

FINAL REPORT WY-1804F



State of Wyoming Department of Transportation

EVALUATION OF THE WYDOT RESEARCH CENTER AND RESEARCH CENTER (PHASE III)



By:

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FORWARD

The purpose of this study was to evaluate the effectiveness of the Wyoming Department of Transportation (WYDOT) Research Center. This study evaluated the performance of the proposals submitted to the WYDOT Research Advisory Committee (RAC) from 2011 to 2016, and developed a methodology for benefit-to-cost analysis (BCA) to be included as one of the future performance measures.

The developed methodology is an evaluation process that encompasses a multilevel analysis that focuses on the outcomes, implementable benefits, and results that research projects and the Research Center have generated. The methodology provides eight performance measurements that are used to summarize the findings of the evaluation. These performance measurements are quantifiable, meaning they are designed to place a score or value on the accomplishments of the Research Center which can then be used to make managerial decisions for the Research Center. For the BCA methodology, two types of costs were included to estimate overall costs: research and implementation. As the benefits depend on the type of strategic intent, a strategic-intent-specific methodology was developed.

The developed methodology was implemented for the WYDOT Research Center to demonstrate how the methodology can be utilized. It was found that the WYDOT Research Center was an effective and valuable asset for WYDOT and the transportation community. Specific recommendations and conclusions for the WYDOT Research Center are presented in the final chapter of this report. Final recommendations for implementing the methodology for any other agency looking to perform an evaluation of their Research Center are also presented in the final chapter of this report.

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<p>16. Abstract: An effective research center within a transportation organization can be a valuable asset to accomplish the goals of the overall mission. It is important to measure the benefits of transportation research center on a regular basis to determine if research budgets have been used effectively, and to maintain the support of management. The purpose of this study was to evaluate the effectiveness of the Wyoming Department of Transportation (WYDOT) Research Center.</p> <p>This study performed a detail analysis on the proposals submitted to Wyoming Department of Transportation (WYDOT) from 2010 to 2016 to evaluate the effectiveness of the Research Center. The analysis included the investigation of performance measures, and compared to the Phase II Study completed in 2012. These performance measures are quantifiable, meaning they are designed to place a score or value on the accomplishments of the Research Center which can then be used to make managerial decisions for the Research Center. As a part of the study, feedback and performance evaluation surveys were conducted from the Principal Investigators (PIs) and the WYDOT Project Champions. In addition, a methodology for benefit-to-cost analysis (BCA) was developed to be included as a future performance measure. This report summarized the analysis, and provided the conclusions and recommendations. Specific recommendations and conclusions for the WYDOT Research Center are presented in the final chapter of this report.</p>					
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Metric Conversion Table

SI* (MODERN METRIC) CONVERSION FACTORS						
Symbol	When You Know	Multiply By	To Find	Symbol	When You Know	Multiply By
LENGTH						
in	inches	25.4	millimeters	mm	millimeters	0.039
ft	feet	0.305	meters	m	meters	3.28
yd	yards	0.914	meters	m	meters	1.09
mi	miles	1.61	kilometers	km	kilometers	0.621
AREA						
in ²	square inches	645.2	square millimeters	mm ²	square millimeters	0.0016
ft ²	square feet	0.093	square meters	m ²	square meters	10.764
yd ²	square yard	0.836	square meters	m ²	square meters	1.195
ac	acres	0.405	hectares	ha	hectares	2.47
mi ²	square miles	2.59	square kilometers	km ²	square kilometers	0.386
VOLUME						
fl oz	fluid ounces	29.57	milliliters	mL	milliliters	0.034
gal	gallons	3.785	liters	L	liters	0.264
ft ³	cubic feet	0.028	cubic meters	m ³	cubic meters	35.314
yd ³	cubic yards	0.765	cubic meters	m ³	cubic meters	1.307
NOTE: volumes greater than 1000 L shall be shown in m ³						
MASS						
oz	ounces	28.35	grams	g	grams	0.035
lb	pounds	0.454	kilograms	kg	kilograms	2.202
T	short tons (2000 lb)	0.907	megagrams (or "metric ton")	Mg (or "t")	megagrams (or "metric ton")	1.103
TEMPERATURE (exact degrees)						
°F	Fahrenheit	5 (F-32)/9 or (F-32)/1.8	Celsius	°C	Celsius	1.8C+32
ILLUMINATION						
fc	foot-candles	10.76	lux	lx	lux	0.0929
1	foot-Lamberts	3.426	candela/m ²	cd/m ²	candela/m ²	0.2919
FORCE and PRESSURE or STRESS						
lbf	pound force	4.45	newtons	N	newtons	0.225
lb/ft ²	pound force per square inch	6.89	kilopascals	kPa	kilopascals	0.145
TEMPERATURE (exact degrees)						
	Fahrenheit		Fahrenheit		Fahrenheit	°F
ILLUMINATION						
fc	foot-candles	0.0929	foot-candles	fc	foot-candles	
1	foot-Lamberts	0.2919	foot-Lamberts	1	foot-Lamberts	
FORCE and PRESSURE or STRESS						
lbf	pound force	0.225	pound force	lbf	pound force	
lb/ft ²	pound force per square inch	0.145	pound force per square inch	lb/ft ²	pound force per square inch	

(Revised March 2003)

*SI is the symbol for the International System of Units. Appropriate to readings could be made to comply with Section 4 of ASTM E880.

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LIST OF ABBREVIATIONS AND SYMBOLS

Abbreviation	Meaning
AASHTO	American Association of State Highway and Transportation Officials
ADT	Average Daily Traffic
AHTD	Arkansas State Highway and Transportation Department
BCA	Benefit-to-Cost Analysis
BCR	Benefit-to-Cost Ratio
DOT	Department of Transportation
FAST Act	Fixing America's Surface Transportation Act
FHWA	Federal Highway Administration
MET	Metropolitan Economic Tool
NCHRP	National Cooperative Highway Research Center (NCHRP)
RAC	Research Advisory Committee
ROI	Return on Investment
SIT	Strategic Investment Tool
TIGER	Transportation Investment Generating Economic Recovery
VSL	Variable Speed Limit Systems
WYDOT	Wyoming Department of Transportation
WYT2/LTAP	Wyoming Technology Transfer Center

CHAPTER 1. INTRODUCTION

Transportation Research Centers are a valuable resource for both national and local agencies. The incorporation of a Research Center in state department of transportation is necessary for meeting the current and future needs of the agency. Many of these Research Centers have the potential to benefit multiple aspects of the transportation systems. It is important to measure the benefits of transportation Research Centers on a routine basis to determine if research budgets have been used effectively (Anderson 2010). The results from such study can be used to evaluate the expenditure of transportation funding and to determine the most appropriate use of available budgets. It is crucial that decision makers dedicate resources in the form of personnel and funding to the most appropriate aspects of transportation planning.

This study evaluated the performance of the 64 research proposals submitted to the Wyoming Department of Transportation (WYDOT) Research Advisory Committee (RAC) from 2011 to 2016. This study also developed a methodology to conduct a Benefit-to-Cost Analysis (BCA) for Research Centers.

Background

Evaluating Research Centers in Federal, state, and local transportation agencies is thought to be a necessity to attain the most efficient and relevant results from these programs. Evaluations of Research Centers ensure that transportation agencies get the highest return on their investments (Smallen 2000). A valuable Research Center in a transportation agency provides improvements in highway safety and enhances the progress of the overall organization by improving infrastructure, and cost avoidances for a variety of systems. When a Research Center is operating efficiently, not only does the sponsoring agency benefit, but also the entire transportation system (Krugler, et al. 2006).

In two previous phases of this study (Schneider, Redd and Ksaibati 2008, Terfehr and Ksaibati 2012), a methodology was developed for evaluation of the WYDOT Research Center. These studies developed a comprehensive process for monitoring the WYDOT Research Center based upon performance measures. In both phases the WYDOT Research Center was concluded to be an effective and valuable asset for WYDOT and the transportation community as a whole. This background section will discuss methodologies developed in the two previous phases.

In the Phase I study, [*Evaluation of WYDOT's Research Center and Research Center \(Phase I\)*](#), the study developed a methodology that identified ten performance measurements that were used to determine the direction, effectiveness, and accomplishments of the WYDOT Research Center. These performance measures were derived using a 2001 National Cooperative Highway Research Center (NCHRP) study, *Performance Measures for Research and Technology Programs* (Sabol 2001). From that study, and surveys taken from Department of Transportation (DOT)'s across the country, the ten performance measurements were selected. These measurements were created to link WYDOT's strategic goals to its Research Center. The goals of the performance measurements are to improve the management of the Research Center by linking program funding, program strategy, and project selection to support WYDOT's strategic plan.

In the Phase II study, [*Evaluating Department of Transportation's Research Center: A Methodology and Case Study*](#) (Phase 2) , a case study of WYDOT's Research Center was completed to demonstrate the use and benefits of the developed methodology. The ten performance measurements developed in the previous study (Phase I) were implemented to evaluate the performance of WYDOT's Research Center. The evaluation focused on the research conducted by WYDOT Research Center from 2005 to 2010. It was found that the WYDOT Research Center is an effective and productive program. The program is able to fund a variety of projects that benefit the traveling public, its employees, as well as the transportation community. The organization of the Research Center allows it to remain flexible and proactive when addressing changing research projects as they evolve throughout their life cycle. The outcomes and results of WYDOT's research projects are beneficial and implementable not only by WYDOT but also by the entire transportation community.

Problem Statement

Evaluating the effectiveness and relevance of DOT Research Center will be a necessity as the funding for these programs becomes performance based. Traditionally, some transportation Research Centers in the United States were allocated funding based on earmarks. Earmarks are provisions in legislation that allocates money for certain programs. In more recent transportation legislation, earmarks are being cut and programs like transportation research are now competing for funding. The future of transportation legislation could decrease or drop earmarking completely. DOT Research Centers could also face similar funding cutbacks if the trends in transportation legislation remain. DOT Research Centers that can perform evaluations on the funded projects, the overhead they incur, and on the effectiveness of the program as a whole will probably improve the outputs of their programs as opportunities for improvement can be identified. Having such evaluations in place will also ensure DOT Research Centers stay competitive with one another and continue to receive the federal funding they require to operate (Barrella, et al. 2010).

In 2017, the WYDOT Research Center contacted the Wyoming Technology Transfer Center (WYT2/LTAP), at the University of Wyoming, to develop a methodology to incorporate a benefit-cost analysis. The WYDOT Research Center is interested in identifying the types of cost benefits that should go into the decision-making process when selecting research projects; what project evaluation measures should be used; and what the relevant methods for analysis and presentation should be. The Research Center is also interested in ways to translate the effects of the investment in the research project into monetary terms and ways to account for the fact that the benefit accrues over a long period of time while capital costs are incurred primarily in the implementation stage.

An evaluation method called BCA is proposed in this report that can be utilized by DOT Research Centers to ensure that they are a valuable asset, not only to their sponsoring organization, but also to the research community as a whole (Adams and Marach 2012). BCA attempts to summarize the overall value of cost of a project or proposal. Federal and state DOT's can use this type of analysis to (1) determine if a decision is feasible; and (2) provide basis for comparing different Research Centers. The methodology is presented in the coming chapters of this report with a case study of how the methodology can be utilized through the WYDOT Research Center.

Research Objectives

The objectives of this study are to:

1. Evaluate performance of the WYDOT Research Center based on the research studies that were conducted after Phase II evaluation in 2010. Since 2010, the performance measures recommended in Phase II have been implemented.
2. Develop strategies that will implement real benefit-to-cost analyses on the performance measures currently used by the WYDOT Research Center.
3. Provide conclusions and recommendations about the effectiveness of the WYDOT Research Center.
4. Make recommendations for implementing the developed methodology for other DOT Research Centers.

Report Organization

A total of eight chapters are contained in this report. Chapter 2, the Literature Review, contains the background information in performance measures and methodologies used in different research centers. A brief introduction of BCA in evaluating transportation investment decisions is also discussed in Chapter 2. In Chapter 3, an overall evaluation methodology developed and used in this study was discussed. Chapter 4 evaluated the performance measures for the proposals submitted from 2010 to 2016. Chapter 5 compares the results of the performance measures with the previous study completed in 2012. Chapter 6 summarizes the surveys conducted for each research project started and completed between January 2011 and July 2017. Chapter 7 developed a methodology for BCA analysis. The conclusions and recommendations of the report are discussed in Chapter 8.

CHAPTER 2. LITERATURE REVIEW

Introduction

This chapter summarizes performance measures and methodologies used in different research studies to evaluate the effectiveness of a research center. As this study focused on the effectiveness of a research center in a state DOT, this literature review was conducted on the performance measures used in other state DOTs. Before discussing the performance measures, a discussion about the research funding allocated to a transportation research center in a state DOT was investigated. Then, the performance measures were discussed to evaluate the effectiveness of a research center of other state DOTs along with WYDOT.

Surface Transportation Funding vs. Research Funding

The [*Fixing American's Surface Transportation Act \(FAST Act\)*](#), authorized the Federal surface transportation programs through fiscal year 2020. The Act grows highway investment from \$40.3 billion to \$46.4 billion - an average annual increase of nearly 3 percent (ARTRA 2016). Table 1 and Figure 1 show the growth of spending over the years from 2015 to 2020. Every year, a small portion of the budget is allocated to research. In 2015, \$115 million was allocated for Highway Research and Development Program to conduct research. In Wyoming, WYDOT is responsible for maintaining the interstates and highways and their budget is about \$633 million annually (WYDOT 2017). Of this budget, approximately \$1.3 million is allocated to research. During 2011 to 2016, a total \$5.6 million was expended in research. The Federal share of the total budget is approximately 47 percent (see Table 2).

Current Performance Measures of WYDOT Research Center

In 2012, a Phase II study was conducted entitled *Evaluating Department of Transportation's Research Center: A Methodology and Case Study* to evaluate the effectiveness of WYDOT's Research Center (Terfehr and Ksaibati 2012). This 2012 study performed a literature review on the performance measurements used in business and government agencies followed by the detailed analysis on the following performance measurements:

- Number of Projects and Amount of Funding per Project by Strategic Intent
- Number of Proposals Responding to Research Center Solicitations
- Number of Needs Statements Submitted by the Agency's Programs
- Outcomes of the Research Projects
- Number of Research Reports Completed Each Year
- Cost-benefit analysis for Individual Projects and the Research Center
- Percentage of Administrative Costs to Overall Program Funding
- Funds Requested by the Research Community versus Funds Available
- Percentage of Projects Completed On-time and Within Budget

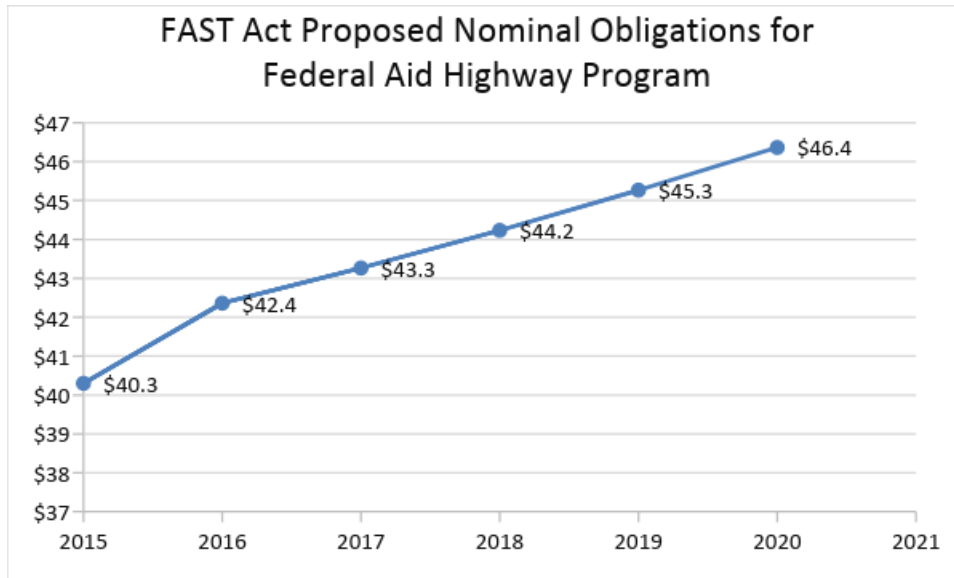
In this Phase III study, all the performance measures mentioned above were evaluated along with developing a BCA methodology. This study performed a detailed literature review on the BCA (see section entitled "Benefit-to-Cost Analysis") that are currently being used in other state

DOTs. Based on this investigation, a methodology was developed to perform BCA as shown in Chapter 3: Evaluation Methodology.

Table 1. Total Federal Spending for Highways.

