248	5	68	27	103	115	40	62	
20	22301300200377	23	235	256	6	72	31	105	116	54	66	Tot. ave
	average=	11.2	140.0	148.4	26.1	29.2	63.0	178.6	178.4	34.7	47.5	86.7

Modified Babaei and Hawkins Results for Dauphin County												
Mod B&H RANK	Structure ID Number	B & H RANK	Buckle RANK	Mod Buckle RANK	Caltrans RANK	Montana RANK	Nevada RANK	SC RANK	Mod SC RANK	Missouri RANK	IDOT RANK	
1	22008304200000	1	4	1	1	2	1	51	16	1	1	
2	22301600100000	2	22	60	8	3	15	106	72	5	4	
3	22008106520000	3	23	16	17	1	3	16	4	2	2	
4	22008304203326	4	3	2	4	4	2	52	17	3	3	
5	22301400300190	5	159	172	19	5	18	352	352	15	8	
6	22008304340000	16	1	3	3	9	4	54	50	4	5	
7	22301200300000	6	177	135	68	8	203	348	348	11	9	
8	22002204200000	11	94	103	2	28	9	14	34	26	54	
9	22032201700000	9	88	120	59	30	198	98	70	47	31	
10	22301200100000	8	186	198	97	12	226	347	347	32	27	
11	22301200800233	10	231	277	34	6	40	349	349	38	19	
12	22002200500208	7	142	140	74	19	107	2	83	93	20	
13	22302200200250	12	133	157	37	39	79	451	451	53	103	
14	22008304601012	39	57	62	39	13	8	61	22	22	11	
15	22008304300800	13	396	408	9	54	26	53	100	6	44	
16	22301701102199	15	232	251	11	52	39	107	117	48	106	
17	22003900201278	18	183	212	25	53	84	405	405	61	144	
18	22300900101034	17	125	128	26	50	126	446	446	92	134	
19	22008304611029	50	58	64	60	17	29	63	54	39	24	
20	22008106601047	34	25	47	57	14	28	19	38	8	7	Tot. ave
	average =	14.0	117.0	127.8	32.5	21.0	62.3	169.7	168.8	30.3	37.8	78.10

Buckle Results for Dauphin County												
Buckle RANK	Structure ID Number	B & H RANK	Mod B&H RANK	Mod Buckle RANK	Caltrans RANK	Montana RANK	Nevada RANK	SC RANK	Mod SC RANK	Missouri RANK	IDOT RANK	
1	22008304340000	16	6	3	3	9	4	54	50	4	5	
2	22008304340713	78	52	24	10	40	32	55	51	12	35	
3	22008304203326	4	4	2	4	4	2	52	17	3	3	
4	22008304200000	1	1	1	1	2	1	51	16	1	1	
5	22008304900000	90	59	9	13	43	35	73	61	37	45	
6	22008304840608	111	86	10	27	74	43	72	60	50	61	
7	22008304700976	83	57	11	31	75	52	68	23	16	13	
8	22008304741403	89	61	12	32	84	55	69	58	18	52	
9	22008304840463	131	113	14	63	105	157	71	24	71	28	
10	22008304501003	45	25	6	22	33	46	57	18	19	6	
11	22008304440634	44	24	5	12	15	37	56	52	30	10	
12	22008304501664	104	77	7	42	90	98	58	19	65	14	
13	22008304540221	125	68	13	7	51	25	59	20	42	12	
14	22008304801909	112	89	17	40	97	69	70	59	33	78	
15	22008304600107	151	140	15	66	127	155	60	21	29	33	
16	22008107401223	110	83	18	71	94	100	35	10	46	18	
17	22008304641054	75	35	21	23	29	34	64	55	24	42	
18	22008304641712	136	95	22	14	55	23	65	3	72	16	
19	22008304641936	68	27	23	18	18	14	66	56	28	39	
20	22008107041120	147	128	24	82	118	115	32	7	57	36	Tot. ave
	average =	86.0	61.5	12.9	29.1	58.2	54.9	59.4	34.0	32.9	27.4	45.60

Modified Buckle Results for Dauphin County												
Mod Buckle RANK	Structure ID Number	B & H RANK	Mod B&H RANK	Buckle RANK	Caltrans RANK	Montana RANK	Nevada RANK	SC RANK	Mod SC RANK	Missouri RANK	IDOT RANK	
1	22008304200000	1	1	4	1	2	1	51	16	1	1	
2	22008304203326	4	4	3	4	4	2	52	17	3	3	
3	22008304340000	16	6	1	3	9	4	54	50	4	5	
4	22008304340713	78	52	2	10	40	32	55	51	12	35	
5	22008304440634	44	24	11	12	15	37	56	52	30	10	
6	22008304501003	45	25	10	22	33	46	57	18	19	6	
7	22008304501664	104	77	12	42	90	98	58	19	65	14	
8	22008106641980	154	141	28	46	142	162	21	5	10	25	
9	22008304900000	90	59	5	13	43	35	73	61	37	45	
10	22008304840608	111	86	6	27	74	43	72	60	50	61	
11	22008304700976	83	57	7	31	75	52	68	23	16	13	
12	22008304741403	89	61	8	32	84	55	69	58	18	52	
13	22008304540221	125	68	13	7	51	25	59	20	42	12	
14	22008304840463	131	113	9	63	105	157	71	24	71	28	
15	22008304600107	151	140	15	66	127	155	60	21	29	33	
16	22008106520000	3	3	23	17	1	3	16	4	2	2	
17	22008304801909	112	89	14	40	97	69	70	59	33	78	
18	22008107401223	110	83	16	71	94	100	35	10	46	18	
19	22008107502454	146	126	55	72	115	104	38	11	59	30	
20	22008107342707	144	120	56	76	111	109	34	9	56	29	Tot. ave
	average =	87.1	66.8	14.9	32.8	65.6	64.5	53.5	29.4	30.2	25.0	47.0

Caltrans Results for Dauphin County												
Caltrans RANK	Structure ID Number	B & H RANK	Mod B&H RANK	Buckle RANK	Mod Buckle RANK	Montana RANK	Nevada RANK	SC RANK	Mod SC RANK	Missouri RANK	IDOT RANK	
1	22008304200000	1	1	4	1	2	1	51	16	1	1	
2	22002204200000	11	8	94	103	28	9	14	34	26	54	
3	22008304340000	16	6	1	3	9	4	54	50	4	5	
4	22008304203326	4	4	3	2	4	2	52	17	3	3	
5	22300700600000	19	22	284	248	68	27	103	115	40	62	
6	22301300200377	20	23	235	256	72	31	105	116	54	66	
7	22008304540221	125	68	13	13	51	25	59	20	42	12	
8	22301600100000	2	2	22	60	3	15	106	72	5	4	
9	22008304300800	13	15	396	408	54	26	53	100	6	44	
10	22008304340713	78	52	2	24	40	32	55	51	12	35	
11	22301701102199	15	16	232	251	52	39	107	117	48	106	
12	22008304440634	44	24	11	5	15	37	56	52	30	10	
13	22008304900000	90	59	5	9	43	35	73	61	37	45	
14	22008304641712	136	95	18	22	55	23	65	3	72	16	
15	22302600700560	31	43	269	266	104	48	166	166	69	135	
16	22707699024676	14	21	81	81	69	21	113	75	62	108	
17	22008106520000	3	3	23	16	1	3	16	4	2	2	
18	22008304641936	68	27	19	23	18	14	66	56	28	39	
19	22301400300190	5	5	159	172	5	18	352	352	15	8	
20	22028300040000	35	47	93	105	106	51	79	65	154	158	Tot. ave
	average =	36.5	27.1	98.2	103.4	40.0	23.1	87.3	77.1	35.5	45.7	57.37

Montana Results for Dauphin County												
Montana RANK	Structure ID Number	B & H RANK	Mod B&H RANK	Buckle RANK	Mod Buckle RANK	Caltrans RANK	Nevada RANK	SC RANK	Mod SC RANK	Missouri RANK	IDOT RANK	
1	22008106520000	3	3	23	16	17	3	16	4	2	2	
2	22008304200000	1	1	4	1	1	1	51	16	1	1	
3	22301600100000	2	2	22	60	8	15	106	72	5	4	
4	22008304203326	4	4	3	2	4	2	52	17	3	3	
5	22301400300190	5	5	159	172	19	18	352	352	15	8	
6	22301200800233	10	11	231	277	34	40	349	349	38	19	
7	22001100100000	71	58	211	247	212	145	1	82	34	15	
8	22301200300000	6	7	177	135	68	203	348	348	11	9	
9	22008304340000	16	6	1	3	3	4	54	50	4	5	
10	22002200501317	38	38	154	147	145	44	3	84	76	17	
11	22002200511275	42	40	147	149	146	45	5	86	79	23	
12	22301200100000	8	10	186	198	97	226	347	347	32	27	
13	22008304601012	39	14	57	62	39	8	61	22	22	11	
14	22008106601047	34	20	25	47	57	28	19	38	8	7	
15	22008304440634	44	24	11	5	12	37	56	52	30	10	
16	22303400100000	53	99	482	479	284	388	452	452	606	170	
17	22008304611029	50	19	58	64	60	29	63	54	39	24	
18	22008304641936	68	27	19	23	18	14	66	56	28	39	
19	22002200500208	7	12	142	140	74	107	2	83	93	20	
20	22002200510165	61	56	146	148	263	154	4	85	94	34	Tot. ave
	average =	28.1	22.8	112.9	118.8	78.1	75.6	120.4	132.5	61.0	22.4	77.24

Nevada Results for Dauphin County												
Nevada RANK	Structure ID Number	B & H RANK	Mod B&H RANK	Buckle RANK	Mod Buckle RANK	Caltrans RANK	Montana RANK	SC RANK	Mod SC RANK	Missouri RANK	IDOT RANK	
1	22008304200000	1	1	4	1	1	2	51	16	1	1	
2	22008304203326	4	4	3	2	4	4	52	17	3	3	
3	22008106520000	3	3	23	16	17	1	16	4	2	2	
4	22008304340000	16	6	1	3	3	9	54	50	4	5	
5	22008305011814	79	33	60	63	41	24	76	25	68	53	
6	22008106940918	95	53	73	71	47	38	27	6	91	65	
7	22008106951752	187	134	80	73	48	78	30	2	80	26	
8	22008304601012	39	14	57	62	39	13	61	22	22	11	
9	22002204200000	11	8	94	103	2	28	14	34	26	54	
10	22707699024738	133	106	185	104	69	57	116	77	74	109	
11	22002202901786	62	28	128	124	44	21	11	90	13	21	
12	22002202911867	63	29	129	125	45	22	13	92	14	22	
13	22028300241975	86	44	71	75	53	32	82	28	89	70	
14	22008304641936	68	27	19	23	18	18	66	56	28	39	
15	22301600100000	2	2	22	60	8	3	106	72	5	4	
16	22030000100964	77	32	86	59	33	31	85	67	20	43	
17	22028300252054	92	55	83	80	55	41	84	30	110	85	
18	22301400300190	5	5	159	172	19	5	352	352	15	8	
19	22301900201401	60	26	150	156	49	25	108	118	25	73	
20	22028300251756	105	72	68	70	64	48	83	29	238	100	Tot. ave
	average =	59.4	34.1	74.8	72.1	33.0	25.0	74.4	59.4	46.4	39.7	51.81

Missouri Results for Dauphin County												
Missouri RANK	Structure ID Number	B & H RANK	Mod B&H RANK	Buckle RANK	Mod Buckle RANK	Caltrans RANK	Montana RANK	Nevada RANK	SC RANK	Mod SC RANK	IDOT RANK	
1	22008304200000	1	1	4	1	1	2	1	51	16	1	
2	22008106520000	3	3	23	16	17	1	3	16	4	2	
3	22008304203326	4	4	3	2	4	4	2	52	17	3	
4	22008304340000	16	6	1	3	3	9	4	54	50	5	
5	22301600100000	2	2	22	60	8	3	15	106	72	4	
6	22008304300800	13	15	396	408	9	54	26	53	100	44	
7	22800300200760	206	195	263	242	90	193	53	173	173	124	
8	22008106601047	34	20	25	47	57	14	28	19	38	7	
9	22302100100000	142	129	316	304	79	42	63	151	151	38	
10	22008106641980	154	141	28	8	46	142	162	21	5	25	
11	22301200300000	6	7	177	135	68	8	203	348	348	9	
12	22008304340713	78	52	2	24	10	40	32	55	51	35	
13	22002202901786	62	28	128	124	44	21	11	11	90	21	
14	22002202911867	63	29	129	125	45	22	12	13	92	22	
15	22301400300190	5	5	159	172	19	5	18	352	352	8	
16	22008304700976	83	57	7	11	31	75	52	68	23	13	
17	22300600600000	129	98	401	298	81	67	75	101	113	140	
18	22008304741403	89	61	8	12	32	84	55	69	58	52	
19	22008304501003	45	25	10	6	22	33	46	57	18	6	
20	22030000100964	77	32	86	59	33	31	16	85	67	43	Tot. ave
	average =	60.6	45.5	109.4	102.9	35.0	42.5	43.9	92.8	91.9	30.1	65.44

IDOT Results for Dauphin County												
IDOT RANK	Structure ID Number	B & H RANK	Mod B&H RANK	Buckle RANK	Mod Buckle RANK	Caltrans RANK	Montana RANK	Nevada RANK	SC RANK	Mod SC RANK	Missouri RANK	
1	22008304200000	1	1	4	1	1	2	1	51	16	1	
2	22008106520000	3	3	23	16	17	1	3	16	4	2	
3	22008304203326	4	4	3	2	4	4	2	52	17	3	
4	22301600100000	2	2	22	60	8	3	15	106	72	5	
5	22008304340000	16	6	1	3	3	9	4	54	50	4	
6	22008304501003	45	25	10	6	22	33	46	57	18	19	
7	22008106601047	34	20	25	47	57	14	28	19	38	8	
8	22301400300190	5	5	159	172	19	5	18	352	352	15	
9	22301200300000	6	7	177	135	68	8	203	348	348	11	
10	22008304440634	44	24	11	5	12	15	37	56	52	30	
11	22008304601012	39	14	57	62	39	13	8	61	22	22	
12	22008304540221	125	68	13	13	7	51	25	59	20	42	
13	22008304700976	83	57	7	11	31	75	52	68	23	16	
14	22008304501664	104	77	12	7	42	90	98	58	19	65	
15	22001100100000	71	58	211	247	212	7	145	1	82	34	
16	22008304641712	136	95	18	22	14	55	23	65	3	72	
17	22002200501317	38	38	154	147	145	10	44	3	84	76	
18	22008107401223	110	83	16	18	71	94	100	35	10	46	
19	22301200800233	10	11	231	277	34	6	40	349	349	38	
20	22002200500208	7	12	142	140	74	19	107	2	83	93	Tot. ave
average =		44.2	30.5	64.8	69.6	44.0	25.7	50.0	90.6	83.1	30.1	53.25

PennDOT Survey Results for Dauphin County													
PennDOT RANK	Structure ID Number	B & H RANK	Mod B&H RANK	Buckle RANK	Mod Buckle RANK	Caltrans RANK	Montana RANK	Nevada RANK	SC RANK	Mod SC RANK	Missouri RANK	IDOT RANK	
1	22008304200000	1	1	4	1	1	2	1	51	16	1	1	
2	22008106520000	3	3	23	16	17	1	3	16	4	2	2	
3	22002200500208	7	12	142	140	74	19	107	2	83	93	20	
4	22707699024665	143	139	82	89	119	73	70	112	74	84	99	
5	22301600100000	2	2	22	60	8	3	15	106	72	5	4	
6	22301200300000	6	7	177	135	68	8	203	348	348	11	9	
7	22008106601047	34	20	25	47	57	14	28	19	38	8	7	
8	22008304340000	16	6	1	3	3	9	4	54	50	4	5	
9	22032201700000	9	9	88	120	59	30	198	98	70	47	31	
10	22300901900601	513	511	407	402	293	480	185	558	558	234	558	
11	22301400300190	5	5	159	172	19	5	18	352	352	15	8	
12	22002202310000	103	97	136	129	203	56	158	134	134	192	87	
13	22008304340713	78	52	2	4	10	40	32	55	51	12	35	
14	22002202911867	63	29	129	125	45	22	12	13	92	14	22	
15	22008106851552	96	70	53	56	65	46	47	26	44	44	83	
16	22028300252054	92	55	83	80	55	41	17	84	30	110	85	
17	22022501301860	214	228	197	211	287	225	310	193	193	262	172	
18	22002200900000	97	75	98	102	99	49	86	6	87	112	77	
19	22008106940918	95	53	73	71	47	38	6	27	6	91	65	
20	22008304601012	39	14	57	62	39	13	8	61	22	22	11	
21	22008304611029	50	19	58	64	60	17	29	63	54	39	24	Tot. ave
	average =	79.3	67.0	96.0	99.5	77.5	56.7	73.2	113.2	113.2	66.8	66.9	78.7

EMS Survey Results for Dauphin County													
EMS RANK	Structure ID Number	B & H RANK	Mod B&H RANK	Buckle RANK	Mod Buckle RANK	Caltrans RANK	Montana RANK	Nevada RANK	SC RANK	Mod SC RANK	Missouri RANK	IDOT RANK	
1	22008106520000	3	3	23	16	17	1	3	16	4	2	2	
2	22302100100000	142	129	316	304	79	42	63	151	151	9	38	
3	22032200600000	132	132	161	177	139	71	87	150	150	138	225	
4	22002201802643	220	223	188	201	173	116	112	132	132	224	236	
5	22002200900000	97	75	98	102	99	49	86	6	87	112	77	
6	22014700401898	179	235	346	342	372	295	276	164	164	337	98	
7	22014702200000	248	250	288	265	302	236	335	230	230	261	177	
8	22014703100842	183	215	356	387	367	201	309	141	141	284	88	
9	22020900700000	300	313	312	335	335	297	359	234	234	270	231	
10	22020901401722	271	281	364	341	358	253	349	237	237	332	240	
11	22020902600000	201	230	297	261	309	218	327	191	191	248	185	
12	22020903200000	212	241	281	293	325	234	336	192	192	251	210	
13	22008106851552	96	70	53	56	65	46	47	26	44	44	83	
14	22008106940918	95	53	73	71	47	38	6	27	6	91	65	
15	22008304601012	39	14	57	62	39	13	8	61	22	22	11	
16	22032201700000	9	9	88	120	59	30	198	98	70	47	31	
17	22032202901298	229	212	189	164	259	206	260	259	259	231	138	
18	22008304200000	1	1	4	1	1	2	1	51	16	1	1	
19	22002200500208	7	12	142	140	74	19	107	2	83	93	20	
20	22301600100000	2	2	22	60	8	3	15	106	72	5	4	Tot. ave
	average =	133.3	135.0	182.9	184.9	171.4	118.5	164.2	123.7	124.3	150.1	108.0	141.6

