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COMPREHENSIVE RISK ANALYSIS FOR STRUCTURE TYPE SELECTION

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16. Abstract

Optimization of bridge selection and design traditionally has been sought in terms of the finished structure. This study presents a more comprehensive risk-based analysis that includes user costs and accidents during the construction phase. Costs for bridge projects include actual comprehensive costs, both to the funding agency, the Colorado Department of Transportation (CDOT), and to the public at large, including assessments associated with accidents and user delay times during the construction phase.

Bridges were selected to represent a cross section of structure types, ADT (average daily traffic volumes), bridge overall length and CDOT region. A total of 43 bridges were targeted for study, and data were able to be compiled on 20 of these. A questionnaire was developed and sent to CDOT bridge personnel, in order to collect general project information as well as detailed information on construction duration, construction traffic control plans (including detour types and mileposts, time of day scheduling and speed reductions), observed congestion and accidents during construction).

Graphs compare the delay costs and bridge costs for each structure, and the trends by region, ADT, construction duration and bridge type. Accident rates were also compared during construction with those before and after (examining property damage, injuries and fatalities). Statistical factor analysis was used to isolate the key factors describing the differences among the bridges studied.

Structure type and construction duration are the important decision variables with respect to user costs, and these two are related. User cost can be reduced by shortening the construction duration for a particular type of structure, or selecting a type that inherently has shorter construction duration. For those bridges with an ADT value less than 10,000, the user cost was no more than about 10% of the construction cost. Also, for construction durations under 20 months the user cost was no more than 30% of the construction cost. For CDOT, concrete box girder prestressed bridges built with current construction practices exhibited user costs more than twice as large as construction costs.

Implementation: The difficulty in obtaining past data suggests that for projects involving high values of ADT, a policy should be implemented of contemporaneous records of construction traffic control, including congestion and accidents. These records should become a permanent part of the closeout documentation for these projects.

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EXECUTIVE SUMMARY

Optimization of bridge selection and design traditionally has been sought in terms of the finished structure. This study presents a more comprehensive risk-based analysis that includes user costs and accidents during the construction phase. Costs for bridge projects include actual comprehensive costs, both to the funding agency, the Colorado Department of Transportation (CDOT), and to the public at large, including assessments associated with accidents and user delay times during the construction phase. This approach can lead to a total cost optimization for more effective and efficient bridge project designs for the citizens of the State of Colorado.

Bridges were selected to represent a cross section of the following attributes:

- Bridge Type (Categories of Structure Type)
- Bridge Overall Length
- Average Daily Traffic (ADT)
- CDOT Region
- Type of feature underneath the bride crossing

From a total of 163 bridges constructed during the period 2000-2007, the above criteria were used to select a total of 43 candidate bridges targeted for study. Data were able to be compiled on 20 of these. A questionnaire was developed and sent to CDOT bridge personnel, in order to collect general project information as well as detailed information on construction duration, construction traffic control plans (including detour types and mileposts, time of day scheduling and speed reductions), observed congestion and accidents during construction). User costs were computed with a well-established delay cost formula, and actual accident data were obtained.

Graphs compare the delay costs and bridge costs for each structure, and the trends by region, ADT, construction duration and bridge type. Accident rates were also compared during construction with those before and after (examining property damage, injuries and fatalities). All accident data were normalized to an equivalent one-year period. Statistical factor analysis was used to isolate the key factors describing the differences among the bridges studied.

Delay costs were seen to exceed the actual bridge construction cost in about half of the bridges studies, particularly in the CDOT Regions with higher ADT (Regions 1, 2 and 6). Accident rates were essentially unchanged during construction for property damage only accidents and fatality accidents, but there was an almost 20% increase in the number of injury accidents.

Structure type and construction duration are the important decision variables with respect to user costs, and these two are related. User cost can be reduced by shortening the construction duration for a particular type of structure, or selecting a type that inherently has shorter construction duration. For those bridges with an ADT value less than 10,000, the user cost was no more than about 10% of the construction cost. Also, for construction durations under 20 months the user cost was no more than 30% of the construction cost.

For CDOT, concrete box girder prestressed bridges built with current construction practices exhibited user costs more than twice as large as construction costs. In summary, delay costs become significant as a ratio to bridge costs when,

- ADT exceeds 10,000
- Construction duration exceeds 20 months
- Concrete box girder prestressed bridges are built with current construction practices

For implementation, the difficulty in obtaining past data suggests that for projects involving high values of ADT, a policy should be implemented of contemporaneous records of construction traffic control, including congestion and accidents. These records should become a permanent part of the closeout documentation for these projects.

Additional quantitative studies are warranted to confirm the user cost calculations over a wider data base. An automated system of data collection as recommended above will make this possible.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

1.0 INTRODUCTION

1.1 Background for the Study

CDOT Staff Bridge currently has procedures and directives for the evaluation and selection of structure type alternatives during preliminary design phase. Chapter 19, Section 19.1.3 of the Bridge Design Manual outlines the preliminary design process for major structures, and includes an outline of the data to be collected, and the factors to be considered. Typically this includes hard data such as roadway alignment, construction phasing, utilities, right-of-way restrictions, hydraulics, geology, safety, constructability, durability, environmental constraints and aesthetic considerations. Preliminary construction cost estimates for each structure layout and type being considered are prepared in accordance with the CDOT Staff Bridge Memorandum dated April 10, 2000, "Preparation of Preliminary Estimates for All Major Structures." This work currently culminates in a Structure Selection Report which documents the structure evaluation process and provides recommendation to the Department regarding the preferred structure layout and type to be used for the particular project and location.

Historically, little soft data (such as traffic operations, user cost for detours and delays, and safety during construction) are typically included in this evaluation and selection process, and if included, no model or consistent procedure is available to evaluate these issues.

Recent investigations through NCHRP, TRB, etc. have begun to quantify direct and indirect construction costs related to accident risk (both rate and severity) during construction, user delay time to the traveling public during construction (both on the route under construction and on detour routes), and safety of workers during various construction operations. The goal of this project is to consider a comprehensive approach for total cost optimization, utilizing a risk-based decision model. Tradeoffs among structural design optimization, direct construction costs, and indirect construction cost to various stakeholders could then be included and quantified by CDOT as desired.

1.2 Objective of the Study

Optimization of bridge selection and design is generally sought in terms of the finished structure. The objective of this study was to present a more comprehensive risk-based analysis that includes user costs and accidents during the construction phase. The availability in a timely manner of the data from CDOT, both in quantity and quality, affected the extent to which this project was able to enumerate the results.

1.3 Expected Benefits of the Study

Costs for bridge projects will be able to include the actual comprehensive costs, both to CDOT and to the public at large, including probabilistically-based risk assessments associated with accidents and user delay times during the construction phase. Consideration of these costs can lead to more effective and efficient bridge project designs for the citizens of the State of Colorado. Appropriate consideration of the CDOT construction costs and the societal impact costs will allow tradeoffs to be considered. Increased awareness and appreciation of the mission of CDOT can be expected from the residents of the state.

2.0 BRIDGE SELECTION PROCESS

The goal of the project was to select about 40 bridges for detailed study. It was felt that this number would be large enough to be representative if the bridges were selected carefully, yet still be a manageable number.

A master list of major structures constructed during the time period of 2000-2007 was obtained from CDOT, and included 329 structures. Appendix A (Table A1 – Characteristics of Bridges Considered) contains a summary version of the key properties for this study of those 329 structures. The columns are self explanatory, except for Str Type (Structure Type), Serv on (Service on Bridge) and Bridge Type, which are explained in Table A2.

The list was narrowed to major structures built in the years 2000-2003 to account for the availability of accident data during the time of construction and two years on either side of the time of construction, in order to compare safety information with normal operating conditions. This resulted in consideration of 217 major structures of potential interest for this study. Some of these major structures were not bridge structures, so restriction to actual bridges reduced the number to 163 bridges.

A number of key components for the study were identified and taken into consideration to ensure that the selection of case studies would be representative of practices within the state of Colorado. These components were:

- Bridge Type (Categories of Structure Type)
- Bridge Overall Length
- Average Daily Traffic (ADT)
- CDOT Region
- Type of feature underneath the bridge crossing

The feature under the bridge was important in determining whether there was interruption to normal traffic flow underneath the bridge, in addition to that affected on the bridge road itself.

Table A3 in Appendix A (Bridge Characteristics and Percentage Representations) summarizes the distribution of bridges by their characteristics. The subcategories of these key components were computed as percentages of the total number of bridges built during the time period of 2000-2003 in an attempt to assure a representative sample to analyze.

The bridges were considered by Region location (see Map of CDOT Engineering Regions in Appendix A) to assure that each of the six regions within the state of Colorado, as designated by CDOT, was reasonably represented. Table A4 (Distribution of Candidate Bridges by CDOT Region) in Appendix A contains a listing of all 163 candidate bridges by CDOT region.

Using these 163 bridges, a representative distribution was sought for all the characteristics. This resulted in a list of 84 prospective bridges. Examination of all 84 prospective bridges indicated that there was some overlap of characteristics. For example, in one case two bridges were identical in characteristics except that one had a road underneath and the other a river; since the prospective list was overrepresented in bridges with a road underneath, just the one with the river was selected. This resulted in 66 candidate bridges, which are described in Table A5, Candidate and Selected Bridges.

Several of the 66 candidate bridges represented multiple bridges on the same project. Since this duplication would add little information to the manner in which the construction process and traffic disruption was handled, it was decided to limit the number of bridges from the same project file. In this manner, 43 of the 66 candidate bridges were targeted for selection (also shown in Table A5). For a few of these bridges, the key contact individual no longer worked for CDOT and was not readily reachable. This lack of availability was crucial because engineer logs were needed to understand types and dates of the phases of traffic interruption and of accidents during construction. Finally, therefore, based on available contact information, the list of selected bridges was reduced to 37 candidate bridges for which CDOT contacts were available for obtaining data for analysis in the study.

A questionnaire was developed in order to determine general project information and then detailed information on construction duration, construction traffic control plans (including detour types and mileposts, time of day scheduling and speed reductions), observed congestion and accidents during construction. All of this information (except general project) was requested for each different phase of the project. This approach was necessary since the needed “soft” data have not been collected into a single record at CDOT. A sample completed questionnaire is included as Appendix D. These questionnaires were sent to the designated CDOT personnel, and follow-up visits offered for assistance in completion.

3.0 ANALYSIS

3.1 Study Bridges

Of the 37 bridges chosen for consideration, 20 were analyzed. This discrepancy is due to difficulties in obtaining the necessary information for the candidate bridges. Table B1 (Summary Information for Analyzed Bridges) and B3 (Traffic Control Summary for Analyzed Bridges) in Appendix B summarize the characteristics and construction practices for all 20 bridges. For convenience, the Structure Types for the analyzed bridges are reproduced and annotated in Table 1 below.

Table 1. Structure Types for the Analyzed Bridges

Bridge Type	Description
CBG	Concrete Box Girder
CBGC	Concrete Box Girder Continuous
CBGCP	Concrete Box Girder Continuous Prestressed
CBGP	Concrete Box Girder Prestressed
CICK	Concrete on Rolled I-Beam – cont & composite
CPGC	Concrete Prestressed Girder – cont & precast
WG	Welded Girder
WGCK	Welded Girder – cont and composite

Figure 1 below displays the distribution of the 20 bridges within the categories of bridge type, CDOT Region, bridge length and average daily traffic volume (ADT). These classifications were utilized to select the original candidate bridges, and it is clear that the 20 assessed bridges still represent a reasonable cross section of types.

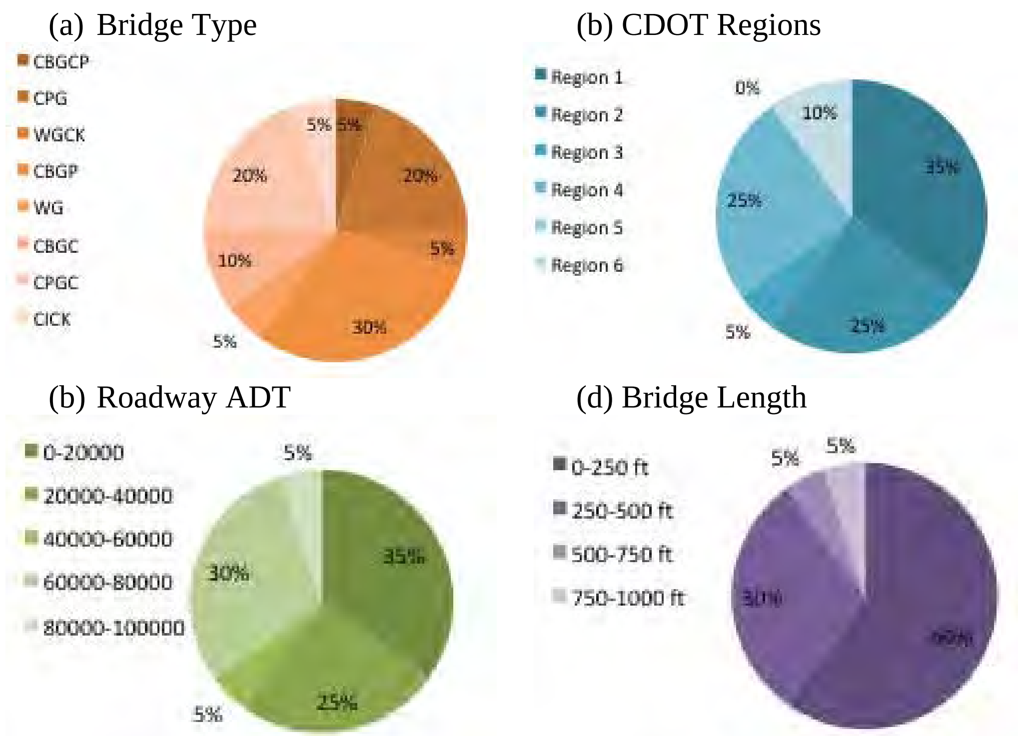


Figure 1. Distribution of study bridges by (a) bridge type, (b) CDOT region, (c) ADT and (d) length

The majority of the bridges examined in this study are short-span variations of prestressed concrete girder bridges: CPG, CPGC, CBGP (Figure 1a and 1d). The main CDOT regions represented are Regions 1, 2, 4 and 6, which encompass all of Eastern Colorado (East of the Continental Divide). Maps C1, C2 and C3 in Appendix C display the locations of the bridges, the bridge type and ADT, respectively. While an attempt was made to have a distribution of average daily traffic volumes (ADT's) across the regions, the limited amount of data restricted this somewhat. For the seven bridges in Region 1, four had ADT's on the order of 20,000 and three were around 70,000. For Region 2, the five bridges consisted of two with ADT values below 10,000 and one each around 40,000, 60,000 and 90,000. There was only one bridge in Region 3, and in Region 4, four bridges had ADT values around 4,000 and one bridge was around 80,000. No bridges were studied in Region 5, and two bridges in Region 6 (ADT values around 24,000 and 79,000).

3.2 Cost Analysis

A goal of this study is to determine if and how bridge type effects user cost in terms of delay time and safety (quantified in terms of injuries and fatalities) during construction. Delay cost is a function of ADT, delay time (t), the duration of the project in days (d), the distribution of freight and cars (V_f and V_v), and the cost per hour of delay for both freight and passenger cars (C_f and C_v, modified to 2010 dollars). The full calculation for delay cost is shown in Equation 1 below (Perrin and Jhaveri 2004).