	FY2015	FY2016	FY2017	FY2018	FY2019	FY2020
	<u>Authorization</u>	<u>Authorization</u>	<u>Authorization</u>	<u>Authorization</u>	<u>Authorization</u>	<u>Authorization</u>
Federal-aid Highway Program (Apportioned):	37,798,000,000	39,727,500,000	40,547,805,000	41,424,020,075	42,358,903,696	43,373,294,311
<i>Estimated Split Among Programs:</i>						
National Highway Performance Program	22,397,991,758	22,332,260,060	22,827,910,827	23,261,963,879	23,741,388,895	24,235,621,114
Surface Transportation Block Grant Program	10,302,372,972	11,162,564,768	11,424,412,150	11,667,786,566	11,876,329,314	12,136,990,131
Highway Safety Improvement Program (HSIP)	2,241,317,774	2,225,594,512	2,275,061,630	2,317,759,770	2,359,554,152	2,407,423,445
Railway-Highway Crossings Program	220,000,000	225,000,000	230,000,000	235,000,000	240,000,000	245,000,000
Safety-related Programs (allocated set-aside from HSIP)	0	3,500,000	3,500,000	3,500,000	3,500,000	3,500,000
Congestion Mitigation and Air Quality Improvement Program	2,315,856,307	2,309,059,935	2,360,308,101	2,405,187,322	2,449,216,207	2,498,960,969
Metropolitan Planning Program	320,461,189	329,270,722	335,938,378	342,996,446	350,360,775	358,516,037
National Highway Freight Program ³	0	1,140,250,003	1,090,673,914	1,189,826,092	1,338,554,353	1,487,282,615
FHWA Administration Expenses:	440,000,000	453,000,000	459,795,000	466,691,925	473,692,304	480,797,689
General Administration/ARC	415,000,000	429,000,000	435,795,000	442,691,925	449,692,304	456,797,689
On-the-Job Training	10,000,000	10,000,000	10,000,000	10,000,000	10,000,000	10,000,000
Disadvantaged Business Enterprises	10,000,000	10,000,000	10,000,000	10,000,000	10,000,000	10,000,000
Highway Use Tax Evasion Projects	2,000,000	4,000,000	4,000,000	4,000,000	4,000,000	4,000,000
Other Programs from Administrative Expenses	3,000,000	0	0	0	0	0
Federal Lands & Tribal Transportation:	1,000,000,000	1,050,000,000	1,075,000,000	1,100,000,000	1,125,000,000	1,150,000,000
Tribal Transportation ⁴	450,000,000	465,000,000	475,000,000	485,000,000	495,000,000	505,000,000
Federal Lands Transportation	300,000,000	335,000,000	345,000,000	355,000,000	365,000,000	375,000,000
Federal Lands Access ⁴	250,000,000	250,000,000	255,000,000	260,000,000	265,000,000	270,000,000
Other Programs:	1,387,000,000	1,677,000,000	1,715,000,000	1,775,000,000	1,840,000,000	1,890,000,000
TIFIA	1,000,000,000	275,000,000	275,000,000	285,000,000	300,000,000	300,000,000
Territorial and Puerto Rico Highway	190,000,000	200,000,000	200,000,000	200,000,000	200,000,000	200,000,000
<i>Puerto Rico Highway [non-add]</i>	<i>150,000,000</i>	<i>158,000,000</i>	<i>158,000,000</i>	<i>158,000,000</i>	<i>158,000,000</i>	<i>158,000,000</i>
<i>Territorial Highway [non-add]</i>	<i>40,000,000</i>	<i>42,000,000</i>	<i>42,000,000</i>	<i>42,000,000</i>	<i>42,000,000</i>	<i>42,000,000</i>
Nationally Significant Freight and Highway Projects	0	800,000,000	850,000,000	900,000,000	950,000,000	1,000,000,000
Construction of Ferry Boats ⁵	67,000,000	80,000,000	80,000,000	80,000,000	80,000,000	80,000,000
Emergency Relief	100,000,000	100,000,000	100,000,000	100,000,000	100,000,000	100,000,000
Nationally Significant Federal Lands and Tribal Projects (<i>General Fund</i>) ⁶	30,000,000	100,000,000	100,000,000	100,000,000	100,000,000	100,000,000
Appalachian Regional Development Program (<i>General Fund</i>)	0	110,000,000	110,000,000	110,000,000	110,000,000	110,000,000
Regional Infrastructure Accelerator Demonstration Program (<i>General Fund</i>)	0	12,000,000	0	0	0	0
Transportation Research:	400,000,000	414,500,000	417,500,000	417,500,000	420,000,000	420,000,000
Highway Research & Development	115,000,000	125,000,000	125,000,000	125,000,000	125,000,000	125,000,000
Technology & Innovation Deployment	62,500,000	67,000,000	67,500,000	67,500,000	67,500,000	67,500,000
Training and Education	24,000,000	24,000,000	24,000,000	24,000,000	24,000,000	24,000,000
Intelligent Transportation Systems (ITS)	100,000,000	100,000,000	100,000,000	100,000,000	100,000,000	100,000,000
University Transportation Centers	72,500,000	72,500,000	75,000,000	75,000,000	77,500,000	77,500,000
Bureau of Transportation Statistics	26,000,000	26,000,000	26,000,000	26,000,000	26,000,000	26,000,000
TOTAL CONTRACT AUTHORITY (Highway Account of the Highway Trust Fund)	40,995,000,000	43,100,000,000	44,005,100,000	44,973,212,000	46,007,596,000	47,104,092,000
TOTAL GENERAL FUND (Subject to Appropriation)	30,000,000	222,000,000	210,000,000	210,000,000	210,000,000	210,000,000
GRAND TOTAL AUTHORIZATIONS	41,025,000,000	43,322,000,000	44,215,100,000	45,183,212,000	46,217,596,000	47,314,092,000

Source: ARTRA. 2016. "“Fixing America’s Surface Transportation Act” A Comprehensive Analysis."



Source: ARTRA. 2016. "“Fixing America’s Surface Transportation Act” A Comprehensive Analysis."

Figure 1. Increase in Federal Spending for Highways, 2015-2020.

Table 2. Total Federal Spending for Highways in States.

State	Actual FY 2015	Est. FY 2016	Est. FY 2017	Est. FY 2018	Est. FY 2019	Est. FY 2020	FY 2016 to 2020 Total	FY 2016 to 2020 Average
Alabama	732,263,043	769,571,910	785,463,731	802,438,701	820,550,261	840,202,114	4,018,226,717	803,645,343
Alaska	483,955,039	508,614,600	519,117,557	530,336,370	542,306,359	555,294,332	2,655,669,218	531,133,844
Arizona	706,182,063	742,166,445	757,492,248	773,862,621	791,329,101	810,281,016	3,875,131,431	775,026,286
Arkansas	499,714,166	525,175,061	536,020,027	547,604,161	559,963,932	573,374,836	2,742,138,017	548,427,603
California	3,542,468,412	3,723,001,547	3,799,881,396	3,882,001,196	3,969,619,475	4,064,689,233	19,439,192,847	3,887,838,569
Colorado	516,112,989	542,412,699	553,613,557	565,577,841	578,343,213	592,194,216	2,832,141,526	566,428,305
Connecticut	484,770,705	509,473,713	519,994,372	531,232,092	543,222,256	556,232,120	2,660,154,553	532,030,911
Delaware	163,267,961	171,587,491	175,130,787	178,915,587	182,953,804	187,335,451	895,923,120	179,184,624
Dist. of Col.	154,002,708	161,850,034	165,192,253	168,762,270	172,571,324	176,704,316	845,080,197	169,016,039
Florida	1,828,689,002	1,921,860,645	1,961,547,473	2,003,939,263	2,049,169,471	2,098,246,272	10,034,763,124	2,006,952,625
Georgia	1,246,238,772	1,309,739,819	1,336,786,115	1,365,675,824	1,396,499,894	1,429,945,392	6,838,647,044	1,367,729,409
Hawaii	163,244,192	171,562,378	175,105,158	178,889,407	182,927,036	187,308,045	895,792,024	179,158,405
Idaho	276,061,294	290,127,532	296,118,707	302,518,228	309,346,239	316,754,938	1,514,865,644	302,973,129
Illinois	1,372,231,384	1,442,156,608	1,471,937,238	1,503,747,647	1,537,687,978	1,574,514,759	7,530,044,230	1,506,008,846
Indiana	919,668,926	966,529,532	986,488,498	1,007,807,822	1,030,554,618	1,055,235,912	5,046,616,382	1,009,323,276
Iowa	474,345,450	498,513,780	508,808,186	519,804,234	531,536,542	544,266,622	2,602,929,364	520,585,873
Kansas	364,737,449	383,321,318	391,236,975	399,692,143	408,713,444	418,501,959	2,001,465,839	400,293,168
Kentucky	641,292,458	673,966,719	687,884,265	702,750,398	718,611,920	735,822,382	3,519,035,684	703,807,137
Louisiana	677,413,014	711,927,496	726,628,943	742,332,405	759,087,323	777,267,157	3,717,243,324	743,448,665
Maine	178,165,560	187,243,965	191,110,574	195,240,722	199,647,412	204,428,868	977,671,541	195,534,308
Maryland	580,007,300	609,563,599	622,151,114	635,596,565	649,942,279	665,508,023	3,182,761,580	636,552,316
Massachusetts	586,191,765	616,064,316	628,786,048	642,374,865	656,873,544	672,605,261	3,216,704,034	643,340,807
Michigan	1,016,207,628	1,067,989,869	1,090,043,951	1,113,601,188	1,138,735,743	1,166,007,859	5,576,378,610	1,115,275,722
Minnesota	629,372,872	661,441,891	675,100,754	689,690,575	705,257,282	722,147,855	3,453,638,357	690,727,671
Mississippi	466,803,812	490,587,875	500,718,610	511,539,831	523,085,607	535,613,291	2,561,545,214	512,309,043
Missouri	913,719,741	960,274,903	980,104,758	1,001,286,170	1,023,885,822	1,048,407,455	5,013,959,108	1,002,791,822
Montana	396,007,464	416,184,959	424,779,247	433,959,302	443,754,023	454,381,736	2,173,059,267	434,611,853
Nebraska	278,976,662	293,191,186	299,245,632	305,712,735	312,612,854	320,099,792	1,530,862,199	306,172,440
Nevada	350,472,546	368,332,024	375,938,098	384,062,585	392,731,061	402,136,745	1,923,200,513	384,640,103
New Hampshire	159,469,843	167,595,715	171,056,584	174,753,337	178,697,613	182,977,330	875,080,579	175,016,116
New Jersey	963,682,664	1,012,792,050	1,033,706,218	1,056,045,847	1,079,881,265	1,105,743,762	5,288,169,142	1,057,633,828
New Mexico	354,439,590	372,498,916	380,191,084	388,407,532	397,174,128	406,686,276	1,944,957,936	388,991,587
New York	1,620,088,460	1,702,649,572	1,737,809,280	1,775,365,392	1,815,436,141	1,858,914,699	8,890,175,084	1,778,035,017
North Carolina	1,006,630,450	1,057,922,052	1,079,768,287	1,103,103,510	1,128,001,186	1,155,016,278	5,523,811,313	1,104,762,263
North Dakota	239,621,802	251,831,294	257,031,648	262,586,445	268,513,174	274,943,940	1,314,906,501	262,981,300
Ohio	1,293,739,008	1,359,663,237	1,387,740,399	1,417,731,235	1,449,730,162	1,484,450,429	7,099,315,462	1,419,863,092
Oklahoma	612,127,810	643,315,998	656,600,603	670,790,656	685,930,829	702,358,595	3,358,996,681	671,799,336
Oregon	482,423,497	507,004,353	517,474,070	528,657,381	540,589,488	553,536,361	2,647,261,653	529,452,331
Pennsylvania	1,583,603,275	1,664,296,550	1,698,664,445	1,735,374,776	1,774,543,112	1,817,042,511	8,689,921,394	1,737,984,279
Rhode Island	211,081,927	221,837,373	226,418,345	231,311,545	236,532,377	242,197,215	1,158,296,855	231,659,371
South Carolina	646,306,850	679,236,584	693,262,955	708,245,330	724,230,875	741,575,911	3,546,551,655	709,310,331
South Dakota	272,190,802	286,059,805	291,966,983	298,276,779	305,009,059	312,313,885	1,493,626,511	298,725,302
Tennessee	815,605,297	857,163,013	874,863,555	893,770,525	913,943,445	935,831,968	4,475,572,506	895,114,501
Texas	3,331,596,800	3,501,354,175	3,573,657,617	3,650,889,094	3,733,291,741	3,822,702,306	18,281,894,933	3,656,378,987
Utah	335,148,600	352,225,393	359,498,902	367,268,156	375,557,614	384,552,048	1,839,102,113	367,820,423
Vermont	195,886,832	205,868,282	210,119,484	214,660,438	219,505,440	224,762,485	1,074,916,129	214,983,226
Virginia	982,180,040	1,032,226,472	1,053,542,076	1,076,310,501	1,100,603,428	1,126,962,342	5,389,644,819	1,077,928,964
Washington	654,304,963	687,644,962	701,844,910	717,012,693	733,196,062	750,755,744	3,590,454,371	718,090,874
West Virginia	421,797,542	443,288,929	452,442,922	462,220,829	472,653,435	483,973,279	2,314,579,394	462,915,879
Wisconsin	726,226,908	763,229,980	778,990,803	795,825,845	813,788,109	833,277,970	3,985,112,707	797,022,541
Wyoming	247,262,623	259,861,381	265,227,558	270,959,481	277,075,196	283,711,020	1,356,834,636	271,366,927
Apportioned Total	37,798,000,000	39,724,000,000	40,544,305,000	41,420,520,075	42,355,403,696	43,369,794,311	207,414,023,082	41,482,804,616

Source: ARTRA. 2016. "'Fixing America's Surface Transportation Act' A Comprehensive Analysis."

Benefit-to-Cost Analysis

Applying BCA in decision making is beneficial in demonstrating accountability within a transportation agency. BCA is meant to identify the benefits to the users of the system and the costs to the agency, providing relative transparency for investment decisions. BCA aims to ensure that transportation investment decisions are based on more than immediate benefits and initial construction costs, and include measures to quantify projected savings in travel time and vehicle operating costs, and reduction in accidents, while also examining life cycle costs of a project. Federal and State DOT's can use this type of analysis to measure the efficiency of spending from the viewpoint of benefits and costs to society, ensuring that the taxpayers receive the best return on investment (ROI) possible (TCRP 2002). At the network or program level, BCA can play a critical role in the development of an overall program to improve its long-term performance. High quality BCA is regarded as having as many of the following characteristics as possible:

- Comprehensiveness (i.e. all societal impacts are included, but only once)
- High reliability of the data and forecasts used to generate estimates
- Appropriate monetization factors, discount rate, and analytical timeframe
- Comparison against a credible baseline
- Consideration of reasonable alternatives, where relevant
- Inclusion of sensitivity analysis or other treatment of uncertainty
- Overall transparency and replicability of the analysis

For both transportation infrastructure, and research and development, the peak benefits traditionally occur in the later years of the investment. It is important to consider the fact that benefits can take the form of improved long-term performance through having larger initial investments and/or investments in preservation. Projects that yield desirable present or short-term benefits may be undertaken based on an immediate need without regard to long-term ROI or strategic goals.

The need to meet the Nation's increasing demand on its transportation system with diminishing capital and resources poses a significant challenge to transportation decision makers. Overall, the national transportation infrastructure is very aged, and because of a focus on reactionary measures instead of strategic, long-term investments, transportation investment options are becoming increasingly expensive. Federal and State DOT's need to allocate every bit of funding efficiently, and as such have opportunities to implement proactive strategies in decision making framework, of which BCA is a critical tool.

To date, there is significant variation in the extent of the use of BCA in state DOT's, with most states using it only for specific project types or planning stages or when it is required for funding. Some states require BCA for projects they deem large or significant or where there is intended safety improvements. Some state DOT's use alternatives to BCA, including life-cycle cost analysis and multifactor scoring systems. Overall, however, there is little institutional support within a number of DOT's for conducting BCA because it is not necessary for most Federal funding programs and existing prioritization and proposal evaluation methods are believed to be working efficiently. Only about 5-6 state DOT's employ the use of systematic BCA in their decision-making, while the others perform it irregularly or only for proposals applying for the

federal Transportation Investment Generating Economic Recovery (TIGER) grant, which requires a BCA. It is perceived that if more Federal programs required BCA than it would certainly influence state DOTs' implementation and use of it.

In agencies where BCA is used, it most commonly isn't a strong predictor of project selection, with factors including public opinion, political support, and available funding having a much greater influence on selection. BCA and its associated data and modeling needs can also prove to be strenuous on agency resources; it may require specialized expertise not present in the organization or may require more working hours, therefore, more funds than other prioritization methods.

The focus of BCA (in DOT's where it is employed) is on impact areas with relatively accessible and straightforward data, methodologies, and monetization factors; most commonly quantified being safety impacts and travel time. Some of the more complex benefits to quantify include emissions, freight, and human environment. Quality issues with state DOTs' BCA methods include improper baselines, speculative benefits, inaccurate traffic demand modeling, and a general lack of transparency and reproducibility. Because, state DOT's are just as likely to adopt a multi-criteria prioritization approach over BCA because of how transparent and objective it can be and the notion that it is easily understood and conveyed. Also, state DOT's using BCA may have a tendency to quantify benefits in a biased manner by focusing on their constituents and expenditures instead of focusing on benefits accruing to and costs borne by all users. In the following sections, current practices to evaluate BCA in different state DOT's are discussed (FHWA 2017).

Arkansas State Highway and Transportation Department (AHTD)

The Arkansas State Highway and Transportation Department (AHTD) uses BCA in safety, planning, and project prioritization areas, as well as multi-factor assessment and engineering judgement for other project types. For safety improvements, BCA is done during project development; forecasts of potential crashes avoided are computed based on historical crash data and a standardized crash modification factor. Crashes avoided are monetized using the KABCO injury scale where: (K = Fatal, A= Incapacitating, B=Non-Incapacitating, C= Not visible but complains of pain, and O = uninjured). The current value of approximately \$5.5 million per fatality avoided. For corridor and planning studies, AHTD performs BCA that draw on methodologies from Federal Highway Administration (FHWA) and the American Association of State Highway and Transportation Officials (AASHTO), specifically emphasizing travel time cost savings, with qualitative assessments of factors including environmental and economic impacts also being considered. In prioritizing projects, AHTD uses a weighted scoring system where each project is gauged against a multi-criteria list. While this process does also estimate impact categories using travel demand models and calculates a measure of ROI and BCA, these are not stand-alone metrics but are assigned scores in the weighted multi-factor analysis. AHTD conducts most of its BCA work in-house, with consultant support on long-range plans and state freight plans. AHTD is actively trying to improve the quality of the data used in analysis and prioritization, expanding their BCA to become more comprehensive, and conducting analysis on local economic impacts. AHTD has been exploring opportunities with using the EconWorks tool, and the REMI and IMPLAN models. Both the multi-criteria scoring and BCA

methodologies are viewed as objective and the process is vetted so as to move away from subjective decision making to performance and merit-based decision making.

California DOT

BCA is widely utilized in the California DOT (CalTrans), having been first introduced in the 1990's. The main model used for BCA is the Excel-based Cal-B/C (short for the California Life-Cycle Benefit and Cost Analysis Model). Cal-B/C is mainly used in sketch-planning and evaluating alternatives, and is capable of analyzing a large variety of project types, being one of the very few multimodal tools available. While the tool has input for nearly all metrics employed in BCA, including congestion, travel times, Average Daily Traffic (ADT), crash data, operating costs, and project details and costs, it does not include induced demand over time. Because of this, the ADT for the no-build scenario will be the same for the 20-year projection as it is presently, as well as the ADT for the no-build and build options presently being identical. This can be a weakness of the tool because these ADT's are applied to travel demand models which produce the forecasted travel metrics to be included in the BCA.

Connecticut DOT

Connecticut DOT (ConnDOT) employs the use of BCA extensively only in projects areas where safety is expected to be improved. ConnDOT's basic methodology has been in place for about 40 years and its overall approach is to gather historical accident data and apply engineering estimates of the "crash reduction factor" associated with the suggested alternatives. The resulting "crashes avoided" are then converted to monetary terms using estimates on the costs of unintentional fatal, injury, or non-injury accidents from the National Safety Council. Most of ConnDOT's BCA is done in-house using an Excel-based tool, but is not done on projects included in FHWA's list of Proven Safety Countermeasures due to their proven cost-effectiveness. Even among safety-related projects, BCA is not the only criterion evaluated due to the uncertainty of projected accident rates and reductions because, generally, actual crash reductions tend to be lower than forecasted. For projects outside of safety, ConnDOT does not conduct BCA and uses a more informal approach where public and political support and funding availability weigh heavily in the decision making process.