Babaei and Hawkins Results for Cumberland County												
B & H RANK	Structure ID Number	Mod B&H RANK	Buckle RANK	Mod Buckle RANK	Caltrans RANK	Montana RANK	Nevada RANK	SC RANK	Mod SC RANK	Missouri RANK	IDOT RANK	
1	21001501700863	3	8	6	4	5	30	14	71	15	5	
2	21001107400000	2	7	16	5	8	9	133	133	19	17	
3	21058101300000	1	2	4	10	1	5	86	105	1	1	
4	21001109800000	5	174	212	6	12	3	8	66	7	14	
5	21203500500000	4	136	154	2	9	2	89	108	4	3	
6	21707699021516	10	47	52	88	55	61	105	49	67	18	
7	21001501501530	6	10	17	12	44	131	12	69	23	99	
8	21001108900000	9	135	126	44	15	52	7	65	24	46	
9	21058100501728	8	251	60	41	61	179	389	389	20	441	
10	21707699023945	14	69	79	107	43	127	128	18	17	12	
11	21101500100878	19	231	175	59	18	203	309	309	72	48	
12	21707699021226	23	45	49	85	79	64	100	46	106	25	
13	21008105140000	17	90	108	24	26	16	65	100	33	83	
14	21008105150413	13	87	100	19	24	15	67	101	34	84	
15	21008104540557	18	124	65	16	30	27	44	22	31	72	
16	21707699022854	25	72	72	46	21	31	118	123	68	61	
17	21011400601951	24	109	130	121	48	221	82	103	53	56	
18	21058100600203	22	252	61	42	82	181	390	390	65	466	
19	21707699022662	21	70	82	14	29	10	115	122	54	78	
20	21001108701474	34	167	185	130	69	177	5	63	188	31	
21	21001108711456	36	159	171	131	70	178	6	64	189	32	
22	21094405801144	20	307	334	13	32	32	136	136	5	71	
23	21707699022130	30	49	54	89	117	66	108	51	128	26	
24	21008104650367	12	97	56	9	22	12	49	26	27	70	
25	21707699023627	11	67	77	8	19	8	126	57	14	60	Tot. ave
	average =	15.4	110.3	97.6	44.8	37.4	72.4	107.1	108.6	50.0	76.6	72.0

Modified Babaei and Hawkins Results for Cumberland County												
Mod B&H RANK	Structure ID Number	B & H RANK	Buckle RANK	Mod Buckle RANK	Caltrans RANK	Montana RANK	Nevada RANK	SC RANK	Mod SC RANK	Missouri RANK	IDOT RANK	
1	21058101300000	3	2	4	10	1	5	86	105	1	1	
2	21001107400000	2	7	16	5	8	9	133	133	19	17	
3	21001501700863	1	8	6	4	5	30	14	71	15	5	
4	21203500500000	5	136	154	2	9	2	89	108	4	3	
5	21001109800000	4	174	212	6	12	3	8	66	7	14	
6	21001501501530	7	10	17	12	44	131	12	69	23	99	
7	21008304140000	68	5	2	1	2	1	79	16	3	2	
8	21058100501728	9	251	60	41	61	179	389	389	20	441	
9	21001108900000	8	135	126	44	15	52	7	65	24	46	
10	21707699021516	6	47	52	88	55	61	105	49	67	18	
11	21707699023627	25	67	77	8	19	8	126	57	14	60	
12	21008104650367	24	97	56	9	22	12	49	26	27	70	
13	21008105150413	14	87	100	19	24	15	67	101	34	84	
14	21707699023945	10	69	79	107	43	127	128	18	17	12	
15	21001107600000	96	25	35	15	3	11	134	134	10	4	
16	21008104640250	26	36	58	11	27	13	46	24	56	73	
17	21008105140000	13	90	108	24	26	16	65	100	33	83	
18	21008104540557	15	124	65	16	30	27	44	22	31	72	
19	21101500100878	11	231	175	59	18	203	309	309	72	48	
20	21094405801144	22	307	334	13	32	32	136	136	5	71	
21	21707699022662	19	70	82	14	29	10	115	122	54	78	
22	21058100600203	18	252	61	42	82	181	390	390	65	466	
23	21707699021226	12	45	49	85	79	64	100	46	106	25	
24	21011400601951	17	109	130	121	48	221	82	103	53	56	
25	21707699022854	16	72	72	46	21	31	118	123	68	61	Tot. ave
	average =	98.2	85.0	31.7	28.6	57.6	109.8	107.1	33.1	76.3	62.73	69.00

Buckle Results for Cumberland County												
Buckle RANK	Structure ID Number	B & H RANK	Mod B&H RANK	Mod Buckle RANK	Caltrans RANK	Montana RANK	Nevada RANK	SC RANK	Mod SC RANK	Missouri RANK	IDOT RANK	
1	21008304160483	103	44	1	3	17	6	80	17	2	6	
2	21058101300000	3	1	4	10	1	5	86	105	1	1	
3	21058101200000	197	113	3	77	63	187	85	40	22	16	
4	21058101401063	112	28	5	18	4	29	87	106	13	7	
5	21008304140000	68	7	2	1	2	1	79	16	3	2	
6	21008304041288	123	33	11	28	7	19	78	38	6	15	
7	21001107400000	2	2	16	5	8	9	133	133	19	17	
8	21001501700863	1	3	6	4	5	30	14	71	15	5	
9	21001501700000	122	31	8	27	6	39	13	70	8	13	
10	21001501501530	7	6	17	12	44	131	12	69	23	99	
11	21793551010007	152	208	9	79	533	237	499	499	423	213	
12	21793563040401	149	206	10	80	529	236	500	500	308	216	
13	21001501401561	219	138	18	182	76	212	11	19	99	59	
14	21008105100858	255	186	19	160	131	176	61	7	77	19	
15	21001108002039	58	49	26	30	111	185	382	382	25	281	
16	21710230005051	102	146	13	7	201	180	431	431	209	484	
17	21720303624001	147	200	14	45	524	235	477	477	304	208	
18	21721803934011	405	465	15	175	523	287	496	496	420	429	
19	21001500700490	258	187	20	201	132	218	229	229	107	62	
20	21008103341044	235	170	21	186	137	143	25	3	76	27	
21	21008103540769	233	169	22	187	133	144	26	4	75	28	
22	21008105702531	224	143	12	134	81	106	72	12	73	11	
23	21008105541172	229	152	24	195	122	174	70	10	78	29	
24	21008105601972	234	160	25	196	126	175	71	11	80	33	
25	21001107600000	96	15	35	15	3	11	134	134	10	4	Tot. ave
	average =	149.4	114.5	14.2	82.3	140.8	127.0	166.0	155.2	99.0	91.4	113.97

Modified Buckle Results for Cumberland County												
Mod Buckle RANK	Structure ID Number	B & H RANK	Mod B&H RANK	Buckle RANK	Caltrans RANK	Montana RANK	Nevada RANK	SC RANK	Mod SC RANK	Missouri RANK	IDOT RANK	
1	21008304160483	103	44	1	3	17	6	80	17	2	6	
2	21008304140000	68	7	5	1	2	1	79	16	3	2	
3	21058101200000	197	113	3	77	63	187	85	40	22	16	
4	21058101300000	3	1	2	10	1	5	86	105	1	1	
5	21058101401063	112	28	4	18	4	29	87	106	13	7	
6	21001501700863	1	3	8	4	5	30	14	71	15	5	
7	21008106101223	237	165	38	120	105	170	77	15	11	10	
8	21001501700000	122	31	9	27	6	39	13	70	8	13	
9	21793551010007	152	208	11	79	533	237	499	499	423	213	
10	21793563040401	149	206	12	80	529	236	500	500	308	216	
11	21008304041288	123	33	6	28	7	19	78	38	6	15	
12	21008105702531	224	143	22	134	81	106	72	12	73	11	
13	21710230005051	102	146	16	7	201	180	431	431	209	484	
14	21720303624001	147	200	17	45	524	235	477	477	304	208	
15	21721803934011	405	465	18	175	523	287	496	496	420	429	
16	21001107400000	2	2	7	5	8	9	133	133	19	17	
17	21001501501530	7	6	10	12	44	131	12	69	23	99	
18	21001501401561	219	138	13	182	76	212	11	19	99	59	
19	21008105100858	255	186	14	160	131	176	61	7	77	19	
20	21001500700490	258	187	19	201	132	218	229	229	107	62	
21	21008103341044	235	170	20	186	137	143	25	3	76	27	
22	21008103540769	233	169	21	187	133	144	26	4	75	28	
23	21001500601043	160	70	77	90	13	156	383	383	26	104	
24	21008105541172	229	152	23	195	122	174	70	10	78	29	
25	21008105601972	234	160	24	196	126	175	71	11	80	33	Tot. ave
	average =	159.1	121.3	16.0	88.9	140.9	132.2	163.8	150.4	99.1	84.5	115.6

Caltrans Results for Cumberland County												
Caltrans RANK	Structure ID Number	B & H RANK	Mod B&H RANK	Buckle RANK	Mod Buckle RANK	Montana RANK	Nevada RANK	SC RANK	Mod SC RANK	Missouri RANK	IDOT RANK	
1	21008304140000	68	7	5	2	2	1	79	16	3	2	
2	21203500500000	5	4	136	154	9	2	89	108	4	3	
3	21008304160483	103	44	1	1	17	6	80	17	2	6	
4	21001501700863	1	3	8	6	5	30	14	71	15	5	
5	21001107400000	2	2	7	16	8	9	133	133	19	17	
6	21001109800000	4	5	174	212	12	3	8	66	7	14	
7	21710230005051	102	146	16	13	201	180	431	431	209	484	
8	21707699023627	25	11	67	77	19	8	126	57	14	60	
9	21008104650367	24	12	97	56	22	12	49	26	27	70	
10	21058101300000	3	1	2	4	1	5	86	105	1	1	
11	21008104640250	26	16	36	58	27	13	46	24	56	73	
12	21001501501530	7	6	10	17	44	131	12	69	23	99	
13	21094405801144	22	20	307	334	32	32	136	136	5	71	
14	21707699022662	19	21	70	82	29	10	115	122	54	78	
15	21001107600000	96	15	25	35	3	11	134	134	10	4	
16	21008104540557	15	18	124	65	30	27	44	22	31	72	
17	21707699022631	32	29	193	132	49	7	114	52	55	88	
18	21058101401063	112	28	4	5	4	29	87	106	13	7	
19	21008105150413	14	13	87	100	24	15	67	101	34	84	
20	21707699020543	31	38	39	42	85	20	90	109	89	109	
21	21707699020625	38	46	42	45	108	23	93	110	93	112	
22	21707699023606	30	43	145	131	47	4	125	128	30	97	
23	21001501001113	72	78	165	165	160	18	145	145	29	67	
24	21008105140000	13	17	90	108	26	16	65	100	33	83	
25	21008105111172	65	67	56	64	77	42	64	33	162	129	Tot. ave
	average =	37.2	27.6	76.2	77.0	41.6	26.2	97.3	96.8	40.7	73.4	59.40

Montana Results for Cumberland County												
Montana RANK	Structure ID Number	B & H RANK	Mod B&H RANK	Buckle RANK	Mod Buckle RANK	Caltrans RANK	Nevada RANK	SC RANK	Mod SC RANK	Missouri RANK	IDOT RANK	
1	21058101300000	3	1	2	4	10	5	86	105	1	1	
2	21008304140000	68	7	5	2	1	1	79	16	3	2	
3	21001107600000	96	15	25	35	15	11	134	134	10	4	
4	21058101401063	112	28	4	5	18	29	87	106	13	7	
5	21001501700863	1	3	8	6	4	30	14	71	15	5	
6	21001501700000	122	31	9	8	27	39	13	70	8	13	
7	21008304041288	123	33	6	11	28	19	78	38	6	15	
8	21001107400000	2	2	7	16	5	9	133	133	19	17	
9	21203500500000	5	4	136	154	2	2	89	108	4	3	
10	21008104651675	169	99	32	37	139	58	50	6	98	8	
11	21008104641546	174	102	33	41	147	60	47	5	97	9	
12	21001109800000	4	5	174	212	6	3	8	66	7	14	
13	21001500601043	160	70	77	23	90	156	383	383	26	104	
14	21001109810485	150	75	207	284	114	14	9	67	9	23	
15	21001108900000	8	9	135	126	44	52	7	65	24	46	
16	21011400400000	183	87	359	195	115	59	81	102	16	75	
17	21008304160483	103	44	1	1	3	6	80	17	2	6	
18	21101500100878	11	19	231	175	59	203	309	309	72	48	
19	21707699023627	25	11	67	77	8	8	126	57	14	60	
20	21203500501906	27	27	134	152	58	90	408	408	239	245	
21	21707699022854	16	25	72	72	46	31	118	123	68	61	
22	21008104650367	24	12	97	56	9	12	49	26	27	70	
23	21001107200000	218	115	27	31	123	62	131	131	35	66	
24	21008105150413	14	13	87	100	19	15	67	101	34	84	
25	21001107010000	210	108	78	122	148	38	144	144	90	82	Tot. ave
	average =	81.1	37.8	80.5	77.8	49.5	40.5	109.2	111.6	37.5	42.7	66.83

Nevada Results for Cumberland County												
Nevada RANK	Structure ID Number	B & H RANK	Mod B&H RANK	Buckle RANK	Mod Buckle RANK	Caltrans RANK	Montana RANK	SC RANK	Mod SC RANK	Missouri RANK	IDOT RANK	
1	21008304140000	68	7	5	2	1	2	79	16	3	2	
2	21203500500000	5	4	136	154	2	9	89	108	4	3	
3	21001109800000	4	5	174	212	6	12	8	66	7	14	
4	21707699023606	30	43	145	131	22	47	125	128	30	97	
5	21581013000000	3	1	2	4	10	1	86	105	1	1	
6	21008304160483	103	44	1	1	3	17	80	17	2	6	
7	21707699022631	32	29	193	132	17	49	114	52	55	88	
8	21707699023627	25	11	67	77	8	19	126	57	14	60	
9	21001107400000	2	2	7	16	5	8	133	133	19	17	
10	21707699022662	19	21	70	82	14	29	115	122	54	78	
11	21001107600000	96	15	25	35	15	3	134	134	10	4	
12	21008104650367	24	12	97	56	9	22	49	26	27	70	
13	21008104640250	26	16	36	58	11	27	46	24	56	73	
14	21001109810485	150	75	207	284	114	14	9	67	9	23	
15	21008105150413	14	13	87	100	19	24	67	101	34	84	
16	21008105140000	13	17	90	108	24	26	65	100	33	83	
17	21008105100190	195	142	63	99	128	46	60	32	71	119	
18	21001501001113	72	78	165	165	23	160	145	145	29	67	
19	21008304041288	123	33	6	11	28	7	78	38	6	15	
20	21707699020543	31	38	39	42	20	85	90	109	89	109	
21	21707699023261	29	26	233	243	29	36	122	125	103	458	
22	21008103540163	89	97	358	355	54	202	149	149	57	472	
23	21707699020625	38	46	42	45	21	108	93	110	93	112	
24	21707699021869	40	48	48	53	52	109	107	116	95	114	
25	21707699020736	39	47	50	46	51	112	94	111	94	113	Tot. ave
	ave =	50.8	34.8	93.8	100.4	27.4	47.0	90.5	87.6	39.8	91.3	66.35

Missouri Results for Cumberland County												
Missouri RANK	Structure ID Number	B & H RANK	Mod B&H RANK	Buckle RANK	Mod Buckle RANK	Caltrans RANK	Montana RANK	Nevada RANK	SC RANK	Mod SC RANK	IDOT RANK	
1	21058101300000	3	1	2	4	10	1	5	86	105	1	
2	21008304160483	103	44	1	1	3	17	6	80	17	6	
3	21008304140000	68	7	5	2	1	2	1	79	16	2	
4	21203500500000	5	4	136	154	2	9	2	89	108	3	
5	21094405801144	22	20	307	334	13	32	32	136	136	71	
6	21008304041288	123	33	6	11	28	7	19	78	38	15	
7	21001109800000	4	5	174	212	6	12	3	8	66	14	
8	21001501700000	122	31	9	8	27	6	39	13	70	13	
9	21001109810485	150	75	207	284	114	14	14	9	67	23	
10	21001107600000	96	15	25	35	15	3	11	134	134	4	
11	21008106101223	237	165	38	7	120	105	170	77	15	10	
12	21202800200646	231	131	155	168	118	40	63	88	107	98	
13	21058101401063	112	28	4	5	18	4	29	87	106	7	
14	21707699023627	25	11	67	77	8	19	8	126	57	60	
15	21001501700863	1	3	8	6	4	5	30	14	71	5	
16	21011400400000	183	87	359	195	115	16	59	81	102	75	
17	21707699023945	10	14	69	79	107	43	127	128	18	12	
18	21202100400904	230	163	321	269	164	53	172	406	406	229	
19	21001107400000	2	2	7	16	5	8	9	133	133	17	
20	21058100501728	9	8	251	60	41	61	179	389	389	441	
21	21101900300000	263	210	369	364	211	93	89	161	161	460	
22	21058101200000	197	113	3	3	77	63	187	85	40	16	
23	21001501501530	7	6	10	17	12	44	131	12	69	99	
24	21001108900000	8	9	135	126	44	15	52	7	65	46	
25	21001108002039	58	49	15	26	30	111	185	382	382	281	Tot. ave
	average =	90.8	49.4	107.3	98.5	51.7	31.3	64.9	115.5	115.1	80.3	80.48