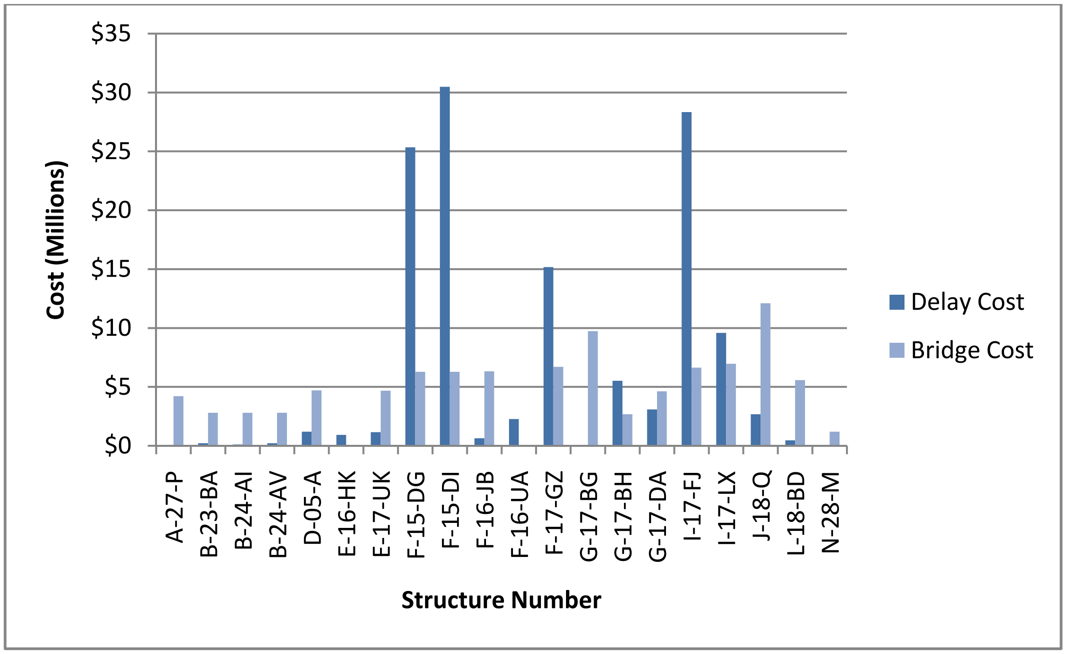
$$C = ADT * t * d * \left(C_v * V_v * F_o + C_f * V_f \right) \qquad \text{Equation (1)}$$

In which:

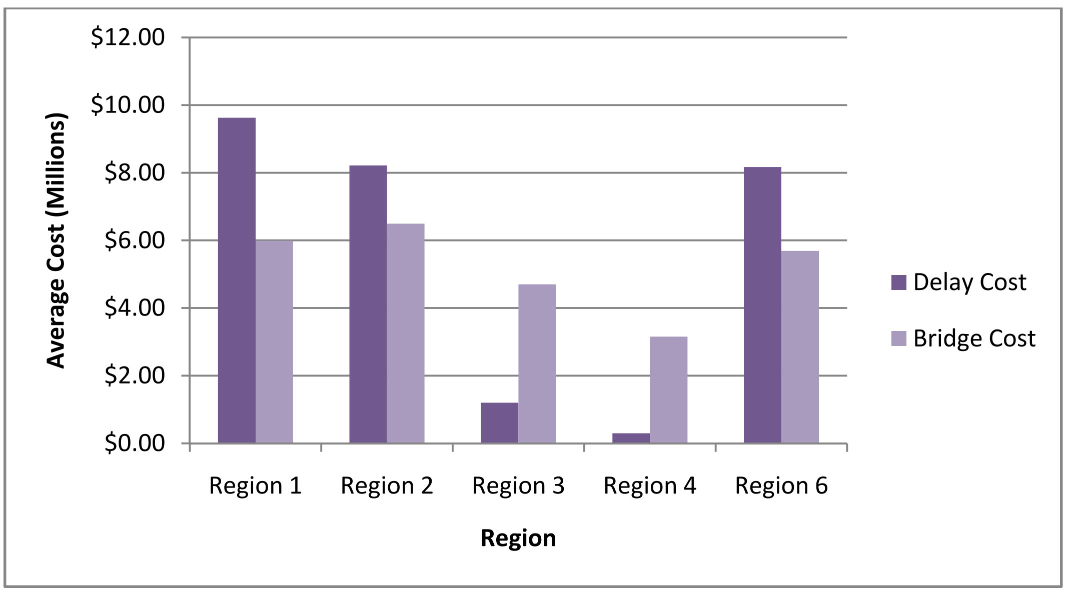
- ADT = average daily traffic volume
- t = delay time
- d = duration of the project in days
- V_f = the fraction of vehicles that are freight (trucks)
- V_v = the fraction of vehicles that are cars
- C_f = cost per hour of delay for freight (trucks)
- C_v = cost per hour of delay for cars
- F_o = vehicle occupancy factor for cars

The cost per hour (modified to 2010 dollars) of delay for freight and vehicles used in analysis are $59.56 and $20.47, respectively (Perrin and Jhaveri 2004). In order to best determine the amount of delay time due to the construction of the study bridges, the length of road affected by each construction was divided by both the original speed limit and the reduced speed limit to obtain the amount of time needed to travel the bridge before and during construction. The difference between these two driving times provides the delay time due to construction. The duration of the construction was determined from the bridge surveys. The values of ADT and percentage of ADT corresponding to freight travel were provided by CDOT. Lastly F_o, the vehicle occupancy factor, i.e., the average number of occupants in a passenger car, was set to 1.2 (Perrin and Jhaveri 2004). The results of these calculations are listed in Table B2 (Bridge Costs and Accident Data) of Appendix B.

User delay cost values, when compared to the corresponding bridge construction costs, provide a valuable tool for future bridge construction decision-making. Bridge construction costs, provided by CDOT, are listed in Appendix Table B2 and are shown graphically below alongside delay cost in Figure 2.

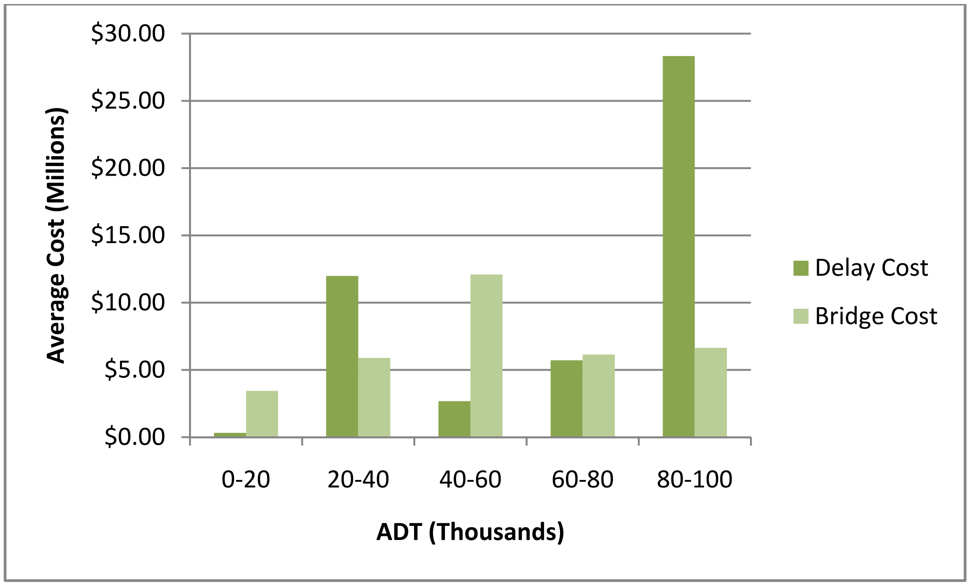
(a)


$35
$30
$25
$20
$15
$10
$5
$0
Cost (Millions)
A-27-P
B-23-BA
B-24-AI
B-24-AV
D-05-A
E-16-HK
E-17-UK
F-15-DG
F-15-DI
F-16-JB
F-16-UA
F-17-GZ
G-17-BG
G-17-BH
G-17-DA
I-17-FJ
I-17-LX
J-18-Q
L-18-BD
N-28-M
Structure Number
Delay Cost
Bridge Cost

(b)


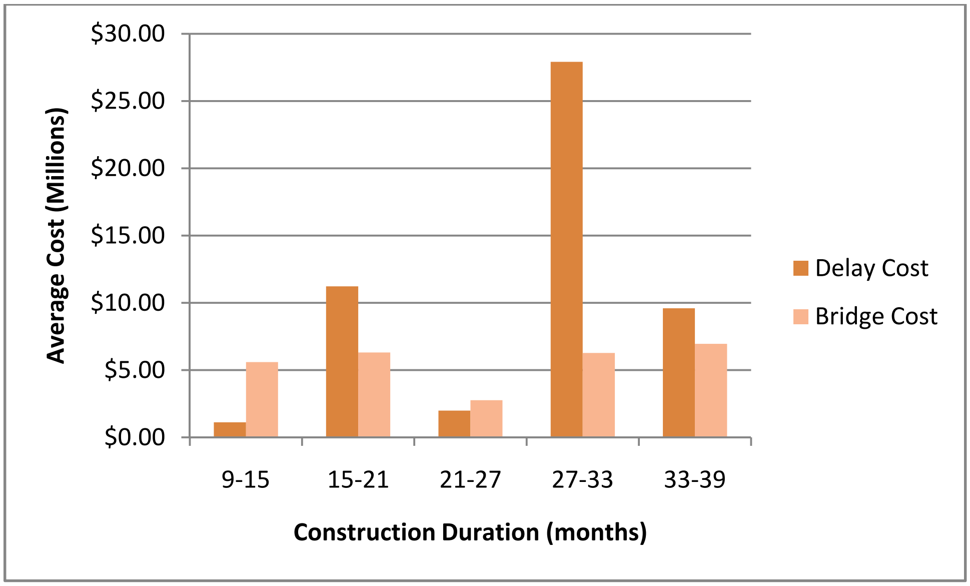
$12.00
$10.00
$8.00
$6.00
$4.00
$2.00
$0.00
Average Cost (Millions)
Region 1
Region 2
Region 3
Region 4
Region 6
Region
Delay Cost
Bridge Cost

(c)



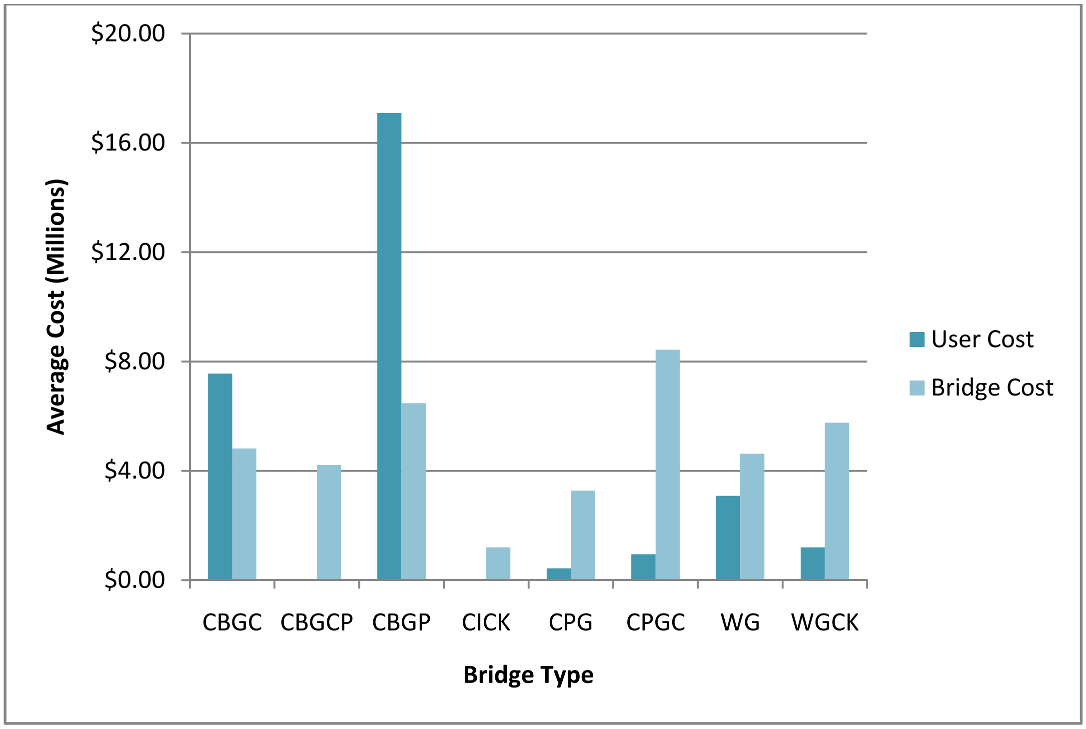
$30.00
$25.00
$20.00
$15.00
$10.00
$5.00
$0.00
Average Cost (Millions)
0-20
20-40
40-60
60-80
80-100
ADT (Thousands)
Delay Cost
Bridge Cost

(d)



$30.00
$25.00
$20.00
$15.00
$10.00
$5.00
$0.00
Average Cost (Millions)
9-15
15-21
21-27
27-33
33-39
Construction Duration (months)
Delay Cost
Bridge Cost

(e)



(f)