Florida DOT

Florida DOT (FDOT) currently employs BCA in a number of settings and is expanding its use alongside other decision-support tools. FDOT's BCA strategies stem from a 2003 Analysis of Work Program, which was prepared using the REMI model of economic analysis and covered projects in highway, transit, and rail. The study was updated in 2006, 2009, and 2015; it was expanded to encompass additional modes, such as sea-and airports, as well as more precise highway safety benefits; and it also includes impacts on the state's employment, income, and other areas of economic analysis. FDOT uses a hybrid approach to project prioritization, a scoring system called the Strategic Investment Tool (SIT). The SIT is used to analyze most project and funding areas. Large projects with capital costs near or greater than \$100 million are also subject to BCA using FDOT's Metropolitan Economic Tool (MET). The SIT scores are calculated primarily with engineering metrics such as crash ratios, volume/capacity ratios, and

level of service, but also include qualitative assessments such as impact on quality of life and alignment with strategic plan goals. The MET analyzes traditional BCA metrics, including travel time and user cost savings, safety improvements, and emissions avoided, and has adopted DOT guidance for the monetization of benefits and other aspects of BCA. It is believed that examining previous forecasts for areas contributing to BCA estimates in order to assess their accuracy would be a valuable research area, if and when FDOT is able to allocate staff hours and/or funding.

Minnesota DOT

Minnesota DOT (MnDOT) regularly uses BCA and is often cited as a national leader in its use. MnDOT's use of BCA is primarily governed by a 2003 Cost-Effectiveness Policy and follows a three-step approach. The first is a conventional BCA using guidelines from AASHTO's User and Non-User Benefit Analysis for Highways and state-specific monetization factors, the second is a "best value assessment" of project alternatives, and the third is a review of additional impacts that are more difficult to quantify, such as economic development. The BCA itself is usually contracted to consultants as part of the broader environmental documentation, and MnDOT establishes the approach and provides recommended values for travel time savings, vehicle operating costs, crashes avoided (by severity), and discount rates, which are updated annually. Currently, the value attributed to a fatal crash avoided is \$10.6 million, based on DOT guidance, and the suggested discount rate is 1.7percent, which is based on the inflation-adjusted return on 30-year treasury bonds. Similar to other agencies, MnDOT does not use the results of BCA to allocate funding or as a primary factor in prioritization, but rather serves as a procedural check to ensure that there is consideration for the most cost-effective alternatives within a project and that selected projects do provide net benefits. MnDOT does, however, continuously evaluate its use of BCA to determine whether or how to expand and update its applications. As such, MnDOT recently incorporated BCA into the application process for two competitive funding solicitations, thus having a greater role in the ranking and evaluation of proposals.

Nevada DOT

Nevada DOT (NDOT) is required by state law to perform a BCA (prior to funding approval) for all projects intended to expand capacity and are expected to cost at least \$25 million. The law requires a present-value framework with factors such as capital and operating costs, safety impacts, environmental impacts, and user costs and travel times encompassed in the BCA. NDOT's Performance Analysis division is responsible for communicating projects that require BCA in an annual BCA plan intended to manage workflow. This plan may also include projects under the \$25 million benchmark, if BCA is perceived as useful in decision making for that project. Most of NDOT's BCA is completed under contracts with state universities, with some being done in-house, using a software tool that was adapted from CalTrans' Cal-B/C model. This model produces output of travel times, safety, vehicle operating costs, and emissions from inputs of forecasted travel demand, congestion and safety data. NDOT has established standardized procedures for monetary values to be used in their tool, such as travel time savings, user costs (fuel and other), accidents, and emissions. These procedures and values were derived from a variety of sources, including the AASHTO Highway Safety Manual, the California Air Resources Board, and the statewide accident and VMT data. NDOT currently uses the KABCO

scale for injury prevention, which places a value of \$5.3 million per fatal accident avoided. Having been in place since 2011, NDOT's BCA policy has received little or no criticism, but past projects have not been reviewed to assess the accuracy of its forecasted BCA. Also, BCA results are only one factor examined during prioritization of projects, with qualitative community, cultural, economic, and freight impacts being considered.

North Carolina DOT

North Carolina DOT (NCDOT) uses a multi-criteria scoring approach to prioritize its capital projects, though there are some BCA elements within the scoring system. This approach was first implemented in 2009, with the goal of moving toward a more data driven and transparent decision making process, and included three main criteria: congestion, safety, and pavement condition. Presently, legislation requires all projects be prioritized according to a quantitative scoring system, with "statewide mobility" (mainly highway) project prioritization based almost exclusively on the scoring results, while "regional impact" and "division needs" (i.e. air and sea travel, pedestrian/bicyclist improvement) projects being prioritized by their scores as well as public input. Data collection and scoring is predominantly done in-house by NCDOT. The scoring system for highway and mobility projects considers congestion, BCA, economic competitiveness, safety, and multimodal/freight/military impacts. The BCA is not a conventional one, but instead a monetized measure of projected travel time savings and safety improvements over a 10-year period, divided by NCDOT's share of the project costs (funding from other sources are not included in NCDOT's cost, thus projects with higher percentages of external funding receive a higher mark). Travel time savings are measured through a travel demand model and valued at about \$12.75 per hour for passenger cars and \$75 per hour for trucks, with metrics such as user operating costs and emissions reduction not being estimated. Safety improvements are estimated using crash reduction factors and are assessed using the KABCO scale, having values of roughly \$4.5 million for fatal/critical accidents, \$117,000 for moderate-to-minor, and \$6,700 for property-damage-only accidents. The 10-year forecast of travel time savings and safety benefits are simply summed, without discounting to present value or adjusting for residual value at the end of the 10-year period. Although it deviates greatly from standard BCA, NCDOT's BCA methodology is not being examined akin to how a standard BCA would be, but rather as a ratio that is scored and encompassed in the multi-criteria evaluation process. Overall, NCDOT's current prioritization process has received positive feedback and is in accordance with law requiring consideration of other quantitative factors, which would be difficult to reproduce using exclusively BCA. It also should be noted that after the 2013 legislation requiring quantitative prioritization, NCDOT formed a stakeholder committee comprised of representatives from MPO's, RPO's, and municipal agencies to form the basis of what would become the scoring criteria. This is perceived to have greatly facilitated the understanding and acceptance of this methodology in the transportation community.

Chapter Summary

Research Centers have significant impacts in transportation technology and planning. The benefits of transportation Research Centers can take many forms. For this reason it is difficult to compile and evaluate these contributions to the various aspects of transportation programs and operations. Various types of benefits were gathered by other state DOTs to understand how the

projects contributed to the transportation systems. There are several performance measures that can be used to evaluate the overall performance of transportation Research Centers. In addition, one of the most commonly used evaluation methods is benefit-to-cost analysis, which compares total incremental benefits with total incremental costs. All of the mentioned methods in this chapter can be used to determine the overall value of a Research Center.

CHAPTER 3. EVALUATION METHODOLOGY

The methodology presented in this chapter can be used to evaluate the performance and effectiveness of the WYDOT Research Center. The breakdown of overall methodology is laid out in Figure 2. The methodology focuses on evaluating performance measures of a set of research projects for a specific time period. The performance evaluation is then compared the 2012 Phase II study (Terfehr and Ksaibati 2012). As a part of the performance evaluation, a survey was sent to Principal Investigators (PI) and the WYDOT Project Champions. Additionally, a methodology was developed to estimate Benefit-to-Cost Ratio (BCR) for each project to be used for future performance evaluation.

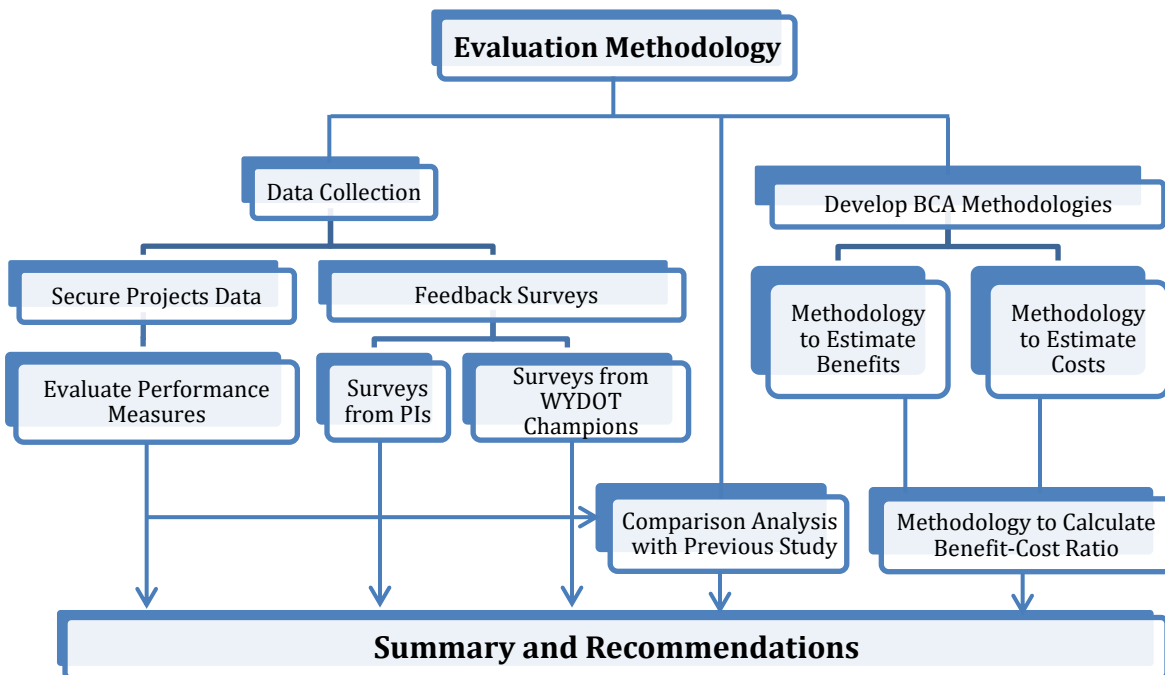


Figure 2. Breakdown of the Evaluation Methodology.

Data Collection

Two types of data were collected in this study: project data gathered from the WYDOT Research Center staff, and data from survey conducted using the Principal Investigators and Projects Champions as respondents. Further, the project data consists of information gathered from all projects proposed and/or funded for a specific time period. The project data consists of the following essential information: proposal data, project I.D., project title, project type, strategic intent, Principal Investigator, sponsoring organizations, WYDOT Project Champion, project area, funding, decision, project start date, and estimated completion date. The survey data is a compilation of responses from the PI and Project Champions. It provides the feedback to

improve the proposal process. In addition, the survey data can identify the level of implementation, benefits, costs, and technology transfer associated with each research project.

Performance Measures

In order to evaluate the effectiveness of the Research Center, the following performance measures were identified:

1. Number of projects and amount of funding per project by strategic intent.
2. Number of proposals responding to the Research Center solicitations.
3. Number of needs statements submitted by the agency's programs.
4. Outcomes of the research projects
5. Number of research reports completed each year
6. Benefit-to-cost analysis for individual projects.
7. Percentage of administrative costs to overall program funding.
8. Funds requested by research community versus funds available.
9. Percentage of projects completed on-time and within budget.

The performance measures listed above should be collected on the proposals submitted and approved for a specific period of time. These measures are also a way to organize the findings of the projects to evaluate the effectiveness of the Research Center. The first performance measure is an overall indication of the direction in which the Research Center is moving. For example, the WYDOT Research Center categorizes all the proposals submitted into six strategic intents: infrastructure upgrade, safety, wildlife study, preservation, shared knowledge, and public affairs. How many projects are submitted in each strategic intent and how many are approved are summarized in this measure. In each strategic intent, how much funding is requested and how much is approved is also summarized. The second performance measure shows how responsive the Research Center is to needs of its program solicitations. The third performance measure summarizes the projects in nine programs (bridge, materials, planning, safety, standards, maintenance, geology, traffic, and environment) to show how willing WYDOT's programs are to utilize the research funding. The fourth performance measure discusses the results of project outcomes categorized into relevant and implementable products, new knowledge, or standards. The fifth performance measure represents the summary of the projects completed each year. The sixth performance measure looks at cost-benefit analysis for both projects and the overall system. The eighth performance measure evaluates the administrative costs and are a check for the Research Center to ensure the greatest return on investment for the Research Center as a whole. The eighth performance measurement further allows the Research Center to fiscally plan ahead and try to meet their proposed research needs. The ninth performance measurement is an internal check to identify research projects that are not completed in a timely manner, as well as projects that meet their proposed budgets and timelines.

The performance measures presented in this report are designed to give an indication of the effectiveness of the Research Center and the projects that it funds. Although some Research Centers may require additional performance measurements to meet their individual needs, the nine performance measurements presented above are a solid foundation for evaluating DOT Research Centers.

Developing Benefit-to-Cost Analysis

A BCA is critical in demonstrating effectiveness of research in a Research Center. The BCA results the Benefit-to-Cost Ratio (BCR) for each project. When the BCR is greater than one. It shows that the benefits of a project is greater than the costs in terms of monetary value. In this study, a methodology to estimate BCR is proposed in Chapter 4: Benefit-to-Cost Analysis (BCA).

Chapter Summary

A methodology was developed in this chapter to evaluate the Research Center. The proposed methodology primarily identified nine performance measures to evaluate the program in terms of several aspects including: funding by strategic intents and agency's programs, projects completed every year, the BCR of each project, percentage of funding spent as administrative costs, total funding versus funds available, and projects completed on time and within budget. A methodology to calculate the BCR of each project is proposed, and can be used as a performance measure in the future. The evaluation developed methodology was implemented in Chapter 4: Data Analysis.

CHAPTER 4. DATA ANALYSIS

Introduction

This chapter summarizes how the WYDOT Research Center was evaluated based on eight performance measures out of the proposed nine performance measured in Chapter 3. Performance measure number 6, which is related to benefit cost analysis is described in Chapter 7 so that it can be implemented in the future. The eight performance measures were performed on the proposals submitted to WYDOT from 2011 to 2016. In the following sections, the summary of the proposals received was discussed followed by the evaluation of the performance measures. Conclusions are set out under each performance measurement.

Summary of the Proposals Received

From 2011 to 2016, 64 research proposals were submitted to WYDOT (see Appendix 1). Table 3 shows the summary of these proposals. The proposals are divided into three project types: proposals (proposals for pooled funds are also included), pre-proposals, and increased funding requests. Proposals are research projects submitted to the Research Advisory Committee (RAC) during the quarterly RAC meeting. During the time frame of this study, 51 proposals were submitted to the RAC, of which, 44 were forwarded to the Executive Staff and FHWA for the final funding approval. During the analysis period, there were ten requests for increased funding. Only seven out of the ten requests for increased funding were approved by the RAC.

A pre-proposal is more than a problem statement and less than a formal proposal, but is still presented to the RAC for review. If a sufficient amount of interest is generated by the RAC, the Principal Investigator is asked to present a formal proposal. In very rare instances, the pre-proposal may be elevated to proposal status during the RAC meeting. From 2011 to 2016, three pre-proposals were submitted to WYDOT and all three were approved to be submitted as full-proposal. Two of these three pre-proposals got actually approval for funding.

Table 3. Summary of the Proposals Approved and Not-approved for Funding, 2011 -2016.

Project Type	2011	2012	2013	2014	2015	2016	Grand Total
Proposal	11	9	9	5	7	10	51
Approved	10	8	5	5	7	9	44
Not Approved	1	1	4	0	0	1	7
Pre-Proposal	0	2	1	0	0	0	3
Approved	0	2	1	0	0	0	3
Increased Funding	2	3	0	1	1	3	10
Approved	2	3	0		0	2	7
Not Approved	0	0	0	1	1	1	3
Grand Total	13	14	10	6	8	13	64

Table 4 shows the proposals submitted by different sponsoring organizations. A total of 20 sponsoring organizations submitted proposals to WYDOT. The top three sponsoring organizations that submitted proposals from 2011 to 2016 were the University of Wyoming, with 28 proposals, InterAlpine, with 6 proposals, and the Teton Science School, with 4 proposals. An additional 17 sponsoring organizations submitted 1 to 3 proposals from 2011 to 2016. The

sponsoring organizations were not identified for the following two proposals: Hands-free and Eyes-free Travel Information System for Smart Phones and Pooled Fund Solicitation 1297 and 2012 Multi-State Asset Management Implementation.

Table 4. Proposals Submitted by Different Sponsoring Organizations, 2011-2016.

Sponsoring Organization	Approved	Not Approved	Grand Total
University of Wyoming	25	3	28
InterAlpine Associates	4	2	6
Teton Science School	3	1	4
Northern Rockies Conservation Cooperative	3	0	3
FHWA (Lead Agency)	1	1	2
KB Engineering	2	0	2
Nebraska DOR (Lead Agency)	1	1	2
USGS	1	1	2
Wyoming Migration Initiative	2	0	2
Applied Research Associates, Inc.	1	0	1
BridgeTech	1	0	1
Colorado State University	1	0	1
Indiana DOT (Lead Agency)	1	0	1
Larry Redd, LLC	1	0	1
Oregon DOT (Lead Agency)	1	0	1
South Dakota DOT (Lead Agency)	1	0	1
Utah State University	1	0	1
Western Ecosystems Technology	1	0	1
WTI, Montana State University	1	0	1
Wyoming DOT (Lead Agency)	1	0	1
Not Provided	1	1	2
Grand Total	54	10	64

Evaluation Based on Performance Measurements

This section summarizes the findings of the eight performance measurements selected for evaluating WYDOT’s Research Center.

Number of Projects and Amount of Funding per Project by Strategic Intent

Table 5 and Figure 3 summarize the proposals using six predetermined strategic intent measures: infrastructure upgrade, safety, preservation, wildlife study, shared knowledge, and public affairs. The list of the strategic intents are sorted based on the number of approved proposals. The top three strategic intent categories are Infrastructure upgrade, with 16 proposals fitting into this category, safety with 12 proposals, and wildlife study with 10 . The proposals with a strategic

intent in public affairs received the least approved proposals with one proposal. Table 5 also indicates the percentage of submitted proposals approved by strategic intent. Approximately 54 (84 percent) of the 64 submitted proposals were approved by WYDOT. Proposals with a strategic intent in infrastructure upgrade, safety, preservation, wildlife study, and shared knowledge had approximately 80 percent or more of the submitted projects approved, while proposal with a strategic intent in public affairs had 50 percent of the submitted projects approved. The relatively high percentage of approval process is due to the fact that proposals require champions from within WYDOT which mean that only proposals with potential benefits to WYDOT are invited for presentation to the RAC.

Table 5. Summary of the Proposals by Project Intent, 2011 -2016.