IDOT Results for Cumberland County												
IDOT RANK	Structure ID Number	B & H RANK	Mod B&H RANK	Buckle RANK	Mod Buckle RANK	Caltrans RANK	Montana RANK	Nevada RANK	SC RANK	Mod SC RANK	Missouri RANK	
1	21058101300000	3	1	2	4	10	1	5	86	105	1	
2	21008304140000	68	7	5	2	1	2	1	79	16	3	
3	21203500500000	5	4	136	154	2	9	2	89	108	4	
4	21001107600000	96	15	25	35	15	3	11	134	134	10	
5	21001501700863	1	3	8	6	4	5	30	14	71	15	
6	21008304160483	103	44	1	1	3	17	6	80	17	2	
7	21058101401063	112	28	4	5	18	4	29	87	106	13	
8	21008104651675	169	99	32	37	139	10	58	50	6	98	
9	21008104641546	174	102	33	41	147	11	60	47	5	97	
10	21008106101223	237	165	38	7	120	105	170	77	15	11	
11	21008105702531	224	143	22	12	134	81	106	72	12	73	
12	21707699023945	10	14	69	79	107	43	127	128	18	17	
13	21001501700000	122	31	9	8	27	6	39	13	70	8	
14	21001109800000	4	5	174	212	6	12	3	8	66	7	
15	21008304041288	123	33	6	11	28	7	19	78	38	6	
16	21058101200000	197	113	3	3	77	63	187	85	40	22	
17	21001107400000	2	2	7	16	5	8	9	133	133	19	
18	21707699021516	6	10	47	52	88	55	61	105	49	67	
19	21008105100858	255	186	14	19	160	131	176	61	7	77	
20	21008105512143	182	111	102	111	287	39	189	69	35	168	
21	21008102742185	225	150	51	28	220	83	164	17	2	64	
22	21008105502205	185	119	110	120	293	45	190	68	34	167	
23	21001109810485	150	75	207	284	114	14	14	9	67	9	
24	21008102601335	232	158	114	27	219	90	165	15	1	66	
25	21707699021226	12	23	45	49	85	79	64	100	46	106	Tot. ave
ave =		115.9	65.6	50.6	52.9	92.4	36.9	75.4	68.2	48.0	45.2	65.11

PennDOT Survey Results for Cumberland County													
PennDOT RANK	Structure ID Number	B & H RANK	Mod B&H RANK	Buckle RANK	Mod Buckle RANK	Caltrans RANK	Montana RANK	Nevada RANK	SC RANK	Mod SC RANK	Missouri RANK	IDOT RANK	
1	21008105502205	185	119	110	120	293	45	190	68	34	167	22	
2	21001107600000	96	15	25	35	15	3	11	134	134	10	4	
3	21008105100190	195	142	63	99	128	46	17	60	32	71	119	
4	21058100301760	199	280	360	356	221	421	411	504	504	151	200	
5	21008304041288	123	33	6	11	28	7	19	78	38	6	15	
6	21001108701474	20	34	167	185	130	69	177	5	63	188	31	
7	21008104840101	220	159	62	98	158	54	80	56	96	36	140	
8	21001109800000	4	5	174	212	6	12	3	8	66	7	14	
9	21008104800066	215	149	53	81	145	51	86	54	30	37	127	
10	21101500100878	11	19	231	175	59	18	203	309	309	72	48	
11	21008105140000	13	17	90	108	24	26	16	65	100	33	83	
12	21001501700000	122	31	9	8	27	6	39	13	70	8	13	
13	21008104640250	26	16	36	58	11	27	13	46	24	56	73	
14	21203500500133	50	58	125	142	60	42	93	138	138	283	68	
15	21707699021516	6	10	47	52	88	55	61	105	49	67	18	
16	21008105110135	190	123	60	67	129	116	28	63	8	79	149	
17	21008304140000	68	7	5	2	1	2	1	79	16	3	2	
18	21011400601951	17	24	109	130	121	48	221	82	103	53	56	
19	21001107400000	2	2	7	16	5	8	9	133	133	19	17	
20	21008104850246	217	151	65	97	149	52	78	57	97	70	128	
21	21008104902459	236	196	118	134	224	59	129	58	98	220	102	Tot. ave
	average =	105.5	75.7	91.5	104.1	96.3	55.6	89.8	100.7	102.0	77.9	68.0	83.8

MIDOT Survey Results for Dauphin County													
MIDOT RANK	Structure ID Number	B & H RANK	Mod B&H RANK	Buckle RANK	Mod Buckle RANK	Caltrans RANK	Montana RANK	Nevada RANK	SC RANK	Mod SC RANK	Missouri RANK	IDOT RANK	
1	22008304200000	1	1	4	1	1	2	1	51	16	1	1	
2	22008106520000	3	3	23	16	17	1	3	16	4	2	2	
3	22008304203326	4	4	3	2	4	4	2	52	17	3	3	
4	22301600100000	2	2	22	60	8	3	15	106	72	5	4	
5	22008304340000	16	6	1	3	3	9	4	54	50	4	5	
6	22008304501003	45	25	10	6	22	33	46	57	18	19	6	
7	22008106601047	34	20	25	47	57	14	28	19	38	8	7	
8	22008304440634	44	24	11	5	12	15	37	56	52	30	10	
9	22008304540221	125	68	13	13	7	51	25	59	20	42	12	
10	22008304700976	83	57	7	11	31	75	52	68	23	16	13	
11	22001100100000	71	58	211	247	212	7	145	1	82	34	15	
12	22008304501664	104	77	12	7	42	90	98	58	19	65	14	
13	22008304601012	39	14	57	62	39	13	8	61	22	22	11	
14	22301400300190	5	5	159	172	19	5	18	352	352	15	8	
15	22301200300000	6	7	177	135	68	8	203	348	348	11	9	
16	22008107401223	110	83	16	18	71	94	100	35	10	46	18	
17	22008304641712	136	95	18	22	14	55	23	65	3	72	16	
18	22002200501317	38	38	154	147	145	10	44	3	84	76	17	
19	22008106951752	187	134	80	73	48	78	7	30	2	80	26	
20	22002200500208	7	12	142	140	74	19	107	2	83	93	20	Tot. ave
	average =	53.0	36.7	57.3	59.4	44.7	29.3	48.3	74.7	65.8	32.2	10.9	46.55

M&M1 Survey Results for Dauphin County													
M&M1 RANK	Structure ID Number	B & H RANK	Mod B&H RANK	Buckle RANK	Mod Buckle RANK	Caltrans RANK	Montana RANK	Nevada RANK	SC RANK	Mod SC RANK	Missouri RANK	IDOT RANK	
1	22008304200000	1	1	4	1	1	2	1	51	16	1	1	
2	22008106520000	3	3	23	16	17	1	3	16	4	2	2	
3	22008304203326	4	4	3	2	4	4	2	52	17	3	3	
4	22301600100000	2	2	22	60	8	3	15	106	72	5	4	
5	22008304501003	45	25	10	6	22	33	46	57	18	19	6	
6	22008304340000	16	6	1	3	3	9	4	54	50	4	5	
7	22008304540221	125	68	13	13	7	51	25	59	20	42	12	
8	22008304700976	83	57	7	11	31	75	52	68	23	16	13	
9	22001100100000	71	58	211	247	212	7	145	1	82	34	15	
10	22008304501664	104	77	12	7	42	90	98	58	19	65	14	
11	22008106601047	34	20	25	47	57	14	28	19	38	8	7	
12	22301400300190	5	5	159	172	19	5	18	352	352	15	8	
13	22008106951752	187	134	80	73	48	78	7	30	2	80	26	
14	22008107401223	110	83	16	18	71	94	100	35	10	46	18	
15	22008304641712	136	95	18	22	14	55	23	65	3	72	16	
16	22008304440634	44	24	11	5	12	15	37	56	52	30	10	
17	22002200500208	7	12	142	140	74	19	107	2	83	93	20	
18	22002200501317	38	38	154	147	145	10	44	3	84	76	17	
19	22008107502454	146	126	55	19	72	115	104	38	11	59	30	
20	22002200511275	42	40	147	149	146	11	45	5	86	79	23	Tot. ave
	average =	60.2	43.9	55.7	57.9	50.3	34.6	45.2	56.4	52.1	37.5	12.5	46.0

M&M2 Survey Results for Dauphin County													
M&M2 RANK	Structure ID Number	B & H RANK	Mod B&H RANK	Buckle RANK	Mod Buckle RANK	Caltrans RANK	Montana RANK	Nevada RANK	SC RANK	Mod SC RANK	Missouri RANK	IDOT RANK	
1	22008304200000	1	1	4	1	1	2	1	51	16	1	1	
2	22008106520000	3	3	23	16	17	1	3	16	4	2	2	
3	22008304203326	4	4	3	2	4	4	2	52	17	3	3	
4	22301600100000	2	2	22	60	8	3	15	106	72	5	4	
5	22008304340000	16	6	1	3	3	9	4	54	50	4	5	
6	22008304501003	45	25	10	6	22	33	46	57	18	19	6	
7	22008304540221	125	68	13	13	7	51	25	59	20	42	12	
8	22008304700976	83	57	7	11	31	75	52	68	23	16	13	
9	22008106601047	34	20	25	47	57	14	28	19	38	8	7	
10	22008304501664	104	77	12	7	42	90	98	58	19	65	14	
11	22001100100000	71	58	211	247	212	7	145	1	82	34	15	
12	22301400300190	5	5	159	172	19	5	18	352	352	15	8	
13	22008106951752	187	134	80	73	48	78	7	30	2	80	26	
14	22008304440634	44	24	11	5	12	15	37	56	52	30	10	
15	22008304641712	136	95	18	22	14	55	23	65	3	72	16	
16	22008107401223	110	83	16	18	71	94	100	35	10	46	18	
17	22002200501317	38	38	154	147	145	10	44	3	84	76	17	
18	22301200300000	6	7	177	135	68	8	203	348	348	11	9	
19	22002200500208	7	12	142	140	74	19	107	2	83	93	20	
20	22002200511275	42	40	147	149	146	11	45	5	86	79	23	Tot. ave
	average =	53.2	38.0	61.8	63.7	50.1	29.2	50.2	71.9	69.0	35.1	11.5	48.5

M&M3 Survey Results for Dauphin County													
M&M3 RANK	Structure ID Number	B & H RANK	Mod B&H RANK	Buckle RANK	Mod Buckle RANK	Caltrans RANK	Montana RANK	Nevada RANK	SC RANK	Mod SC RANK	Missouri RANK	IDOT RANK	
1	22008304200000	1	1	4	1	1	2	1	51	16	1	1	
2	22008106520000	3	3	23	16	17	1	3	16	4	2	2	
3	22008304203326	4	4	3	2	4	4	2	52	17	3	3	
4	22301600100000	2	2	22	60	8	3	15	106	72	5	4	
5	22008304501003	45	25	10	6	22	33	46	57	18	19	6	
6	22001100100000	71	58	211	247	212	7	145	1	82	34	15	
7	22008304700976	83	57	7	11	31	75	52	68	23	16	13	
8	22008304501664	104	77	12	7	42	90	98	58	19	65	14	
9	22008107401223	110	83	16	18	71	94	100	35	10	46	18	
10	22008107502454	146	126	55	19	72	115	104	38	11	59	30	
11	22002200500208	7	12	142	140	74	19	107	2	83	93	20	
12	22301400300190	5	5	159	172	19	5	18	352	352	15	8	
13	22008107342707	144	120	56	20	76	111	109	34	9	56	29	
14	22008304540221	125	68	13	13	7	51	25	59	20	42	12	
15	22002200501317	38	38	154	147	145	10	44	3	84	76	17	
16	22030000710851	106	110	145	150	217	27	119	88	103	144	40	
17	22002200511275	42	40	147	149	146	11	45	5	86	79	23	
18	22008106951752	187	134	80	73	48	78	7	30	2	80	26	
19	22008304641712	136	95	18	22	14	55	23	65	3	72	16	
20	22008107041120	147	128	20	24	82	118	115	32	7	57	36	Tot. ave
average =		75.3	59.3	64.9	64.9	65.4	45.5	58.9	57.6	51.1	48.2	16.7	55.2

M&M4 Survey Results for Dauphin County													
M&M4 RANK	Structure ID Number	B & H RANK	Mod B&H RANK	Buckle RANK	Mod Buckle RANK	Caltrans RANK	Montana RANK	Nevada RANK	SC RANK	Mod SC RANK	Missouri RANK	IDOT RANK	
1	22008304200000	1	1	4	1	1	2	1	51	16	1	1	
2	22008106520000	3	3	23	16	17	1	3	16	4	2	2	
3	22008304203326	4	4	3	2	4	4	2	52	17	3	3	
4	22301600100000	2	2	22	60	8	3	15	106	72	5	4	
5	22008304340000	16	6	1	3	3	9	4	54	50	4	5	
6	22008106601047	34	20	25	47	57	14	28	19	38	8	7	
7	22008304440634	44	24	11	5	12	15	37	56	52	30	10	
8	22008304501003	45	25	10	6	22	33	46	57	18	19	6	
9	22001100100000	71	58	211	247	212	7	145	1	82	34	15	
10	22008304700976	83	57	7	11	31	75	52	68	23	16	13	
11	22301400300190	5	5	159	172	19	5	18	352	352	15	8	
12	22008107401223	110	83	16	18	71	94	100	35	10	46	18	
13	22008304501664	104	77	12	7	42	90	98	58	19	65	14	
14	22008107502454	146	126	55	19	72	115	104	38	11	59	30	
15	22002202901786	62	28	128	124	44	21	11	11	90	13	21	
16	22002202911867	63	29	129	125	45	22	12	13	92	14	22	
17	22008304540221	125	68	13	13	7	51	25	59	20	42	12	
18	22008106951752	187	134	80	73	48	78	7	30	2	80	26	
19	22030000710851	106	110	145	150	217	27	119	88	103	144	40	
20	22008107342707	144	120	56	20	76	111	109	34	9	56	29	Tot. ave
average =		67.8	49.0	55.5	56.0	50.4	38.9	46.8	59.9	54.0	32.8	14.3	47.8

M&M5 Survey Results for Dauphin County													
M&M5 RANK	Structure ID Number	B & H RANK	Mod B&H RANK	Buckle RANK	Mod Buckle RANK	Caltrans RANK	Montana RANK	Nevada RANK	SC RANK	Mod SC RANK	Missouri RANK	IDOT RANK	
1	22008304200000	1	1	4	1	1	2	1	51	16	1	1	
2	22008106520000	3	3	23	16	17	1	3	16	4	2	2	
3	22008304203326	4	4	3	2	4	4	2	52	17	3	3	
4	22301600100000	2	2	22	60	8	3	15	106	72	5	4	
5	22008304340000	16	6	1	3	3	9	4	54	50	4	5	
6	22008106601047	34	20	25	47	57	14	28	19	38	8	7	
7	22008304440634	44	24	11	5	12	15	37	56	52	30	10	
8	22008304501003	45	25	10	6	22	33	46	57	18	19	6	
9	22001100100000	71	58	211	247	212	7	145	1	82	34	15	
10	22008304700976	83	57	7	11	31	75	52	68	23	16	13	
11	22008107401223	110	83	16	18	71	94	100	35	10	46	18	
12	22008304501664	104	77	12	7	42	90	98	58	19	65	14	
13	22008107502454	146	126	55	19	72	115	104	38	11	59	30	
14	22008304540221	125	68	13	13	7	51	25	59	20	42	12	
15	22030000710851	106	110	145	150	217	27	119	88	103	144	40	
16	22008107342707	144	120	56	20	76	111	109	34	9	56	29	
17	22301400300190	5	5	159	172	19	5	18	352	352	15	8	
18	22002202901786	62	28	128	124	44	21	11	11	90	13	21	
19	22002202911867	63	29	129	125	45	22	12	13	92	14	22	
20	22030000700795	114	131	156	166	228	36	132	87	102	143	49	Tot. ave
	average =	64.1	48.9	59.3	60.6	59.4	36.8	53.1	62.8	59.0	36.0	15.5	50.5

M&M6 Survey Results for Dauphin County													
M&M6 RANK	Structure ID Number	B & H RANK	Mod B&H RANK	Buckle RANK	Mod Buckle RANK	Caltrans RANK	Montana RANK	Nevada RANK	SC RANK	Mod SC RANK	Missouri RANK	IDOT RANK	
1	22008304200000	1	1	4	1	1	2	1	51	16	1	1	
2	22008106520000	3	3	23	16	17	1	3	16	4	2	2	
3	22008304203326	4	4	3	2	4	4	2	52	17	3	3	
4	22301600100000	2	2	22	60	8	3	15	106	72	5	4	
5	22008304340000	16	6	1	3	3	9	4	54	50	4	5	
6	22008106601047	34	20	25	47	57	14	28	19	38	8	7	
7	22008304440634	44	24	11	5	12	15	37	56	52	30	10	
8	22008304501003	45	25	10	6	22	33	46	57	18	19	6	
9	22001100100000	71	58	211	247	212	7	145	1	82	34	15	
10	22008304700976	83	57	7	11	31	75	52	68	23	16	13	
11	22008107401223	110	83	16	18	71	94	100	35	10	46	18	
12	22008304501664	104	77	12	7	42	90	98	58	19	65	14	
13	22008107502454	146	126	55	19	72	115	104	38	11	59	30	
14	22030000710851	106	110	145	150	217	27	119	88	103	144	40	
15	22008107342707	144	120	56	20	76	111	109	34	9	56	29	
16	22301400300190	5	5	159	172	19	5	18	352	352	15	8	
17	22002202901786	62	28	128	124	44	21	11	11	90	13	21	
18	22002202911867	63	29	129	125	45	22	12	13	92	14	22	
19	22030000700795	114	131	156	166	228	36	132	87	102	143	49	
20	22002200500208	7	12	142	140	74	19	107	2	83	93	20	Tot. ave
	average =	58.2	46.1	65.8	67.0	62.8	35.2	57.2	59.9	62.2	38.5	15.9	51.7