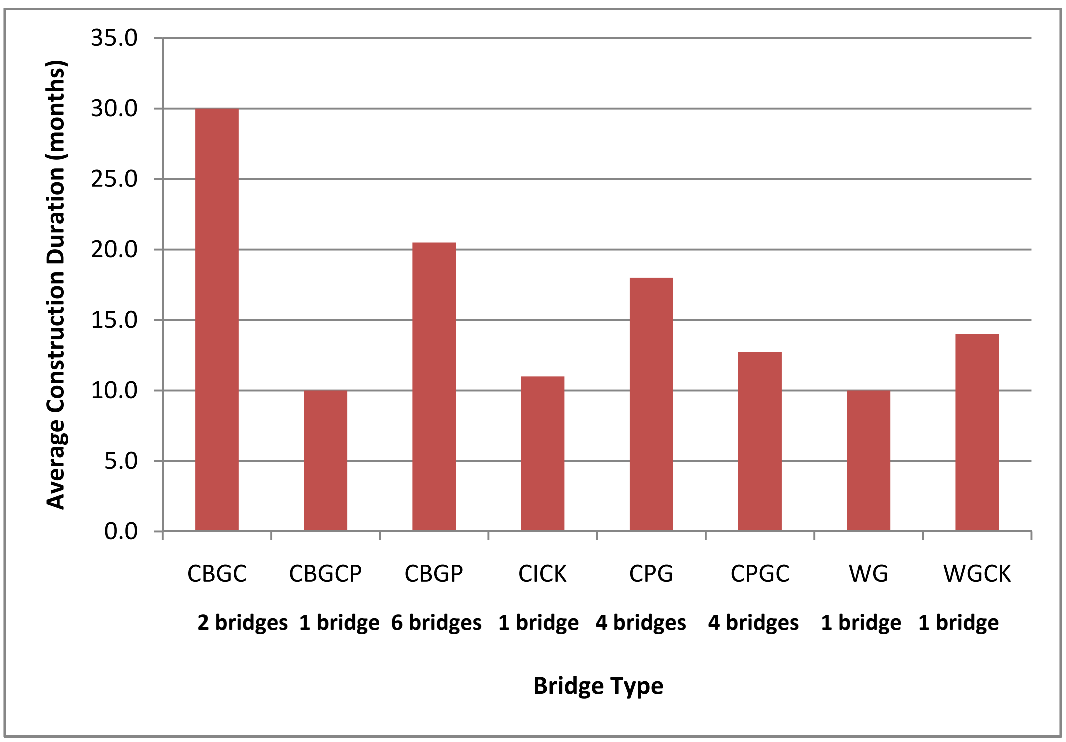


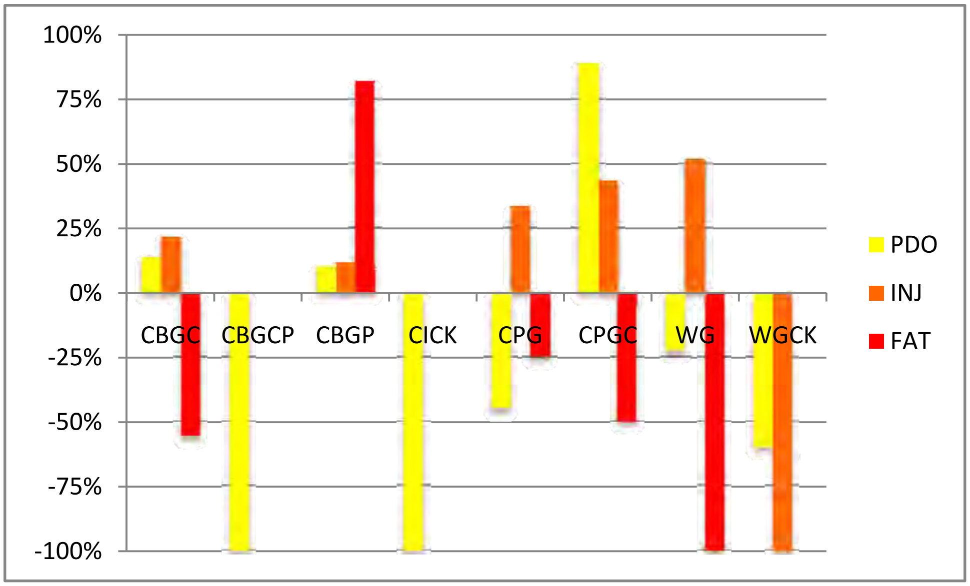
Figure 2. Distribution of bridge construction and user delay cost in millions of dollars by (a) each bridge, (b) CDOT Region, (c) ADT, (d) construction duration, (e) bridge type, and (f) average construction duration in months by bridge type.

It is evident from Figure 2 that user delay cost accounts for a significant amount of cost, typically on the same order as the total bridge construction cost. The exception is for those regions in which bridges that were analyzed had low ADT's or construction duration (see Figures 2c and d). For instance, the bridge in Region 3 had an ADT of 2300, and four of the five bridges analyzed in Region 4 had an ADT of 4200 or less (see Table B1 for more details). The structure types with the greatest delay cost, as compared to construction cost, are CBGP and CBGC, with delay to bridge cost ratios of 2.64 and 1.57, respectively (Figure 2e). The structure CBGP also had the largest overall user delay cost of 17 million dollars. Since delay cost is calculated based on construction duration and speed limit reduction, a combination of these factors are likely responsible for the large user cost values. Figure 2f displays construction durations (obtained from the questionnaires as the time between "Date construction began" until "Date of substantial completion") for each of the study structure types. Additionally, from Figure 2b, it is evident that Regions 1, 2, and 6 have large user delay costs. This is significant, since these regions represent many of the larger population centers in Colorado, including Denver, Colorado Springs, and surrounding suburbs. Figures C4 and C5 in Appendix C map both user delay cost and the ratio of delay cost to bridge cost for each bridge.

In addition to the user cost attributed to an increase in travel time during bridge construction, the cost of injuries and fatalities must also be taken into account. While studies quantify a human life in terms of monetary values, here the change in property damage only (PDO), injuries (INJ) and fatalities (FAT) quantities during construction dates are contrasted to those from the comparison dates, comprised of two years before and after construction. The data are actual accident data supplied by CDOT. The percentage difference of accident data as defined in terms of the comparison dates is listed in Table B2 in Appendix B, with distributions shown below in Figure 3.

These comparisons were made by noting the actual number of each type of accident during construction, and then normalizing that to an equivalent one-year period. Then the comparison four years (two years before construction and two years after construction) were also normalized to an annual figure.

On average, property damage decreased slightly by 0.9%, while injuries increased 18.7% and fatalities decreased by 1% (Appendix B).

(a)


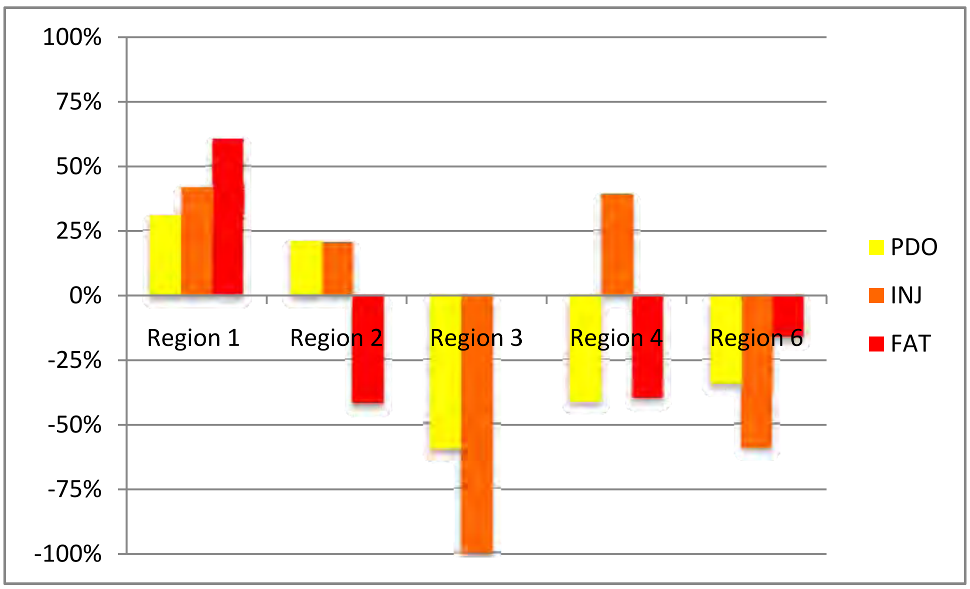
(b)


Figure 3. Percentage difference distributions by (a) bridge type and (b) CDOT region

A breakdown of percentage differences of damages by bridge type and CDOT regions are shown in Figure 3. These results are logical because in construction zones the number of property damage only (PDO) accidents and injuries (INJ) would be expected to increase due to congestion associated with reduced speed limits and lane closures. The rate of fatalities would not be expected to rise, due to the slower speed compared to normal road conditions. Figure 3a displays an increase in all accident categories for structure type CBGP, which also demonstrated a large delay cost to bridge construction ratio and overall largest delay cost value. The structures CBGC, CPG, CPGC, and WG all experienced a significant increase in injuries.

3.3 Factor Analysis

Factor analysis is a statistical technique used to isolate a reduced number of factors, which can account for the variability of a larger number of variables (Kline 1994). In this study, the statistical software SPSS was used to perform principal components analysis, a popular form of factor analysis in which the total variance is analyzed and the resultant orthogonal factor axes are rotated (varimax rotation) in order to make the factors more understandable in relation to the original variables. The goal is to unearth an underlying set of factors that explains most of the variation in a set of data. If this can be done, the original variables can be replaced by a smaller and more meaningful set of basic factors. Since these factors are a statistical artifact, their interpretation must come by looking at the correlation (so-called factor loadings) of the original variables on each of the factors. If successful, the result identifies a nearly unique set of variables for each factor.

Since the aim of this study is to determine how structure type affects user cost, four variables were used for factor analysis. These variables were structure type, construction duration, ADT, and delay cost. The Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy was used to assess the quality of data input into factor analysis. Ideally, the KMO sampling value is equal to one; for this analysis the value is 0.58. Typically values greater than 0.5 are preferable as indicators of adequate sampling. The KMO value of 0.58 is within this tolerance, and is likely to improve with the addition of more sampling points (bridges). With the number of bridges available at this time, the number of variables was limited to four in order to obtain a satisfactory KMO measure.

Figure 4 outlines the extraction of two factors from the four original input variables. With four factors, i.e., the four original variables, 100% of the original variance is accounted. The two extracted factors still encompass a significant amount of variance, 72%. These results indicate that most of the variability in the data can be explained by just two factors.

Factor	Initial Eigenvalues			Extraction Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	1.990	49.742	49.742	1.990	49.742	49.742
2	.894	22.358	72.100	.894	22.358	72.100
3	.737	18.417	90.517			
4	.379	9.483	100.000			

Factor	Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %
1	1.552	38.795	38.795
2	1.332	33.304	72.100
3			
4			

Figure 4. Total variance explained by principal components (principal factors) analysis

In order to determine the underlying significance of these two extracted factors, a graph of the rotated factor scores is shown in Figure 5. These scores indicate the loading of each variable on each factor. From the graph, it is clear that delay cost and construction duration both have very high loadings on factor 1, and very low on factor 2. Similarly, structure type and ADT have high loadings on factor 2, and low on factor 1. Therefore, the two important factors can be fairly uniquely related to the original four variables, and results can be implied from two meaningful factors. One factor is related to the duration of construction and resultant delay cost. Since the latter is dependent on the former, one is led to the conclusion that construction duration is a key variable. The other factor is highly dependent on structure type and ADT. The conclusion is that certain structure types and levels of ADT are leading to projects that need special consideration.

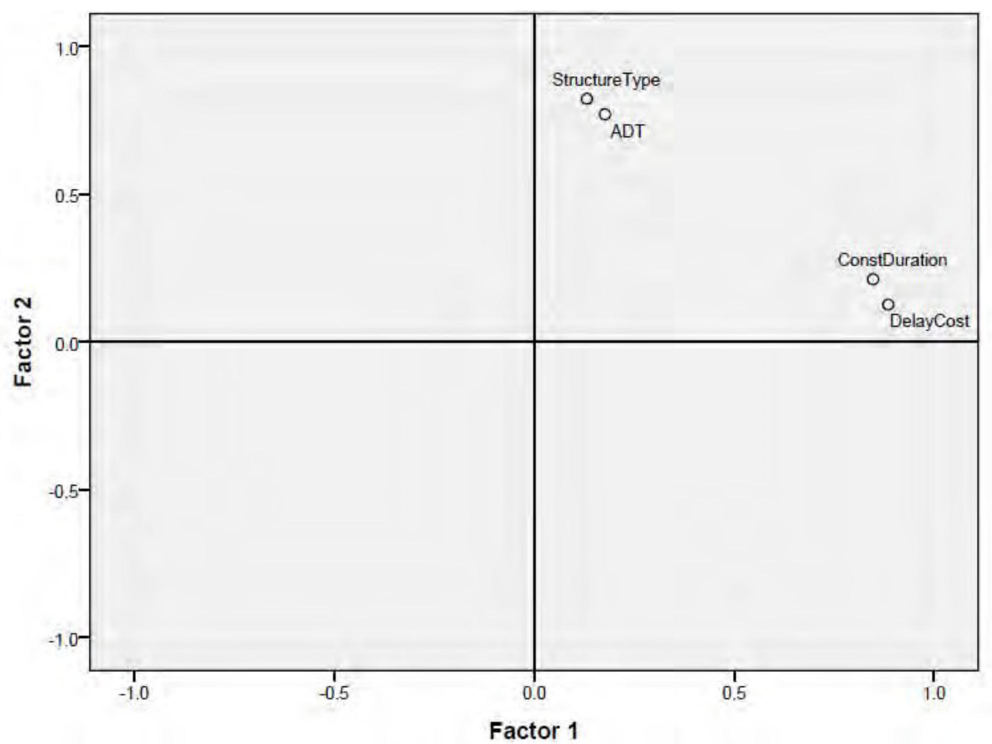


Figure 5. Rotated factor plot

The implication of this analysis is that two factors explain three-quarters of the variability among the data. The first factor is only slightly more dominant than the second, and it is heavily related to construction duration and delay cost. Thus project duration should be strongly considered in bridge construction planning. As anticipated, project duration is a major determinant of delay cost, influenced of course by structure type. Figure 2f on page 10 displays the distribution of average project duration in months by structure type. Structure type CBGC required the greatest amount of time for project completion (Fig. 2f). The second factor is almost as important as the first, and it is heavily influenced by structure type, and somewhat by ADT. However, structure type can ultimately affect the duration of a project, and therefore bridge selection should be carefully considered. Additionally, ADT has a direct influence on delay cost, since the number of vehicles on the road directly influence the delay cost of a bridge project.

4.0 CONCLUSIONS

From Table B2 and Figure 2 there are several conclusions and guidelines that suggest themselves, although with the caveat that more data will be needed before these can be considered final.

The two factors that explain most of the variability among the data are highly related to construction duration and delay cost (factor 1) and structure type and ADT (factor 2). Delay cost is a derived quantity, and ADT is not dependent on bridge type. It is clear then that structure type and construction duration are important decision quantities to consider, and these are related. These affect delay cost through the ADT. The most important decision variable for user cost is the duration of construction. In order to reduce user cost, the construction duration can be shortened for a particular type of structure, which involves scheduling and cost implications. Alternatively, the structure type with short construction duration can be selected, thus reducing user cost without altering the construction process.

One clear trend is the relationship between average daily traffic volume (ADT) and the ratio of delay cost to bridge cost (see table B2 and Figure 2c). For instance, with one exception, all bridges in the study with ADT values below 10,000 had cost ratios (delay cost divided by bridge cost) under 10%. The one exception was a welded girder bridge that had single lane traffic diversion with a four mile stretch of roadway affected. Unfortunately, there were no bridges in the study that had ADT values between 7200 and 20,000, so the division of 10,000 is a conservative estimate that could possibly be increased after verification with more studies.

Another observation is that only bridges with construction durations exceeding 20 months had cost ratios of 30% or greater, again with one exception: a welded girder bridge in Region 1 that had an ADT value of more than 65,000. It may be worth noting that the exceptions for higher delay costs in this and the preceding paragraph were both welded girder bridges.

Those studied bridges with cost ratios greater than 220% were all concrete box girder prestressed structures (CBGP). As a matter of note, of the six CBGP bridges in the study, four had cost ratios greater than 2.2 (with three of those above 4.0). The remaining two CBGP bridges in the study were missing data on bridge costs, so no cost ratio could be computed.

In Summary, delay costs become significant as a ratio to bridge costs when:

- ADT exceeds 10,000
- Construction duration exceeds 20 months
- Concrete box girder prestressed bridges are built with current construction practices

5.0 RECOMMENDATIONS

The limited number of bridges available for study indicated a significant delay cost to bridge cost ratio for longer construction durations, associated with certain structural materials. Nevertheless, more quantitative studies should be performed if an automated procedure is desired to identify candidate bridges for user cost studies before final material for bridge construction is selected. The number of bridges studied prevented the inclusion of a larger number of variables in the factor analysis.

For projects involving high values of ADT, CDOT should adopt a policy of contemporaneous records of construction traffic control, including congestion and accidents. From the questionnaire that was developed, the key information should be distilled to allow determination of key aspects related to user costs. These records should become a permanent part of the closeout documentation for these projects. Such data will be essential for CDOT to move in the direction of evaluating the effect of construction operations on the public. By requiring such a Project Closeout Form on projects with high values of ADT, CDOT personnel on those projects will understand the importance of such data to the public.