Strategic Intent	Approved	Not Approved	Grand Total	Percent Approved
Infrastructure Upgrade	16	2	18	89%
Safety	12	2	14	86%
Wildlife Study	10	2	12	83%
Preservation	8	1	9	89%
Shared Knowledge	7	2	9	78%
Public Affairs	1	1	2	50%
Grand Total	54	10	64	84%

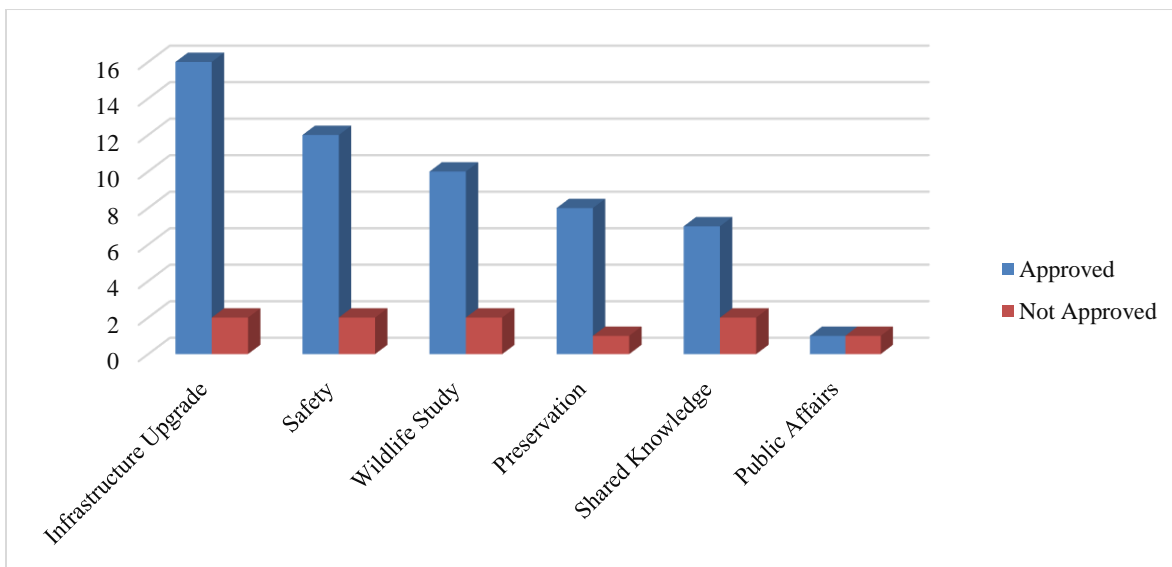


Figure 3. Proposals Approved and Not-approved for Funding by Strategic Intent, 2011 – 2016.

The total amount of funding for the six strategic intent measures, from 2011 to 2016 is shown in Table 6. The list of strategic intent measures is ordered in descending amount of approved

funding. Strategic intent measures in infrastructure upgrade, safety, and wildlife study received the highest amount of funding, with approximately \$1.4 million, \$1.39 million, and \$1.2 million respectively. The least funded strategic intent is public affairs with approximately \$40,000.

Table 6. Funding Levels and Number of Projects Approved by Strategic Intent, 2011 -2016.

Strategic Intent	Approved	Not Approved	Grand Total
Infrastructure Upgrade	\$ 1,435,508	\$ 230,145	\$ 1,665,653
Safety	\$ 1,386,820	\$ 155,803	\$ 1,542,623
Wildlife Study	\$ 1,186,506	\$ 241,840	\$ 1,428,346
Preservation	\$ 994,280	\$ 188,200	\$ 1,182,480
Shared Knowledge	\$ 695,454	\$ 205,000	\$ 900,454
Public Affairs	\$ 40,143	\$ 6,000	\$ 46,143
Grand Total	\$ 5,738,711	\$ 1,026,988	\$ 6,765,699

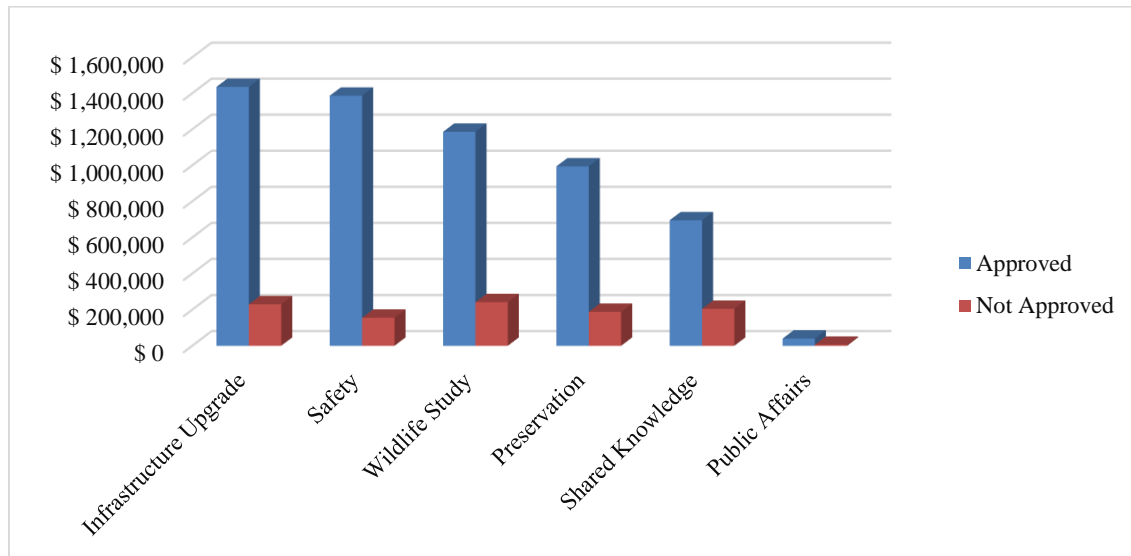


Figure 4. Project Funding Levels by Strategic Intent, 2011 – 2016.

Figure 4 provides a graphical representation of the funding level by strategic intent measure. Table 7 indicates the average funding per year and average duration per project from 2011 to 2016. In this table, the total duration of funding is the summation of all the projects durations for each strategic intent measure. This was used to determine the average duration per project dividing the total duration by the number of projects. Similarly, the average funding per year was determined by dividing the total funding by the total duration. The overall average funding per project is \$53,605 with an average duration of 2 years. The strategic intent with the largest amount of funding per project was wildlife study with \$84,020, while the least funding per project was preservation with \$34,779.

Table 7. Average Funding and Duration per Project, 2011 -2016.

Strategic Intent	Number of Projects	Funding	Total Duration of Funding (years)	Average Funding per Project	Average Duration per Project
Wildlife Study	12	\$ 1,428,346	17	\$ 84,020	1.4
Safety	14	\$ 1,542,623	24	\$ 64,276	1.7
Shared Knowledge	9	\$ 900,454	19	\$ 47,392	2.1
Public Affairs	2	\$ 46,143	1	\$ 46,143	0.5
Infrastructure Upgrade	18	\$ 1,665,653	37	\$ 45,018	2.1
Preservation	9	\$ 1,182,480	34	\$ 34,779	3.8
Grand Total	64	\$ 6,765,699	132		
Average				\$ 53,605	1.93

Number of Needs Statements Submitted by the Agency’s Programs

A summary of the proposals based on project area from 2011 to 2016 is shown in Table 8. Proposals were separated into project areas based upon the WYDOT program that sponsored or proposed the project. The project areas included nine WYDOT programs (Bridge, Materials, Planning, Safety, Maintenance, Standards, Traffic, Geology, and Environment) as well as three WYDOT districts (Districts 3, 4, and 5). The project areas with the most proposals approved was bridge (9), district 5 (8), and materials (8). While the project areas with the least number of approved projects was geology (2), traffic (2) and environment (1).

Table 8. Summary of the Proposals Based on Project Area, 2011 -2016.

Row Labels	Approved	Not Approved	Grand Total
Bridge	9	1	10
District 5	8	1	9
Materials	8	0	8
District 3	6	1	7
Planning	5	0	5
Safety	5	0	5
Standards	3	1	4
Maintenance	3	3	6
District 4	2	0	2
Geology	2	1	3
Traffic	2	1	3
Environment	1	1	2
Grand Total	54	10	64

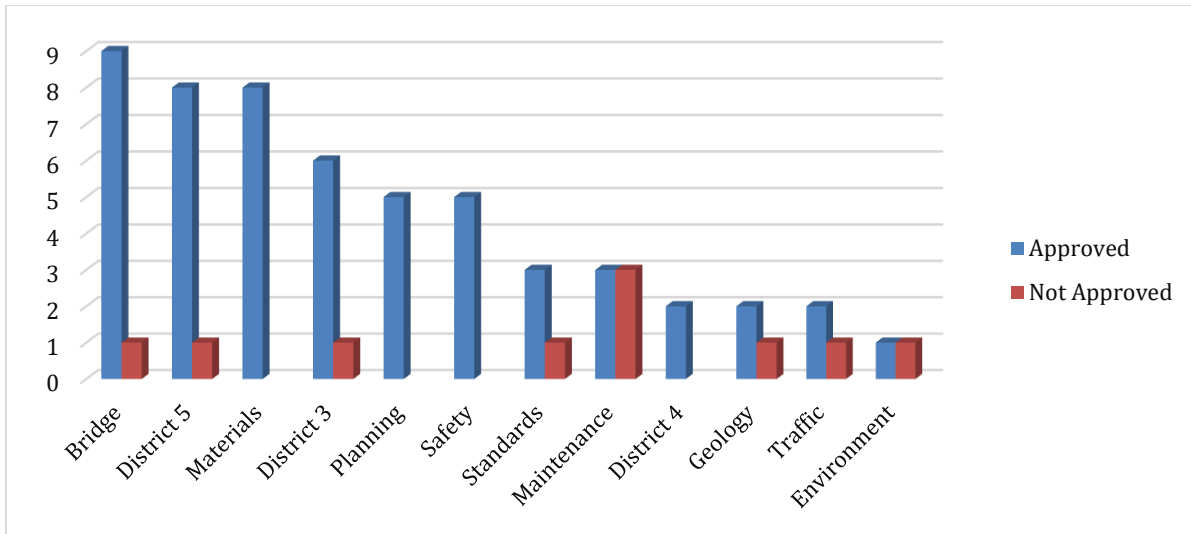


Figure 5. Summary of the Proposals Based on Project Area, 2011 -2016.

Figure 5 shows the number of proposals per project area as well as comparing the approved and not approved proposals.

Table 9 provides a summary of the funding based on project area for 2011 to 2016. The project areas with the most approved funding was bridge with approximately \$1.2 million, district 3 with approximately \$1 million, and materials with approximately \$900,000. While the project areas with the least amount of approved funding was maintenance with \$170,000, geology with \$160,000 and environment with \$87,000. It can be seen that out of five districts, three of them (Districts 3, 4, and 5) received funding of approximately \$2.1 million which is about 31 percent of total. The remaining districts (Districts 1 and 2) are encouraged to submit proposals to address their research needs.

Table 9. Summary of Funding Based on Project Area, 2011 -2016.

Row Labels	Approved	Not Approved	Grand Total
Bridge	\$ 1,181,041	\$ 195,000	\$ 1,376,041
District 3	\$ 977,364	\$ 50,000	\$ 1,027,364
Materials	\$ 858,974	\$ 0	\$ 858,974
District 5	\$ 744,375	\$ 197,340	\$ 941,715
Safety	\$ 431,613	\$ 0	\$ 431,613
Planning	\$ 403,851	\$ 0	\$ 403,851
Traffic	\$ 279,675	\$ 6,000	\$ 285,675
Standards	\$ 255,846	\$ 10,000	\$ 265,846
District 4	\$ 187,004	\$ 0	\$ 187,004
Maintenance	\$ 172,034	\$ 447,137	\$ 619,171
Geology	\$ 160,372	\$ 77,011	\$ 237,383
Environment	\$ 86,562	\$ 44,500	\$ 131,062
Grand Total	\$ 5,738,711	\$ 1,026,988	\$ 6,765,699

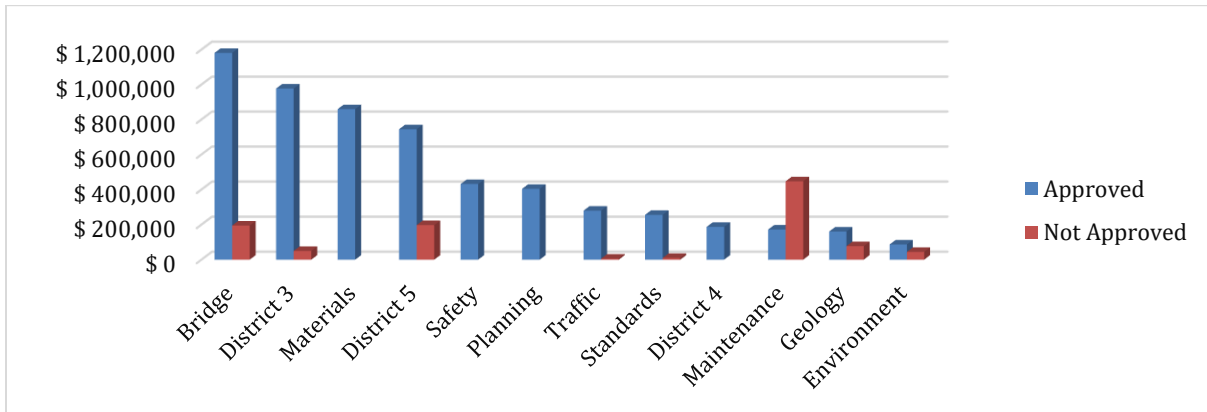


Figure 6. Summary of the Funding Based on Project Area, 2011 -2016.

Outcomes of the Research Projects

Projects that were completed from 2011 to 2016 were categorized in the following outcome categories: knowledge, product, or standard. These are the same categories which were used in Phase II Evaluation. The knowledge category includes projects concerning specifications, design guidelines, product performance, product evaluation, and etc. The product category includes projects such as software, management plans, or improvement programs, and etc. The standard category includes product selection policies, implementation of Mechanistic-Empirical Pavement Design, characterization of materials, and etc. Each of the outcomes were then broken down into the following categories: full implementation, partial implementation, no implementation. Project outcomes in knowledge had four full implementation projects, four partially implemented projects and two projects with no implementation. Projects with an

outcome in product had no fully implemented projects, three partially implemented projects and one projects with no implementation. Projects with an outcome in standard had two fully implemented projects, three partially implemented projects and no projects with no implementation. The outcome of the completed research projects are shown in **Figure 7**.

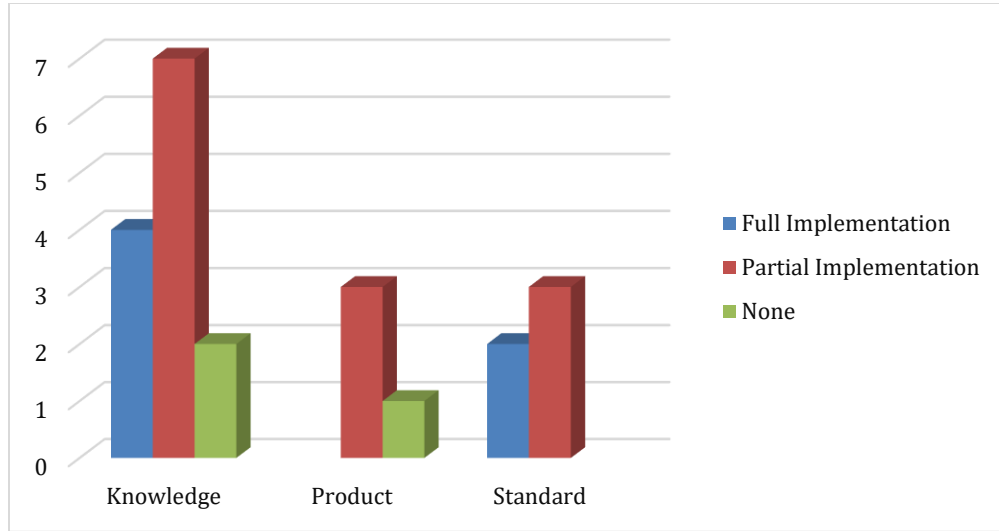


Figure 7. Project Outcome based on Level of Implementation.

Figure 8 shows the funding expended for the above outcome measures based on level of implementation. Project outcomes in knowledge had \$685,000 in funding for fully implemented projects, \$940,000 in funding for partially implemented projects and \$220,000 in funding for projects with no implementation. Projects with an outcome in product had no funding for fully implemented projects, \$315,000 in funding for partially implemented projects and \$130,000 in funding for projects with no implementation. Projects with an outcome in standard had \$400,000 in funding for fully implemented projects, \$200,000 in funding for partially implemented projects and no funding for projects with no implementation.

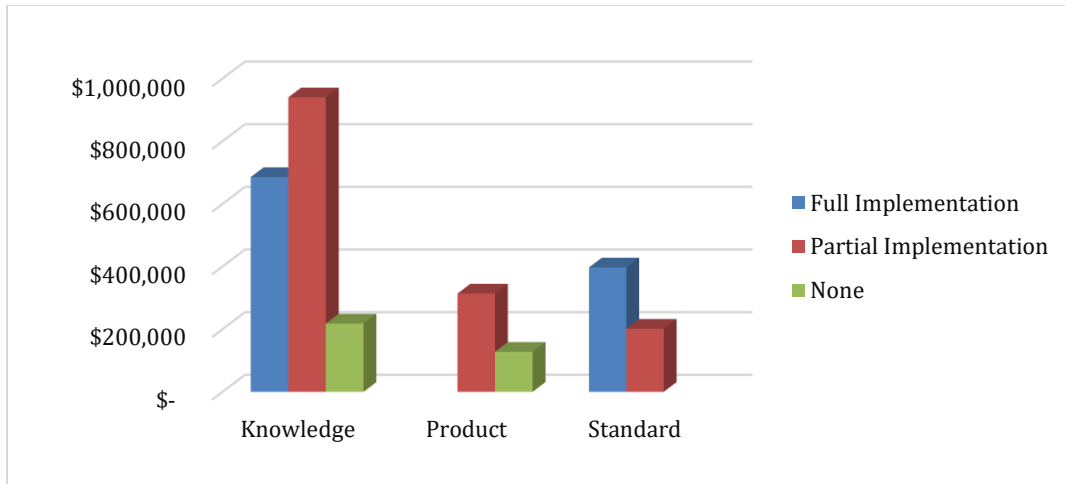


Figure 8. Funding for Project Outcome based on Level of Implementation.

From 2011 to 2016, six proposals for pooled fund projects were approved. Table 10 lists the approved proposals for pooled fund projects. Of the six submitted proposals, two were for funding increase requests. The strategic intents of the pooled fund projects were preservation, shared knowledge, and safety.