M&M4a Survey Results for Dauphin County													
M&M4a RANK	Structure ID Number	B & H RANK	Mod B&H RANK	Buckle RANK	Mod Buckle RANK	Caltrans RANK	Montana RANK	Nevada RANK	SC RANK	Mod SC RANK	Missouri RANK	IDOT RANK	
1	22008304200000	1	1	4	1	1	2	1	51	16	1	1	
2	22008106520000	3	3	23	16	17	1	3	16	4	2	2	
3	22008304203326	4	4	3	2	4	4	2	52	17	3	3	
4	22301600100000	2	2	22	60	8	3	15	106	72	5	4	
5	22008304340000	16	6	1	3	3	9	4	54	50	4	5	
6	22008304440634	44	24	11	5	12	15	37	56	52	30	10	
7	22008304501003	45	25	10	6	22	33	46	57	18	19	6	
8	22008106601047	34	20	25	47	57	14	28	19	38	8	7	
9	22002202901786	62	28	128	124	44	21	11	11	90	13	21	
10	22002202911867	63	29	129	125	45	22	12	13	92	14	22	
11	22008304700976	83	57	7	11	31	75	52	68	23	16	13	
12	22008107401223	110	83	16	18	71	94	100	35	10	46	18	
13	22008107502454	146	126	55	19	72	115	104	38	11	59	30	
14	22008304501664	104	77	12	7	42	90	98	58	19	65	14	
15	22008107342707	144	120	56	20	76	111	109	34	9	56	29	
16	22301400300190	5	5	159	172	19	5	18	352	352	15	8	
17	22008106951752	187	134	80	73	48	78	7	30	2	80	26	
18	22001100100000	71	58	211	247	212	7	145	1	82	34	15	
19	22008304900000	90	59	5	9	13	43	35	73	61	37	45	
20	22008304540221	125	68	13	13	7	51	25	59	20	42	12	Tot. ave
	average =	67.0	46.5	48.5	48.9	40.2	39.7	42.6	59.2	51.9	27.5	14.6	44.2

M&M4b Survey Results for Dauphin County													
M&M4b RANK	Structure ID Number	B & H RANK	Mod B&H RANK	Buckle RANK	Mod Buckle RANK	Caltrans RANK	Montana RANK	Nevada RANK	SC RANK	Mod SC RANK	Missouri RANK	IDOT RANK	
1	22008304200000	1	1	4	1	1	2	1	51	16	1	1	
2	22008106520000	3	3	23	16	17	1	3	16	4	2	2	
3	22008304203326	4	4	3	2	4	4	2	52	17	3	3	
4	22301600100000	2	2	22	60	8	3	15	106	72	5	4	
5	22008304340000	16	6	1	3	3	9	4	54	50	4	5	
6	22008106601047	34	20	25	47	57	14	28	19	38	8	7	
7	22008304440634	44	24	11	5	12	15	37	56	52	30	10	
8	22008304501003	45	25	10	6	22	33	46	57	18	19	6	
9	22001100100000	71	58	211	247	212	7	145	1	82	34	15	
10	22301400300190	5	5	159	172	19	5	18	352	352	15	8	
11	22008304700976	83	57	7	11	31	75	52	68	23	16	13	
12	22030000710851	106	110	145	150	217	27	119	88	103	144	40	
13	22008304501664	104	77	12	7	42	90	98	58	19	65	14	
14	22008304540221	125	68	13	13	7	51	25	59	20	42	12	
15	22030000700795	114	131	156	166	228	36	132	87	102	143	49	
16	22008107401223	110	83	16	18	71	94	100	35	10	46	18	
17	22008106951752	187	134	80	73	48	78	7	30	2	80	26	
18	22008107502454	146	126	55	19	72	115	104	38	11	59	30	
19	22008107342707	144	120	56	20	76	111	109	34	9	56	29	
20	22002200500208	7	12	142	140	74	19	107	2	83	93	20	Tot. ave
	average =	67.6	53.3	57.6	58.8	61.1	39.5	57.6	63.2	54.2	43.3	15.6	52.0

M&M4c Survey Results for Dauphin County													
M&M4c RANK	Structure ID Number	B & H RANK	Mod B&H RANK	Buckle RANK	Mod Buckle RANK	Caltrans RANK	Montana RANK	Nevada RANK	SC RANK	Mod SC RANK	Missouri RANK	IDOT RANK	
1	22008304200000	1	1	4	1	1	2	1	51	16	1	1	
2	22008106520000	3	3	23	16	17	1	3	16	4	2	2	
3	22008304203326	4	4	3	2	4	4	2	52	17	3	3	
4	22301600100000	2	2	22	60	8	3	15	106	72	5	4	
5	22008304340000	16	6	1	3	3	9	4	54	50	4	5	
6	22008304440634	44	24	11	5	12	15	37	56	52	30	10	
7	22008304501003	45	25	10	6	22	33	46	57	18	19	6	
8	22008106601047	34	20	25	47	57	14	28	19	38	8	7	
9	22002202901786	62	28	128	124	44	21	11	11	90	13	21	
10	22002202911867	63	29	129	125	45	22	12	13	92	14	22	
11	22008304700976	83	57	7	11	31	75	52	68	23	16	13	
12	22008107401223	110	83	16	18	71	94	100	35	10	46	18	
13	22008107502454	146	126	55	19	72	115	104	38	11	59	30	
14	22008304501664	104	77	12	7	42	90	98	58	19	65	14	
15	22008107342707	144	120	56	20	76	111	109	34	9	56	29	
16	22301400300190	5	5	159	172	19	5	18	352	352	15	8	
17	22008106951752	187	134	80	73	48	78	7	30	2	80	26	
18	22001100100000	71	58	211	247	212	7	145	1	82	34	15	
19	22008304900000	90	59	5	9	13	43	35	73	61	37	45	
20	22008304540221	125	68	13	13	7	51	25	59	20	42	12	Tot. ave
	average =	67.0	46.5	48.5	48.9	40.2	39.7	42.6	59.2	51.9	27.5	14.6	44.2

M&M4d Survey Results for Dauphin County													
M&M4d RANK	Structure ID Number	B & H RANK	Mod B&H RANK	Buckle RANK	Mod Buckle RANK	Caltrans RANK	Montana RANK	Nevada RANK	SC RANK	Mod SC RANK	Missouri RANK	IDOT RANK	
1	22008304200000	1	1	4	1	1	2	1	51	16	1	1	
2	22008106520000	3	3	23	16	17	1	3	16	4	2	2	
3	22008304203326	4	4	3	2	4	4	2	52	17	3	3	
4	22301600100000	2	2	22	60	8	3	15	106	72	5	4	
5	22008304340000	16	6	1	3	3	9	4	54	50	4	5	
6	22008304440634	44	24	11	5	12	15	37	56	52	30	10	
7	22008106601047	34	20	25	47	57	14	28	19	38	8	7	
8	22008304501003	45	25	10	6	22	33	46	57	18	19	6	
9	22001100100000	71	58	211	247	212	7	145	1	82	34	15	
10	22008304700976	83	57	7	11	31	75	52	68	23	16	13	
11	22301400300190	5	5	159	172	19	5	18	352	352	15	8	
12	22008107401223	110	83	16	18	71	94	100	35	10	46	18	
13	22002202901786	62	28	128	124	44	21	11	11	90	13	21	
14	22002202911867	63	29	129	125	45	22	12	13	92	14	22	
15	22008107502454	146	126	55	19	72	115	104	38	11	59	30	
16	22008304501664	104	77	12	7	42	90	98	58	19	65	14	
17	22008106951752	187	134	80	73	48	78	7	30	2	80	26	
18	22008304540221	125	68	13	13	7	51	25	59	20	42	12	
19	22008107342707	144	120	56	20	76	111	109	34	9	56	29	
20	22030000710851	106	110	145	150	217	27	119	88	103	144	40	Tot. ave
	average =	67.8	49.0	55.5	56.0	50.4	38.9	46.8	59.9	54.0	32.8	14.3	47.8

M&M4e Survey Results for Dauphin County													
M&M4e RANK	Structure ID Number	B & H RANK	Mod B&H RANK	Buckle RANK	Mod Buckle RANK	Caltrans RANK	Montana RANK	Nevada RANK	SC RANK	Mod SC RANK	Missouri RANK	IDOT RANK	
1	22008304200000	1	1	4	1	1	2	1	51	16	1	1	
2	22008106520000	3	3	23	16	17	1	3	16	4	2	2	
3	22008304203326	4	4	3	2	4	4	2	52	17	3	3	
4	22301600100000	2	2	22	60	8	3	15	106	72	5	4	
5	22008304340000	16	6	1	3	3	9	4	54	50	4	5	
6	22008106601047	34	20	25	47	57	14	28	19	38	8	7	
7	22008304440634	44	24	11	5	12	15	37	56	52	30	10	
8	22008304501003	45	25	10	6	22	33	46	57	18	19	6	
9	22001100100000	71	58	211	247	212	7	145	1	82	34	15	
10	22008304700976	83	57	7	11	31	75	52	68	23	16	13	
11	22301400300190	5	5	159	172	19	5	18	352	352	15	8	
12	22008107401223	110	83	16	18	71	94	100	35	10	46	18	
13	22008304501664	104	77	12	7	42	90	98	58	19	65	14	
14	22008107502454	146	126	55	19	72	115	104	38	11	59	30	
15	22002202901786	62	28	128	124	44	21	11	11	90	13	21	
16	22002202911867	63	29	129	125	45	22	12	13	92	14	22	
17	22008304540221	125	68	13	13	7	51	25	59	20	42	12	
18	22008106951752	187	134	80	73	48	78	7	30	2	80	26	
19	22030000710851	106	110	145	150	217	27	119	88	103	144	40	
20	22008107342707	144	120	56	20	76	111	109	34	9	56	29	Tot. ave
	average =	67.8	49.0	55.5	56.0	50.4	38.9	46.8	59.9	54.0	32.8	14.3	47.8

PennDOT Survey Results for Dauphin County													
PennDOT RANK	Structure ID Number	MIDOT RANK	M&M1 RANK	M&M2 RANK	M&M3 RANK	M&M4 RANK	M&M5 RANK	M&M6 RANK	M&M4a RANK	M&M4b RANK	M&M4c RANK	M&M4d RANK	M&M4e RANK
1	22008304200000	1	1	1	1	1	1	1	1	1	1	1	1
2	22008106520000	2	2	2	2	2	2	2	2	2	2	2	2
3	22002200500208	20	17	19	11	22	21	20	21	20	21	21	22
4	22707699024665	87	81	91	97	44	43	41	56	43	56	47	44
5	22301600100000	4	4	4	4	4	4	4	4	4	4	4	4
6	22301200300000	15	25	18	31	46	70	67	63	39	63	52	48
7	22008106601047	7	11	9	38	6	6	6	8	6	8	7	6
8	22008304340000	5	6	5	41	5	5	5	5	5	5	5	5
9	22032201700000	54	55	51	58	90	105	104	97	86	97	94	90
10	22300901900601	554	509	512	518	196	224	222	201	194	198	198	196
11	22301400300190	14	12	12	12	11	17	16	16	10	16	11	11
12	22002202310000	80	82	83	159	60	57	56	81	49	81	62	60
13	22008304340713	39	68	62	162	53	49	47	47	57	47	50	53
14	22002202911867	33	37	33	148	16	19	18	10	24	10	14	16
15	22008106851552	86	96	92	436	96	90	89	77	94	77	91	93
16	22028300252054	85	94	81	446	101	102	101	93	92	92	100	101
17	22022501301860	181	141	157	98	198	226	223	188	208	189	201	198
18	22002200900000	71	72	76	62	32	30	28	28	33	29	31	32
19	22008106940918	72	75	74	427	63	73	68	45	69	46	59	63
20	22008304601012	13	34	21	73	26	31	29	25	25	25	25	26
21	22008304611029	38	63	49	424	58	55	54	62	55	62	58	58
	average =	69.6	70.7	69.1	154.7	53.8	58.6	57.2	53.8	53.1	53.8	54.0	53.8

EMS Survey Results for Dauphin County													
EMS RANK	Structure ID Number	MIDOT RANK	M&M1 RANK	M&M2 RANK	M&M3 RANK	M&M4 RANK	M&M5 RANK	M&M6 RANK	M&M4a RANK	M&M4b RANK	M&M4c RANK	M&M4d RANK	M&M4e RANK
1	22008106520000	2	2	2	2	2	2	2	2	2	2	2	2
2	22302100100000	55	45	45	60	40	36	38	39	52	38	39	40
3	22032200600000	515	516	544	461	130	156	152	134	128	134	132	130
4	22002201802643	157	483	286	474	141	126	123	133	146	133	141	141
5	22002200900000	71	72	76	62	32	30	28	28	33	29	31	32
6	22014700401898	77	67	71	59	99	95	95	116	88	116	101	99
7	22014702200000	193	149	165	109	223	240	237	216	228	214	223	224
8	22014703100842	70	60	67	55	91	89	87	110	82	110	95	91
9	22020900700000	245	202	220	151	274	282	280	270	280	270	273	275
10	22020901401722	251	209	228	166	290	297	296	278	294	278	294	290
11	22020902600000	198	152	172	111	233	246	243	217	235	218	230	233
12	22020903200000	230	180	200	131	251	262	260	251	256	251	252	251
13	22008106851552	86	96	92	436	96	90	89	77	94	77	91	93
14	22008106940918	72	75	74	427	63	73	68	45	69	46	59	63
15	22008304601012	13	34	21	73	26	31	29	25	25	25	25	26
16	22032201700000	54	55	51	58	90	105	104	97	86	97	94	90
17	22032202901298	146	120	125	79	164	193	188	160	165	161	162	161
18	22008304200000	1	1	1	1	1	1	1	1	1	1	1	1
19	22002200500208	20	17	19	11	22	21	20	21	20	21	21	22
20	22301600100000	4	4	4	4	4	4	4	4	4	4	4	4
	average =	123.0	127.0	123.2	146.5	113.6	119.0	117.2	111.2	114.4	111.3	113.5	113.4

MIDOT Results for Cumberland County													
MIDOT RANK	Structure ID Number	B & H RANK	Mod B&H RANK	Buckle RANK	Mod Buckle RANK	Caltrans RANK	Montana RANK	Nevada RANK	SC RANK	Mod SC RANK	Missouri RANK	IDOT RANK	
1	21058101300000	3	1	2	4	10	1	5	86	105	1	1	
2	21008304140000	68	7	5	2	1	2	1	79	16	3	2	
3	21203500500000	5	4	136	154	2	9	2	89	108	4	3	
4	21008104651675	169	99	32	37	139	10	58	50	6	98	8	
5	21008104641546	174	102	33	41	147	11	60	47	5	97	9	
6	21001107600000	96	15	25	35	15	3	11	134	134	10	4	
7	21001501700863	1	3	8	6	4	5	30	14	71	15	5	
8	21008105702531	224	143	22	12	134	81	106	72	12	73	11	
9	21008106101223	237	165	38	7	120	105	170	77	15	11	10	
10	21008304160483	103	44	1	1	3	17	6	80	17	2	6	
11	21707699023945	10	14	69	79	107	43	127	128	18	17	12	
12	21707699021516	6	10	47	52	88	55	61	105	49	67	18	
13	21058101401063	112	28	4	5	18	4	29	87	106	13	7	
14	21008105512143	182	111	102	111	287	39	189	69	35	168	20	
15	21008102601335	232	158	114	27	219	90	165	15	1	66	24	
16	21008102742185	225	150	51	28	220	83	164	17	2	64	21	
17	21707699021226	12	23	45	49	85	79	64	100	46	106	25	
18	21008105100858	255	186	14	19	160	131	176	61	7	77	19	
19	21008105502205	185	119	110	120	293	45	190	68	34	167	22	
20	21707699022130	23	30	49	54	89	117	66	108	51	128	26	Tot. ave
	average =	116.1	70.6	45.4	42.2	107.1	46.5	84.0	74.3	41.9	59.4	12.7	63.63

M&M1 Results for Cumberland County													
M&M1 RANK	Structure ID Number	B & H RANK	Mod B&H RANK	Buckle RANK	Mod Buckle RANK	Caltrans RANK	Montana RANK	Nevada RANK	SC RANK	Mod SC RANK	Missouri RANK	IDOT RANK	
1	21058101300000	3	1	2	4	10	1	5	86	105	1	1	
2	21008104651675	169	99	32	37	139	10	58	50	6	98	8	
3	21008104641546	174	102	33	41	147	11	60	47	5	97	9	
4	21008105702531	224	143	22	12	134	81	106	72	12	73	11	
5	21008106101223	237	165	38	7	120	105	170	77	15	11	10	
6	21008304140000	68	7	5	2	1	2	1	79	16	3	2	
7	21707699023945	10	14	69	79	107	43	127	128	18	17	12	
8	21707699021516	6	10	47	52	88	55	61	105	49	67	18	
9	21707699021226	12	23	45	49	85	79	64	100	46	106	25	
10	21008103341044	235	170	20	21	186	137	143	25	3	76	27	
11	21008103540769	233	169	21	22	187	133	144	26	4	75	28	
12	21008105100858	255	186	14	19	160	131	176	61	7	77	19	
13	21008102742185	225	150	51	28	220	83	164	17	2	64	21	
14	21707699022130	23	30	49	54	89	117	66	108	51	128	26	
15	21008102601335	232	158	114	27	219	90	165	15	1	66	24	
16	21707699021183	28	35	44	48	84	123	65	99	45	131	30	
17	21707699020569	36	42	40	43	81	139	67	91	41	137	34	
18	21707699020618	33	40	41	44	82	134	68	92	42	134	35	
19	21707699020871	34	41	43	47	83	135	69	95	43	136	36	
20	21707699021475	37	45	46	51	87	145	70	104	48	140	37	Tot. ave
	average =	113.7	81.5	38.8	34.4	115.5	87.7	92.5	73.9	28.0	81.9	20.7	69.84

M&M2 Results for Cumberland County													
M&M2 RANK	Structure ID Number	B & H RANK	Mod B&H RANK	Buckle RANK	Mod Buckle RANK	Caltrans RANK	Montana RANK	Nevada RANK	SC RANK	Mod SC RANK	Missouri RANK	IDOT RANK	
1	21058101300000	3	1	2	4	10	1	5	86	105	1	1	
2	21008304140000	68	7	5	2	1	2	1	79	16	3	2	
3	21008104651675	169	99	32	37	139	10	58	50	6	98	8	
4	21008104641546	174	102	33	41	147	11	60	47	5	97	9	
5	21008105702531	224	143	22	12	134	81	106	72	12	73	11	
6	21008106101223	237	165	38	7	120	105	170	77	15	11	10	
7	21707699023945	10	14	69	79	107	43	127	128	18	17	12	
8	21707699021516	6	10	47	52	88	55	61	105	49	67	18	
9	21203500500000	5	4	136	154	2	9	2	89	108	4	3	
10	21008105512143	182	111	102	111	287	39	189	69	35	168	20	
11	21008102742185	225	150	51	28	220	83	164	17	2	64	21	
12	21707699021226	12	23	45	49	85	79	64	100	46	106	25	
13	21008102601335	232	158	114	27	219	90	165	15	1	66	24	
14	21008105502205	185	119	110	120	293	45	190	68	34	167	22	
15	21008105100858	255	186	14	19	160	131	176	61	7	77	19	
16	21707699022130	23	30	49	54	89	117	66	108	51	128	26	
17	21707699021183	28	35	44	48	84	123	65	99	45	131	30	
18	21001501700863	1	3	8	6	4	5	30	14	71	15	5	
19	21707699020569	36	42	40	43	81	139	67	91	41	137	34	
20	21707699020618	33	40	41	44	82	134	68	92	42	134	35	Tot. ave
average =		105.4	72.1	50.1	46.9	117.6	65.1	91.7	73.4	35.5	78.2	16.8	68.4