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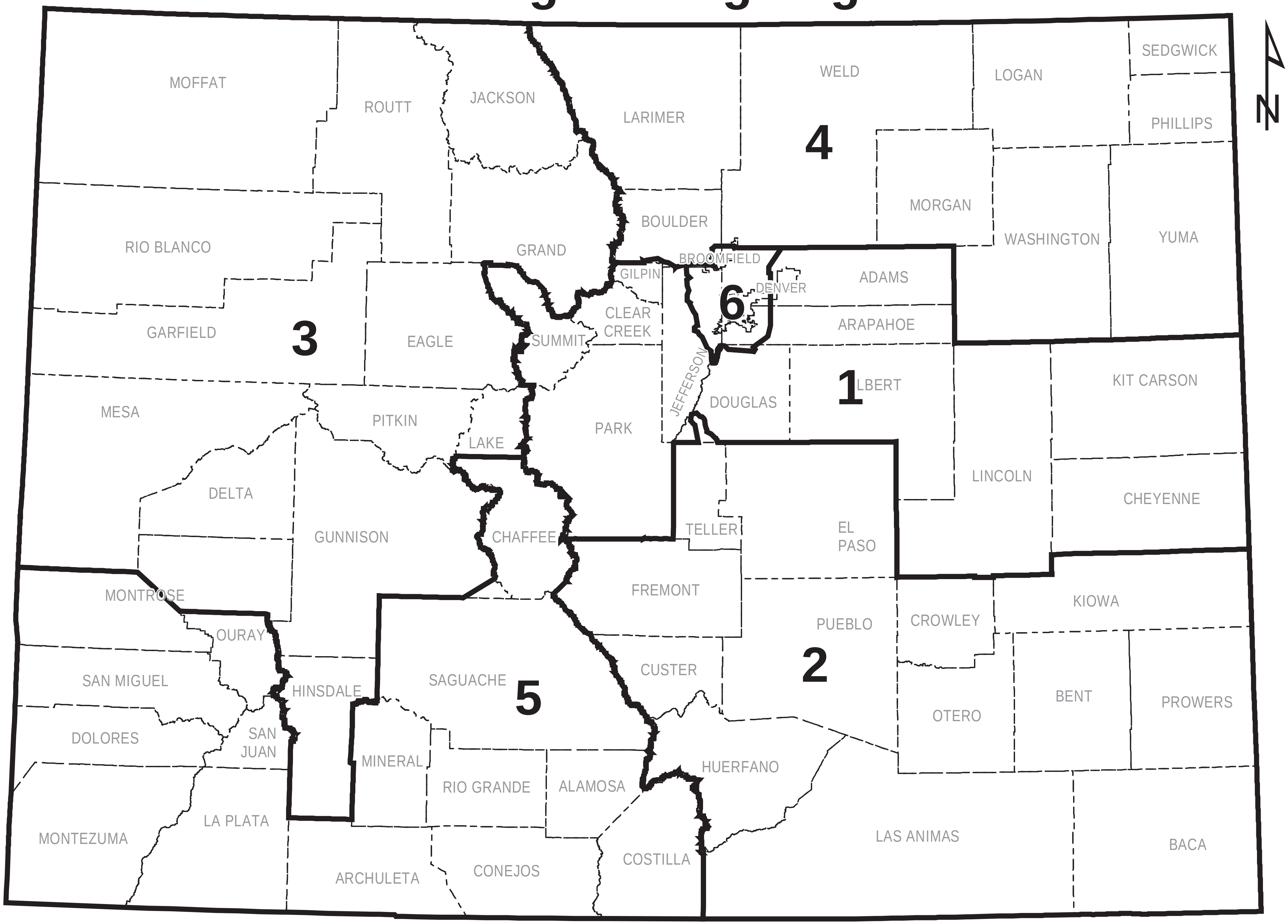

Data Source: CDOT 2008

Published: June 2008

Table A1 - Characteristics of Bridges Considered

Structure Number	Year Built	Str Type	ADT	Truck %	Serv On	Lanes On	Length (ft)	Maxspan (ft)	Detour (mile)	Re-gion	Feature Intersected	Bridge Type
A-27-P	2000	6	1500	10	1	2	264.0	104.0	4	4	UP RR	CBGCP
A-28-Z	2001	1	670	21	1	2	32.0	16.4	4	4	SAND CREEK	CBC
B-16-P MINOR	2000	1	42300	3	1	7	12.0	12.0	1	4	PEDESTRIAN UNDERPASS	CBC
B-17-DD	2005	5	3100	16	1	2	87.0	42.3	1	4	SPRING CREEK	CPG
B-23-AW	2005	5	3000	6	1	4	216.9	107.0	1	4	PAWNEE CREEK	CBGP
B-23-BA	2003	5	4200	30	1	2	113.0	110.0	1	4	SH 63 ML	CPG
B-23-BB	2003	5	4200	30	1	2	114.0	110.0	1	4	SH 63 ML	CPG
B-24-AD	2003	5	4200	30	1	2	88.0	85.3	1	4	COUNTY ROAD 14	CPG
B-24-AI	2002	1	4200	30	1	2	88.0	86.0	1	4	COUNTY ROAD 14	CPG
B-24-AU	2003	5	4200	30	1	2	88.0	85.3	1	4	FARM ROAD	CPG
B-24-AV	2003	5	4200	30	1	2	88.0	86.0	1	4	FARM ROAD	CPG
B-24-AW	2003	5	4200	30	1	2	88.0	86.0	1	4	FARM ROAD	CPG
B-24-AX	2003	5	4200	25	1	2	88.0	85.3	0	4	FARM ROAD	CPG
B-24-AY	2003	5	4200	30	1	2	88.0	86.0	1	4	FARM ROAD	CPG
B-24-AZ	2003	5	4200	30	1	2	88.0	85.3	1	4	FARM ROAD	CPG
B-27-J	2004	6	1500	23	1	2	169.1	83.0	4	4	N.FK.FRENCHMAN CREEK	CPGC
B-28-C	2005	1	2200	15	1	2	24.6	11.5	2	4	DRAW	CBC
C-09-AC	2001	1	3900	3	1	2	22.0	10.6	1	3	MCKINNIS CREEK	CBC
C-10-D	2000	1	2200	12	1	2	22.1	22.1	99	3	DIAMOND CREEK	CBC
C-11-J	2005	1	750	15	1	2	58.0	0.0	99	3	GRIZZLY CREEK	CBC
C-14-A MINOR	2000	1	16600	2	1	5	16.2	16.2	12	4	PEDESTRIAN UNDERPASS	PCBC
C-14-C MINOR	2002	1	6700	3	1	2	12.0	12.0	3	4	Ped. Underpass	CBC
C-15-F	2003	1	5100	3	1	2	33.0	15.0	24	4	DICKSON GULCH	CBC
C-15-O	2002	6	5100	3	1	2	136.0	62.3	3	4	Big Thompson River	CBGP
C-15-U	2003	1	5100	3	5	2	129.0	124.6	3	4	BIG THOMPSON RIVER	CSGP
C-15-Y	2003	6	5100	3	5	2	145.0	68.7	24	4	N FK BIG THOMPSON RIVER	CBGC
C-16-B MINOR	2002	1	17100	6	1	4	16.0	16.0	1	4	PEDESTRIAN UNDERPASS	CBC
C-16-BC	2005	6	15800	3	1	4	164.0	81.0	3	4	DRY CREEK	CPGC
C-16-BH	2003	1	19200	4	5	4	45.0	39.4	1	4	GREELEY-LOVELAND CANAL	CS
C-16-BI	2002	1	11200	5	5	2	45.0	42.0	1	4	GREELEY-LOVELAND CANAL	CS
C-16-BX	2004	5	11300	3	5	4	196.0	97.0	3	4	US 287 ML	CPG
C-16-CF	2005	6	11200	3	1	5	204.9	93.0	3	4	BURLINGTON RR	CPGC
C-16-CK	2005	6	11200	3	1	4	120.0	117.0	2	4	FIRST STREET	CPG
C-16-DA	2005	5	8800	5	1	2	149.0	72.0	3	4	BIG THOMPSON RIVER	CBGP
C-16-DD	2005	5	8600	6	1	2	218.9	72.5	6	4	BIG THOMPSON RIVER	CBGP

Selected bridges are highlighted in blue.

Table A1 - Characteristics of Bridges Considered

Structure Number	Year Built	Str Type	ADT	Truck %	Serv On	Lanes On	Length (ft)	Maxspan (ft)	Detour (mile)	Re-gion	Feature Intersected	Bridge Type
C-16-I	2005	1	14400	5	1	4	20.0	20.0	2	4	LAKE DITCH	CBC
C-17-BD	2003	1	6000	7	1	2	47.0	47.0	2	4	GREELEY CANAL NO 2	CSP
C-19-AK	2000	5	4100	22	1	2	128.0	124.0	1	4	BIJOU CANAL	CPG
C-20-AA	2001	1	330	9	1	2	28.0	28.0	1	4	BIJOU CANAL	CBC
C-20-Q	2001	6	330	9	1	2	497.0	124.0	14	4	SOUTH PLATTE RIVER	CPG
C-21-BN	2005	5	7600	23	1	2	129.0	129.0	1	4	COUNTY ROAD	CPG
C-21-BO	2005	5	7600	23	1	2	129.0	129.0	1	4	COUNTY ROAD	CPG
C-22-BU	2005	5	18000	20	1	4	131.0	129.0	10	4	COUNTY ROAD	CPG
C-22-BV	2005	1	18000	20	1	4	131.0	129.0	10	4	COUNTY ROAD	CPG
D-02-I	2000	1	1600	9	1	2	21.0	10.0	99	3	DRAW	CBC
D-04-R	2006	1	722	25	1	2	33.0	16.0	38	3	BLACKS GULCH	CBC
D-05-A	2000	4	2300	18	1	2	271.9	134.0	62	3	WHITE RIVER	WGCK
D-11-A	2004	6	2300	12	1	2	259.9	110.0	84	3	UP RR	CBGCP
D-11-J	2004	6	3000	11	1	2	328.9	152.0	12	3	COLORADO RIVER	CPGC
D-12-Z	2002	1	2300	12	1	2	21.6	10.3	62	3	Corral Creek	CBC
D-13-A MINOR	2004	1	9000	5	1	3	12.7	12.7	1	3	TRAIL	CBC
D-13-V	2007	1	4500	7	1	2	28.0	14.0	1	3	STILLWATER CREEK	CBC
D-15-BC	2004	6	29200	4	5	4	205.9	132.0	1	4	BOULDER CREEK	CSGCP
D-15-I	2000	6	14900	4	1	3	121.0	58.3	7	4	ST VRAIN CREEK	CBGC
D-16-DV	2003	6	17950	5	1	3	174.1	85.6	1	4	LEFT HAND CREEK	CBGC
D-16-DW	2003	6	17950	5	1	2	174.1	85.5	1	4	LEFTHAND CREEK	CBGC
D-16-DX	2003	6	17950	5	1	2	290.2	143.5	1	4	ST VRAIN RIVER	CBGC
D-16-DY	2003	6	17950	5	1	2	290.2	143.5	1	4	ST. VRAIN RIVER	CBGC
D-16-Q MINOR	2004	1	8800	6	1	3	14.0	14.0	2	4	PEDESTRIAN UNDERPASS	CBC
D-17-CR	2004	5	38400	11	1	4	129.0	125.0	2	4	COUNTY ROAD	CBGP
D-17-CT	2004	5	38400	11	1	4	14.0	14.0	2	4	COUNTY ROAD	CBGP
D-17-DM	2004	5	39850	11	1	3	127.0	124.0	1	4	COUNTY ROAD 6	CBGP
D-17-DN	2004	5	39850	11	1	3	127.0	124.0	1	4	COUNTY ROAD 6	CBGP
D-17-DQ	2004	1	76800	11	1	4	59.0	23.0	6	4	DRAW	CBC
D-17-DR	2000	1	44000	14	1	1	30.5	8.5	4	4	CHANNEL MD-B	CBC
D-17-DS	2000	1	675	11	1	2	31.0	9.8	4	4	CHANNEL MD-B SR	CBC
D-17-DT	2000	1	675	11	1	2	26.0	6.6	4	4	CHANNEL MD-B SR	CBC
D-17-DU	2000	1	67500	11	1	8	22.0	22.0	4	4	LOWER BOULDER DITCH	CBC
D-17-DY	2004	1	79700	11	1	6	328.9	196.0	3	4	I 25 ML	CBGP
D-17-EF	2003	1	79700	11	1	8	13.0	13.0	1	4	BULL CANAL	CBC

Selected bridges are highlighted in blue.

Table A1 - Characteristics of Bridges Considered

Structure Number	Year Built	Str Type	ADT	Truck %	Serv On	Lanes On	Length (ft)	Maxspan (ft)	Detour (mile)	Re-gion	Feature Intersected	Bridge Type
D-17-EG	2004	1	76800	11	1	6	509.9	10.0	1	4	DRAW	CBC
D-18-BR	2000	6	4700	18	6	3	183.0	88.6	7	4	I 76 ML	CPGC
D-18-BS	2000	6	8250	19	1	3	230.8	75.4	1	4	BOX ELDER CRK FRM ACC. R	CPGC
D-18-BT	2000	6	8250	19	1	3	231.0	75.4	1	4	BOX ELDER CRK FRM. ACCES	CPGC
D-18-BU	2000	6	8250	19	6	2	159.0	72.2	0	4	COUNTY ROAD 49	CPGC
D-18-BV	2000	6	8250	19	6	2	160.0	72.2	0	4	COUNTY ROAD 49	CPGC
D-18-BW	2000	6	165	19	1	2	230.0	75.4	6	4	BOX ELDER CREEK SR	CPGC
D-20-K	2005	5	4100	22	1	2	344.9	85.0	5	4	KIOWA CREEK	CPG
D-23-C	2000	1	2200	23	1	2	44.0	13.7	27	4	CAMP CREEK	CBC
E-12-I	2002	5	3400	11	1	2	134.7	131.7	61	1	BLUE RIVER	CPG
E-13-Y	2004	1	16400	6	1	2	23.0	23.0	1	3	PEDESTRIAN UNDERPASS	CBC
E-14-AC	2005	3	550	7	1	3	24.0	24.0	4	1	GAME CROSSING	SAC
E-14-BH	2000	5	71	7	1	2	79.6	76.0	4	1	W FORK CLEAR CREEK SR	CBGP
E-16-HK	2001	5	78600	4	1	4	56.7	53.0	2	4	RAMP B & BIKEPATH	CBGP
E-16-KY	2001	5	86200	3	5	4	313.8	161.0	0	6	US 36 ML	CPGC
E-16-L MINOR	2000	1	79700	4	1	8	16.0	16.0	2	4	RTD PED. UNDERPASS	CBC
E-16-NK	2000	1	13800	6	1	6	20.7	20.7	10	6	CROKE CANAL	CBC
E-16-PX	2002	6	44500	2	6	6	344.3	170.6	1	6	US 36 ML	CPGC
E-16-RB	2001	5	1E+05	4	6	7	198.4	97.9	1	6	PECOS STREET	CBGC
E-16-WC	2001	1	39000	5	5	6	22.0	22.0	3	6	LITTLE DRY CREEK TRAIL	CBC
E-16-WD	2003	6	44100	5	6	8	246.4	121.0	10	6	US 287 ML	CPGC
E-16-WE	2003	1	44100	5	6	8	246.9	121.0	10	6	WBND US 287 ML	CPGC
E-16-WG	2006	3	75900	3	3	6	233.9	233.9	1	4	U 36 ML	SA
E-16-WW	2006	5	82900	3	1	6	60.1	57.0	1	6	Promenade Dr.	CPG
E-17-ABI	2005	6	32400	5	6	4	200.9	102.0	3	6	I-270	CPGC
E-17-ABJ	2003	4	83100	15	1	10	805.4	220.8	1	6	NWP	SDGC
E-17-ABU	2006	5	83100	15	5	6	267.9	134.0	1	6	I25 ML	CPGC
E-17-AC MINOR	2003	1	26400	26	1	4	13.9	13.9	4	6	FARM UNDERPASS	CBC
E-17-QB	2003	5	41600	17	1	3	149.0	146.0	1	6	RAMP TO I76 WB R	CBGP
E-17-QC	2003	5	41600	17	1	3	146.0	146.0	1	6	RAMP TO WB I76 R	CBGP
E-17-QD	2003	5	41600	17	1	3	159.0	156.0	1	6	RAMP TO I76 WBND	CBGP
E-17-QF	2000	6	41600	17	1	1	247.9	108.0	1	6	OVER YORK STREET	CPGC
E-17-QG	2003	6	41600	17	1	1	160.0	85.0	1	6	YORK ST. R	CPGC
E-17-QH	2003	1	72800	15	1	5	172.0	170.0	1	6	WASHINGTON STREET	CBGP
E-17-QP	2003	6	28600	15	1	2	829.0	160.7	2	6	I76 RAMP,SH224,CLEAR CRK	CPGC

Selected bridges are highlighted in blue.