Table 10. List of the Approved Projects from Pooled Fund, 2011 -2016.

NO	PROPOSAL DATE	WYDOT I.D.	PROJECT TITLE	PROJECT TYPE	STRATEGIC INTENT
1	1/12/2011	TPF-5(253)	Pooled Fund TPF-5(253): Member-level Redundancy in Built-up Steel Members	Contracted Proposals	Preservation
2	4/13/2011	TPF-5(193)	Pooled Fund TPF-5(193): Midwest States Regional Pooled Fund Project	Increased Funding	Shared Knowledge
3	7/8/2015	TPF-5(317)	Pooled Fund TPF-5(317): Evaluation of Low Cost Safety Improvements	Contracted Proposals	Safety
4	10/7/2015	TPF-5(337)	Pooled Fund TPF-5(337): Avalanche Research Pooled Fund	Contracted Proposals	Safety
5	1/18/2016	TPF-5(310)	Pooled Fund TPF-5(310): Peer Exchange	Contracted Proposals	Shared Knowledge
6	10/19/2011	TPF-5(054)	Pooled Fund TPF-5(054): Maintenance Decision Support System	Increased Funding	Preservation

Table 11 summarizes the amount of funding for proposals submitted from 2011 to 2016. The table is separated into contracted projects (approved proposals not including pooled fund) and pooled fund projects. The total amount of funding from 2011 to 2016 was approximately \$6.8 million with pooled fund projects accounting for 9 percent.

Table 11. Summary of the Proposals Submitted, 2011 -2016.

	2011	2012	2013	2014	2015	2016	Grand Total
Contract	\$ 1,123,587	\$ 1,544,284	\$ 1,218,927	\$ 437,341	\$ 289,130	\$ 1,541,528	\$ 6,154,797
Pooled Fund	\$ 305,000	\$ 0	\$ 0	\$ 0	\$ 300,000	\$ 5,902	\$ 610,902
Grand Total	\$ 1,428,587	\$ 1,544,284	\$ 1,218,927	\$ 437,341	\$ 589,130	\$ 1,547,430	\$ 6,765,699
% Pooled Fund	21.3 %	0 %	0 %	0 %	50.9%	0.38%	9%

Number of Research Reports Completed Each Year

The number of research projects completed each year from 2012 to 2017 is shown in Table 12. In this table, 2011 was not included since no project was completed that year and 2017 is included since projects completed that year were approved during or prior to 2016.

From 2012 to 2017, 29 projects were completed with strategic intent measures in infrastructure upgrade, preservation, safety, shared knowledge, and wildlife study. Fiscal Year 2015 had the most projects completed, 10; while fiscal year 2012 had the least, 2 Strategic intent measure in safety and infrastructure upgrade had the most projects completed, with seven projects, and shared knowledge had the least, with four projects.

Table 12. Number of Research Reports Completed Each Year, 2012 -2017.

Strategic Intent	2012	2013	2014	2015	2016	2017	Grand Total
Infrastructure Upgrade	1	1	2	0	1	2	7
Preservation	0	1	0	3	1	0	5
Safety	0	1	1	3	0	2	7
Shared Knowledge	1	2	0	1	0	0	4
Wildlife Study	0	0	1	3	1	1	6
Grand Total	2	5	4	10	3	5	29

Percentage of Administrative Costs to Overall Program Funding

Table 13 shows the administrative funding for the WYDOT Research Center compared to the overall project funding from 2011 to 2016. The year with the highest percent of administrative costs was 2014, with 20.3 percent of the overall research budget. The year with the lowest percent of administrative costs was 2012, with 6.3 percent of the overall research budget. The average percent of administrative costs from 2011 to 2016 was 9.4 percent of the overall research budget.

Table 13. Administrative Funding Compared to Overall Research Funding, 2011-2016.

Year	Admin. Costs	Overall Research Funding	Percent of Admin. costs
2011	\$118,642	\$1,547,229	7.70%
2012	\$103,898	\$1,648,182	6.30%
2013	\$130,887	\$1,349,814	9.70%
2014	\$111,070	\$548,411	20.30%
2015	\$108,805	\$697,935	15.60%
2016	\$107,801	\$1,655,231	6.50%
Average	\$113,517	\$1,241,134	9.10%

Funds Requested by the Research Community versus Funds Available

Tables 14 and 15 show the requested funding and the funding available by strategic intent from 2011 to 2016. The total amount of funding requested from 2011 to 2016 was approximately \$6.8 million, only \$5.7 million was approved due to the limited availability of funds or the quality of the proposals.

Table 14. Funds Requested by Project Area, 2011 -2016.

Project Area	Contract	Pooled Fund	Grand Total	Contract	Pooled Fund	Grand Total
District 3	\$1,027,364	\$0	\$1,027,364	7	0	7
Bridge	\$911,041	\$465,000	\$1,376,041	7	3	10
District 5	\$866,715	\$75,000	\$941,715	8	1	9
Materials	\$858,974	\$0	\$858,974	8	0	8
Maintenance	\$594,171	\$25,000	\$619,171	5	1	6
Safety	\$431,613	\$0	\$431,613	5	0	5
Planning	\$403,851	\$0	\$403,851	5	0	5
Traffic	\$285,675	\$0	\$285,675	3	0	3
Standards	\$249,944	\$15,902	\$265,846	2	2	4
Geology	\$237,383	\$0	\$237,383	3	0	3
District 4	\$157,004	\$30,000	\$187,004	1	1	2
Environment	\$131,062	\$0	\$131,062	2	0	2
Grand Total	\$6,154,797	\$610,902	\$6,765,699	56	8	64

Table 15. Funds Available by Project Area, 2011 -2016.

Project Area	Contract	Pooled Fund	Grand Total	Contract	Pooled Fund	Grand Total
District 3	\$977,364	\$0	\$977,364	6	0	6
Bridge	\$911,041	\$270,000	\$1,181,041	7	2	9
Materials	\$669,375	\$75,000	\$744,375	7	1	8
District 5	\$858,974	\$0	\$858,974	8	0	8
Safety	\$147,034	\$25,000	\$172,034	2	1	3
Planning	\$431,613	\$0	\$431,613	5	0	5
Traffic	\$403,851	\$0	\$403,851	5	0	5
Standards	\$279,675	\$0	\$279,675	2	0	2
Geology	\$249,944	\$5,902	\$255,846	2	1	3
District 4	\$160,372	\$0	\$160,372	2	0	2
Maintenance	\$157,004	\$30,000	\$187,004	1	1	2
Environment	\$86,562	\$0	\$86,562	1	0	1
Grand Total	5,332,809	\$405,902	\$5,738,711	48	6	54

Percentage of Projects Completed on-time and within budget

A total of 27 projects, out of 30 projects were completed on time and within budget during the time period from 2011 to 2017, approximately 90 percent of the total projects. A list of the projects not completed on-time and/or within budget from 2011 to 2017 is shown in Table 16. A total of three projects were not completed on time and within budget.

Table 16. List of the Projects NOT completed On-time and Within Budget, 2011 -2016.

Proposal date	Project I.D.	Project Title	Project Type	Strategic Intent
4/7/2014	RS04214	Developing Wyoming Specific Bridge Deterioration Models for Bridge Management	Proposal	Preservation
4/11/2012	RS03212	Structural Health Monitoring of Highway Bridges Subject to Overweight Trucks, Phase - I	Proposal	Preservation
7/11/2012	RS08212	Multi-Measure Performance Assessment and Benchmarking of the Divisions of the Wyoming Highway Patrol	Proposal	Shared Knowledge

Chapter Summary

The outcomes and results of WYDOT’s research projects are beneficial and implementable not only to WYDOT but also to the transportation community. The evaluation of the research projects focused on the research conducted by the WYDOT Research Center from 2011 to 2016. It was found that the WYDOT Research Center is an effective and productive program. The

program is able to fund a variety of projects that benefit the traveling public, its employees, as well as the transportation research community. The organization of the Research Center allows it to remain flexible and proactive when addressing changing research projects as they evolve throughout their life cycle.

CHAPTER 5. COMPARISON WITH THE PHASE II STUDY

Introduction

In this chapter, the performance measures for the projects from 2011 to 2016 were compared with the Phase II Study. Phase II study titled *Evaluating Department of Transportation's Research Centers: A Methodology and Case Study* was completed in June 2012. The Phase II study included the projects from 2005 to 2010. In this Phase III study, the projects from 2011 to 2016 were evaluated. Both Phases II and III included six years' worth of data. Table 17 compares the summary of the approved/ not approved projects between Phases II and III. The Table clearly shows that the Research Center is consistent when it comes to evaluating/funding proposals in both time periods.

Table 17. Breakdown of Project Types Proposed to the RAC.

Project Type	Phase II Study, 2005-2010 (6 Years)	Phase III Study, 2011-2016 (6 Years)
Proposal	50	51
Approved	44	44
Not Approved	9	7
Pre-Proposals	5	3
Approved	3	3
Requests for Increased Funding	10	10
Approved	8	7
Not Approved	2	3
Grand Total	65	64

Evaluation Based on Performance Measures

This section compares the performance measures between Phase III and Phase II. The following performance measures were compared in this evaluation:

- Amount of Funding per Project by Strategic Intent
- Outcomes of the Research Projects
- Number of Research Reports Completed Each Year
- Percentage of Administrative Costs to Overall Program Funding
- Funds Requested by the Research Community versus Funds Available
- Percentage of Projects Completed On-time and Within Budget

Amount of Funding per Project by Strategic Intent

Table 18 compares the funding approved during the time period of Phase II versus Phase III. It can be seen that approximately five to six millions of funding were approved in every phase. This translate into about \$1 million per year. The Phase III funding for wildlife studies was doubled the Phase II funding. Also, the funding for shared knowledge was increased from \$61,150 to \$695,454.

Table 18. Comparison of Approved Funding between Phase II Study and Phase III Study.

Strategic Intent	Phase II Study, 2005-2010 (6 Years)		Phase III Study, 2011-2016 (6 Years)	
	Projects Approved	Funding	Projects Approved	Funding
Infrastructure Upgrade	18	\$ 1,437,147	16	\$ 1,435,508
Safety	15	\$ 1,996,787	12	\$ 1,386,820
Wildlife Study	5	\$ 514,849	10	\$ 1,186,506
Preservation	14	\$ 1,087,450	8	\$ 994,280
Shared Knowledge	3	\$ 61,150	7	\$ 695,454
Public Affairs	2	\$ 162,972	1	\$ 40,143
Grand Total	57	\$ 5,260,355	54	\$ 5,738,711

Outcomes of the Research Projects

Table 19 presents the average pooled fund per year between Phases II and III. In Phase III, the average percentage of pooled fund was decreased from 16.8 percent to 9 percent compared to Phase II.

Table 19. Comparison of Pooled Fund between Phase II Study and Phase III Study.

Project Type	Phase II Study, 2005-2010 (6 Years)	Phase III Study, 2011-2016 (6 Years)
Average budget per year from Pooled Fund	\$161,667	\$101,817
Overall Research Budget per Year	\$960,156	\$1,127,617
Percent Pooled Funds	16.8%	9%

Number of Research Reports Completed Each Year

In Phase III, a total of 29 projects were completed –about 4.8 projects per year. Whereas, in Phase II, a total of 19 projects were completed, about 3.17 projects per year. Comparing these two studies, it can be seen that the rate of completion of projects is higher in Phase III than Phase II.

Percentage of Administrative Costs to Overall Program Funding

Table 20 presents the average administrative costs per year between Phase II and III. In Phase III, the average administrative costs per year was \$113,517 – which represents 34 percent increase compared to Phase II. But, the percentage of administrative costs based on overall research budget (approximately 9 percent) did not change when comparing Phases II and III.

Table 20. Comparison of Administrative Costs between Phases II and III.

Project Type	Phase II Study, 2005-2010 (6 Years)	Phase III Study, 2011-2016 (6 Years)
Average Administrative Costs per Year	\$84,748	\$113,517
Overall Research Budget per Year	\$960,156	\$1,241,134
Percent of Administrative Costs	9%	9.1%

Funds Requested by the Research Community versus Funds Available

Table 21 compares the funds requested and approved between Phases II and III. In Phase III, approximately \$6.7 million were requested. Out of this requested fund, \$5.7 million were approved – which represents 85 percent of the requested funds. On the other hand, in Phase II, approximately \$5.2 million were approved out of \$7.2 million requested fund – which is 73 percent of requested funds.

Table 21. Comparison of Funds Requested by the Research Community versus Funds Approved between Phase II and III Study.

Strategic Intent	Phase II Study, 2005-2010 (6 Years)		Phase III Study, 2011-2016 (6 Years)	
	Funding Requested	Funding Approved	Funding Requested	Funding Approved
Infrastructure Upgrade	\$ 1,437,147	\$ 1,437,147	\$ 1,665,653	\$ 1,435,508
Safety	\$ 2,877,205	\$ 1,996,787	\$ 1,542,623	\$ 1,386,820
Wildlife Study	\$ 860,549	\$ 514,849	\$ 1,428,346	\$ 1,186,506
Preservation	\$ 1,746,300	\$ 1,087,450	\$ 1,182,480	\$ 994,280
Shared Knowledge	\$ 61,150	\$ 61,150	\$ 900,454	\$ 695,454
Public Affairs	\$ 220,972	\$ 162,672	\$ 46,143	\$ 40,143
Grand Total	\$ 7,203,323	\$ 5,260,355	\$ 6,765,699	\$ 5,738,711

Percentage of Projects Completed On-time and Within Budget

Table 22 compares the funding approved between Phase II and III. In Phase III, 89 percent of the approved projects were completed on-time and within budget. When compared with the Phase II Study, this percentage is almost the same.

Table 22. Comparison of Projects Completed On-time and Within Budget between Phase II and Phase III Study.

Project Type	Phase II Study, 2005-2010 (6 Years)			Phase III Study, 2011-2016 (6 Years)		
	Total Projects	On-time and Within Budget	Percent	Total Projects	On-time and Within Budget	Percent
Contracted	15	13	87%	29	26	89%
Pooled Fund	5	0	0	1	1	100%

Chapter Summary

Based on the comparison of the project performance between Phases II and III, it can be seen that very similar number of projects were submitted (65 submitted in Phase II, and 64 submitted in Phase III) and approved (55 approved in Phase II, and 54 approved in Phase III). The total approved funding was increased in Phase III from \$5.26 million to \$5.74 million (9.1 percent increase). The rate of completion of projects in Phase III is significantly higher than Phase II.

CHAPTER 6. SURVEYS

Introduction

As part of this study, surveys were conducted for all research projects which were started and completed between January 2011 and July 2017. The list of the research projects (29 projects) is shown in Table 23. Three different surveys were sent to the Principal Investigators and Project Champions in September, 2017. The surveys included: the Researchers Feedback Survey, the Phase I Performance Evaluation, and the Phase II Performance Evaluation survey. The Researchers Feedback Survey was sent to all Principal Investigators. The Phase I Performance Evaluation surveys were sent to Project Champions within two years of the completion of the research study, while the Phase II Performance Evaluation surveys were sent to champions after two years of the completion of the research projects. The responses from the surveys are presented in Appendix 3.

Researcher Feedback Surveys

The Researcher Feedback Survey asked Principal Investigators to leave comments and suggestions on the proposal process, WYDOT Research Center staff, Project Champion, lessons learned from the project, opportunities for follow up research, and improvements to the WYDOT Research Center. Figure 9 provides the list of questions from the research feedback form. Researcher Feedback Surveys were sent to the PIs of 29 projects shown in Table 23. Only 28 out of the 29 surveys got filled out by the Principal Investigators.

Table 23. List of the Projects included in the Surveys.

Project I.D.	Project Title
RS01213	Developing a Database and Web Viewing Tool for Ungulate Migrations in Wyoming
RS02212	Managing Risks in the Project Pipeline - Minimizing the Impacts of Highway Funding Uncertainties
RS02214	Developing an Effective Shoulder and Centerline Rumble Strip Policy to Accommodate All Roadway Users
RS03209	Implementation of the Mechanistic-Empirical Pavement Design Guide in WYDOT
RS03211	Evaluation of the Wyoming Research Center and Research Center (Phase II)
RS03212	Structural Health Monitoring of Highway Bridges Subject to Overweight Trucks, Phase I
RS03214	Assessment and Evaluation of I-80 Truck Loads and Their Load Effects
RS03215	Planning-Support for Mitigation of Wildlife Vehicle Collisions and Highway Impacts on Migration Routes in Wyoming
RS03216	Calibrating Crash Modification Factors for Wyoming
RS04211	Investigation of Silica Fume Concrete Bridge Overlay Failures
RS04212	Evaluation of a Mitigation Site: Amphibian Population
RS04213	Characterization of Material Properties for Mechanistic-Empirical Pavement Design in Wyoming
RS04214	Developing Wyoming Specific Bridge Deterioration Models for Bridge Management
RS04216	Traffic Thresholds in Deer Road Crossing Behavior
RS05211	Instrumentation and Analysis of Frost Heave Mitigation on WY 70, Encampment, WY
RS05212	Evaluating the Effects of Deer Delineators in Wildlife-Vehicle Collisions in Northwest Wyoming
RS05213	A Literature Review of Approach Slab and its Settlement for Roads and Bridges in Wyoming
RS05215	Developing Mitigation Strategies to Reduce Truck Crash Rates in Wyoming Highways
RS06211	Comprehensive Technology Assessment for Avalanche Hazard Management
RS06212	Evaluating the Risk of Alkali Silica Reaction in Wyoming
RS06213	Wyoming Low Volume Roads Traffic Volume Estimation
RS06215	Historic Winter Weather Assessment for Snow Fence Design using a Numerical Weather Model
RS07211	Improving Traveler Information on Rural Corridors in Wyoming through the Use of Intelligent Transportation Systems
RS07212	Jackson South Snow Supporting Structures Proposed Performance and Health Monitoring at WYDOT Project No. N104085, Teton County, Jackson, WY
RS08211	Evaluating Base Widening Methods
RS08212	Multi-Measure Performance Assessment and Benchmarking of the Divisions of the Wyoming Highway Patrol
RS09211	Developing a Roadway Safety Improvement Program for Indian Reservations
RS10211	Criteria for a WYDOT Culvert Selection Policy
RS11211	Pronghorn and Mule Deer Use of Underpasses along US Highway 191

Proposal Process	1. Rate your satisfaction with the proposal process: <input type="radio"/> Very Satisfied <input type="radio"/> Satisfied <input type="radio"/> Dissatisfied
	2. What did you like about the proposal process?
	3. What did you dislike about the proposal process?
Research Center Staff	4. Rate your satisfaction with the Research Center staff: <input type="radio"/> Very Satisfied <input type="radio"/> Satisfied <input type="radio"/> Dissatisfied
	5. As a researcher, what suggestions can you provide to improve the management and the administration of the program?
Project Champion	6. Rate your satisfaction with the project sponsor: <input type="radio"/> Very Satisfied <input type="radio"/> Satisfied <input type="radio"/> Dissatisfied
	7. What suggestions can you provide to improve the interaction with the project sponsor?
Lessons Learned	8. Briefly, what are the three most important and transferable lessons learned from this project?
Follow-up Research	9. Is follow-up research warranted? <input type="radio"/> Yes <input type="radio"/> No
	10. If yes, please explain why?
Continuous Improvement	11. Please provide other suggestions to improve the Research Center.