M&M3 Results for Cumberland County													
M&M3 RANK	Structure ID Number	B & H RANK	Mod B&H RANK	Buckle RANK	Mod Buckle RANK	Caltrans RANK	Montana RANK	Nevada RANK	SC RANK	Mod SC RANK	Missouri RANK	IDOT RANK	
1	21058101300000	3	1	2	4	10	1	5	86	105	1	1	
2	21008104651675	169	99	32	37	139	10	58	50	6	98	8	
3	21008104641546	174	102	33	41	147	11	60	47	5	97	9	
4	21008105702531	224	143	22	12	134	81	106	72	12	73	11	
5	21008106101223	237	165	38	7	120	105	170	77	15	11	10	
6	21008103540769	233	169	21	22	187	133	144	26	4	75	28	
7	21008103341044	235	170	20	21	186	137	143	25	3	76	27	
8	21707699021516	6	10	47	52	88	55	61	105	49	67	18	
9	21707699023945	10	14	69	79	107	43	127	128	18	17	12	
10	21008105100858	255	186	14	19	160	131	176	61	7	77	19	
11	21707699021226	12	23	45	49	85	79	64	100	46	106	25	
12	21707699021183	28	35	44	48	84	123	65	99	45	131	30	
13	21707699022130	23	30	49	54	89	117	66	108	51	128	26	
14	21707699020569	36	42	40	43	81	139	67	91	41	137	34	
15	21707699020618	33	40	41	44	82	134	68	92	42	134	35	
16	21707699020871	34	41	43	47	83	135	69	95	43	136	36	
17	21707699021475	37	45	46	51	87	145	70	104	48	140	37	
18	21008102742185	225	150	51	28	220	83	164	17	2	64	21	
19	21707699021297	51	63	34	50	86	171	71	102	47	147	39	
20	21008102601335	232	158	114	27	219	90	165	15	1	66	24	Tot. ave
	average =	112.9	84.3	40.3	36.8	119.7	96.2	96.0	75.0	29.5	89.1	22.5	72.9

M&M4 Results for Cumberland County													
M&M4 RANK	Structure ID Number	B & H RANK	Mod B&H RANK	Buckle RANK	Mod Buckle RANK	Caltrans RANK	Montana RANK	Nevada RANK	SC RANK	Mod SC RANK	Missouri RANK	IDOT RANK	
1	21058101300000	3	1	2	4	10	1	5	86	105	1	1	
2	21008304140000	68	7	5	2	1	2	1	79	16	3	2	
3	21203500500000	5	4	136	154	2	9	2	89	108	4	3	
4	21008104651675	169	99	32	37	139	10	58	50	6	98	8	
5	21008104641546	174	102	33	41	147	11	60	47	5	97	9	
6	21001501700863	1	3	8	6	4	5	30	14	71	15	5	
7	21001107600000	96	15	25	35	15	3	11	134	134	10	4	
8	21008106101223	237	165	38	7	120	105	170	77	15	11	10	
9	21008105702531	224	143	22	12	134	81	106	72	12	73	11	
10	21008103341044	235	170	20	21	186	137	143	25	3	76	27	
11	21008103540769	233	169	21	22	187	133	144	26	4	75	28	
12	21001109800000	4	5	174	212	6	12	3	8	66	7	14	
13	21001108900000	8	9	135	126	44	15	52	7	65	24	46	
14	21008105100858	255	186	14	19	160	131	176	61	7	77	19	
15	21707699021516	6	10	47	52	88	55	61	105	49	67	18	
16	21008304160483	103	44	1	1	3	17	6	80	17	2	6	
17	21001107400000	2	2	7	16	5	8	9	133	133	19	17	
18	21008105541172	229	152	23	24	195	122	174	70	10	78	29	
19	21008105601972	234	160	24	25	196	126	175	71	11	80	33	
20	21707699021226	12	23	45	49	85	79	64	100	46	106	25	Tot. ave
	average =	114.9	73.5	40.6	43.3	86.4	53.1	72.5	66.7	44.2	46.2	15.8	59.7

M&M5 Results for Cumberland County													
M&M5 RANK	Structure ID Number	B & H RANK	Mod B&H RANK	Buckle RANK	Mod Buckle RANK	Caltrans RANK	Montana RANK	Nevada RANK	SC RANK	Mod SC RANK	Missouri RANK	IDOT RANK	
1	21058101300000	3	1	2	4	10	1	5	86	105	1	1	
2	21008304140000	68	7	5	2	1	2	1	79	16	3	2	
3	21203500500000	5	4	136	154	2	9	2	89	108	4	3	
4	21008104651675	169	99	32	37	139	10	58	50	6	98	8	
5	21008104641546	174	102	33	41	147	11	60	47	5	97	9	
6	21001501700863	1	3	8	6	4	5	30	14	71	15	5	
7	21001107600000	96	15	25	35	15	3	11	134	134	10	4	
8	21008106101223	237	165	38	7	120	105	170	77	15	11	10	
9	21008105702531	224	143	22	12	134	81	106	72	12	73	11	
10	21008103341044	235	170	20	21	186	137	143	25	3	76	27	
11	21008103540769	233	169	21	22	187	133	144	26	4	75	28	
12	21001108900000	8	9	135	126	44	15	52	7	65	24	46	
13	21008105100858	255	186	14	19	160	131	176	61	7	77	19	
14	21707699021516	6	10	47	52	88	55	61	105	49	67	18	
15	21001107400000	2	2	7	16	5	8	9	133	133	19	17	
16	21001109800000	4	5	174	212	6	12	3	8	66	7	14	
17	21008105541172	229	152	23	24	195	122	174	70	10	78	29	
18	21008105601972	234	160	24	25	196	126	175	71	11	80	33	
19	21707699021226	12	23	45	49	85	79	64	100	46	106	25	
20	21707699022130	23	30	49	54	89	117	66	108	51	128	26	Tot. ave
	average =	110.9	72.8	43.0	45.9	90.7	58.1	75.5	68.1	45.9	52.5	16.8	61.8

M&M6 Results for Cumberland County													
M&M6 RANK	Structure ID Number	B & H RANK	Mod B&H RANK	Buckle RANK	Mod Buckle RANK	Caltrans RANK	Montana RANK	Nevada RANK	SC RANK	Mod SC RANK	Missouri RANK	IDOT RANK	
1	21058101300000	3	1	2	4	10	1	5	86	105	1	1	
2	21008304140000	68	7	5	2	1	2	1	79	16	3	2	
3	21203500500000	5	4	136	154	2	9	2	89	108	4	3	
4	21008104651675	169	99	32	37	139	10	58	50	6	98	8	
5	21008104641546	174	102	33	41	147	11	60	47	5	97	9	
6	21001501700863	1	3	8	6	4	5	30	14	71	15	5	
7	21001107600000	96	15	25	35	15	3	11	134	134	10	4	
8	21008105702531	224	143	22	12	134	81	106	72	12	73	11	
9	21001108900000	8	9	135	126	44	15	52	7	65	24	46	
10	21707699021516	6	10	47	52	88	55	61	105	49	67	18	
11	21001107400000	2	2	7	16	5	8	9	133	133	19	17	
12	21001109800000	4	5	174	212	6	12	3	8	66	7	14	
13	21707699021226	12	23	45	49	85	79	64	100	46	106	25	
14	21008106101223	237	165	38	7	120	105	170	77	15	11	10	
15	21707699022130	23	30	49	54	89	117	66	108	51	128	26	
16	21707699020569	36	42	40	43	81	139	67	91	41	137	34	
17	21707699020618	33	40	41	44	82	134	68	92	42	134	35	
18	21707699020871	34	41	43	47	83	135	69	95	43	136	36	
19	21707699021183	28	35	44	48	84	123	65	99	45	131	30	
20	21707699021297	51	63	34	50	86	171	71	102	47	147	39	Tot. ave
average =		60.7	42.0	48.0	52.0	65.3	60.8	51.9	79.4	55.0	67.4	18.7	54.6

M&M4a Results for Cumberland County													
M&M4a RANK	Structure ID Number	B & H RANK	Mod B&H RANK	Buckle RANK	Mod Buckle RANK	Caltrans RANK	Montana RANK	Nevada RANK	SC RANK	Mod SC RANK	Missouri RANK	IDOT RANK	
1	21058101300000	3	1	2	4	10	1	5	86	105	1	1	
2	21203500500000	5	4	136	154	2	9	2	89	108	4	3	
3	21008304140000	68	7	5	2	1	2	1	79	16	3	2	
4	21001107600000	96	15	25	35	15	3	11	134	134	10	4	
5	21001501700863	1	3	8	6	4	5	30	14	71	15	5	
6	21008103341044	235	170	20	21	186	137	143	25	3	76	27	
7	21008103540769	233	169	21	22	187	133	144	26	4	75	28	
8	21008106101223	237	165	38	7	120	105	170	77	15	11	10	
9	21008104651675	169	99	32	37	139	10	58	50	6	98	8	
10	21001109800000	4	5	174	212	6	12	3	8	66	7	14	
11	21008104641546	174	102	33	41	147	11	60	47	5	97	9	
12	21008105702531	224	143	22	12	134	81	106	72	12	73	11	
13	21001107400000	2	2	7	16	5	8	9	133	133	19	17	
14	21008304160483	103	44	1	1	3	17	6	80	17	2	6	
15	21008105100858	255	186	14	19	160	131	176	61	7	77	19	
16	21001109810485	150	75	207	284	114	14	14	9	67	9	23	
17	21008105541172	229	152	23	24	195	122	174	70	10	78	29	
18	21008105601972	234	160	24	25	196	126	175	71	11	80	33	
19	21058101200000	197	113	3	3	77	63	187	85	40	22	16	
20	21707699021516	6	10	47	52	88	55	61	105	49	67	18	Tot. ave
	average =	131.3	81.3	42.1	48.9	89.5	52.3	76.8	66.1	44.0	41.2	14.2	62.5

M&M4b Results for Cumberland County													
M&M4b RANK	Structure ID Number	B & H RANK	Mod B&H RANK	Buckle RANK	Mod Buckle RANK	Caltrans RANK	Montana RANK	Nevada RANK	SC RANK	Mod SC RANK	Missouri RANK	IDOT RANK	
1	21058101300000	3	1	2	4	10	1	5	86	105	1	1	
2	21008304140000	68	7	5	2	1	2	1	79	16	3	2	
3	21008104651675	169	99	32	37	139	10	58	50	6	98	8	
4	21008104641546	174	102	33	41	147	11	60	47	5	97	9	
5	21203500500000	5	4	136	154	2	9	2	89	108	4	3	
6	21001501700863	1	3	8	6	4	5	30	14	71	15	5	
7	21001107600000	96	15	25	35	15	3	11	134	134	10	4	
8	21008106101223	237	165	38	7	120	105	170	77	15	11	10	
9	21008105702531	224	143	22	12	134	81	106	72	12	73	11	
10	21001108900000	8	9	135	126	44	15	52	7	65	24	46	
11	21008103341044	235	170	20	21	186	137	143	25	3	76	27	
12	21008103540769	233	169	21	22	187	133	144	26	4	75	28	
13	21707699021516	6	10	47	52	88	55	61	105	49	67	18	
14	21001109800000	4	5	174	212	6	12	3	8	66	7	14	
15	21008105100858	255	186	14	19	160	131	176	61	7	77	19	
16	21707699021226	12	23	45	49	85	79	64	100	46	106	25	
17	21707699023945	10	14	69	79	107	43	127	128	18	17	12	
18	21008304160483	103	44	1	1	3	17	6	80	17	2	6	
19	21707699022130	23	30	49	54	89	117	66	108	51	128	26	
20	21008105541172	229	152	23	24	195	122	174	70	10	78	29	Tot. ave
average =		104.8	67.6	45.0	47.9	86.1	54.4	73.0	68.3	40.4	48.5	15.2	59.2

M&M4c Results for Cumberland County													
M&M4c RANK	Structure ID Number	B & H RANK	Mod B&H RANK	Buckle RANK	Mod Buckle RANK	Caltrans RANK	Montana RANK	Nevada RANK	SC RANK	Mod SC RANK	Missouri RANK	IDOT RANK	
1	21058101300000	3	1	2	4	10	1	5	86	105	1	1	
2	21203500500000	5	4	136	154	2	9	2	89	108	4	3	
3	21008304140000	68	7	5	2	1	2	1	79	16	3	2	
4	21001107600000	96	15	25	35	15	3	11	134	134	10	4	
5	21008103341044	235	170	20	21	186	137	143	25	3	76	27	
6	21008103540769	233	169	21	22	187	133	144	26	4	75	28	
7	21008106101223	237	165	38	7	120	105	170	77	15	11	10	
8	21001109800000	4	5	174	212	6	12	3	8	66	7	14	
9	21001107400000	2	2	7	16	5	8	9	133	133	19	17	
10	21001501700863	1	3	8	6	4	5	30	14	71	15	5	
11	21008105702531	224	143	22	12	134	81	106	72	12	73	11	
12	21008104651675	169	99	32	37	139	10	58	50	6	98	8	
13	21008304160483	103	44	1	1	3	17	6	80	17	2	6	
14	21008104641546	174	102	33	41	147	11	60	47	5	97	9	
15	21001109810485	150	75	207	284	114	14	14	9	67	9	23	
16	21008105100858	255	186	14	19	160	131	176	61	7	77	19	
17	21058101200000	197	113	3	3	77	63	187	85	40	22	16	
18	21008105541172	229	152	23	24	195	122	174	70	10	78	29	
19	21008105601972	234	160	24	25	196	126	175	71	11	80	33	
20	21707699021516	6	10	47	52	88	55	61	105	49	67	18	Tot. ave
	average =	131.3	81.3	42.1	48.9	89.5	52.3	76.8	66.1	44.0	41.2	14.2	62.5

M&M4d Results for Cumberland County													
M&M4d RANK	Structure ID Number	B & H RANK	Mod B&H RANK	Buckle RANK	Mod Buckle RANK	Caltrans RANK	Montana RANK	Nevada RANK	SC RANK	Mod SC RANK	Missouri RANK	IDOT RANK	
1	21058101300000	3	1	2	4	10	1	5	86	105	1	1	
2	21203500500000	5	4	136	154	2	9	2	89	108	4	3	
3	21008304140000	68	7	5	2	1	2	1	79	16	3	2	
4	21001107600000	96	15	25	35	15	3	11	134	134	10	4	
5	21001501700863	1	3	8	6	4	5	30	14	71	15	5	
6	21008103341044	235	170	20	21	186	137	143	25	3	76	27	
7	21008103540769	233	169	21	22	187	133	144	26	4	75	28	
8	21008106101223	237	165	38	7	120	105	170	77	15	11	10	
9	21001109800000	4	5	174	212	6	12	3	8	66	7	14	
10	21001107400000	2	2	7	16	5	8	9	133	133	19	17	
11	21008104651675	169	99	32	37	139	10	58	50	6	98	8	
12	21008105702531	224	143	22	12	134	81	106	72	12	73	11	
13	21008104641546	174	102	33	41	147	11	60	47	5	97	9	
14	21008304160483	103	44	1	1	3	17	6	80	17	2	6	
15	21001109810485	150	75	207	284	114	14	14	9	67	9	23	
16	21008105100858	255	186	14	19	160	131	176	61	7	77	19	
17	21008105541172	229	152	23	24	195	122	174	70	10	78	29	
18	21008105601972	234	160	24	25	196	126	175	71	11	80	33	
19	21058101200000	197	113	3	3	77	63	187	85	40	22	16	
20	21707699021516	6	10	47	52	88	55	61	105	49	67	18	Tot. ave
	average =	131.3	81.3	42.1	48.9	89.5	52.3	76.8	66.1	44.0	41.2	14.2	62.5

M&M4e Results for Cumberland County													
M&M4e RANK	Structure ID Number	B & H RANK	Mod B&H RANK	Buckle RANK	Mod Buckle RANK	Caltrans RANK	Montana RANK	Nevada RANK	SC RANK	Mod SC RANK	Missouri RANK	IDOT RANK	
1	21058101300000	3	1	2	4	10	1	5	86	105	1	1	
2	21008304140000	68	7	5	2	1	2	1	79	16	3	2	
3	21203500500000	5	4	136	154	2	9	2	89	108	4	3	
4	21001501700863	1	3	8	6	4	5	30	14	71	15	5	
5	21008104651675	169	99	32	37	139	10	58	50	6	98	8	
6	21008104641546	174	102	33	41	147	11	60	47	5	97	9	
7	21001107600000	96	15	25	35	15	3	11	134	134	10	4	
8	21008106101223	237	165	38	7	120	105	170	77	15	11	10	
9	21008103341044	235	170	20	21	186	137	143	25	3	76	27	
10	21008103540769	233	169	21	22	187	133	144	26	4	75	28	
11	21008105702531	224	143	22	12	134	81	106	72	12	73	11	
12	21001109800000	4	5	174	212	6	12	3	8	66	7	14	
13	21001107400000	2	2	7	16	5	8	9	133	133	19	17	
14	21008304160483	103	44	1	1	3	17	6	80	17	2	6	
15	21008105100858	255	186	14	19	160	131	176	61	7	77	19	
16	21008105541172	229	152	23	24	195	122	174	70	10	78	29	
17	21008105601972	234	160	24	25	196	126	175	71	11	80	33	
18	21707699021516	6	10	47	52	88	55	61	105	49	67	18	
19	21001108900000	8	9	135	126	44	15	52	7	65	24	46	
20	21001109810485	150	75	207	284	114	14	14	9	67	9	23	Tot. ave
	average =	121.8	76.1	48.7	55.0	87.8	49.9	70.0	62.2	45.2	41.3	15.7	61.2