Table A1 - Characteristics of Bridges Considered

Structure Number	Year Built	Str Type	ADT	Truck %	Serv On	Lanes On	Length (ft)	Maxspan (ft)	Detour (mile)	Re-gion	Feature Intersected	Bridge Type
E-17-QS	2003	4	72800	15	6	3	331.9	180.0	1	6	SH 270 ML	WGCK
E-17-QT	2003	4	20800	17	6	4	331.9	180.0	1	6	I 270 ML	WGCK
E-17-UG	2002	6	27000	21	5	4	990.0	145.0	1	6	I76 ML	CPGC
E-17-UK	2003	5	24300	21	1	6	84.0	82.0	5	6	SECOND CREEK	CPG
E-17-UM	2002	6	12750	21	1	2	220.9	72.0	1	6	THIRD CREEK	CPGC
E-17-UP	2001	6	77100	10	6	4	630.0	170.6	1	6	WASHINGTON ST/S PLATTE R	CPGC
E-17-UQ	2001	6	4900	10	1	1	301.0	148.0	1	6	SOUTH PLATTE RIVER R	CPGC
E-17-UR	2003	6	69800	10	1	5	1875.0	188.3	5	6	BNSF RR/CITY STREETS	CPGC
E-17-UU	2003	6	69800	10	6	5	1874.8	188.0	5	6	RR & CITY STREETS	CPGC
E-17-UW	2003	6	77100	10	1	6	629.8	170.5	1	6	WASH.ST./S.PLATTE RIVER	CPGC
E-17-UX	2003	6	4600	10	6	2	299.9	149.0	1	6	Platte R.	CPGC
E-17-UY	2003	5	1E+05	10	1	3	138.0	136.0	5	6	SH 265 Brighton Blvd.	CSGP
E-17-UZ	2002	6	12000	10	1	2	202.4	100.0	2	6	BIG DRY CREEK	CBGC
E-17-WB	2003	4	7200	21	1	1	519.9	140.0	0	6	CAMERON DR,BNSF,3RD CRK	WGCK
E-17-WO	2003	5	25500	21	1	1	211.9	104.0	0	6	RELOCATED 3RD CREEK R	CPGC
E-17-WZ	2000	6	66900	12	6	6	236.0	114.8	0	6	US 6 ML	CBGP
E-17-XX	2002	5	42500	5	1	6	159.5	157.0	1	6	SMITH RD,UP RR	CPG
E-17-YY	2002	6	25500	21	1	7	677.8	133.0	1	6	I76, BNSFRR	CPGC
E-17-YZ	2002	6	2700	0	1	1	218.9	71.0	1	6	RELOCATED THIRD CREEK	CPGC
E-17-ZA	2002	6	37800	9	1	4	778.8	130.0	1	6	US85, UPRR, FULTON DITCH	CPGC
E-17-ZB	2002	6	37800	9	6	4	230.9	114.0	1	6	US 85	CPGC
E-17-ZD	2003	4	83100	15	8	8	1261.7	170.0	1	6	I25, E470 ML, RAMPS	WGCK
E-17-ZE	2003	4	83100	15	7	6	802.8	227.9	1	6	I25, NWP	WGCK
E-17-ZK	2002	6	41550	15	1	3	252.6	124.0	1	6	NWP/E470	CICKP
E-17-ZL	2004	6	83100	17	5	6	272.4	130.3	2	6	I-25	CPGC
E-17-ZM	2003	4	83100	15	1	4	1359.3	171.2	0	6	NWP	SDGC
E-17-ZN	2003	6	83800	15	1	8	326.5	161.0	1	6	I-25	CBGCP
E-17-ZO	2002	6	37800	9	1	4	781.8	130.0	1	6	US85, UPRR, FULTON DITCH	CPGC
E-17-ZP	2003	6	41550	15	1	3	252.6	124.0	1	6	NWP/E470	CSGP
E-17-ZW	2006	6	57600	3	6	10	274.7	135.0	2	6	I 25 ML	CBGCP
E-17-ZY	2002	6	25500	21	1	7	677.8	133.0	1	6	I76, BNSFRR	CPGC
E-17-ZZ	2005	6	25800	11	5	2	1046.7	218.9	9	6	US 6 ML	CBGCP
E-19-Z	2000	6	2700	4	1	2	525.4	105.0	1	1	KIOWA CREEK	CPGC
F-10-AC	2001	5	2800	15	1	2	156.4	153.6	1	3	EAGLE RIVER	CPG
F-10-AH	2005	5	2200	16	1	2	126.1	123.0	65	3	EAGLE RIVER	CBGP

Selected bridges are highlighted in blue.

Table A1 - Characteristics of Bridges Considered

Structure Number	Year Built	Str Type	ADT	Truck %	Serv On	Lanes On	Length (ft)	Maxspan (ft)	Detour (mile)	Re-gion	Feature Intersected	Bridge Type
F-10-D	2003	6	17650	9	1	2	167.0	82.0	1	3	City Streeet	CPGC
F-10-W	2003	6	17650	9	1	2	167.0	82.0	1	3	CITY STREET	CPGC
F-15-AD	2000	3	430	5	1	2	174.0	170.5	1	1	SODA CREEK	WGK
F-15-DG	2002	5	25100	5	1	6	74.5	72.0	23	1	CONIFER ROAD	CBGP
F-15-DH	2003	6	20900	5	5	2	198.1	96.3	1	1	US 285 ML	CPGC
F-15-DI	2003	5	20900	5	1	6	61.0	59.0	0	1	PLEASANT PARK RD.	CBGP
F-15-DJ	2002	5	23400	5	1	6	54.4	52.2	23	1	KENNEDY GULCH RD	CBGP
F-16-GD	2000	3	49200	9	3	6	206.0	203.4	4	6	US 85 ML (SANTA FE DR)	STT
F-16-JB	2003	6	25800	8	1	2	214.9	105.0	3	1	SH 85 ML	CPGC
F-16-JK	2002	5	2E+05	6	6	10	1636.6	152.0	1	6	BRDWY,BNSF,UPRR,RTD,LR	CBGP
F-16-KN	2003	6	34800	5	5	4	214.9	110.0	0	6	US 285 ML	CPGC
F-16-KO	2004	5	21600	11	1	2	112.6	110.0	4	6	DAD CLARK GULCH	CPG
F-16-NC	2001	6	27300	5	3	5	259.9	128.9	0	6	PEDESTRIAN OVERPASS	CBG
F-16-NF	2004	5	89200	7	1	1	135.0	135.0	1	6	I70 WBND RAMP	CBGP
F-16-QJ	2003	6	40000	6	1	1	325.9	131.6	2	6	WALNUT CONNECTOR R	CBGP
F-16-SF	2003	1	30300	4	5	1	100.0	10.0	2	6	DRAINAGE	PCBC
F-16-SP	2004	4	17970	6	2	12	732.3	170.0	1	6	BROADWAY/KENTUCKY AVE.	WGCK
F-16-TW	2002	5	38400	4	2	6	177.0	49.2	3	6	BNSF RR, UP RR	CBG
F-16-UA	2002	5	22800	5	1	6	50.0	48.0	1	1	NORTH ACCESS ROAD	CBGP
F-16-WJ	2007	1	17400	2	1	2	12.0	6.0	1	6	STORM DRAINAGE	CBC
F-17-AX	2000	4	11500	7	6	2	426.9	154.0	2	6	I 225 RAMP R	WGCK
F-17-DZ	2000	4	11830	7	6	2	465.9	175.0	2	6	I 225 RAMP SBND R	WGCK
F-17-FJ	2005	6	21200	4	1	2	476.1	165.0	1	6	NB I-25 Offramp to I-225	CPGC
F-17-FW	2004	5	2E+05	4	1	8	61.0	58.5	1	6	I225 RAMP	CPG
F-17-GX	2002	4	71600	4	7	10	335.5	164.0	1	6	SH 83	CBGP
F-17-GZ	2002	6	78700	4	6	8	335.6	164.0	1	6	SH 83 ML	CBGP
F-17-HV	2005	6	56750	7	1	2	205.6	104.0	1	6	ILIFF AVE	CBGCP
F-17-HZ	2005	6	56250	6	1	3	205.5	105.0	1	6	ILIFF AVE.	CBGCP
F-17-IL	2003	5	1E+05	5	1	2	78.6	75.2	1	6	PEDESTRIAN UNDERPASS	CBGP
F-17-IW	2004	5	59150	7	1	3	86.6	83.6	1	6	2ND AVE	CBGP
F-17-IX	2004	5	59150	7	1	2	86.8	83.8	1	6	2ND AVE.	CBGCP
F-17-KB	2002	5	62850	5	1	2	91.4	78.7	1	6	PEDESTRIAN UNDERPASS	CBGP
F-17-KI	2003	6	1500	4	1	1	215.3	77.0	1	6	RTD UNDERPASS R	CBGP
F-17-KJ	2002	4	38000	6	1	1	665.5	170.5	1	6	SH 83 ML R	SBGC
F-17-KK	2002	6	7160	4	7	2	1342.7	253.9	1	6	OVER I225, SH83, RAMP	CBGCP

Selected bridges are highlighted in blue.

Table A1 - Characteristics of Bridges Considered

Structure Number	Year Built	Str Type	ADT	Truck %	Serv On	Lanes On	Length (ft)	Maxspan (ft)	Detour (mile)	Re-gion	Feature Intersected	Bridge Type
F-17-KS	2003	6	78700	4	1	9	176.0	115.0	5	6	OVER VAUGHN WAY	CBGCP
F-17-KT	2003	5	1500	4	1	1	57.4	54.1	1	6	PEDESTRIAN UNDERPASS	CBGP
F-17-KU	2003	5	62850	5	1	2	82.0	79.0	1	6	PEDESTRIAN UNDERPASS	CBGP
F-17-KW	2003	6	80400	4	1	6	222.9	125.0	5	6	HAMPDEN AVE.	CBGC
F-17-KX	2003	5	80400	4	1	2	59.0	56.0	5	6	PEDESTRIAN/BIKEWAY	CBGP
F-17-LU	2004	6	60300	8	6	2	205.4	106.7	1	6	SH 30 ML	CBGCP
F-17-LV	2004	5	60300	8	6	2	205.4	105.9	1	6	SH 30 ML	CBGCP
F-17-MQ	2003	6	93250	6	6	4	256.9	165.0	1	6	UNIVERSITY BLVD	CPGC
F-17-NA	2004	6	2E+05	6	5	8	428.9	125.0	1	6	I 25 ML	CPGC
F-17-NB	2005	6	17380	6	1	1	348.3	93.0	1	6	I-25 Offramp to Broadway	CPGC
F-17-NC	2003	6	2E+05	6	6	10	394.9	146.0	3	6	I 25 ML & LRT	CPGC
F-17-ND	2005	6	17380	6	1	1	225.5	113.0	1	6	Light Rail	CPGC
F-17-NE	2004	6	2E+05	6	6	8	327.2	122.9	1	6	I 25 ML	CPGC
F-17-NF	2004	6	2E+05	6	5	8	375.6	144.1	1	6	I 25 ML	CPGC
F-17-NG	2005	6	17830	6	1	1	396.9	115.0	1	6	Light Rail	CPGC
F-17-NH	2004	6	2E+05	6	5	8	367.1	133.3	3	6	I 25 ML	CPGC
F-17-NI	2002	6	2E+05	6	5	12	314.0	121.4	1	6	I 25 ML	CPGC
F-17-NJ	2003	6	93250	6	6	4	256.9	164.5	1	6	UNIVERSITY BLVD.	CPGC
F-17-NO	2003	6	2E+05	7	5	10	216.9	122.0	1	6	I25 ML & LRT	CPGC
F-17-NP	2005	5	54200	3	1	10	38.7	38.7	1	6	Light Rail	CPG
F-17-NQ	2005	5	19090	4	1	2	56.4	52.7	1	6	Light Rail	CBG
F-17-NS	2004	6	2E+05	6	6	8	245.9	96.0	2	6	I 25 ML	CPGC
F-17-NV	2005	5	57700	3	1	8	36.0	36.0	1	6	Light Rail Tracks	CBG
F-17-NW	2005	1	2E+05	5	1	10	20.0	20.0	1	6	PED.TUNNEL @ STHMOOR STA	CBC
F-17-NX	2004	6	2E+05	5	5	13	279.9	122.0	2	6	I25 ML & LRT	CPGC
F-17-NZ	2003	5	60900	5	1	4	474.0	474.0	3	6	TUNNEL SB	CSGP
F-17-OC	2006	6	54200	3	6	10	226.9	120.0	1	6	I 25 ML	CPGC
F-17-OD	2005	4	20030	5	6	2	1437.1	199.9	1	6	I25 ML	WGCK
F-17-OE	2006	5	18830	6	1	2	144.5	137.0	1	6	Light Rail Tracks	CPG
F-17-OK	2005	6	62850	5	1	4	268.4	132.0	1	6	CHERRY CREEK	CPGC
F-17-ON	2006	5	2E+05	6	2	1	989.7	161.0	1	6	I25 OFFRAMP	CDTPG
F-17-OO	2003	3	2E+05	6	3	12	316.9	178.0	0	6	PEDESTRIAN BRIDGE	STT
F-17-OT	2006	6	57700	3	6	10	160.3	78.7	4	6	I 25 ML	CPGC
F-17-OY	2005	5	10550	0	1	1	37.5	33.5	1	6	Light Rail	CBG
F-17-PD	2004	3	16000	8	3	11	396.2	396.2	0	6	I25 ML	STT

Selected bridges are highlighted in blue.