Figure 9. Research Feedback Form Questions.

The first section of the Researchers Feedback survey evaluated Principal Investigators satisfaction and like/dislike of the proposal process. Figure 10 illustrates the Principal Investigators satisfaction with the proposal process. Sixty-seven percent of the Principal Investigators were very satisfied with the proposals process while 33 percent were satisfied with the proposal process. None of the Principal Investigators had a dissatisfied response to the proposal process.

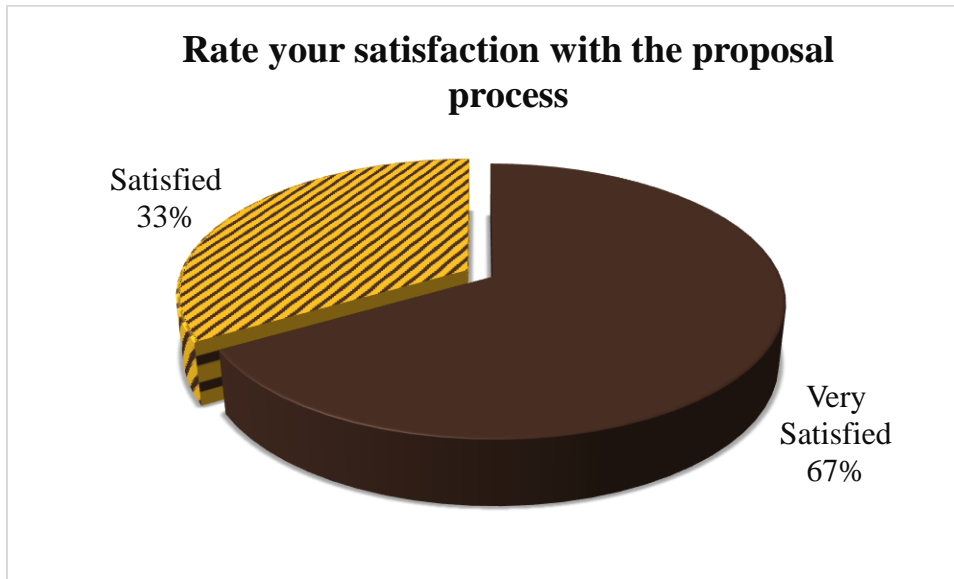


Figure 10. Principal Investigators Satisfaction with the Proposal Process.

Principal investigators comment on their satisfaction with the proposal process was positive. Out of the 28 feedback surveys received, 21 Principal Investigators provided positive comments on the proposal process. The majority of the comments complimented the involvement and feedback of the RAC during the proposal process as well as the transparency of the proposal process. One of the principal instigators commented that, “I appreciated the constructive and thoughtful input from the RAC at the time of the proposal presentation.” Another Principal Investigator commented that, “The process is transparent; oral presentations of proposals allows time for Q&A to clarify points of interest, reducing misunderstanding; feedback and decisions are provided promptly.” Some of the Principal Investigators commented on the fast response and flexibility of the proposal process. A Principal Investigator commented, “Appreciated the flexibility where possible and the assistance I received from staff when I needed guidance or had questions.” While another commented, “I appreciated the help I got from Enid and the flexibility given in the process. If process is too involved and too rigid it makes it difficult for all parties. It is important to be accountable but better to [be] flexible.” A few of the Principal Investigators commented on their enjoyment working with WYDOT.

Of the 28 feedback surveys received, three Principal Investigators commented on their dislike of some aspects of the proposals process. Two of the comments indicated that traveling for presentations was a hindrance to some Principal Investigator. One Principal Investigator commented,

“We actually enjoyed travelling from Jackson to Cheyenne many times throughout the process. Face to face communication was beneficial to the success of the project. Objectively, however, travelling 13 hours roundtrip, paying for meals and lodging, for 30

minutes of presentation, could be viewed as burdensome and potentially exclusionary by some.”

One of the comments indicated that there were some difficulties with feedback during the proposal process. Another Principal Investigator commented, “It is sometimes difficult to get strong feedback on which parts of the proposal are most useful to WYDOT. It would be helpful to hear which parts of a multi-part proposal were most appealing to the RAC and why.”

The second section of the Research Feedback survey evaluated Principal Investigators satisfaction with the WYDOT Research Center staff. Figure 11 illustrates Principal Investigators satisfaction with the WYDOT Research Center staff. The satisfaction of Principal Investigators with the WYDOT Research Center staff was overwhelmingly very satisfactory with 82 percent. While 18 percent of Principal Investigators were satisfied with the WYDOT Research Center staff. None of the Principal Investigators were dissatisfied with the WYDOT Research Center staff.

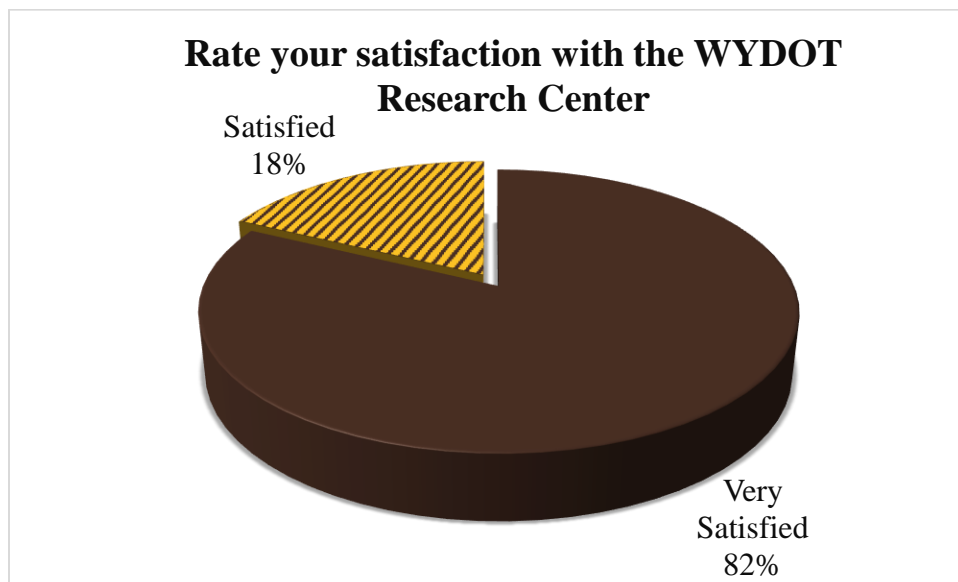


Figure 11. Principal Investigators Satisfaction with the WYDOT Research Center Staff.

Multiple Principal Investigators left suggestions for improving the management and administration of the WYDOT Research Center. In total 16 Principal Investigators commented with suggestions. Most of the Principal Investigators provided comments on their satisfaction with the Research Center staff rather than suggestions for improvement. The comments indicated that the WYDOT Research Center staff was very supportive and maintained good communication. A Principal Investigator commented, “The program administration and management are excellent. Enid is highly communicative and accessible, organized and thoughtful, and she and the RAC work hard to enable good research to get done.” The few Principal Investigators that provided suggestions for improvement indicated that with the rotation of RAC member it was difficult to anticipate questions and concerns while preparing for proposal or update presentations. One Principal Investigator indicated,

As an applicant, it was sometimes unclear about which WYDOT staff would be rotating in and out of the RAC. Anticipating questions and concerns from RAC members you had met with previously was always a component of preparing for proposal or update presentations. If possible it would be helpful to know the current composition of the RAC with some ability to speak to the individual member's interests (i.e. short biography, specialization, interaction with past projects).

Another Principal Investigator suggested that providing a list of frequently asked questions to submitters would reduce questions to the WYDOT Research Center staff. One Principal Investigator had difficulties during a project with project funding/expenditures not matching WYDOT figures. The Principal Investigator suggested that a financial summary sheet for projects should be provided every quarter to reduce financial discrepancies.

The third section of the Research Feedback survey evaluated Principal Investigators satisfaction with the Project Champions. Figure 12 illustrates Principal Investigators satisfaction with the Project Champions. An overwhelming 89 percent of the Principal Investigators indicated that their satisfaction with the project sponsor was very satisfactory, while only 11 percent of Principal Investigators were satisfied with the project sponsor. None of the Principal Investigators were dissatisfied with the WYDOT Project Champions.

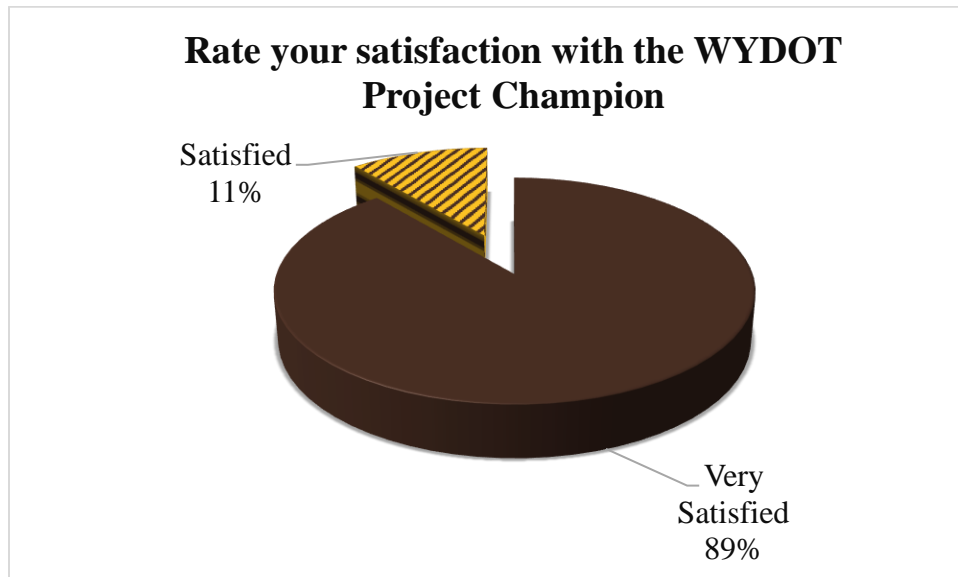


Figure 12. Principal Investigators Satisfaction with the WYDOT Project Champion.

Of the 28 feedback surveys received, 18 Principal Investigators commented on their interaction with the Project Champions. Many of the Principal Investigators had no suggestions on improving the interaction with the Project Champions but rather commented on their satisfaction with interacting with the Project Champions. The comments indicated that the Project Champions were very supportive and helpful during the research project. One Principal Investigator commented,

We thoroughly enjoyed working with Shelby Carlson. She was extremely practical in her approach to this project. Her ability to ask difficult questions, listen to and accept difficult answers, put us in touch with the proper WYDOT staff when we had questions was invaluable to the success of this project. We really appreciated that she did all these things while balancing an extremely heavy workload.

The Principal Investigators that provided suggestions to improve the interaction with the Project Champions indicated that providing guidelines on an appropriate level of interaction with the Project Champions would be beneficial. One Principal Investigator commented, "... it would be helpful to have some guidelines about what a good level of interaction with the champion is. It is sometimes hard to know how often the champion wants an update." Another suggestion for improvement from the Principal Investigators indicated that a follow-up meeting a couple of years after the completion of the research project to discuss implementation of the project would be beneficial.

The fourth section of the Research Feedback survey requested that Principal Investigators list the three most important and transferable lessons learned from the project. Of the 28 feedback surveys received, 23 Principal Investigators listed the most important and transferable lessons learned from the projects. Table 24 lists the responses from the Principal Investigators for the lessons learned.

Table 24. List of Lessons Learned from Responding Principal Investigators.

Project	Lessons Learned
Developing a Database and Web Viewing tool for Ungulate Migrations in Wyoming	<ol style="list-style-type: none"> 1. Takes patience and persistence to get cooperation from other researchers to share data. 2. Sharing and archiving data is an important aspect of research. To ensure that the data is captured in a way that it can be used and shared and archived for the future. 3. Takes flexibility and patience when working with multiple partners and multiple datasets. It is also difficult to predict time frames as we were dependent on others to respond and share information.
Developing an Effective Shoulder and Centerline Rumble Strip Policy to Accommodate All Roadway Users	<ol style="list-style-type: none"> 1. A guide was prepared for selecting rumble strips. 2. WYDOT has implemented the recommendations of the study. 3. Rumble strips are effective in reducing crashes.
Evaluation of the Wyoming Research Center and Research Center (Phase II)	<ol style="list-style-type: none"> 1. Performance measures were established. 2. Surveys to researchers will help enhance the operation. 3. Additional surveys will help in quantifying the benefits of research.
Structural Health Monitoring and Highway Bridge Subject to Overweight Trucks, Phase 1	<ol style="list-style-type: none"> 1. Our initial hypothesis that FBG sensors are appropriate for long-term SHM of bridges has been confirmed by recent literature. 2. We have developed an innovative mechanism for triggering the SHM system using RFID technology. This approach will facilitate continuous monitoring of bridges for the effects of permit vehicles. 3. The data collection and analysis challenges associated with bridge monitoring are massive. Additional research will be needed to develop automated systems for data reduction, analysis, and application to rating software.

Planning-Support for Mitigation of Wildlife Vehicle Collisions and Highway Impacts on Migration Routes in Wyoming	Thanks to this project, we know that the spatial and temporal patterns of deer-vehicle collisions are very meaningful biologically and can be used, together with deer movement data, to identify places where deer are most vulnerable to the impacts of roads. This is enormously helpful in prioritizing which locations are most in need of mitigations and what kind of mitigations are most appropriate to reduce deer-vehicle collisions on Wyoming's roads.
Investigation of Silica Fume Concrete Bridge Overlay Failures	<ol style="list-style-type: none"> 1. Premature silica fume bridge deck overlay failures were caused by weak (micro cracked) substrate concrete and cracking, curling and debonding of the overlay due to high drying shrinkage characteristics of the silica fume concrete. 2. Service life including bonding of silica fume overlays are highly dependent on several factors including: soundness of the concrete substrate and surface preparation, drying shrinkage characteristics of the silica fume concrete and crack resistance of the silica flume concrete overlay. 3. Specifying, measuring and using a very low-shrinkage concrete as verified by ASTM C157 is critical to extending the surface life of silica flume bridge deck overlays.
Evaluation of a Mitigation Site: Amphibian Population	<ol style="list-style-type: none"> 1. Good collaborative effort. 2. Interest of WYDOT cooperators. 3. Broadened scope of the use of the data.
Characterization of Material Properties for Mechanistic-Empirical Pavement Design in Wyoming	<ol style="list-style-type: none"> 1. A process for selecting materials properties was established. 2. WYDOT was presented with multiple ways to select aggregate strength. 3. The study will facilitate the full implementation of the MEPDG
Instrumentation and Analysis of Frost Heave Mitigation on WY 70, Encampment, WY	<ol style="list-style-type: none"> 1. The injectable polymer foam stabilized the frost heave. 2. The process was rapid and provided many safety benefits over conventional reconstruction methods. 3. The thickness of polymer can be predicted using a modification of a procedure developed by the US military.
Effects of Wildlife Warning Reflectors ("Deer Delineators") on Wildlife-Vehicle Collisions in Central Wyoming	<ol style="list-style-type: none"> 1. Streiter-Lite reflectors have some benefit to reducing wildlife-vehicle collisions that appears to be worth their cost. 2. There are likely other more cost-beneficial ways to reduce wildlife-vehicle collisions, such as reducing night-time speed limits. 3. The success of white canvas bags in reducing WVC may lead to some new, inexpensive technologies for reducing WVC.
Evaluating the Effects of Deer Delineators in Wildlife-Vehicle Collisions in Northwest Wyoming	<ol style="list-style-type: none"> 1. Deer reflectors have some limited effectiveness in reducing WVC. 2. White bags on posts worked better than reflectors and further technology should be explored. 3. Before-after collision data are not very useful for testing the effectiveness of WVC mitigations unless their effectiveness is extremely high.
A Literature Review of Approach Slab and its Settlement for Roads and Bridges in Wyoming	<ol style="list-style-type: none"> 1. Engage with WYDOT especially the champion as early as possible. 2. Seek assistance from the champion. 3. Understand the needs and deliverables of the project.
Developing Mitigation Strategies to Reduce Truck Crash Rates in Wyoming Highways	<ol style="list-style-type: none"> 1. Enforcement impacts crashes. 2. Enforcement agencies in Wyoming have similar resources to other agencies in the region. 3. Specific recommendations were provided to the trucking industry, WYDOT, and Wyoming Highway Patrol.
Evaluating the Risk of Alkali Silica Reaction in Wyoming	<ol style="list-style-type: none"> 1. Reactivity of Wyoming Aggregates. 2. Data on local materials. 3. Field site to provide long term data.

Wyoming Low Volume Roads Traffic Volume Estimation	<ol style="list-style-type: none"> 1. Traffic volumes on LVR can be predicted in three different ways. 2. The regression modeling is the easiest to implement. 3. The TDM is the most accurate.
Historic Winter Weather Assessment for Snow Fence Design using a Numerical Weather Model	<ol style="list-style-type: none"> 1. Updated wind field data for snow fence design. 2. Model verified snow data for snow fence design. 3. Blowing snow remains a major hazard during winter in Wyoming.
Improving Traveler Information on Rural Corridors in Wyoming through the Use of Intelligent Transportation Systems	<ol style="list-style-type: none"> 1. Bluetooth / Wi-Fi sensors not a good technology for I-80 corridor due to low penetration rates. 2. Travel time index gives a consistent and reliable measure of condition severity. 3. Use of travel time reporting likely would enhance WYDOT's traveler information system
Evaluating Base Widening Methods	Tapered joints for pavement widening project was determined to have lower long term impacts on pavement than vertical joints.
Developing a Roadway Safety Improvement Program for Indian Reservations	<ol style="list-style-type: none"> 1. A systematic process should be implemented when evaluating safety on tribal lands. 2. Lots of coordination is needed among stakeholder to make sure that the safety projects are successful. 3. DOTs should work closely with tribal representatives to enhance roadway safety on tribal roads.
Pronghorn and Mule Deer Use of Underpasses along US Highway 191	<ol style="list-style-type: none"> 1. Wildlife crossing structures work. 2. Pronghorn prefer to move over roadways. 3. Mule deer can move under or over roadways.