PennDOT Survey Results for Cumberland County													
PennDOT RANK	Structure ID Number	MIDOT RANK	M&M1 RANK	M&M2 RANK	M&M3 RANK	M&M4 RANK	M&M5 RANK	M&M6 RANK	M&M4a RANK	M&M4b RANK	M&M4c RANK	M&M4d RANK	M&M4e RANK
1	21008105502205	19	23	14	31	49	48	44	54	45	61	54	50
2	21001107600000	6	48	31	209	7	7	7	4	7	4	4	7
3	21008105100190	93	398	205	401	100	114	114	111	96	116	113	105
4	21058100301760	209	137	147	137	249	263	256	283	237	306	288	267
5	21008304041288	43	61	53	374	55	55	53	53	59	52	53	54
6	21001108701474	27	27	23	24	38	37	34	42	36	46	42	39
7	21008104840101	109	413	318	417	118	110	110	122	115	127	123	120
8	21001109800000	33	54	50	369	12	16	12	10	14	8	9	12
9	21008104800066	102	408	246	414	117	109	109	128	114	133	129	121
10	21101500100878	60	55	58	48	86	96	92	93	76	94	93	89
11	21008105140000	79	220	95	392	85	79	75	87	78	89	86	85
12	21001501700000	41	58	52	372	51	50	48	45	53	43	45	49
13	21008104640250	73	203	89	391	79	72	67	86	74	91	89	82
14	21203500500133	61	68	67	201	43	42	39	46	40	50	48	45
15	21707699021516	12	8	8	8	15	14	10	20	13	20	20	18
16	21008105110135	99	402	226	408	123	133	133	139	111	149	145	129
17	21008304140000	2	6	2	50	2	2	2	3	2	3	3	2
18	21011400601951	66	57	60	49	74	91	87	79	75	78	79	78
19	21001107400000	40	49	51	73	17	15	11	13	31	9	10	13
20	21008104850246	103	411	270	415	112	104	102	118	110	124	120	116
21	21008104902459	81	82	83	370	58	58	56	65	57	77	70	61
	average =	64.7	151.8	102.3	245.4	71.0	72.1	69.6	76.2	68.7	80.0	77.3	73.4

MNT1 Survey Results for Dauphin County													
MNT1 RANK	Structure ID Number	B & H RANK	Mod B&H RANK	Buckle RANK	Mod Buckle RANK	Caltrans RANK	Montana RANK	Nevada RANK	SC RANK	Mod SC RANK	Missouri RANK	IDOT RANK	
1	22008106520000	3	3	23	16	17	1	3	16	4	2	2	
2	22008304200000	1	1	4	1	1	2	1	51	16	1	1	
3	22301600100000	2	2	22	60	8	3	15	106	72	5	4	
4	22008304203326	4	4	3	2	4	4	2	52	17	3	3	
5	22301400300190	5	5	159	172	19	5	18	352	352	15	8	
6	22301200800233	10	11	231	277	34	6	40	349	349	38	19	
7	22001100100000	71	58	211	247	212	7	145	1	82	34	15	
8	22301200300000	6	7	177	135	68	8	203	348	348	11	9	
9	22002200501317	38	38	154	147	145	10	44	3	84	76	17	
10	22002200511275	42	40	147	149	146	11	45	5	86	79	23	
11	22008304340000	16	6	1	3	3	9	4	54	50	4	5	
12	22301200100000	8	10	186	198	97	12	226	347	347	32	27	
13	22303400100000	53	99	482	479	284	16	388	452	452	606	170	
14	22008106601047	34	20	25	47	57	14	28	19	38	8	7	
15	22008304601012	39	14	57	62	39	13	8	61	22	22	11	
16	22008304440634	44	24	11	5	12	15	37	56	52	30	10	
17	22002200500208	7	12	142	140	74	19	107	2	83	93	20	
18	22002200510165	61	56	146	148	263	20	154	4	85	94	34	
19	22008304611029	50	19	58	64	60	17	29	63	54	39	24	
20	22008304641936	68	27	19	23	18	18	14	66	56	28	39	Tot. ave
	average =	28.1	22.8	112.9	118.8	78.1	10.5	75.6	120.4	132.5	61.0	22.4	71.2

MNT2 Survey Results for Dauphin County													
MNT2 RANK	Structure ID Number	B & H RANK	Mod B&H RANK	Buckle RANK	Mod Buckle RANK	Caltrans RANK	Montana RANK	Nevada RANK	SC RANK	Mod SC RANK	Missouri RANK	IDOT RANK	
1	22008106520000	3	3	23	16	17	1	3	16	4	2	2	
2	22008304200000	1	1	4	1	1	2	1	51	16	1	1	
3	22301600100000	2	2	22	60	8	3	15	106	72	5	4	
4	22008304203326	4	4	3	2	4	4	2	52	17	3	3	
5	22301400300190	5	5	159	172	19	5	18	352	352	15	8	
6	22301200800233	10	11	231	277	34	6	40	349	349	38	19	
7	22001100100000	71	58	211	247	212	7	145	1	82	34	15	
8	22301200300000	6	7	177	135	68	8	203	348	348	11	9	
9	22002200501317	38	38	154	147	145	10	44	3	84	76	17	
10	22002200511275	42	40	147	149	146	11	45	5	86	79	23	
11	22008304340000	16	6	1	3	3	9	4	54	50	4	5	
12	22301200100000	8	10	186	198	97	12	226	347	347	32	27	
13	22303400100000	53	99	482	479	284	16	388	452	452	606	170	
14	22008106601047	34	20	25	47	57	14	28	19	38	8	7	
15	22008304601012	39	14	57	62	39	13	8	61	22	22	11	
16	22008304440634	44	24	11	5	12	15	37	56	52	30	10	
17	22002200500208	7	12	142	140	74	19	107	2	83	93	20	
18	22002200510165	61	56	146	148	263	20	154	4	85	94	34	
19	22008304611029	50	19	58	64	60	17	29	63	54	39	24	
20	22008304641936	68	27	19	23	18	18	14	66	56	28	39	Tot. ave
	average =	28.1	22.8	112.9	118.8	78.1	10.5	75.6	120.4	132.5	61.0	22.4	71.2

MNT3 Survey Results for Dauphin County													
MNT3 RANK	Structure ID Number	B & H RANK	Mod B&H RANK	Buckle RANK	Mod Buckle RANK	Caltrans RANK	Montana RANK	Nevada RANK	SC RANK	Mod SC RANK	Missouri RANK	IDOT RANK	
1	22008106520000	3	3	23	16	17	1	3	16	4	2	2	
2	22008304200000	1	1	4	1	1	2	1	51	16	1	1	
3	22008304203326	4	4	3	2	4	4	2	52	17	3	3	
4	22301600100000	2	2	22	60	8	3	15	106	72	5	4	
5	22008304340000	16	6	1	3	3	9	4	54	50	4	5	
6	22301400300190	5	5	159	172	19	5	18	352	352	15	8	
7	22008106601047	34	20	25	47	57	14	28	19	38	8	7	
8	22008304601012	39	14	57	62	39	13	8	61	22	22	11	
9	22008304440634	44	24	11	5	12	15	37	56	52	30	10	
10	22008304611029	50	19	58	64	60	17	29	63	54	39	24	
11	22008304641936	68	27	19	23	18	18	14	66	56	28	39	
12	22002202901786	62	28	128	124	44	21	11	11	90	13	21	
13	22002202911867	63	29	129	125	45	22	12	13	92	14	22	
14	22001100100000	71	58	211	247	212	7	145	1	82	34	15	
15	22032200420865	66	30	178	200	85	23	30	95	108	27	47	
16	22301200800233	10	11	231	277	34	6	40	349	349	38	19	
17	22301900201401	60	26	150	156	49	25	19	108	118	25	73	
18	22008305011814	79	33	60	63	41	24	5	76	25	68	53	
19	22301000610730	80	34	119	132	29	26	22	104	71	41	63	
20	22002204200000	11	8	94	103	2	28	9	14	34	26	54	Tot. ave
	average =	38.4	19.1	84.1	94.1	39.0	14.2	22.6	83.4	85.1	22.2	24.1	47.8

MNT4 Survey Results for Dauphin County													
MNT4 RANK	Structure ID Number	B & H RANK	Mod B&H RANK	Buckle RANK	Mod Buckle RANK	Caltrans RANK	Montana RANK	Nevada RANK	SC RANK	Mod SC RANK	Missouri RANK	IDOT RANK	
1	22008106520000	3	3	23	16	17	1	3	16	4	2	2	
2	22008304200000	1	1	4	1	1	2	1	51	16	1	1	
3	22008304203326	4	4	3	2	4	4	2	52	17	3	3	
4	22301600100000	2	2	22	60	8	3	15	106	72	5	4	
5	22008304340000	16	6	1	3	3	9	4	54	50	4	5	
6	22301400300190	5	5	159	172	19	5	18	352	352	15	8	
7	22008106601047	34	20	25	47	57	14	28	19	38	8	7	
8	22008304601012	39	14	57	62	39	13	8	61	22	22	11	
9	22008304440634	44	24	11	5	12	15	37	56	52	30	10	
10	22008304611029	50	19	58	64	60	17	29	63	54	39	24	
11	22008304641936	68	27	19	23	18	18	14	66	56	28	39	
12	22002202901786	62	28	128	124	44	21	11	11	90	13	21	
13	22002202911867	63	29	129	125	45	22	12	13	92	14	22	
14	22001100100000	71	58	211	247	212	7	145	1	82	34	15	
15	22008305011814	79	33	60	63	41	24	5	76	25	68	53	
16	22301900201401	60	26	150	156	49	25	19	108	118	25	73	
17	22032200420865	66	30	178	200	85	23	30	95	108	27	47	
18	22301000610730	80	34	119	132	29	26	22	104	71	41	63	
19	22002204200000	11	8	94	103	2	28	9	14	34	26	54	
20	22008304641054	75	35	17	21	23	29	34	64	55	24	42	Tot. ave
	average =	41.7	20.3	73.4	81.3	38.4	15.3	22.3	69.1	70.4	21.5	25.2	43.5

MNT5 Survey Results for Dauphin County													
MNT5 RANK	Structure ID Number	B & H RANK	Mod B&H RANK	Buckle RANK	Mod Buckle RANK	Caltrans RANK	Montana RANK	Nevada RANK	SC RANK	Mod SC RANK	Missouri RANK	IDOT RANK	
1	22008106520000	3	3	23	16	17	1	3	16	4	2	2	
2	22008304200000	1	1	4	1	1	2	1	51	16	1	1	
3	22008304203326	4	4	3	2	4	4	2	52	17	3	3	
4	22301600100000	2	2	22	60	8	3	15	106	72	5	4	
5	22008304340000	16	6	1	3	3	9	4	54	50	4	5	
6	22301400300190	5	5	159	172	19	5	18	352	352	15	8	
7	22008106601047	34	20	25	47	57	14	28	19	38	8	7	
8	22008304601012	39	14	57	62	39	13	8	61	22	22	11	
9	22008304440634	44	24	11	5	12	15	37	56	52	30	10	
10	22008304611029	50	19	58	64	60	17	29	63	54	39	24	
11	22008304641936	68	27	19	23	18	18	14	66	56	28	39	
12	22001100100000	71	58	211	247	212	7	145	1	82	34	15	
13	22008304641054	75	35	17	21	23	29	34	64	55	24	42	
14	22002202901786	62	28	128	124	44	21	11	11	90	13	21	
15	22002202911867	63	29	129	125	45	22	12	13	92	14	22	
16	22301200300000	6	7	177	135	68	8	203	348	348	11	9	
17	22008305011814	79	33	60	63	41	24	5	76	25	68	53	
18	22032200420865	66	30	178	200	85	23	30	95	108	27	47	
19	22301200800233	10	11	231	277	34	6	40	349	349	38	19	
20	22301900201401	60	26	150	156	49	25	19	108	118	25	73	Tot. ave
	average =	37.9	19.1	83.2	90.2	42.0	13.3	32.9	98.1	100.0	20.6	20.8	50.7

MNT6 RANK	Structure ID Number	B & H RANK	Mod B&H RANK	Buckle RANK	Mod Buckle RANK	Caltrans RANK	Montana RANK	Nevada RANK	SC RANK	Mod SC RANK	Missouri RANK	IDOT RANK	
1	22008106520000	3	3	23	16	17	1	3	16	4	2	2	
2	22008304200000	1	1	4	1	1	2	1	51	16	1	1	
3	22008304203326	4	4	3	2	4	4	2	52	17	3	3	
4	22301600100000	2	2	22	60	8	3	15	106	72	5	4	
5	22008304340000	16	6	1	3	3	9	4	54	50	4	5	
6	22301400300190	5	5	159	172	19	5	18	352	352	15	8	
7	22008106601047	34	20	25	47	57	14	28	19	38	8	7	
8	22008304601012	39	14	57	62	39	13	8	61	22	22	11	
9	22008304440634	44	24	11	5	12	15	37	56	52	30	10	
10	22008304611029	50	19	58	64	60	17	29	63	54	39	24	
11	22008304641936	68	27	19	23	18	18	14	66	56	28	39	
12	22001100100000	71	58	211	247	212	7	145	1	82	34	15	
13	22002202901786	62	28	128	124	44	21	11	11	90	13	21	
14	22002202911867	63	29	129	125	45	22	12	13	92	14	22	
15	22301200300000	6	7	177	135	68	8	203	348	348	11	9	
16	22008304641054	75	35	17	21	23	29	34	64	55	24	42	
17	22008305011814	79	33	60	63	41	24	5	76	25	68	53	
18	22032200420865	66	30	178	200	85	23	30	95	108	27	47	
19	22301200800233	10	11	231	277	34	6	40	349	349	38	19	
20	22301900201401	60	26	150	156	49	25	19	108	118	25	73	Tot. ave
	average =	37.9	19.1	83.2	90.2	42.0	13.3	32.9	98.1	100.0	20.6	20.8	50.7

MNT7 Survey Results for Dauphin County													
MNT7 RANK	Structure ID Number	B & H RANK	Mod B&H RANK	Buckle RANK	Mod Buckle RANK	Caltrans RANK	Montana RANK	Nevada RANK	SC RANK	Mod SC RANK	Missouri RANK	IDOT RANK	
1	22008106520000	3	3	23	16	17	1	3	16	4	2	2	
2	22008304200000	1	1	4	1	1	2	1	51	16	1	1	
3	22008304203326	4	4	3	2	4	4	2	52	17	3	3	
4	22301600100000	2	2	22	60	8	3	15	106	72	5	4	
5	22008304340000	16	6	1	3	3	9	4	54	50	4	5	
6	22301400300190	5	5	159	172	19	5	18	352	352	15	8	
7	22008106601047	34	20	25	47	57	14	28	19	38	8	7	
8	22008304440634	44	24	11	5	12	15	37	56	52	30	10	
9	22008304601012	39	14	57	62	39	13	8	61	22	22	11	
10	22008304611029	50	19	58	64	60	17	29	63	54	39	24	
11	22008304641936	68	27	19	23	18	18	14	66	56	28	39	
12	22001100100000	71	58	211	247	212	7	145	1	82	34	15	
13	22301200300000	6	7	177	135	68	8	203	348	348	11	9	
14	22008304641054	75	35	17	21	23	29	34	64	55	24	42	
15	22301200800233	10	11	231	277	34	6	40	349	349	38	19	
16	22002202901786	62	28	128	124	44	21	11	11	90	13	21	
17	22002202911867	63	29	129	125	45	22	12	13	92	14	22	
18	22008305011814	79	33	60	63	41	24	5	76	25	68	53	
19	22032200420865	66	30	178	200	85	23	30	95	108	27	47	
20	22002200501317	38	38	154	147	145	10	44	3	84	76	17	Tot. ave
	average =	36.8	19.7	83.4	89.7	46.8	12.6	34.2	92.8	98.3	23.1	18.0	50.5

PennDOT Survey Results for Dauphin County								
PennDOT RANK	Structure ID Number	MNT1 RANK	MNT2 RANK	MNT3 RANK	MNT4 RANK	MNT5 RANK	MNT6 RANK	MNT7 RANK
1	22008304200000	2	2	2	2	2	2	2
2	22008106520000	1	1	1	1	1	1	1
3	22002200500208	17	17	64	64	54	57	53
4	22707699024665	73	73	71	71	63	68	63
5	22301600100000	3	3	4	4	4	4	4
6	22301200300000	8	8	22	22	16	15	13
7	22008106601047	14	14	7	7	7	7	7
8	22008304340000	11	11	5	5	5	5	5
9	22032201700000	24	24	45	43	37	37	37
10	22300901900601	482	279	267	260	223	278	223
11	22301400300190	5	5	6	6	6	6	6
12	22002202310000	56	56	49	49	44	46	44
13	22008304340713	41	41	31	31	28	31	28
14	22002202911867	22	22	13	13	15	14	17
15	22008106851552	46	46	37	37	35	36	35
16	22028300252054	42	42	32	33	36	34	36
17	22022501301860	233	227	233	228	227	224	227
18	22002200900000	49	49	40	40	38	39	38
19	22008106940918	38	38	28	28	32	29	32
20	22008304601012	15	15	8	8	8	8	9
21	22008304611029	19	19	10	10	10	10	10
	average =	57.2	47.2	46.4	45.8	42.4	45.3	42.4

EMS Survey Results for Dauphin County								
EMS RANK	Structure ID Number	MNT1 RANK	MNT2 RANK	MNT3 RANK	MNT4 RANK	MNT5 RANK	MNT6 RANK	MNT7 RANK
1	22008106520000	1	1	1	1	1	1	1
2	22302100100000	39	39	78	82	95	86	86
3	22032200600000	71	71	69	70	62	67	67
4	22002201802643	119	119	113	115	119	120	120
5	22002200900000	49	49	40	40	38	39	38
6	22014700401898	295	319	322	323	323	321	321
7	22014702200000	236	243	247	241	239	233	233
8	22014703100842	195	195	219	217	216	207	207
9	22020900700000	297	321	318	317	316	314	314
10	22020901401722	254	264	276	279	268	268	268
11	22020902600000	219	223	229	227	226	223	223
12	22020903200000	232	236	248	247	243	235	235
13	22008106851552	46	46	37	37	35	36	35
14	22008106940918	38	38	28	28	32	29	32
15	22008304601012	15	15	8	8	8	8	9
16	22032201700000	24	24	45	43	37	37	37
17	22032202901298	208	209	204	199	197	194	194
18	22008304200000	2	2	2	2	2	2	2
19	22002200500208	17	17	64	64	54	57	53
20	22301600100000	3	3	4	4	4	4	4
	average =	118.0	121.7	127.6	127.2	125.8	124.1	124.0