Table A1 - Characteristics of Bridges Considered

Structure Number	Year Built	Str Type	ADT	Truck %	Serv On	Lanes On	Length (ft)	Maxspan (ft)	Detour (mile)	Re-gion	Feature Intersected	Bridge Type
F-17-PR	2004	5	2E+05	4	1	9	56.8	53.8	1	6	I 25 ML	CPG
F-17-PS	2004	5	2E+05	5	2	9	53.5	50.5	1	6	I25 ML	CPG
F-17-QA	2005	6	2E+05	4	1	2	305.8	153.7	1	6	Light Rail Tracks	CPGC
F-17-QB	2005	5	2E+05	4	1	2	74.7	70.7	1	6	Light Rail Tracks	CPG
F-17-QE	2005	3	1E+05	8	2	2	249.9	241.4	1	6	S I225 TO S I25	WGK
F-17-QF	2005	4	60900	5	2	-1	555.1	229.6	1	6	SB LRT OVER SB I225	WGCK
F-17-QH	2005	5	1E+05	8	2	6	118.3	112.0	1	6	SB 225 TO SB 25	CPG
F-18-BK	2005	4	1300	8	1	2	469.9	77.8	2	1	BOX ELDER CREEK	CICK
F-19-M	2002	6	1800	3	1	2	210.4	104.0	6	1	Wolf Creek	CBGC
F-22-U	2005	1	650	37	1	2	40.8	20.0	8	4	DRAW	CBC
G-08-F MINOR	2000	1	17000	4	1	5	10.0	10.0	1	3	PEDESTRIAN UNDERPASS	CBC
G-08-H	2003	3	17000	4	3	4	329.9	329.9	99	3	SH 82 ML	STT
G-09-C MINOR	2000	1	18600	4	1	2	10.0	10.0	62	3	PEDESTRIAN UNDERPASS	CBC
G-09-I	2000	5	17000	4	1	6	113.0	110.0	62	3	SNOWMASS CREEK	CPG
G-09-J	2003	6	18600	4	1	2	409.9	160.0	99	3	DRAW	CPGC
G-09-K	2005	6	18600	4	1	2	409.9	160.0	99	3	DRAW	CPGC
G-09-L	2003	6	18600	4	1	2	202.9	98.5	99	3	DRAW	CPGC
G-09-M	2004	5	18600	4	1	2	482.9	120.0	0	3	DRAW	CPGC
G-09-N	2003	5	18600	4	1	2	949.8	170.0	1	3	DRAW	CBGCP
G-09-O	2003	6	18600	4	1	2	949.8	170.0	30	3	DRAW	CBGCP
G-15-A	2002	3	3700	11	3	3	212.9	129.5	1	1	US 285 ML	STT
G-17-BG	2002	5	73100	10	5	8	258.9	130.0	1	1	I25 ML	CPGC
G-17-BH	2002	6	78100	9	5	6	201.9	103.0	1	1	I 25 ML	CBGC
G-17-BI	2003	6	3275	9	1	2	195.0	96.3	1	1	PLUM CREEK	CPGC
G-17-CE	2002	5	11200	7	1	2	40.0	36.1	9	1	Mitchell Gulch	CSP
G-17-CS	2005	3	78100	9	2	4	174.0	68.9	1	1	UP RR	RG
G-17-CT	2005	5	90600	8	6	4	247.9	125.0	0	1	I 25 ML	CSGP
G-17-DA	2001	3	65500	9	5	4	563.0	219.8	1	1	I25 ML & PLUM CREEK	WG
G-22-BY	2000	6	3000	16	1	2	495.0	121.4	4	1	BIG SANDY CREEK	CPGC
G-22-BZ	2000	6	4600	14	1	2	238.0	83.4	7	1	UP RR	CPGC
H-02-AX	2001	1	11900	6	1	2	23.0	23.0	2	3	HUNTER WASH	CBC
H-02-EG	2005	5	15300	19	6	4	177.0	86.0	0	3	I 70 ML	CPG
H-09-B MINOR	2000	1	15400	12	1	8	14.0	14.0	1	3	PEDESTRIAN UNDERPASS	CBC
H-09-E MINOR	2003	1	23200	3	1	5	17.7	17.7	1	3	PEDESTRIAN UNDERPASS	CBC
H-09-Q MINOR	2001	1	23200	3	1	5	16.0	16.0	62	3	PEDESTRIAN UNDERPASS	CBC

Selected bridges are highlighted in blue.

Table A1 - Characteristics of Bridges Considered

Structure Number	Year Built	Str Type	ADT	Truck %	Serv On	Lanes On	Length (ft)	Maxspan (ft)	Detour (mile)	Re-gion	Feature Intersected	Bridge Type
H-09-R	2000	6	15400	12	1	2	359.0	118.1	1	3	SHALE BLUFFS	CPGC
H-09-S	2000	6	15400	12	1	2	304.0	98.4	1	3	SHALE BLUFFS	CPGC
H-09-T	2000	1	15400	12	1	4	20.0	20.0	1	3	GAME CROSSING	CBC
H-16-I	2000	5	2000	6	1	2	91.0	88.6	21	2	TROUT CREEK	CBGP
H-17-BB	2004	4	65700	9	1	4	324.0	131.2	1	2	DIRTY WOMAN CREEK R	WGC
H-17-CA	2004	1	62500	10	1	6	20.7	10.4	1	2	DIRTY WOMAN CREEK	CBC
H-17-CJ	2005	5	10000	6	1	6	145.0	143.0	1	2	BLACK SQUIRREL CRK	CPG
H-17-CZ	2004	5	65700	9	6	6	188.6	92.0	1	2	I 25 ML	CPGC
H-17-DA	2004	3	9700	2	1	4	78.2	75.7	1	2	DIRTY WOMAN CREEK	WG
I-03-N	2000	1	8500	9	1	6	82.0	26.2	62	3	KANNAH CREEK	CBC
I-15-AV	2000	5	2500	18	1	3	120.2	117.1	1	2	S FK SOUTH PLATTE RVR	CPG
I-16-A	2003	4	2900	4	5	4	24.0	24.0	99	2	GAME CROSSING	SAC
I-16-AE	2004	5	16700	4	1	4	95.5	92.6	99	2	RULE CREEK	CPG
I-16-B MINOR	2004	1	16700	4	1	5	14.0	14.0	1	2	BIKE PATH CROSSING	CBC
I-16-E MINOR	2004	1	16700	4	1	5	16.0	16.0	1	2	FARM ACCESS ROAD	CBC
I-17-CD	2002	6	51350	7	6	3	229.9	113.0	0	2	WOODMEN ROAD	CBG
I-17-CE	2002	6	51350	7	6	3	229.9	113.0	0	2	WOODMEN ROAD	CBG
I-17-FJ	2002	5	88200	9	6	6	949.8	150.0	1	2	CHEYENNE CRK/NEVADA AVE.	CBGP
I-17-GK	2002	4	41550	10	1	4	227.9	113.0	1	2	PINE CREEK	WGCK
I-17-GV	2002	4	41550	10	1	4	227.9	113.0	1	2	PINE CREEK	WGCK
I-17-GY	2004	6	51350	7	1	3	188.5	92.6	1	2	COTTONWOOD CREEK	CPGC
I-17-JR	2003	6	28300	2	1	5	314.1	104.4	3	2	FOUNTAIN CREEK	CPGC
I-17-LR	2000	6	50700	7	6	3	207.0	101.7	0	2	Uintah Street	CBGP
I-17-LT	2000	6	53450	7	6	3	181.0	88.6	0	2	FONTANERO STREET	CBGP
I-17-LX	2000	6	61700	11	6	6	208.0	105.0	1	2	SH 29 ML	CBGC
I-17-LY	2000	3	61700	11	3	4	299.6	82.0	0	2	PEDRESTRIAN OVERPASS R	STT
I-17-MG	2002	5	88200	9	1	2	44.0	39.0	0	2	CHEYENNE CREK	CBGP
I-17-MH	2003	5	8820	9	1	2	43.0	36.1	0	2	CHEYENNE CREEK	CS
I-17-MJ	2005	4	24500	3	1	4	457.9	175.0	3	2	KETTLE CREEK	WGCK
I-17-MK	2005	4	24500	3	1	5	457.9	140.0	3	2	KETTLE CREEK	WGCK
I-17-NE	2001	6	3910	3	1	4	300.0	118.1	1	2	COTTONWOOD CREEK	CPGC
I-17-NU	2005	5	26550	3	1	2	153.0	150.0	3	2	PINE CREEK	CPG
I-17-NV	2005	5	26550	3	1	2	152.6	150.0	3	2	PINE CREEK	CPG
I-18-AC	2000	6	32200	8	6	6	266.4	132.0	1	2	N. POWERS BLVD.	CBGC
I-18-BF	2000	1	28300	8	1	4	143.6	23.1	1	2	EAST FOR SAND CREEK	CBC

Selected bridges are highlighted in blue.

Table A1 - Characteristics of Bridges Considered

Structure Number	Year Built	Str Type	ADT	Truck %	Serv On	Lanes On	Length (ft)	Maxspan (ft)	Detour (mile)	Re-gion	Feature Intersected	Bridge Type
I-18-R	2000	1	12600	12	1	3	28.7	13.9	1	2	DRAW	PCBC
J-04-D	2001	1	350	14	1	2	26.0	12.0	2	3	Ironstone Canal	CBC
J-12-AM	2003	1	3000	26	1	2	30.2	14.4	99	5	N.FK.SOUTH ARKANSAS RVR	CBC
J-12-F	2003	1	3000	26	1	2	20.4	20.4	99	5	WELDON CREEK	CBC
J-16-C	2001	4	1200	8	1	2	1224.2	265.9	99	2	AREQUA GULCH	WGCK
J-17-AA	2002	6	7900	9	1	4	150.0	72.1	0	2	BIG TURKEY CREEK	CPGC
J-17-AC	2004	5	9500	8	1	4	136.0	133.0	80	2	LITTLE FOUNTAIN CREEK	CPG
J-17-AD	2002	1	7900	9	1	4	96.0	49.0	62	2	DRAW	CBC
J-17-AE	2002	1	7900	9	1	4	37.0	18.0	62	2	DRAW	CBC
J-17-I	2002	1	7900	9	1	4	77.0	16.4	62	2	RED CREEK	CBC
J-18-AI	2001	5	14700	2	1	4	131.0	124.6	2	2	CREWS GULCH	CPG
J-18-Q	2002	6	44300	12	6	4	195.0	95.0	0	2	I25 ML	CPGC
J-27-Q	2004	0	760	36	1	2	40.0	4.0	12	1	DRAW	CMP
K-05-BQ	2002	6	6850	5	1	3	151.0	72.2	1	3	UNCOMPAGRE RIVER	CPGC
K-13-F	2000	1	3000	8	1	2	49.8	24.4	62	5	DRAW	CBC
K-16-AP	2000	6	1400	8	1	2	98.0	95.0	4	2	ADOBE CREEK	CBGP
K-16-BW	2000	1	1400	8	1	2	41.0	20.0	4	2	NEWLIN CREEK	CBC
K-16-BZ	2000	1	1100	7	1	2	39.0	19.7	4	2	DRAW	CBC
K-16-CH	2002	6	7900	9	1	4	160.0	78.7	0	2	BEAVER CREEK	CPGC
K-16-P	2006	1	5073	12	1	2	53.0	10.0	4	2	BRUSH HOLLOW CREEK	CBC
K-18-BV	2003	4	57900	5	5	6	1195.7	79.0	7	2	I25 ML,RR,FOUNTAIN CREEK	WGCK
K-18-GG	2002	6	43800	8	6	4	364.0	196.8	0	2	US 50 ML & SH 47 ML	CBGC
K-18-GQ	2006	5	14350	12	1	2	152.5	150.0	1	2	PORTER DRAW	CPG
K-26-J	2003	5	2400	58	1	2	138.5	136.0	12	2	NE GRANDE RES OUTLET	CPG
L-11-G	2003	5	440	18	1	2	72.5	70.0	30	5	SAGUACHE CREEK	CBGP
L-15-E	2006	1	790	6	1	2	61.7	20.0	4	2	WILMER GULCH	CBC
L-18-BD	2003	5	7200	6	5	2	309.9	121.0	1	2	SH 227 ML, SALT CREEK	CPGC
L-18-BE	2003	5	24600	5	1	4	115.5	113.0	3	2	CF&I RR, CF RR	CBGP
L-20-A	2002	5	1000	9	1	2	411.0	134.5	3	2	KRAMER CREEK	CPGC
L-21-AB	2001	1	6000	13	1	4	25.0	13.1	2	2	Patterson Hollow	CBC
L-25-D	2004	5	2600	19	1	2	101.0	98.5	2	2	LUBERS DRAINAGE DITCH	CPG
L-25-F	2004	5	2600	19	1	2	70.0	67.5	2	2	DRAW	CPG
L-26-BH	2004	1	2900	17	1	4	36.8	17.6	2	2	RIVERVIEW CANAL	CBC
L-27-I	2003	5	1300	13	1	2	265.9	88.5	3	2	WOLF CREEK	CBGP
M-17-BE	2003	6	8600	11	1	2	129.0	125.0	1	2	SCROGGS ARROYO	CPGC

Selected bridges are highlighted in blue.

Table A1 - Characteristics of Bridges Considered

Structure Number	Year Built	Str Type	ADT	Truck %	Serv On	Lanes On	Length (ft)	Maxspan (ft)	Detour (mile)	Re-gion	Feature Intersected	Bridge Type
M-17-BF	2004	5	7600	19	1	2	108.0	106.0	1	2	GREASEWOOD ARROYO	CBGP
M-22-BD	2002	5	240	21	1	2	163.0	65.0	9	2	DRAW	CBGCP
M-22-BE	2002	1	240	21	1	2	41.0	20.0	2	2	Draw	CBC
M-23-K	2002	5	1750	12	1	2	70.4	67.5	1	2	OTERO CANAL	CPG
N-03-J	2000	6	1600	10	1	2	79.0	75.4	99	5	STONER CREEK	CPG
N-09-F	2002	1	2500	12	0	2	1025.7	48.0	99	5	WOLF CREEK PASS	TUNC
N-18-AA	2001	6	5200	21	1	2	209.0	101.7	1	2	WALSEN ARROYO	CPGC
N-28-L	2002	1	170	24	1	2	82.5	20.0	14	2	DRAW	CBC
N-28-M	2002	3	170	24	1	2	170.0	64.0	14	2	LITTLE BEAR CREEK	CICK
N-28-N	2002	1	170	24	1	2	82.5	20.0	14	2	NORTH BEAR CREEK	CBC
O-26-Q	2000	1	3100	55	1	2	44.0	13.1	2	2	DRAW	CBC
P-06-AB	2005	5	3200	8	5	2	249.9	124.0	3	5	LOS PINOS RIVER	CBGCP
P-17-AF	2000	1	680	7	1	2	27.0	26.2	99	2	DRAW	CBC
P-18-AX	2005	6	8600	5	1	2	299.7	99.6	4	2	PURGATOIRE RIVER	CBGCP

Total Structures	329

Selected bridges are highlighted in blue.