The fifth section of the Research Feedback survey requested that Principal Investigators indicate whether follow-up research is warranted. Figure 13 illustrates Principal Investigators indication of whether follow-up research was warranted. Seventy-nine percent of the Principal Investigators indicated that follow-up research was warranted, while only 21 percent indicated that no follow-up research was warranted.

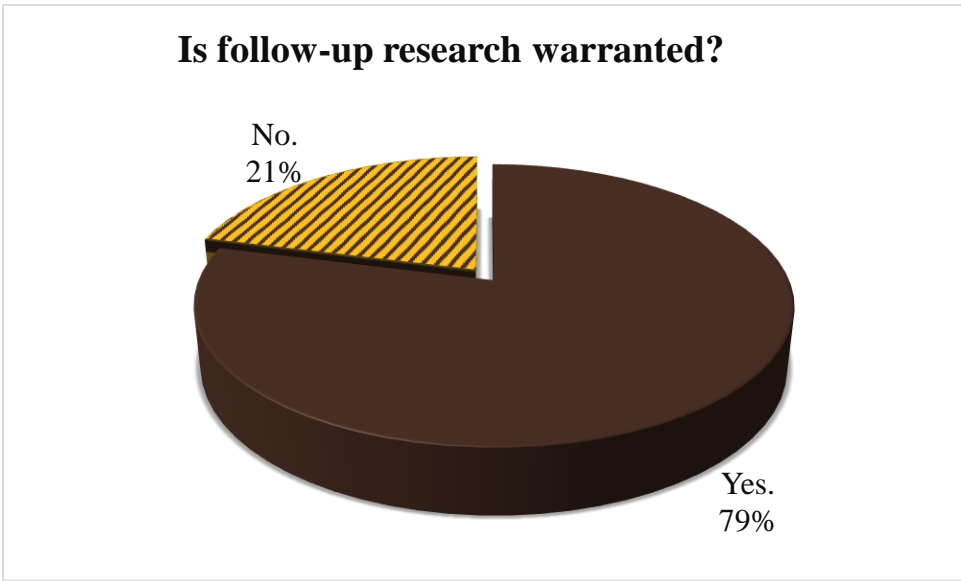


Figure 13. Principal Investigators Indication if Follow-up Research is Warranted.

The final section of the Research Feedback survey requested Principal Investigators to provide feedback for improving the interaction with the WYDOT Research Center. Of the 28 responses, 10 Principal Investigators provided suggestions for improving the interaction with the WYDOT Research Center. The suggestions from the Principal Investigators indicated when a research report is submitted it is hard to determine the person the report should reach and if the report was valuable or not. Another suggestion from the Principal Investigators was that the RAC should provide additional feedback to unsuccessful proposals so that applicants can improve their future proposals.

WYDOT Champions Phase I Surveys

The Phase I Performance Evaluation survey was developed in *Evaluating Department of Transportation's Research Centers: A Methodology and Case Study* by Justin Terfehr and Khaled Ksaibati. Figure 14 shows the questions from the Phase I Performance Evaluation form. The survey consists of eight multiple choice questions. This survey was sent to Project Champions within two years of the competition of the research projects for projects listed in Table 23. Eighteen surveys were received from Project Champions.

1. Were all of the proposed objectives of the research project fulfilled?
 - All objectives were fulfilled
 - Some objectives were fulfilled
 - No objectives were fulfilled
2. Expected future level of implementation with WYDOT.
 - Full implementation
 - Partial Implementation
 - No implementation
 - Results do not recommend implementation
3. External technology transfer.
 - Any national, regional, or local presentation, publications, etc.
 - No external technology transfer
4. Internal technology transfer.
 - Presentations created and used by the Research Center or relevant departments within WYDOT
 - No internal technology transfer
5. Was a research report created?
 - A professional and concise research report was created, meeting WYDOT's expectations
 - No research report was created or an inadequate research report was submitted
6. Was the research project completed within its proposed timeline?
 - The project was completed within its proposed timeline or within approved extensions
 - The project was completed within one month of its timeline
 - The project was completed after one month of its proposed timeline
 - The project was not completed
7. Was the project completed within its proposed budget?
 - The project was completed with its proposed budget or within an approved funding
 - The project was not completed within its budget
8. Was the researcher feedback form completed?
 - Yes
 - No

Figure 14. Phase I Performance Evaluation Questions.

The first question of the Phase I Performance Evaluation requested that Project Champions indicate the level at which the projects objectives were fulfilled. Figure 15 illustrates Project Champion evaluation of the level at which research project objectives were fulfilled. Of the 18 responses, 78 percent of the Project Champion indicated that all objectives of the research project were fulfilled, while 22 percent indicated that some of the objectives of the research project were fulfilled.

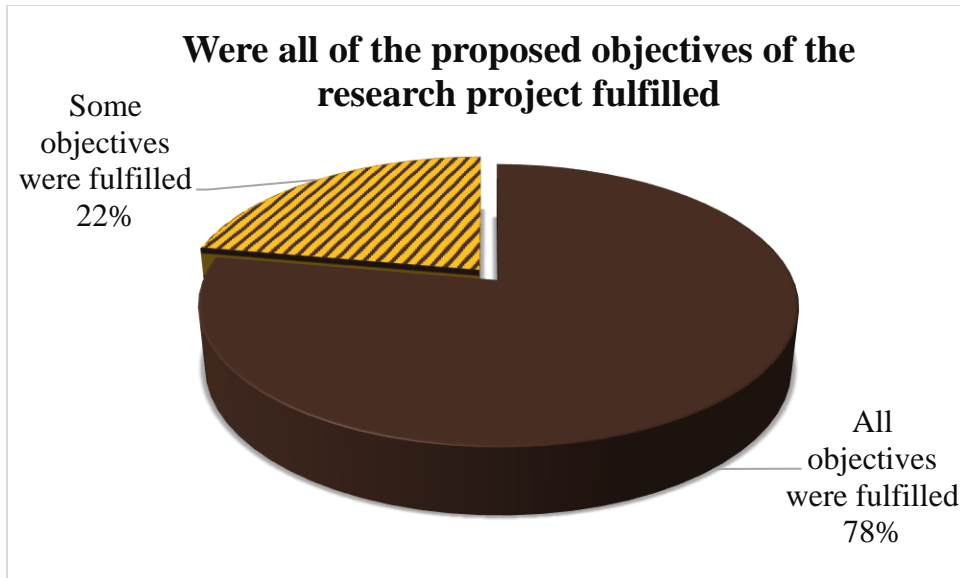


Figure 15. Level at which Project Objectives were Fulfilled.

The second question of the Phase I Performance Evaluation asked Project Champions to indicate the research project expected a future level of implementation within WYDOT. Figure 16 illustrates the Project Champion evaluation of the expected future level of implementation within WYDOT. Of the responses, 44 percent of the Project Champions indicated that the research project expected full future implementation, 50 percent expected partial implementation within WYDOT, and 6 percent of Project Champions expected no implementation within WYDOT.

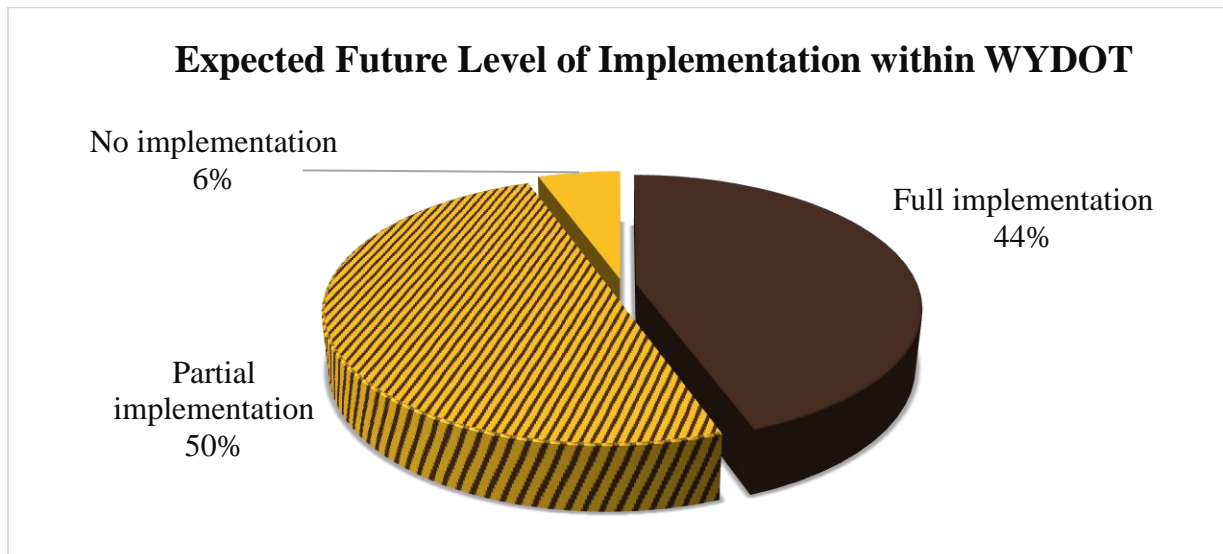


Figure 16. Expected Future Level of Implementation within WYDOT.

The third question of the Phase I Performance Evaluations asked Project Champions to indicate if external technology transfer occurred for the research project. Figure 17 illustrates Project

Champions evaluation regarding whether external technology transfer occurred for the research project. Of the 18 responses, 78 percent of the Project Champions indicated some national, regional, or local presentations, publications, etc., while only 22 percent indicated no external technology transfer occurred.

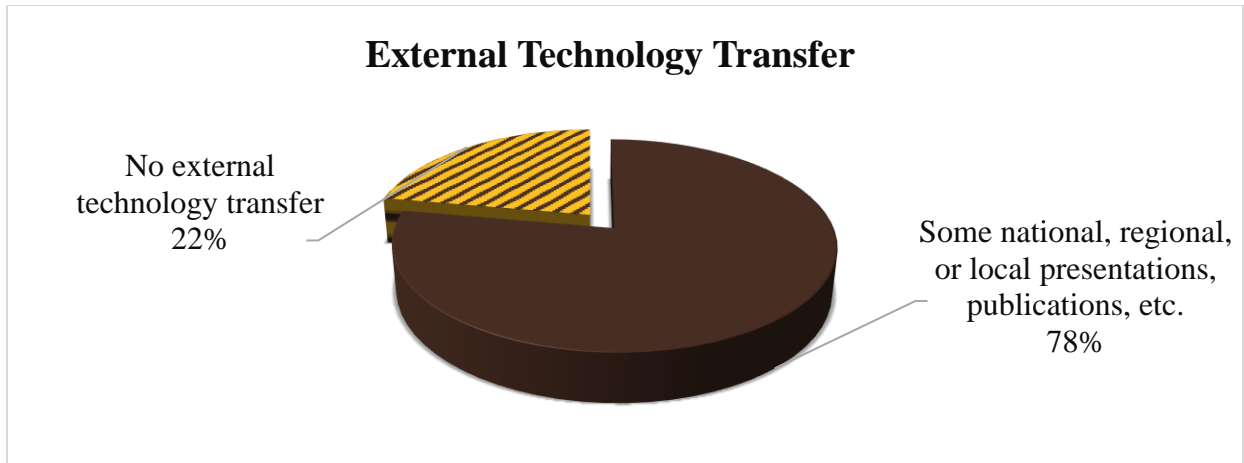


Figure 17. External Technology Transfer.

The fourth question of the Phase I Performance Evaluations asked Project Champions to indicate whether internal technology transfer occurred for the research project. Figure 18 illustrates Project Champion evaluation on whether internal technology transfer occurred for the research project. Of the 18 responses, 81 percent of the Project Champions indicated that research findings were presented to relevant departments within WYDOT; while 19 percent indicated no internal technology transfer occurred.

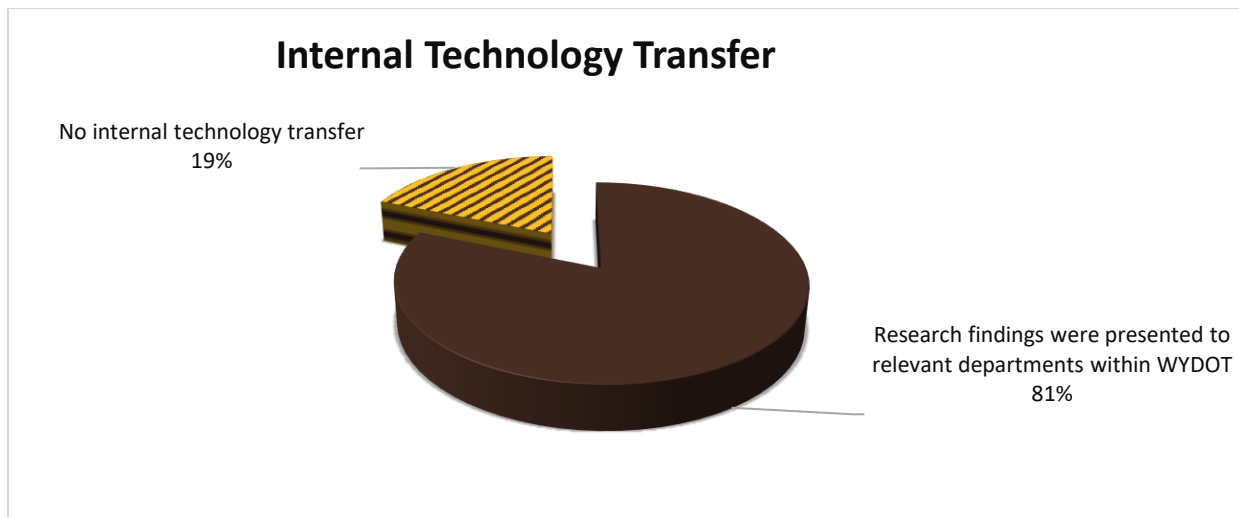


Figure 18. Internal Technology Transfer.

The fifth question of the Phase I Performance Evaluations requested that Project Champions indicate if a research report was created. All 18 Project Champion indicated that a professional and concise report was created, meeting WYDOT’s expectations.

The sixth question of the Phase I performance Evaluations requested that Project Champions indicate if research projects were completed within the proposed timeline. Figure 19 illustrates Project Champions evaluation if the research project was completed within its proposed timeline. Of the 18 responses, 83 percent of the Project Champions indicated that the research project was completed within its proposed timeline, while 11 percent indicated the research project was completed 1 month after its proposed timeline. Six percent of the Project Champion indicated the project was not completed within its proposed timeline.

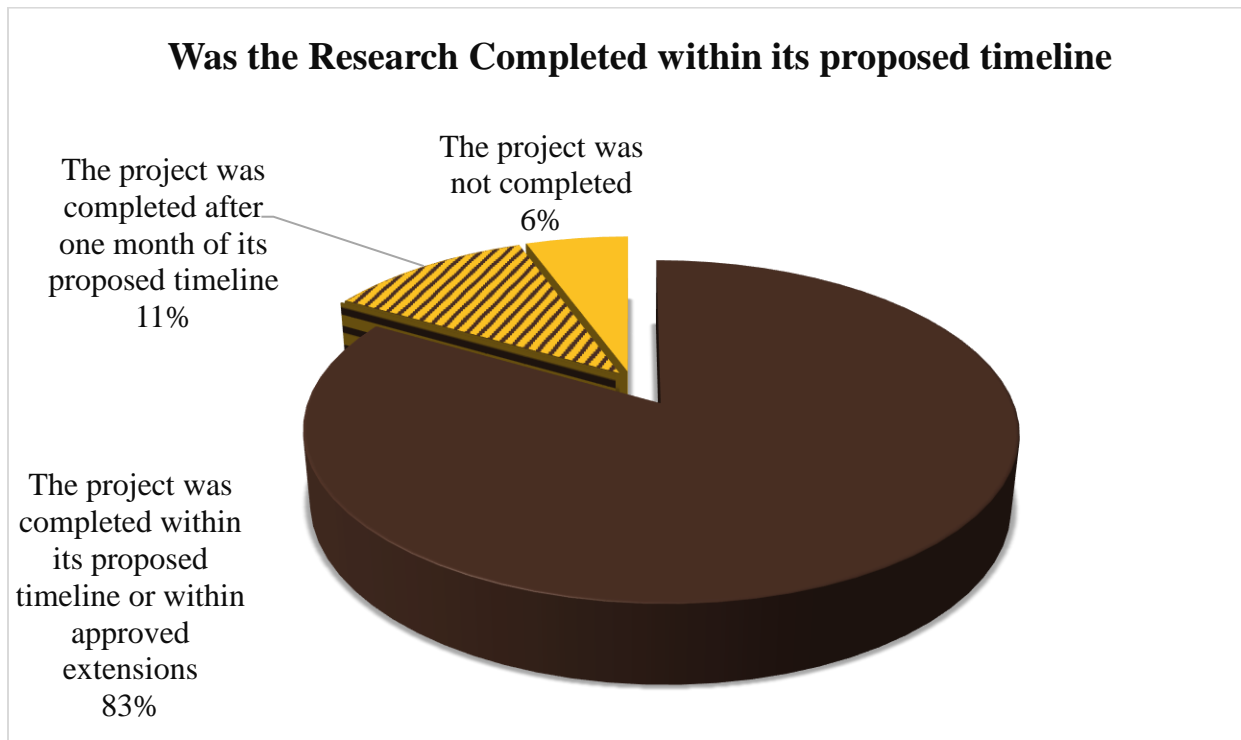


Figure 19. Was the research Completed within Its Proposed Timeline

The seventh question of the Phase I Performance Evaluation asked Project Champions to indicate if the research project was completed within its proposed budget. All 18 Project Champions indicated that the research project were completed within their proposed budgets.

WYDOT Champions Phase II Surveys

The Phase II Performance Evaluation survey was developed in *Evaluating Department of Transportation’s Research Centers: A Methodology and Case Study* by Justin Terfehr and Khaled Ksaibati. Figure 20 shows the questions from the Phase II Performance Evaluation form. The survey consists of five multiple choice questions as well as explanatory questions. This

survey was sent to Project Champions two years after the competition of the research project for projects listed in Table 25. Ten surveys were received from the Project Champions.