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MNT1 Survey Results for Cumberland County													
MNT1 RANK	Structure ID Number	B & H RANK	Mod B&H RANK	Buckle RANK	Mod Buckle RANK	Caltrans RANK	Montana RANK	Nevada RANK	SC RANK	Mod SC RANK	Missouri RANK	IDOT RANK	
1	21058101300000	3	1	2	4	10	1	5	86	105	1	1	
2	21008304140000	68	7	5	2	1	2	1	79	16	3	2	
3	21001107600000	96	15	25	35	15	3	11	134	134	10	4	
4	21058101401063	112	28	4	5	18	4	29	87	106	13	7	
5	21001501700863	1	3	8	6	4	5	30	14	71	15	5	
6	21001501700000	122	31	9	8	27	6	39	13	70	8	13	
7	21008304041288	123	33	6	11	28	7	19	78	38	6	15	
8	21001107400000	2	2	7	16	5	8	9	133	133	19	17	
9	21008104651675	169	99	32	37	139	10	58	50	6	98	8	
10	21008104641546	174	102	33	41	147	11	60	47	5	97	9	
11	21203500500000	5	4	136	154	2	9	2	89	108	4	3	
12	21001500601043	160	70	77	23	90	13	156	383	383	26	104	
13	21008304160483	103	44	1	1	3	17	6	80	17	2	6	
14	21001109800000	4	5	174	212	6	12	3	8	66	7	14	
15	21001108900000	8	9	135	126	44	15	52	7	65	24	46	
16	21001109810485	150	75	207	284	114	14	14	9	67	9	23	
17	21011400400000	183	87	359	195	115	16	59	81	102	16	75	
18	21101500100878	11	19	231	175	59	18	203	309	309	72	48	
19	21001107200000	218	115	27	31	123	23	62	131	131	35	66	
20	21203500501906	27	27	134	152	58	20	90	408	408	239	245	Tot. ave
	average =	87.0	38.8	80.6	75.9	50.4	10.7	45.4	111.3	117.0	35.2	35.6	62.5

MNT2 Survey Results for Cumberland County													
MNT2 RANK	Structure ID Number	B & H RANK	Mod B&H RANK	Buckle RANK	Mod Buckle RANK	Caltrans RANK	Montana RANK	Nevada RANK	SC RANK	Mod SC RANK	Missouri RANK	IDOT RANK	
1	21058101300000	3	1	2	4	10	1	5	86	105	1	1	
2	21008304140000	68	7	5	2	1	2	1	79	16	3	2	
3	21001107600000	96	15	25	35	15	3	11	134	134	10	4	
4	21058101401063	112	28	4	5	18	4	29	87	106	13	7	
5	21001501700000	122	31	9	8	27	6	39	13	70	8	13	
6	21001501700863	1	3	8	6	4	5	30	14	71	15	5	
7	21008304041288	123	33	6	11	28	7	19	78	38	6	15	
8	21001107400000	2	2	7	16	5	8	9	133	133	19	17	
9	21203500500000	5	4	136	154	2	9	2	89	108	4	3	
10	21008104651675	169	99	32	37	139	10	58	50	6	98	8	
11	21008104641546	174	102	33	41	147	11	60	47	5	97	9	
12	21001109800000	4	5	174	212	6	12	3	8	66	7	14	
13	21001109810485	150	75	207	284	114	14	14	9	67	9	23	
14	21001500601043	160	70	77	23	90	13	156	383	383	26	104	
15	21008304160483	103	44	1	1	3	17	6	80	17	2	6	
16	21011400400000	183	87	359	195	115	16	59	81	102	16	75	
17	21001108900000	8	9	135	126	44	15	52	7	65	24	46	
18	21101500100878	11	19	231	175	59	18	203	309	309	72	48	
19	21707699023627	25	11	67	77	8	19	8	126	57	14	60	
20	21008104650367	24	12	97	56	9	22	12	49	26	27	70	Tot. ave
average =		77.2	32.9	80.8	73.4	42.2	10.6	38.8	93.1	94.2	23.6	26.5	53.9

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MNT3 Survey Results for Cumberland County													
MNT3 RANK	Structure ID Number	B & H RANK	Mod B&H RANK	Buckle RANK	Mod Buckle RANK	Caltrans RANK	Montana RANK	Nevada RANK	SC RANK	Mod SC RANK	Missouri RANK	IDOT RANK	
1	21058101300000	3	1	2	4	10	1	5	86	105	1	1	
2	21008304140000	68	7	5	2	1	2	1	79	16	3	2	
3	21001107600000	96	15	25	35	15	3	11	134	134	10	4	
4	21001501700863	1	3	8	6	4	5	30	14	71	15	5	
5	21058101401063	112	28	4	5	18	4	29	87	106	13	7	
6	21001501700000	122	31	9	8	27	6	39	13	70	8	13	
7	21008304041288	123	33	6	11	28	7	19	78	38	6	15	
8	21001107400000	2	2	7	16	5	8	9	133	133	19	17	
9	21203500500000	5	4	136	154	2	9	2	89	108	4	3	
10	21008104651675	169	99	32	37	139	10	58	50	6	98	8	
11	21008104641546	174	102	33	41	147	11	60	47	5	97	9	
12	21001109800000	4	5	174	212	6	12	3	8	66	7	14	
13	21001109810485	150	75	207	284	114	14	14	9	67	9	23	
14	21001500601043	160	70	77	23	90	13	156	383	383	26	104	
15	21001108900000	8	9	135	126	44	15	52	7	65	24	46	
16	21008304160483	103	44	1	1	3	17	6	80	17	2	6	
17	21011400400000	183	87	359	195	115	16	59	81	102	16	75	
18	21707699023627	25	11	67	77	8	19	8	126	57	14	60	
19	21203500501906	27	27	134	152	58	20	90	408	408	239	245	
20	21707699022854	16	25	72	72	46	21	31	118	123	68	61	Tot. ave
	average =	77.6	33.9	74.7	73.1	44.0	10.7	34.1	101.5	104.0	34.0	35.9	56.7

MNT4 Survey Results for Cumberland County													
MNT4 RANK	Structure ID Number	B & H RANK	Mod B&H RANK	Buckle RANK	Mod Buckle RANK	Caltrans RANK	Montana RANK	Nevada RANK	SC RANK	Mod SC RANK	Missouri RANK	IDOT RANK	
1	21058101300000	3	1	2	4	10	1	5	86	105	1	1	
2	21008304140000	68	7	5	2	1	2	1	79	16	3	2	
3	21001107600000	96	15	25	35	15	3	11	134	134	10	4	
4	21058101401063	112	28	4	5	18	4	29	87	106	13	7	
5	21001501700863	1	3	8	6	4	5	30	14	71	15	5	
6	21001501700000	122	31	9	8	27	6	39	13	70	8	13	
7	21001107400000	2	2	7	16	5	8	9	133	133	19	17	
8	21008304041288	123	33	6	11	28	7	19	78	38	6	15	
9	21203500500000	5	4	136	154	2	9	2	89	108	4	3	
10	21008104651675	169	99	32	37	139	10	58	50	6	98	8	
11	21008104641546	174	102	33	41	147	11	60	47	5	97	9	
12	21001109800000	4	5	174	212	6	12	3	8	66	7	14	
13	21001500601043	160	70	77	23	90	13	156	383	383	26	104	
14	21001109810485	150	75	207	284	114	14	14	9	67	9	23	
15	21008304160483	103	44	1	1	3	17	6	80	17	2	6	
16	21001108900000	8	9	135	126	44	15	52	7	65	24	46	
17	21011400400000	183	87	359	195	115	16	59	81	102	16	75	
18	21707699023627	25	11	67	77	8	19	8	126	57	14	60	
19	21001107200000	218	115	27	31	123	23	62	131	131	35	66	
20	21008104650367	24	12	97	56	9	22	12	49	26	27	70	Tot. ave
average =		87.5	37.7	70.6	66.2	45.4	10.9	31.8	84.2	85.3	21.7	27.4	51.7

MNT5 Survey Results for Cumberland County													
MNT5 RANK	Structure ID Number	B & H RANK	Mod B&H RANK	Buckle RANK	Mod Buckle RANK	Caltrans RANK	Montana RANK	Nevada RANK	SC RANK	Mod SC RANK	Missouri RANK	IDOT RANK	
1	21058101300000	3	1	2	4	10	1	5	86	105	1	1	
2	21008304140000	68	7	5	2	1	2	1	79	16	3	2	
3	21001107600000	96	15	25	35	15	3	11	134	134	10	4	
4	21058101401063	112	28	4	5	18	4	29	87	106	13	7	
5	21001501700000	122	31	9	8	27	6	39	13	70	8	13	
6	21001501700863	1	3	8	6	4	5	30	14	71	15	5	
7	21008304041288	123	33	6	11	28	7	19	78	38	6	15	
8	21001107400000	2	2	7	16	5	8	9	133	133	19	17	
9	21203500500000	5	4	136	154	2	9	2	89	108	4	3	
10	21008104651675	169	99	32	37	139	10	58	50	6	98	8	
11	21008104641546	174	102	33	41	147	11	60	47	5	97	9	
12	21001500601043	160	70	77	23	90	13	156	383	383	26	104	
13	21001109800000	4	5	174	212	6	12	3	8	66	7	14	
14	21008304160483	103	44	1	1	3	17	6	80	17	2	6	
15	21001109810485	150	75	207	284	114	14	14	9	67	9	23	
16	21001108900000	8	9	135	126	44	15	52	7	65	24	46	
17	21011400400000	183	87	359	195	115	16	59	81	102	16	75	
18	21001107200000	218	115	27	31	123	23	62	131	131	35	66	
19	21101500100878	11	19	231	175	59	18	203	309	309	72	48	
20	21008104540557	15	18	124	65	16	30	27	44	22	31	72	Tot. ave
	average =	86.4	38.4	80.1	71.6	48.3	11.2	42.3	93.1	97.7	24.8	26.9	56.4

MNT6 Survey Results for Cumberland County													
MNT6 RANK	Structure ID Number	B & H RANK	Mod B&H RANK	Buckle RANK	Mod Buckle RANK	Caltrans RANK	Montana RANK	Nevada RANK	SC RANK	Mod SC RANK	Missouri RANK	IDOT RANK	
1	21058101300000	3	1	2	4	10	1	5	86	105	1	1	
2	21008304140000	68	7	5	2	1	2	1	79	16	3	2	
3	21001107600000	96	15	25	35	15	3	11	134	134	10	4	
4	21001501700863	1	3	8	6	4	5	30	14	71	15	5	
5	21058101401063	112	28	4	5	18	4	29	87	106	13	7	
6	21001501700000	122	31	9	8	27	6	39	13	70	8	13	
7	21001107400000	2	2	7	16	5	8	9	133	133	19	17	
8	21008304041288	123	33	6	11	28	7	19	78	38	6	15	
9	21008104651675	169	99	32	37	139	10	58	50	6	98	8	
10	21203500500000	5	4	136	154	2	9	2	89	108	4	3	
11	21008104641546	174	102	33	41	147	11	60	47	5	97	9	
12	21001109800000	4	5	174	212	6	12	3	8	66	7	14	
13	21008304160483	103	44	1	1	3	17	6	80	17	2	6	
14	21001500601043	160	70	77	23	90	13	156	383	383	26	104	
15	21001108900000	8	9	135	126	44	15	52	7	65	24	46	
16	21001109810485	150	75	207	284	114	14	14	9	67	9	23	
17	21011400400000	183	87	359	195	115	16	59	81	102	16	75	
18	21203500501906	27	27	134	152	58	20	90	408	408	239	245	
19	21101500100878	11	19	231	175	59	18	203	309	309	72	48	
20	21707699022854	16	25	72	72	46	21	31	118	123	68	61	Tot. ave
	average =	76.9	34.3	82.9	78.0	46.6	10.6	43.9	110.7	116.6	36.9	35.3	61.1

MNT7 Survey Results for Cumberland County													
MNT7 RANK	Structure ID Number	B & H RANK	Mod B&H RANK	Buckle RANK	Mod Buckle RANK	Caltrans RANK	Montana RANK	Nevada RANK	SC RANK	Mod SC RANK	Missouri RANK	IDOT RANK	
1	21058101300000	3	1	2	4	10	1	5	86	105	1	1	
2	21008304140000	68	7	5	2	1	2	1	79	16	3	2	
3	21001107600000	96	15	25	35	15	3	11	134	134	10	4	
4	21058101401063	112	28	4	5	18	4	29	87	106	13	7	
5	21001501700863	1	3	8	6	4	5	30	14	71	15	5	
6	21001501700000	122	31	9	8	27	6	39	13	70	8	13	
7	21008304041288	123	33	6	11	28	7	19	78	38	6	15	
8	21001107400000	2	2	7	16	5	8	9	133	133	19	17	
9	21008104651675	169	99	32	37	139	10	58	50	6	98	8	
10	21008104641546	174	102	33	41	147	11	60	47	5	97	9	
11	21203500500000	5	4	136	154	2	9	2	89	108	4	3	
12	21001500601043	160	70	77	23	90	13	156	383	383	26	104	
13	21008304160483	103	44	1	1	3	17	6	80	17	2	6	
14	21001109800000	4	5	174	212	6	12	3	8	66	7	14	
15	21001108900000	8	9	135	126	44	15	52	7	65	24	46	
16	21001109810485	150	75	207	284	114	14	14	9	67	9	23	
17	21011400400000	183	87	359	195	115	16	59	81	102	16	75	
18	21101500100878	11	19	231	175	59	18	203	309	309	72	48	
19	21001107200000	218	115	27	31	123	23	62	131	131	35	66	
20	21203500501906	27	27	134	152	58	20	90	408	408	239	245	Tot. ave
average =		87.0	38.8	80.6	75.9	50.4	10.7	45.4	111.3	117.0	35.2	35.6	62.5

PennDOT Survey Results for Cumberland County								
PennDOT RANK	Structure ID Number	MNT1 RANK	MNT2 RANK	MNT3 RANK	MNT4 RANK	MNT5 RANK	MNT6 RANK	MNT7 RANK
1	21008105502205	121	41	52	52	42	47	44
2	21001107600000	3	3	3	3	3	3	3
3	21008105100190	112	45	43	43	51	46	50
4	21058100301760	170	409	479	484	497	484	484
5	21008304041288	7	7	7	8	7	8	7
6	21001108701474	27	68	72	72	64	66	66
7	21008104840101	107	56	54	51	50	55	52
8	21001109800000	14	12	12	12	14	12	14
9	21008104800066	105	50	47	46	46	49	45
10	21101500100878	18	18	26	24	19	19	18
11	21008105140000	117	25	25	28	31	27	32
12	21001501700000	6	5	6	6	5	6	6
13	21008104640250	97	27	27	22	29	26	29
14	21203500500133	312	47	41	42	43	39	41
15	21707699021516	405	55	57	57	47	51	47
16	21008105110135	115	119	117	118	106	112	110
17	21008304140000	2	2	2	2	2	2	2
18	21011400601951	139	48	56	56	45	50	46
19	21001107400000	8	8	8	7	8	7	8
20	21008104850246	109	51	48	47	48	53	48
21	21008104902459	110	59	59	59	58	57	58
	average =	100.2	55.0	59.1	59.0	57.9	58.0	57.6

APPENDIX D

IMPORTANCE METHOD, MNT5, SURVEY

RE: NCEER HIGHWAY PROJECT, DTFH61-92-C-00112
Evaluation of Structure Importance

Dear Sir/Madam:

Modjeski and Masters, Inc. has been working on a seismic research project which is investigating the importance rating for bridges. This project is with the National Center for Earthquake Engineering Research. In prioritization of bridges for seismic retrofits, importance is one factor in the prioritization equation (see attached flowchart from Seismic Retrofitting Manual for Highway Bridges Pub. No. FHWA-RD-94-052, May 1995).

Modjeski and Masters, Inc. reviewed 12 importance equations developed by States and/or individuals. Most of these equations are designed to work with data from bridge management systems(BMS). After analyzing the results of these methods from several test databases, Modjeski and Masters has selected one modified method, MNT5, for further analysis.

We are asking if you and/or several of your employees could review the method we are currently recommending as summarized in the attachments to this letter. If someone else in your organization would be better suited to respond to this letter, please pass it on to them. We have included a diskette with an EXCEL Macro that could be used with your BMS Data. We are interested in how the MNT5 method will work with different databases and your opinions on the methods results. We have enclosed a response form in order for you to provide your comments.

Enclosed is a diskette with an EXCEL file. The file includes the MNT5 Macro and a portion of one of our test databases. This will show an example of how the macro works with BMS data. We have also enclosed instructions on how to setup and use the MNT5 Macro.

If you have any questions, please call me or Mr. Andrew L. Thomas.

We would appreciate it if you could return your response to us by February 28, 1997.

Thank you for your time and consideration on this matter.

Very truly yours,

_____

SCOTT R. ESHENAUR,
Associate

Modjeski and Masters, Inc.

Evaluation of Structure Importance
(Task 112-D-2(B))
(FHWA Contract DTFH61-92-C-00112)

The overall objective of Task 112-D-2 is to identify, assess and develop improvements to existing methodologies for defining structure importance, and to provide recommended definitions of importance and classification systems based on importance.

Modjeski and Masters is currently recommending using a modification of the Montana method, MNT5. From our test data and surveys, we feel it provides the most accurate importance ranking while giving the best distribution of importance. MNT5 considers the following Bridge Management Data:

Route Carried
- Route Type
- ADT
- Average ADT
- Detour
- Bridge Length
- Maximum Bridge Length
- Rail Traffic

Route Crossed
- Route Type
- ADT
- Rail Traffic
- Water Crossing

The MNT5 equation is defined below:

MNT5 Equation:

$$C = [(RT_{carry})(DL_{carry}*N_{carry})] + (2/3)[(RT_{cross})(0.9*N_{cross})] + (1/4)[(ADT_{carry}/\text{Ave ADT})(L)]^{0.25} + RV_{cross}$$

where:
N_{carry} = $(ADT_{carry}/\text{Ave ADT})^{0.25}$ for route being considered
= 1 for bridges carrying railroads
N_{cross} = $(ADT_{cross}/\text{Ave ADT})^{0.25}$ for route being considered
DL_{carry} = Detour Length Coefficient for route on the structure
RV_{cross} = L/L_{max} for river crossings
RT_{carry} = 1.1 for Principal Arterial Routes on the structure
= 1.0 for railroads on the structure
= 0.9 for all other structures

RT_{cross} = 0.9 for Principal Arterial Routes under the structure
= 0.9 for railroads under the structure
= 0.8 for all other structures

The following is instructions on the use of the importance equation currently being recommended by Modjeski and Masters. The various bridge inventory items are being referenced from "Recording and Coding Guide for the Structure Inventory and Appraisal of the Nation's Bridges" dated December 1988. The required inventory items are as follows:

Item 5 - Inventory Route
Item 26 - Functional Classification
Item 29 - Average Daily Traffic
Item 19 - Bypass, Detour Length
Item 49 - Structure Length
Item 42 - Type of Service

Item 5 is required in order to determine if the route is on or under the structure being considered. Items 26, 29 and 42 are required for both routes on and under the structure.