Table A2 - Explanation of Terms in Table A1

Bridge Type	
CBC	Concrete Box Culvert
CBG	Concrete Box Girder
CBGC	Concrete Box Girder Continuous
CBGCP	Concrete Box Girder Continuous Prestressed
CBGP	Concrete Box Girder Prestressed
CDTPG	Concrete Double-Tee Prestressed Girder
CICK	Concrete on Rolled I-Beam - Continuous & Composite
CICKP	Concrete on Rolled I-Beam - Continuous Composite Prestressed
CMP	Corrugated Metal Pipe
CPG	Concrete Prestressed Girder (Precast)
CPGC	Concrete Prestressed Girder Continuous (Precast)
CS	Concrete Slab
CSGCP	Concrete Slab & Girder Continuous Prestressed (Poured in Place)
CSGP	Concrete Slab & Girder Prestressed (Poured in Place)
CSP	Concrete Slab Prestressed
PCBC	Concrete Box Culvert Precast
RG	Riveted Plate Girder
SA	Steel Arch
SAC	Steel Arch Culvert
SBGC	Steel Box Girder Continuous
SDGC	Steel Deck Girder with Floor Beam System
STT	Steel Thru Truss
TUNC	Tunnel-Concrete Lined
WG	Welded Girder
WGC	Welded Girder Continuous
WGCK	Welded Girder Continuous & Composite
WGK	Welded Girder Composite

Structure Type - Main Span (Str Type)	
1	Concrete
2	Concrete Continuous
3	Steel
4	Steel Continuous
5	Prestressed Concrete
6	Prestressed Concrete Continuous
0	Other

Service on Bridge (Serv On)	
1	Highway
2	Railroad
3	Pedestrian-Bicycle
4	Highway-Railroad
5	Highway-Pedestrian
6	Overpass Structure or Interchange Leve
7	Interchange Level 3
8	Interchange Level 4
9	Building or Plaza
0	Other

Characteristics represented by study bridges are highlighted in green.

Table A3 - Bridge Characteristics and Percentage Representations

Total Bridges	163

Under	# Bridges	% Built
Road	97	59.51%
Other	66	40.49%
Total	163	100.00%

Regions	**# Bridges**	**% Built**
1	18	11.04%
2	33	20.25%
3	13	7.98%
4	28	17.18%
5	2	1.23%
6	69	42.33%
Total	163	100.00%

Type	**# Bridges**	**% Built**
CBG	56	34.36%
CPG	79	48.47%
CSG	4	2.45%
CI	2	1.23%
S/W	22	13.50%
Total	163	100.00%

ADT	**# Bridges**	**% Built**	**Code**
0-20000	79	48.47%	1
20000-40000	23	14.11%	2
40000-60000	22	13.50%	3
60000-80000	19	11.66%	4
80000-100000	12	7.36%	5
100000-125000	1	0.61%	6
125000-150000	2	1.23%	7
150000-200000	5	3.07%	8
Total	163	100.00%	

Length	**# Bridges**	**% Built**	**Code**
0-250	98	60.12%	1
250-500	40	24.54%	2
500-750	8	4.91%	3
750-1000	9	5.52%	4
1000-1250	2	1.23%	5
1250-1500	3	1.84%	6
1500-1750	1	0.61%	7
1750-2000	2	1.23%	8
Total	163	100.00%	

Table A4 - Distribution of Candidate Bridges by CDOT Region

		REGION 1 ADT Range (in thousands)							
Type	**Length (ft)**	**0-20**	**20-40**	**40-60**	**60-80**	**80-100**	**100-125**	**125-150**	**150-200**
	0-250	CBGP, CBGC	4 CBGP		CBGC				
	250-500								
	500-750								
CBG*	750-1000								
	1000-1250								
	1250-1500								
	1500-1750								
	1750-2000								
	0-250	CPG, 2 CPGC	2 CPGC						
	250-500	CPGC			CPGC				
	500-750	CPGC							
CP*	750-1000								
	1000-1250								
	1250-1500								
	1500-1750								
	1750-2000								
	0-250								
	250-500								
	500-750								
CSG*	750-1000								
	1000-1250								
	1250-1500								
	1500-1750								
	1750-2000								
	0-250								
	250-500								
	500-750								
CI*	750-1000								
	1000-1250								
	1250-1500								
	1500-1750								
	1750-2000								
	0-250	WGK, STT							
	250-500								
W*	500-750				WG				
or	750-1000								
S*	1000-1250								
	1250-1500								
	1500-1750								
	1750-2000								

Table A4 - Distribution of Candidate Bridges by CDOT Region

		REGION 2							
		ADT Range (in thousands)							
Type	Length (ft)	0-20	20-40	40-60	60-80	80-100	100-125	125-150	150-200
CBG*	0-250	2 CBGP, CBGCP	CBGP	2 CBG, 2 CBGP	CBGC	CBGP			
	250-500	CBGP	CBGC	CBGC					
	500-750								
	750-1000					CBGP			
	1000-1250								
	1250-1500								
	1500-1750								
	1750-2000								
CP*	0-250	4 CPG, 4 CPGC		CPGC					
	250-500	3 CPGC	CPGC						
	500-750								
	750-1000								
	1000-1250								
	1250-1500								
	1500-1750								
	1750-2000								
CSG*	0-250								
	250-500								
	500-750								
	750-1000								
	1000-1250								
	1250-1500								
	1500-1750								
	1750-2000								
CI*	0-250	CICK							
	250-500								
	500-750								
	750-1000								
	1000-1250								
	1250-1500								
	1500-1750								
	1750-2000								
W* or S*	0-250			2 WGCK					
	250-500				STT				
	500-750								
	750-1000								
	1000-1250	WGCK		WGCK					
	1250-1500								
	1500-1750								
	1750-2000								

Table A4 - Distribution of Candidate Bridges by CDOT Region

		REGION 3							
		ADT Range (in thousands)							
Type	Length (ft)	0-20	20-40	40-60	60-80	80-100	100-125	125-150	150-200
CBG*	0-250								
	250-500								
	500-750								
	750-1000	2 CBGCP							
	1000-1250								
	1250-1500								
	1500-1750								
	1750-2000								
CP*	0-250	2 CPG, 4 CPGC							
	250-500	3 CPGC							
	500-750								
	750-1000								
	1000-1250								
	1250-1500								
	1500-1750								
	1750-2000								
CSG*	0-250								
	250-500								
	500-750								
	750-1000								
	1000-1250								
	1250-1500								
	1500-1750								
	1750-2000								
CI*	0-250								
	250-500								
	500-750								
	750-1000								
	1000-1250								
	1250-1500								
	1500-1750								
	1750-2000								
W* or S*	0-250								
	250-500	WGCK, STT							
	500-750								
	750-1000								
	1000-1250								
	1250-1500								
	1500-1750								
	1750-2000								

Table A4 - Distribution of Candidate Bridges by CDOT Region

		REGION 4							
		ADT Range (in thousands)							
Type	**Length (ft)**	**0-20**	**20-40**	**40-60**	**60-80**	**80-100**	**100-125**	**125-150**	**150-200**
CBG*	0-250	CBGP, 4 CBGC			CBGP				
	250-500	CBGCP, 2 CBGC							
	500-750								
	750-1000								
	1000-1250								
	1250-1500								
	1500-1750								
	1750-2000								
CP*	0-250	11 CPG, 6 CPGC							
	250-500	CPG							
	500-750								
	750-1000								
	1000-1250								
	1250-1500								
	1500-1750								
	1750-2000								
CSG*	0-250	CSGP							
	250-500								
	500-750								
	750-1000								
	1000-1250								
	1250-1500								
	1500-1750								
	1750-2000								
CI*	0-250								
	250-500								
	500-750								
	750-1000								
	1000-1250								
	1250-1500								
	1500-1750								
	1750-2000								
W* or S*	0-250								
	250-500								
	500-750								
	750-1000								
	1000-1250								
	1250-1500								
	1500-1750								
	1750-2000								

Table A4 - Distribution of Candidate Bridges by CDOT Region

		REGION 5							
		ADT Range (in thousands)							
Type	**Length (ft)**	**0-20**	**20-40**	**40-60**	**60-80**	**80-100**	**100-125**	**125-150**	**150-200**
CBG*	0-250	CBGP							
	250-500								
	500-750								
	750-1000								
	1000-1250								
	1250-1500								
	1500-1750								
	1750-2000								
CP*	0-250	CPG							
	250-500								
	500-750								
	750-1000								
	1000-1250								
	1250-1500								
	1500-1750								
	1750-2000								
CSG*	0-250								
	250-500								
	500-750								
	750-1000								
	1000-1250								
	1250-1500								
	1500-1750								
	1750-2000								
CI*	0-250								
	250-500								
	500-750								
	750-1000								
	1000-1250								
	1250-1500								
	1500-1750								
	1750-2000								
W* or S*	0-250								
	250-500								
	500-750								
	750-1000								
	1000-1250								
	1250-1500								
	1500-1750								
	1750-2000								

Table A4 - Distribution of Candidate Bridges by CDOT Region

		REGION 6							
		ADT Range (in thousands)							
Type	Length (ft)	0-20	20-40	40-60	60-80	80-100	100-125	125-150	150-200
	0-250	CBGC, 2 CBGP	CBG	3 CBGP	4 CBGP, CBG	CBGC, CBGP	CBGC	CBGP	
	250-500		CBG	CBGP	2 CBGP	CBGCP			
	500-750								
CBG*	750-1000								
	1000-1250								
	1250-1500	CBGCP							
	1500-1750								CBGP
	1750-2000								
	0-250	2 CPGC	CPG, 3 CPGC	4 CPGC, CPG					CPGC
	250-500	2 CPGC		CPGC		3 CPGC			2 CPGC
	500-750		2 CPGC		2 CPGC				
CP*	750-1000		4 CPGC						
	1000-1250								
	1250-1500								
	1500-1750								
	1750-2000				2 CPGC				
	0-250							CSGP	
	250-500			CSGP	CSGP				
	500-750								
CSG*	750-1000								
	1000-1250								
	1250-1500								
	1500-1750								
	1750-2000								
	0-250								
	250-500			CICKP					
	500-750								
CI*	750-1000								
	1000-1250								
	1250-1500								
	1500-1750								
	1750-2000								
	0-250			STT					
	250-500	2 WGCK	WGCK		WGCK				STT
W*	500-750	WGCK	SBGC						
or	750-1000					SDGC, WGCK			
S*	1000-1250								
	1250-1500					SDGC, WGCK			
	1500-1750								
	1750-2000								

Table A5 - Candidate and Selected Bridges

		Characteristics (see Table A3 for codes)				
# pick	Bridge	intersected	type	region	adt code	length code
1	I-17-CD	road	CBG	2	3	1
	I-17-CE	not selected	not selected	not selected	not selected	not selected
1	F-16-NC	road	CBG	6	2	2
1	G-17-BH	road	CBG	1	4	1
1	I-17-LX	road	CBG	2	4	1
1	E-16-RB	road	CBG	6	6	1
1	G-09-N	other	CBG	3	1	4
	G-09-O	not selected	not selected	not selected	not selected	not selected
1	A-27-P	other	CBG	4	1	2
1	F-17-KK	road	CBG	6	1	6
1	E-17-ZN	road	CBG	6	5	2
1	F-15-DG	road	CBG	1	2	1
	F-15-DI	not selected	not selected	not selected	not selected	not selected
	F-15-DJ	not selected	not selected	not selected	not selected	not selected
	F-16-UA	not selected	not selected	not selected	not selected	not selected
1	I-17-LR	road	CBG	2	3	1
	I-17-LT	not selected	not selected	not selected	not selected	not selected
1	I-17-FJ	road	CBG	2	5	4
1	E-16-HK	road	CBG	4	4	1
1	L-11-G	other	CBG	5	1	1
1	F-17-GX	road	CBG	6	4	2
	F-17-GZ	not selected	not selected	not selected	not selected	not selected
1	F-17-IL	other	CBG	6	7	1
1	F-16-JK	road	CBG	6	8	7
1	N-28-M	other	CI	2	1	1
1	E-17-ZK	road	CI	6	3	2
1	B-23-BA	road	CPG	4	1	1
	B-23-BB	not selected	not selected	not selected	not selected	not selected
1	B-24-AD	road	CPG	4	1	1
	B-24-AI	not selected	not selected	not selected	not selected	not selected
1	B-24-AU	road	CPG	4	1	1
	B-24-AV	not selected	not selected	not selected	not selected	not selected
	B-24-AW	not selected	not selected	not selected	not selected	not selected
	B-24-AX	not selected	not selected	not selected	not selected	not selected
	B-24-AY	not selected	not selected	not selected	not selected	not selected
	B-24-AZ	not selected	not selected	not selected	not selected	not selected
1	N-03-J	other	CPG	5	1	1
1	E-17-UK	other	CPG	6	2	1
1	F-15-DH	road	CPG	1	2	1
	F-16-JB	not selected	not selected	not selected	not selected	not selected
1	G-17-BG	road	CPG	1	4	2
1	L-18-BD	road	CPG	2	1	2

Table A5 - Candidate and Selected Bridges

# pick	Bridge	intersected	type	region	adt code	length code
1	J-18-Q	road	CPG	2	3	1
1	F-10-D	road	CPG	3	1	1
	F-10-W	not selected	not selected	not selected	not selected	not selected
1	E-17-QP	road	CPG	6	2	4
	E-17-UG	not selected	not selected	not selected	not selected	not selected
	E-17-ZA	not selected	not selected	not selected	not selected	not selected
	E-17-ZO	not selected	not selected	not selected	not selected	not selected
1	E-17-UR	road	CPG	6	4	8
	E-17-UU	not selected	not selected	not selected	not selected	not selected
1	E-16-KY	road	CPG	6	5	2
	F-17-MQ	not selected	not selected	not selected	not selected	not selected
	F-17-NJ	not selected	not selected	not selected	not selected	not selected
1	F-17-NC	road	CPG	6	8	2
	F-17-NI	not selected	not selected	not selected	not selected	not selected
1	F-17-NZ	road	CSG	6	4	2
1	E-17-UY	road	CSG	6	7	1
1	F-17-KJ	road	S/W	6	2	3
1	E-17-ZM	road	S/W	6	5	6
1	G-17-DA	road	S/W	1	4	3
1	K-18-BV	road	S/W	2	3	5
1	D-05-A	other	S/W	3	1	2
1	E-17-QS	road	S/W	6	4	2
1	E-17-ZD	road	S/W	6	5	6
1	F-15-AD	other	S/W	1	1	1
43						

Appendix B

Table B1. Study Bridge Characteristics

Study No.	Structure No.	Bridge Type	Structure Type	Location (Nearest Town)	Rural/ Urban	ADT	% ADT Truck	CDOT Region
1	A-27-P	CBGCP	6	Julesburg	Rural	1500	10%	4
2	B-23-BA	CPG	5	Sterling	Rural	4200	30%	4
3	B-24-AI	CPG	1	Sterling	Rural	4200	30%	4
4	B-24-AV	CPG	5	Sterling	Rural	4200	30%	4
5	D-05-A	WGCK	4	Meeker	Rural	2300	18%	3
6	E-16-HK	CBGP	5	Broomfield	Urban	78600	4%	4
7	E-17-UK	CPG	5	Commerce City	Rural	24300	21%	6
8	F-15-DG	CBGP	5	Conifer	Rural	25100	5%	1
9	F-15-DI	CBGP	5	Conifer	Rural	20900	5%	1
10	F-16-JB	CPGC	6	Highlands Ranch	Rural	25800	8%	1
11	F-16-UA	CBGP	5	Conifer	Rural	22800	5%	1
12	F-17-GZ	CBGP	6	Denver/Aurora	Urban	78700	4%	6
13	G-17-BG	CPGC	5	Castle Rock	Urban	73100	10%	1
14	G-17-BH	CBGC	6	Castle Rock	Urban	78100	9%	1
15	G-17-DA	WG	3	Castle Rock	Urban	65500	9%	1
16	I-17-FJ	CBGP	5	Colorado Springs	Urban	88200	9%	2
17	I-17-LX	CBGC	6	Colorado Springs	Urban	61700	11%	2
18	J-18-Q	CPGC	6	Fountain	Urban	44300	12%	2
19	L-18-BD	CPGC	5	Pueblo	Rural	7200	6%	2
20	N-28-M	CICK	3	Lycan	Rural	170	24%	2

Table B2. Study Bridge Accident Data

Study No.	Delay Cost (mill. $)	Bridge Cost (mill. $)	Cost Ratio	% Difference in Safety			ADT	Const. Duration (mo.)
				PDO	INJ	FAT		
1	$0.00	$4.21	0.00	-100%	0%	0%	1500	10
2	$0.22	$2.81	0.08	-100%	67%	-100%	4200	24
3	$0.11	$2.81	0.04	-33%	100%	0%	4200	12
4	$0.22	$2.81	0.08	-60%	0%	0%	4200	24
5	$1.20	$4.70	0.26	-60%	-100%	0%	2300	14
6	$0.93	N/A	N/A	87%	28%	-100%	78600	16
7	$1.16	$4.68	0.25	13%	-33%	0%	24300	12
8	$25.35	$6.28	4.04	34%	96%	234%	25100	27
9	$30.49	$6.28	4.86	3%	33%	324%	20900	27
10	$0.64	$6.32	0.10	104%	39%	-100%	25800	10
11	$2.27	N/A	N/A	-29%	-48%	167%	22800	12
12	$15.18	$6.71	2.26	-82%	-85%	-33%	78700	21
13	$0.00	$9.73	0.00	108%	80%	0%	73100	14
14	$5.52	$2.68	2.06	17%	42%	-100%	78100	24
15	$3.09	$4.63	0.67	-23%	52%	-100%	65500	10
16	$28.34	$6.64	4.27	48%	45%	-100%	88200	20
17	$9.60	$6.96	1.38	10%	2%	-11%	61700	36
18	$2.68	$12.10	0.22	41%	-27%	-100%	44300	12
19	$0.46	$5.57	0.08	104%	83%	0%	7200	15
20	$0.00	$1.20	0.00	-100%	0%	0%	170	11
AVE	$6.37	$5.39	1.15	-0.89%	18.65%	-0.95%		

Table B3. Study Bridge Construction Practices

Study No.	Bridge Type	Const. Duration (mo.)	Length Affected (mi.)	Detour	Congestion Noticeable	Methods of Handling Traffic
1	CBGCP	10	1.24	NO	NO	Other: New Structure Building Adjacent to Existing
2	CPG	24	1.02	NO	NO	Shifting Lanes
3	CPG	12	1.01	NO	NO	Shifting Lanes
4	CPG	24	1.02	NO	NO	Shifting Lanes
5	WGCK	14	4.11	NO	YES	One Lane Operation Only, Other: Shoulder Width Reduction
6	CBGP	16	0.31	YES	YES	Other: Complete Diversion Around Bridge
7	CPG	12	1.00	NO	NO	Shifting Lanes
8	CBGP	27	4.50	NO	NO	Shifting Lanes
9	CBGP	27	4.50	NO	NO	Shifting Lanes
10	CPGC	10	0.90	YES	NO	Shifting Lanes
11	CBGP	12	1.00	YES	YES	Closure/Detour
12	CBGP	21	1.00	YES	YES	Shifting Lanes, Reduction in Lane Width & no. of Lanes
13	CPGC	14	0.00	YES	NO	Closure/Detour
14	CBGC	24	2.50	NO	NO	Shifting Lanes
15	WG	10	2.00	NO	NO	Shifting Lanes
16	CBGP	20	3.04	NO	Intermittent	Shifting Lanes, Lane Width Reduction
17	CBGC	36	0.38	YES	Intermittent	One Lane Operation Only, Shifting Lanes, Reduction in Lane Width & no. of Lanes, Closure/Detour (Same for Both)
18	CPGC	12	0.38	YES	Intermittent	
19	CPGC	15	1.78	NO	YES	Shifting Lanes
20	CICK	11	0.40	YES	NO	Closure/Detour

Appendix C

Figure C1. Map of Study Bridge Sites

Figure C2. Map of Bridge Structure Types

Figure C3. Map of Bridge ADT

Figure C4. Map of Bridge Delay Cost (mill $)

Figure C5. Map of Bridge Delay Cost/Bridge Cost

Colorado Department of Transportation/University of Colorado
Bridge Research Project – Risk Based Structure Selection

The purpose of this research project is to evaluate the benefit and value of including construction risk and user costs into the CDOT structure selection process.

One of the pre-selected bridge projects that we will be analyzing is one in which you had a recent key role. To assist us with this research project, we are requesting your input regarding construction information and method(s) used to handle traffic during construction of the bridge(s). Please review the information that we've provided for accuracy and fill-in the absent data to the best of your knowledge. We thank you for your time and assistance.

INTERVIEW INFORMATION

CDOT Person Interviewed: ______
Date: **September 18, 2008**

PART 1 - GENERAL PROJECT INFORMATION
(information to be provided by CU team)

Project Location: Nearest Town **State Hwy 138 near Julesburg**
Rural ☒
Urban Project ☐
Bridge Structure Number: **A-27-P**
Sub-account number: **10786**
Project Number(s): **C138A-006**
Year Built: **2000**
Route: **138A**
Mile Post: **MP 47.0**
CDOT Region **Region 4**
Resident Engineer: **Brett Locke**
Program Engineer: **Rick Gabel**
Project Engineer: **Frank Lopez**
Second Project Engineer (if applicable): ______

A. Bridge Information

1. What type of bridge was constructed? (to be provided by CU team from CDOT Structure Log).

______

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Bridge Research Project – Risk Based Structure Selection

2. Type of Project:
   - Bridge Replacement: ☒ Yes ☐ No
   - New Alignment/New Structure: ☒ Yes ☐ No
   - Interchange Reconstruction: ☐ Yes ☒ No
   - Other: ______

   Additional Project Information (provide any description that you feel would be helpful to better explain the nature of the project):

3. Was the bridge construction phased? ☒ Yes ☐ No
   (may be available on plans)
   If so, how many phases were used? **Two phases**

4. Was a unique bridge construction method used? ☐ Yes ☒ No
   If yes, please provide a brief summary. ______

5. Was falsework and/or shoring adjacent to the traveling public (within typical roadway section) required for construction of the bridge? ☒ Yes ☐ No
   If Yes was there a vertical height restriction? ☒ Yes ☐ No
   If Yes was there a horizontal restriction in lane or shoulder width? ☒ Yes ☐ No

B. Project Limits And Construction Duration

1. What was the duration of construction?
   - Date construction began: **March 22, 2000**
   - Date of substantial completion: **January 10, 2001**

2. What were the mile points at the beginning and end of the work zone?
   (available on plans)
   - Mile point at beginning: **46.877**
   - Mile point at end: **47.123**

C. Construction Traffic Control Plans

It would be helpful to the research project to have a set of these plans and associated specifications from the Contract Documents for our use.

Are copies of the plans still available? ☐ Yes ☒ No

If so, please provide us a scanned pdf copy of the construction traffic control plans and specifications for our use; and return with this questionnaire.

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Bridge Research Project – Risk Based Structure Selection

D. Alternative Construction

(Suggestion: Respond to this question <u>after</u> completing Part 2 for actual construction traffic control used on project.)

1. In hindsight, could the project have been designed or constructed differently to reduce construction time or impact to traffic? Please explain. **No**

2. Could working multiple shifts have occurred without an increase in traffic obstruction time? Please explain. **No**

3. Was there non-traffic construction work that could have been done on a different shift that would have shortened the project time? Please explain. **No**

4. Other thoughts/comments:

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Bridge Research Project – Risk Based Structure Selection

PART 2 - CONSTRUCTION INFORMATION

Complete Sections A through C for each major construction phase (additional pages have been included for up to 3 phases. Add/complete more pages if necessary for additional phases).

Phase 1

A. Construction Traffic Control

1. Was traffic control required during construction? ☒ Yes ☐ No

2. Did the contractor propose and use an alternate method of traffic control other than that shown in the contract documents? ☐ Yes ☒ No

   If yes, please provide a brief explanation:

3. What was the basic method of handling traffic? (Check all that apply.)
   - ☐ One Lane Operation Only (Flagging or signal)
   - ☐ Shifting Lanes
   - ☐ Closure/Detour
   - ☐ Reduction in Number of Lanes
   - ☐ Lane Width Reduction
   - ☒ Other: Traffic used existing roadway while new structure was built adjacent

   a. Was this method short duration (during the construction day only) or used for multiple days/weeks?
   - ☐ Short Duration
   - ☒ Multiple

4. What was the length of time that traffic was impacted during the bridge construction and/or project? **6 months**

5. Was traffic impacted differently for the individual phases of the bridge construction project? **Yes**

6. What time of day did construction work occur that impacted traffic? **Mornings and evenings**

7. Was there traffic impact to the facility intersected (the feature beneath the bridge) as a result of bridge constructed? ☐ Yes ☒ No

8. Was a speed reduction required through the construction zone, and if so what was the posted speed? **No**

9. In your opinion was congestion due to construction traffic control noticeable?
   ☐ Yes ☒ No ☐ Intermittent ☐ Throughout project

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Bridge Research Project – Risk Based Structure Selection

B. Detour Information

1. Was a detour employed during bridge construction? ☐ Yes ☒ No

2. What was the nature of the detour? **n/a**

3. What was the time period of the detour? (in place during construction day only, permanent during construction period, etc.) **n/a**

4. What were the mile points at the start and end of the detour?
   Mile point at start: **n/a**
   Mile point at end: **n/a**

5. What was the length of the detour? **n/a**

6. What was the speed through the detour compared to the normal operating conditions of the detoured area? **n/a**

7. What was the impact to users as a result of the detour route? **n/a**

8. How much congestion was there along the detour route relative to normal operating conditions of the original route? **n/a**

9. Were variable message signs used? ☒ Yes ☐ No

10. Was a website and/or newsletters used? ☐ Yes ☒ No

C. Accidents During Construction for this Phase

1. Were there any accidents in the work zone during construction?
   ☐ Yes ☒ No

2. Were any of these accidents construction related, in your opinion?
   ☐ Yes ☒ No

PART 2 – CONSTRUCTION INFORMATION

Complete Sections A through C for each major construction phase (additional pages have been included for up to 3 phases. Add/complete more pages if necessary for additional phases).

Phase 2

A. Construction Traffic Control

1. Was traffic control required during construction? ☒ Yes ☐ No

2. Did the contractor propose and use an alternate method of traffic control other than that shown in the contract documents? ☐ Yes ☒ No

   If yes, please provide a brief explanation:

3. What was the basic method of handling traffic? (Check all that apply.)

   ☐ One Lane Operation Only (Flagging or signal)
   ☐ Shifting Lanes
   ☐ Closure/Detour
   ☐ Reduction in Number of Lanes
   ☐ Lane Width Reduction
   ☒ Other: Traffic used existing roadway while new structure was built adjacent

   a. Was this method short duration (during the construction day only) or used for multiple days/weeks?

      ☐ Short Duration
      ☒ Multiple

4. What was the length of time that traffic was impacted during the bridge construction and/or project? **6 months**

5. Was traffic impacted differently for the individual phases of the bridge construction project? **Yes**

6. What time of day did construction work occur that impacted traffic? **Mornings and evenings**

7. Was there traffic impact to the facility intersected (the feature beneath the bridge) as a result of bridge constructed? ☐ Yes ☒ No

8. Was a speed reduction required through the construction zone, and if so what was the posted speed? **No**

9. In your opinion was congestion due to construction traffic control noticeable?

   ☐ Yes ☒ No ☐ Intermittent ☐ Throughout project

B. Detour Information

1. Was a detour employed during bridge construction? ☐ Yes ☒ No

2. What was the nature of the detour? **n/a**

3. What was the time period of the detour? (in place during construction day only, permanent during construction period, etc.) **n/a**

4. What were the mile points at the start and end of the detour?
   Mile point at start: **n/a**
   Mile point at end: **n/a**

5. What was the length of the detour? **n/a**

6. What was the speed through the detour compared to the normal operating conditions of the detoured area? **n/a**

7. What was the impact to users as a result of the detour route? **n/a**

8. How much congestion was there along the detour route relative to normal operating conditions of the original route? **n/a**

9. Were variable message signs used? ☒ Yes ☐ No

10. Was a website and/or newsletters used? ☐ Yes ☒ No

C. Accidents During Construction for this Phase

1. Were there any accidents in the work zone during construction?
   ☐ Yes ☒ No

2. Were any of these accidents construction related, in your opinion?
   ☐ Yes ☒ No

Colorado Department of Transportation/University of Colorado
Bridge Research Project – Risk Based Structure Selection

PART 2 – CONSTRUCTION INFORMATION

Complete Sections A through C for each major construction phase (additional pages have been included for up to 3 phases. Add/complete more pages if necessary for additional phases).

Phase 3

A. Construction Traffic Control

1. Was traffic control required during construction? ☒ Yes ☐ No

2. Did the contractor propose and use an alternate method of traffic control other than that shown in the contract documents? ☐ Yes ☒ No

   If yes, please provide a brief explanation:

   ___

3. What was the basic method of handling traffic? (Check all that apply.)
   - ☐ One Lane Operation Only (Flagging or signal)
   - ☐ Shifting Lanes
   - ☐ Closure/Detour
   - ☐ Reduction in Number of Lanes
   - ☐ Lane Width Reduction
   - ☒ Other: Traffic used existing roadway while new structure was built adjacent

   a. Was this method short duration (during the construction day only) or used for multiple days/weeks?
   - ☐ Short Duration
   - ☒ Multiple

4. What was the length of time that traffic was impacted during the bridge construction and/or project? **6 months**

5. Was traffic impacted differently for the individual phases of the bridge construction project? **Yes**

6. What time of day did construction work occur that impacted traffic? **Morning and evening**

7. Was there traffic impact to the facility intersected (the feature beneath the bridge) as a result of bridge constructed? ☐ Yes ☒ No

8. Was a speed reduction required through the construction zone, and if so what was the posted speed? **No**

9. In your opinion was congestion due to construction traffic control noticeable?
   ☐ Yes ☒ No ☐ Intermittent ☐ Throughout project

B. Detour Information

1. Was a detour employed during bridge construction? ☐ Yes ☒ No

2. What was the nature of the detour? **n/a**

3. What was the time period of the detour? (in place during construction day only, permanent during construction period, etc.) **n/a**

4. What were the mile points at the start and end of the detour?
   Mile point at start: **n/a**
   Mile point at end: **n/a**

5. What was the length of the detour? **n/a**

6. What was the speed through the detour compared to the normal operating conditions of the detoured area? **n/a**

7. What was the impact to users as a result of the detour route? **n/a**

8. How much congestion was there along the detour route relative to normal operating conditions of the original route? **n/a**

9. Were variable message signs used? ☒ Yes ☐ No

10. Was a website and/or newsletters used? ☐ Yes ☒ No

C. Accidents During Construction for this Phase

1. Were there any accidents in the work zone during construction?
   ☐ Yes ☒ No

2. Were any of these accidents construction related, in your opinion?
   ☐ Yes ☒ No