An average ADT, Item 29, for routes on the structure must be determined to be used as the reference value in the calculation of N_r. The maximum bridge length, Item 49, must be determined for the RV_{cross} reference value. The actual values from Items 29 and 49 will be used in the calculation of a structures importance.

The Functional Classification, Item 26, is to be used to determine the RT_{carry} and the RT_{cross} coefficients. For the route on the structure, RT_{carry} shall be used as 1.1 when Item 26 = 1, 2, 11, 12 or 14. Otherwise, RT_{carry} shall be 0.9. For the route under the structure, RT_{cross} shall be 0.9 or 0.8 respectively.

The Detour Length in miles, Item 19, is to be used to determine DL_{carry}. DL_{carry} shall be determined as follows:

Detour length > 98;	DL_{carry} = 1.2
50 < Detour length ≤ 98;	DL_{carry} = 1.0
10 < Detour length ≤ 50;	DL_{carry} = 0.9
3 < Detour length ≤ 10;	DL_{carry} = 0.8
0 < Detour length ≤ 3;	DL_{carry} = 0.7

Item 42, Type of Service, is used to determine several variables including the variables listed above. To describe the use of this Inventory Item, we will use "?" as a wildcard. If Item 42 equals 2? or 4?, the structure carries rail traffic. If Item 42 equals ?2, ?4, ?7, ?8, the structure crosses a railroad. If Item 42 equals ?5, ?6, ?7, ?8, or ?9, the structure crosses water. This information shall be used as follows:

If railroad on structure: N_{carry} = 1.0, DL_{carry} = 1.0, RT_{carry} = 1.0
If railroad under structure: ADT_{cross} = ave. ADT, RT_{cross} = 0.9
If water under structure: RV_{cross} = Structure Length/max. Length

Modjeski and Masters, Inc.

Instructions for EXCEL Macro, MNT5

The diskette included with this survey contains an EXCEL Version 5.0 File. This file includes a copy of the test macro for the proposed Importance Calculation method and a test input file as an example. The test file includes 300 bridges. The test file run should take approximately 2 minutes to run.

These instructions will aid in applying the MNT5 Macro to your Bridge Management System (BMS) database. When possible, we suggest using a sub-set of your entire database as a first trial. A first trial of several hundred bridges instead of several thousand bridges would be much simpler. The first step in applying MNT5 is to setup the input file. The example input file has extra database fields not required by the MNT5 Macro. The data fields being used from the input file are highlighted in red. The National Inventory Items corresponding to the required fields are listed in the previous general information sheets.

All required fields need to be filled in the correct columns for both routes on and under the structure being considered in order for the macro to run properly. Columns between the required fields may be left blank. The method used to import the data fields into EXCEL will depend on the Database Software. EXCEL will accept Dbase, various spreadsheets or text files. The maximum number of rows in EXCEL is 16384, so if there are more records than this 2 runs will be required to calculate importance of all bridges. Also note that if an input file uses all 16384 rows, the macro run could take several hours to run.

Once the input file has been completed, several minor modifications to the macro are needed. These modifications will customize the results to be specific to your database. The modifications are to be made on lines 10, 20, 30, 40 and 50 of the MNT5 Macro. On Line 10 the "j" range must be changed to reflect the maximum number of records for 1 structure in the input record. On Lines 20, 40 and 50 the average ADT must replace the 10402 value. The average ADT should be based for routes on the structures only. Finally, on Line 30 the maximum structure length should replace the 5188 value.

One modification must be made to the equation in the MNT5 sheet. The average ADT value should replace the 10402 value in the equation. A copy of the equation used in the MNT5 sheet is at the bottom of the Macro sheet.

After these modification have been made, the MNT5 Macro is ready to run. After the run is complete, the results can be exported to a database for faster ranking of the results.

If there are any questions, please feel free to call Mr. Andrew L. Thomas at (717) 790-9565.

Evaluation of Structure Importance
RESPONSE FORM

Please Return Form to:
ATTN: Andrew L. Thomas
Modjeski and Masters, Inc.
P.O. BOX 2345
Harrisburg, PA 17105

State: _____ Name (optional): _____

Position: _____ Telephone (optional): _____

May we contact you for additional information? _____

Does your organization presently have an importance ranking system? _____

If yes, please describe it: _____

_____

_____

_____

Database Information:

Number of Bridges: _____

Software: _____ Is software Windows compatible? ____

Maximum Bridge Length: _____

Average ADT: _____

Macro Information:

Do you have Excel Version 5 (or later version)? ___

If yes, did the MNT5 macro run? ___

What, if any, problems occurred setting up the input file? _____

_____

What, if any, problems occurred exporting the results? _____

_____

Results Information:

Were the bridge(s) you expected most important ranked that way? _____

Do you have a current listing of importance ranking of bridges? _____

If yes, Did the MNT5 Equation produce similar results? _____

What, if any, type of bridge (i.e. railroad, interstate, rural) was ranked too high? _____

What, if any, type of bridge (i.e. railroad, interstate, rural) was ranked too low? _____

On a scale of one to ten with ten being the best, your rank of this importance method is _____

Would this importance method meet your needs? ____ Why or why not? ___

_____
_____
_____
_____

Would you consider using this importance method instead of what you are presently using? _____ Why or Why not? _____

_____
_____
_____
_____

Additional Comments: _____

_____
_____
_____
_____
_____

Note: If needed, attach extra sheets for any additional or continued comments.

APPENDIX E
PROPOSED REVISIONS TO DIVISION I-A SECTIONS 3.3 AND 3.4 WITH CUSTOMARY U.S. UNITS

This appendix provides the suggested revision of Division I-A Sections 3.3 and 3.4 in customary U.S. units.

3.3 IMPORTANCE CLASSIFICATION

An Importance Classification (I_C) shall be assigned for all bridges for the purpose of determining the Seismic Performance Category (SPC) in Article 3.4 as follows:

I_C = 1.2 for "critical" bridges: those bridges which are required to remain functional for all traffic after an earthquake of the same magnitude as the design earthquake and provide at least a minimum level of functionality for emergency vehicles or for security/defense purposes immediately after a large earthquake, e.g., 2500 year return period event.

I_C = 1.1 for "essential" bridges: those bridges which are required to provide at least a minimum level of functionality for emergency vehicles or for security/defense purposes after an earthquake of the same magnitude as the design earthquake.

I_C = 1.0 for "other" bridges: all other bridges

The Importance Classification shall include Social/Survival and Security/Defense considerations. If the recommended classification method is used, these requirements shall be considered to be fulfilled. Factors such as socioeconomic or emergency route considerations may also be considered as deemed appropriate by the owner. A methodology for including emergency routes in the determination of structural importance is described in the commentary. Additional owner specified socioeconomic factors can be implemented similar to emergency routes or by the use of additional or modified RT_{carry} and/or RT_{cross} factors. The addition and/or modification of "RT" factors is preferred for socioeconomic factors because it will increase only the importance contribution of the route being considered. The emergency route method given in the commentary increases the contribution of all importance considerations as apposed to only the route being considered i.e., route carried, route crossed, river crossing, etc.

If the owner has a method to classify bridges as "critical", "essential" or "other" bridges, it may be used in lieu of the provisions specified herein. However, if the owner does not have an importance classification system in place, bridges may be classified using the following equation which is based on data from the National Bridge Inventory (NBI) Database:

C = Bridge importance value

$$= [RT_{carry}(DL_{carry}*N_{carry})] + 0.6(RT_{cross}*N_{cross}) + 0.25[(ADT_{carry}/\text{Ave ADT})L]^{0.25} + RV_{cross}$$

where:

"carry" indicates the critical route on the bridge;

"cross" indicates the critical route under the bridge;

RT_{carry} = Factor for nature of route:
= 1.1 for Interstate Route or Principal Artery,
= 0.9 for all other routes and for railroad bridges;

DL_{carry} = Factor representing criticality of detour length:
= 1.2 for Detour Lengths > 98 mi,
= 1.0 for 50 mi < Detour Lengths ≤ 98 mi,
= 0.9 for 10 mi < Detour Lengths ≤ 50 mi,
= 0.8 for 3 mi < Detour Lengths ≤ 10 mi,
= 0.7 for Detour Lengths ≤ 3 mi,
= 1.0 for bridges carrying railroads;

N_{carry} = Factor representing criticality of traffic congestion:
= $(ADT_{carry}/\text{Ave ADT})^{0.25}$,
= 0.8 for bridges carrying railroads;

ADT_{carry} = Average Daily Traffic on the bridge;

L = Bridge length(ft);

RT_{cross} = Factor for nature of route:
= 0.8 for all routes,
= 0.0 for no route under the bridge;

N_{cross} = Factor representing criticality of traffic congestion:
= $(ADT_{cross}/\text{Ave ADT})^{0.25}$;

RV_{cross} = Ratio of bridge length to longest bridge in the database:
= L/L_{max};

Ave ADT = Average ADT_{carry} in the classification database;

L_{max} = Maximum bridge length(ft) in the classification database.

All bridges shall be ranked in order of importance, with the maximum importance value (C_{max}) being the most critical bridge in the classification database. After the bridges are ranked in order of importance, the bridge rank percentile shall be determined. Bridge rank percentile is the percentage of bridges ranked lower than the bridge being considered and can be obtained by using the following equation:

Bridge Rank Percentile = (total number of bridges - current bridge rank)/(total number of bridges)*100

These rank percentiles shall be used to determine the Importance Classifications:

"critical" bridges are those bridges in the 95th percentile or higher,

"essential" bridges are those bridges ranked in or above the 65th but below the 95th percentile,

"other" bridges are those bridges ranked below the 65th percentile.

DIVISION I-A COMMENTARY: C3.3

The importance rankings for the complete database are required for this importance classification method. Once the importance rankings have been developed, they may be used without recalculating them as long as the NBI Records are not revised. The Engineer shall then only be required to calculate the Importance Value, C, for new structures and determine their Importance Classification in the established rankings. For a new structure, an estimated ADT at the time of opening should be used in the calculation of the importance value, not the design ADT which is usually taken as a projected 20-year ADT. A projected ADT would not be comparable to existing structures with an established ADT and therefore skews the results towards all new structures having higher importance rankings.

If a state has confirmed emergency routes, the importance value, C, could be increased by 10% for that route. This is not included in the design specifications in order to allow individual states with specified emergency routes some freedom in adjusting the importance they want to assign to their emergency routes. An example of a modified importance equation would be as follows:

$$C = ER * \{[(RT_{carry})(DL_{carry} * N_{carry})] + 0.6(RT_{cross} * N_{cross}) + 0.25[(ADT_{carry}/\text{Ave ADT})(L)]^{0.25} + RV_{cross}\}$$

where:
ER = 1.1 for confirmed emergency route
1.0 for others

If an owner has a method to rank bridges for seismic importance but does not have a method to assign the "critical", "essential", and "other" classifications, the bridge rank percentiles in the design specification may be used with the existing seismic importance rankings to determine the Importance Classifications.

3.4 SEISMIC PERFORMANCE CATEGORIES

Each bridge shall be assigned to one of four Seismic Performance Categories (SPC), A through D, based on the Acceleration Coefficient, A, and the Importance Classification (I_C), as shown in Table 3.4. Minimum analysis and design requirements are governed by the SPC.

The product of the Acceleration Coefficient, A, and the Importance Classification, I_C is only used to determine the SPC of a structure. The actual Acceleration Coefficient, A, shall be used in all other calculations.

TABLE 3.4 Seismic Performance Category (SPC)

SPC	Range of I_cA
*A	$I_cA \leq 0.09$
B	$0.09 < I_cA \leq 0.19$
C	$0.19 < I_cA \leq 0.29$
**D	$0.29 < I_cA$
* For "critical" bridges ($I_c = 1.2$), $I_cA > 0.09$ ** For "other" bridges ($I_c = 1.0$), $I_cA \leq 0.29$	

DIVISION I-A COMMENTARY: C3.4

The product I_cA has a maximum value of 0.29 for "other" bridges. This maximum value is used to prevent an "other" bridge from being assigned to SPC D. This corresponds to the requirements of the AASHTO Sixteenth Edition of the Standard Specification of Highway Bridges, Division I-A.

The product I_cA has a minimum value of 0.09 for "critical" bridges. This minimum value is used to prevent a "critical" bridge from being assigned to SPC A.

APPENDIX F
PROPOSED REVISIONS TO LRFD SECTIONS 3.10.3 AND C3.10.3 WITH CUSTOMARY U.S UNITS

This appendix provides the suggested revision of LRFD Sections 3.10.3 and C3.10.3 in customary U.S. units. If these articles are adopted, new definitions and references must be added to the notation and reference lists in LRFD Section 3.

3.10.3 Importance Categories

For the purpose of Article 3.10, the Owner shall classify bridges into one of three importance categories taken as:

- critical bridges,
- essential bridges, or
- other bridges.

The basis of classification shall include social/survival and security/defense requirements. Use of Equation 1 shall be considered as satisfying these requirements. Additional socioeconomic or emergency route considerations as deemed appropriate by the owner may be included in establishing Importance Classifications. Additional owner specified socioeconomic factors may also be implemented similar to emergency routes or by the use of additional or modified RT_{carry} and/or RT_{cross} factors. When classifying a bridge, consideration should be given to possible future changes in conditions and requirements.

Other owner approved methods to classify bridges as "critical", "essential" or "other" bridges may be used. Where such owner approved methods do not exist, importance classifications may be determined as specified herein based on data from the National Bridge Inventory (NBI) Records:

C = bridge importance value

C3.10.3

"Essential" bridges are generally those that should, as a minimum, be open to emergency vehicles and for security/defense purposes immediately after the design earthquake, i.e., a 475-year return period event. However, some bridges must remain open to all traffic after the design earthquake and be usable by emergency vehicles and for security/defense purposes immediately after a large earthquake, e.g., a 2,500-year return period event. These should be regarded as "critical" bridges.

The addition and/or modification of "RT" factors is preferred for socioeconomic factors because it will increase only the importance contribution of the route being considered. The emergency route method given below increases the contribution of all importance considerations as apposed to only the route being considered i.e., route carried, route crossed, river crossing, etc.

If a state has confirmed emergency routes, the importance value, C, could be increased by 10% for that route. This is not included in the design specifications in order to allow individual states with specified emergency routes some freedom in adjusting the importance they want to assign to their emergency routes. An example of a modified importance equation is:

C = bridge importance value

$$=[RT_{carry}(DL_{carry}N_{carry})]+0.6(RT_{carry}N_{cross}) +0.25\left[\left(\frac{ADT_{carry}}{AveADT}\right)L\right]^{0.25}+RV_{cross}$$

(3.10.3-1)

where:

"carry" indicates the critical route on the bridge;

"cross" indicates the critical route under the bridge;

RT_{carry} = Factor for nature of route:
= 1.1 for Interstate Route or Principal Artery,
= 0.9 for all other routes including railroads;

DL_{carry} = Factor representing criticality of detour length:
= 1.2 for Detour Lengths > 98 mi,
= 1.0 for 50 mi < Detour Lengths ≤ 98 mi,
= 0.9 for 10 mi < Detour Lengths ≤ 50 mi,
= 0.8 for 3 mi < Detour Lengths ≤ 10 mi,
= 0.7 for Detour Lengths ≤ 3 mi,
= 1.0 for bridges carrying railroads;

N_{carry} = Factor representing criticality of traffic congestion:
= $(ADT_{carry}/\text{Ave ADT})^{0.25}$,
= 0.8 for bridges carrying railroads;

ADT_{carry}= Average Daily Traffic on the bridge;

L = Bridge length(ft);

RT_{cross} = Factor for nature of route:
= 0.8 for all routes,
= 0.0 for no route under the bridge;

N_{cross} = Factor representing criticality of traffic congestion:
= $(ADT_{cross}/\text{Ave ADT})^{0.25}$;

$$=ER[[RT_{carry}(DL_{carry}N_{carry})]+0.6(RT_{carry}N_{cross}) +0.25\left[\left(\frac{ADT_{carry}}{AveADT}\right)L\right]^{0.25}+RV_{cross}]$$

(C3.10.3-1)

where:
ER = 1.1 for confirmed emergency route
1.0 for others

RV_{cross} = Ratio of bridge length to longest bridge in the database:
= L/L_{max};

Ave ADT= Average ADT_{carry} in the classification database;

L_{max} = Maximum bridge length(ft) in the classification database.

All of the bridges shall be ranked in order of importance, with the maximum importance value (C_{max}) being the most critical bridge in the classification database. After the bridges are ranked in order of importance, the bridge rank percentile shall be determined as:

Bridge Rank Percentile =
= (total number of bridges - current bridge rank)/(total number of bridges)*100
(3.10.3-2)

These rank percentiles shall be used to determine the Importance Classifications:

"critical" bridges are those bridges in the 95th percentile or higher,

"essential" bridges are those bridges ranked in or above the 65th but below the 95th percentile,

"other" bridges are those bridges ranked below the 65th percentile.

4.7.4.3.1 Selection of Method (insert before Table 1)

When determining the minimum analysis requirements from Table 1, the bridge importance categories as defined in Article 3.10.3 shall be used.

The importance rankings for the complete database are required for this importance classification method to be used. Once the importance rankings for the complete database have been developed, they may be used without recalculating them as long as the NBI Records are not revised. The Engineer shall then only be required to calculate the Importance Value, C, for new structures and determine their Importance Classification in the established rankings. For a new structure, an estimated ADT at the time of opening should be used in the calculation of the importance value, not the design ADT which is usually taken as a projected 20-year ADT. A projected ADT would not be comparable to existing structures with an established ADT and therefore skews the results towards all new structures having higher importance rankings.

Bridge rank percentile is the percentage of bridges ranked lower than the bridge being considered. If an owner has a method to rank bridges for seismic importance but does not have a method to assign the importance classifications, the bridge rank percentiles may be used with the existing seismic importance rankings to determine the importance classifications.

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