<p>1. Have the results of the research project contributed to WYDOT's mission?</p> <ul style="list-style-type: none"><input type="radio"/> Yes<input type="radio"/> No <p>If yes, briefly describe which aspect of WYDOT's mission have been advanced or affected by the result of the research project:</p>
<p>2. Have the results of the research project been implemented within WYDOT?</p> <ul style="list-style-type: none"><input type="radio"/> Full implementation<input type="radio"/> Partial implementation<input type="radio"/> No implementation <p>If level of implementation has changed from the phase I evaluation, please explain:</p>
<p>3. What is the cost/benefit associated with this project?</p> <ul style="list-style-type: none"><input type="radio"/> Benefits associated with her results f project exceeds cost of project<input type="radio"/> Benefits associated with the results of project do not exceeds cost of project<ul style="list-style-type: none">▪ Total project cost =▪ Estimated dollar savings or benefits associated with implantation of the project =
<p>4. Have the results of the project had any impacts on national, regional, or local organizations or agencies?</p> <ul style="list-style-type: none"><input type="radio"/> Yes<input type="radio"/> No <p>If yes, briefly identify the organization or agency that was impacted, and what affect the research project has on them:</p>
<p>5. Has additional research been pursued or conducted as a result of this project within WYDOT?</p> <ul style="list-style-type: none"><input type="radio"/> Yes, additional research has been approved.<input type="radio"/> No, additional research has not been approved <p>If yes, identify the project.</p>

Figure 20. Phase II Performance Evaluation Questions.

Table 25. List of the Projects included in the Phase II Surveys.

Project I.D.	Project Title
RS02212	Managing Risks in the Project Pipeline - Minimizing the Impacts of Highway Funding Uncertainties
RS03209	Implementation of the Mechanistic- Empirical Pavement Design Guide in WYDOT
RS03211	Evaluation of the Wyoming Research Center and Research Program (Phase II)
RS04211	Investigation of Silica Fume Concrete Bridge Overlay Failures
RS04212	Evaluation of a Mitigation Site: Amphibian Population
RS05211	Instrumentation and Analysis of Frost Heave Mitigation on WY 70, Encampment, WY
RS05213	A Literature Review of Approach Slab and its Settlement for Roads and Bridges in Wyoming
RS06212	Evaluating the Risk of Alkali Silica Reaction in Wyoming
RS07211	Improving Traveler Information on Rural Corridors in Wyoming through the Use of Intelligent Transportation Systems
RS08211	Evaluating Base Widening Methods
RS09211	Developing a Roadway Safety Improvement Program for Indian Reservations
RS10211	Criteria for a WYDOT Culvert Selection Policy

The first question of the Phase II Performance Evaluation survey requested that Project Champions indicate if the research project has contributed to WYDOT’s mission. All 10 surveys that were received indicated that the research projects contributed to WYDOT’s mission. The explanations for why the research project contributed to WYDOT’s mission in shown in Table 26.

Table 26. Explanation on why the Project Contributed to WYDOT’s Mission.

Project	Explanation on why the project contributed to WYDOT’s mission
Managing Risks in the Project Pipeline - Minimizing the Impacts of Highway Funding Uncertainties	It has allowed WYDOT to optimize its resources more efficiently and allowed WYDOT to impact performance better.
Evaluation of the Wyoming Research Center and Research Center (Phase II)	I believe it has allowed the Research Center to better focus its energies on more productive mission based research.
Investigation of Silica Fume Concrete Bridge Overlay Failures	The silica fume modified concrete overlay specifications have been modified based on the research.
Evaluation of a Mitigation Site: Amphibian Population	One of the goals to fulfill mission: exercise good stewardship of our resources - this research project assisted in evaluating effective wetland creation; first time we studied effects on amphibians and reptiles.
Instrumentation and Analysis of Frost Heave Mitigation on WY 70, Encampment, WY	This research project give WYDOT another option in dealing with problem frost heaves on roadways.
A Literature Review of Approach Slab and its Settlement for Roads and Bridges in Wyoming	The way that approach backfill is constructed has been improved.
Evaluating the Risk of Alkali Silica Reaction in Wyoming	WYDOT is continually trying to find or develop better methods for evaluating aggregates for alkali silica reaction. The ideal test has not been developed and research is ongoing.
Evaluating Base Widening Methods	It has helped us evaluate the different geometric options for base widening of roadways.
Developing a Roadway Safety Improvement Program for Indian Reservations	Coordination with the Wind River Indian Reservation on Traffic Safety.
Criteria for a WYDOT Culvert Selection Policy	Improving safety by reducing pavement settlements over culverts. Increasing efficiency by allowing more competition of pipe products.

The second question of the Phase II Performance Evaluation survey requested that Project Champions indicate the level of implementation within WYDOT for the research projects. Figure 21 shows the Project Champions response for the level of implementation within WYDOT for the research projects. Project Champions indicated that 20 percent of projects were fully implemented within WYDOT, 60 percent of projects were partially implemented within WYDOT, and 20 percent of the projects had no level of implementation within WYDOT.

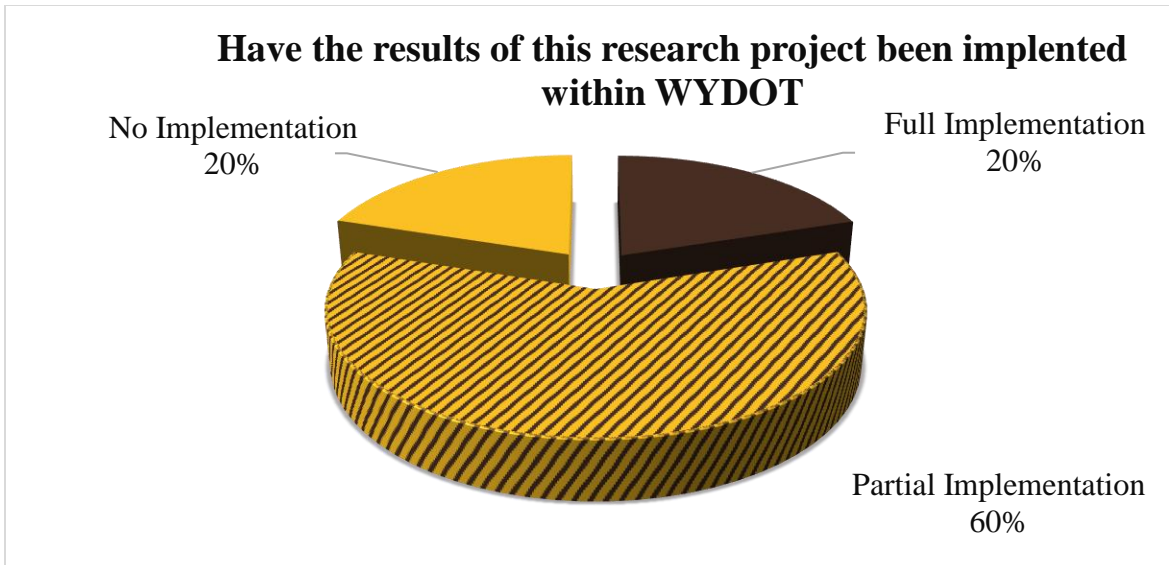


Figure 21. Project Implementation within WYDOT.

The third question of the Phase II Performance Evaluation survey requested that Project Champions identify the benefits and costs of the research projects. Figure 22 shows the Project Champions responses for the cost/benefit associated with the research projects. They indicated that 40 percent of projects had benefits that exceed the cost of the project, while 60 percent indicated that benefits cannot be identified. The survey also requested Project Champions to estimate the benefit cost ratio of the research project. Out of the 10 responses only 1 was able to identify a benefit/cost ratio. This is a confirmation that a well-documented process for estimating benefit to cost ratio is needed.

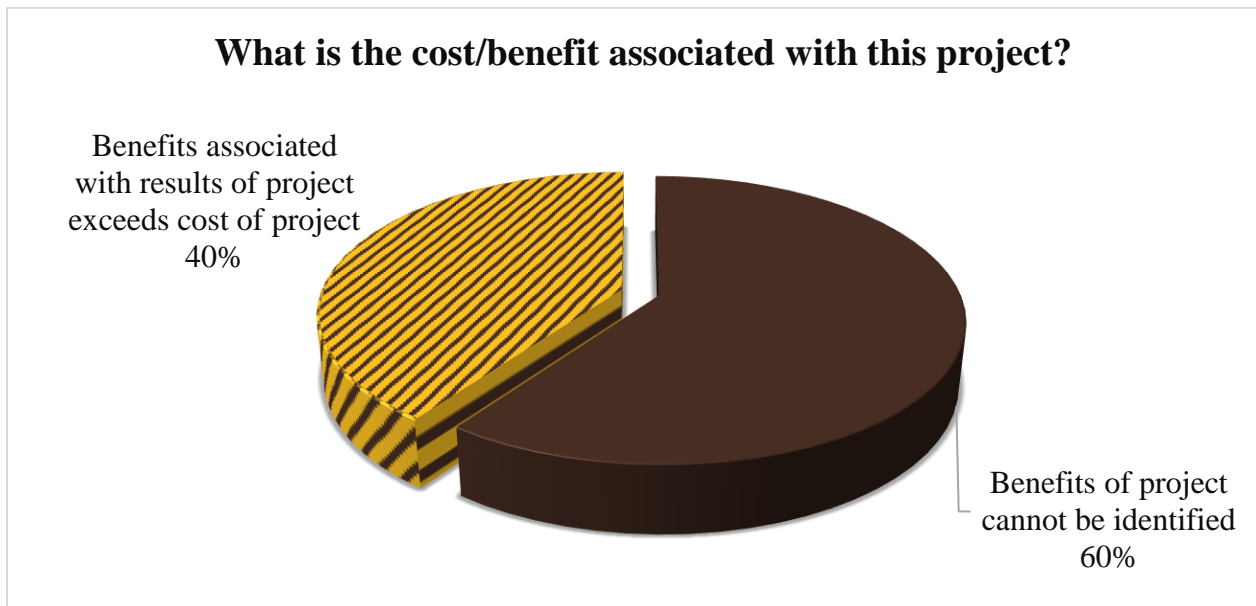


Figure 22. Cost/Benefits Associated with the Projects.

The fourth question of the Phase II Performance Evaluation survey requested that Project Champions indicate if the research project resulted in an external technology transfer. Figure 23 shows the Project Champion's response about the impact of projects on national, regional or local organizations. Project Champions indicated that 40 percent of research projects had an impact on national, regional, local organizations or agencies, while 60 percent indicated that no external technology transfer occurred.

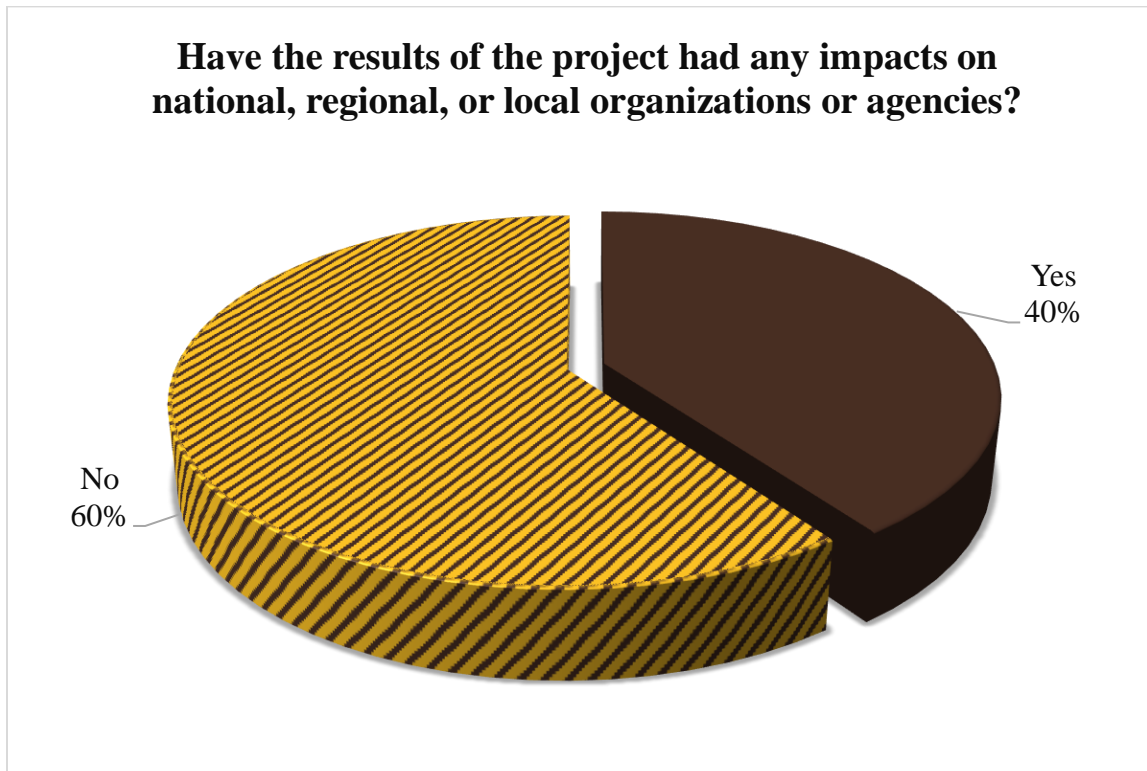


Figure 23. External Technology Transfer.

The final question of the Phase II Performance Evaluation survey requested that Project Champions indicate if the research project has resulted in additional research. Figure 24 shows the Project Champion's response on if additional research has occurred as a result of the project. Project Champions indicated that 33 percent of the research projects had resulted in additional research, while 67 percent indicated that the research projects did not result in additional research.

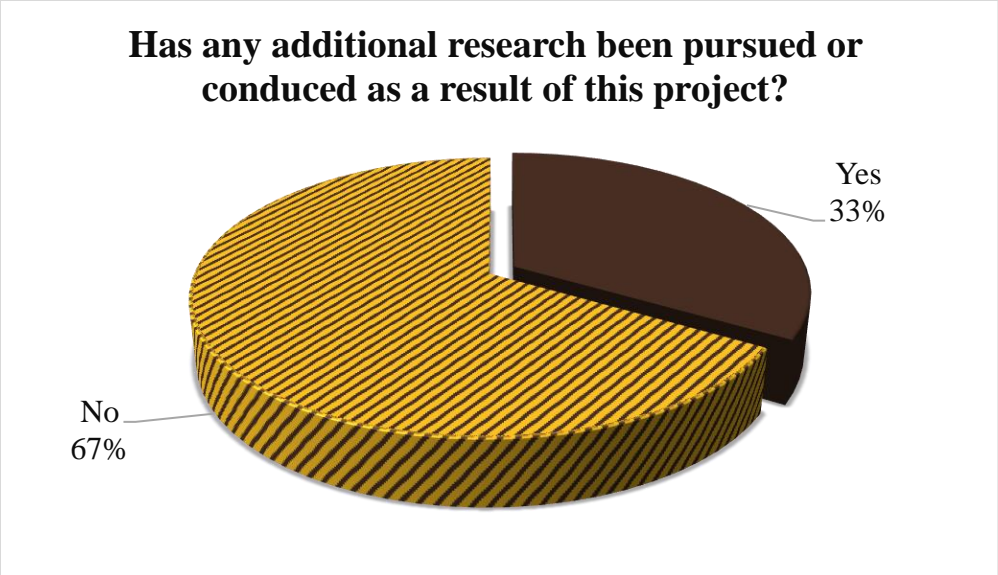


Figure 24. Additional Research.

Chapter Summary

The surveys conducted in this study included the feedback from the Principal Investigators and the Project Champions. Twenty-eight surveys were received from the Principal Investigators, 18 surveys were received from Phase I Performance Evaluation Survey, and 10 surveys were received from Phase II Performance Evaluation Survey. The results of the surveys indicated that most of the Principal Investigators and Project Champions had a high satisfaction of the research projects they worked on. The survey results also indicate a significant level of implementation of the findings of the research projects within WYDOT and at the regional/national levels.

CHAPTER 7. METHODOLOGY FOR BENEFIT-TO-COST ANALYSIS (BCA)

The third stage of this report was to develop a methodology for implementing a benefit cost analysis for evaluating completed research projects. The Benefit-Cost Analysis (BCA) is intended to quantify the actual impacts the project's results had on the society. This evaluation is meant to be initially performed during the proposal development process and then completed at least two years after the project's end date to allow for measuring the implementation within the DOT. Figure 25 shows the steps for developing a BCA. The first step is to develop a methodology to quantify the benefits and costs for each project. The next step is to develop a BCA tool to implement the BCA methodology. The BCA tool serves as a guideline and provides information, examples, and resources to estimate the Benefit-to-Cost Ratio (BCR). The final step estimates the BCR for each project using the BCA tool. The BCR will be added as a new performance measure for future evaluation of the Research Center. In this study, the first step, General BCA Methodology, is developed and discussed in the following sections.

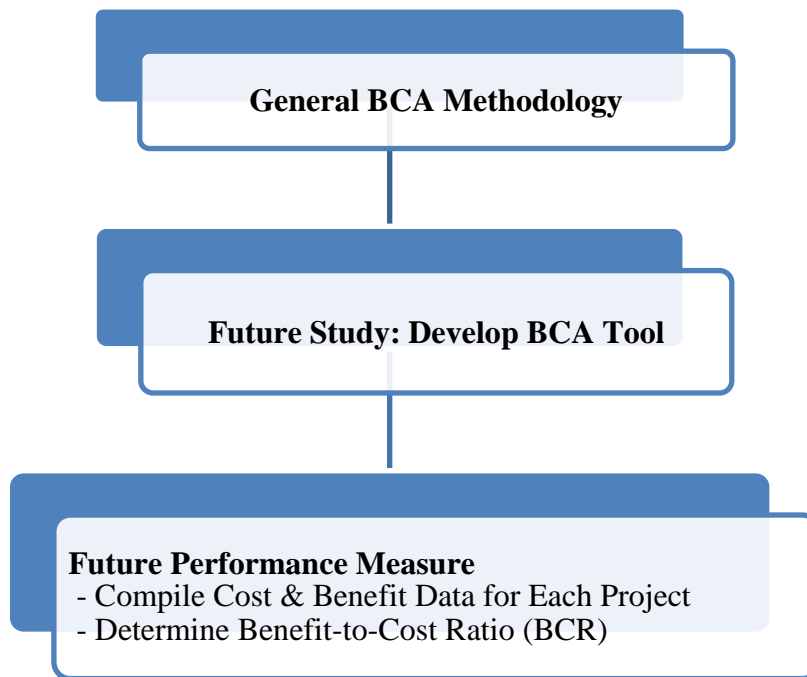


Figure 25. The Steps for BCA Analysis.

General BCA Methodology

The general methodology for BCA introduces the steps of performing the economic analysis to estimate the cost effectiveness of the project implemented. The cost effectiveness of the project is represented by the BCR formulated as below:

$$\text{Benefit to Cost Ratio (BCR)} = \frac{\text{Present Value (\$) of Benefits}}{\text{Present Value (\$) of Costs}}$$

If a project is economically justifiable, its BCR is larger than one, which indicates the project has greater return of benefits than its associated costs. In this study, the overall BCR methodology can be seen in Figure 26. The BCR estimation is primarily divided into two phases: estimation of benefits and estimation of costs. The estimated benefits and costs are used to estimate the BCR in the final step of methodology. In the following sections, these two phases are discussed in more detail.

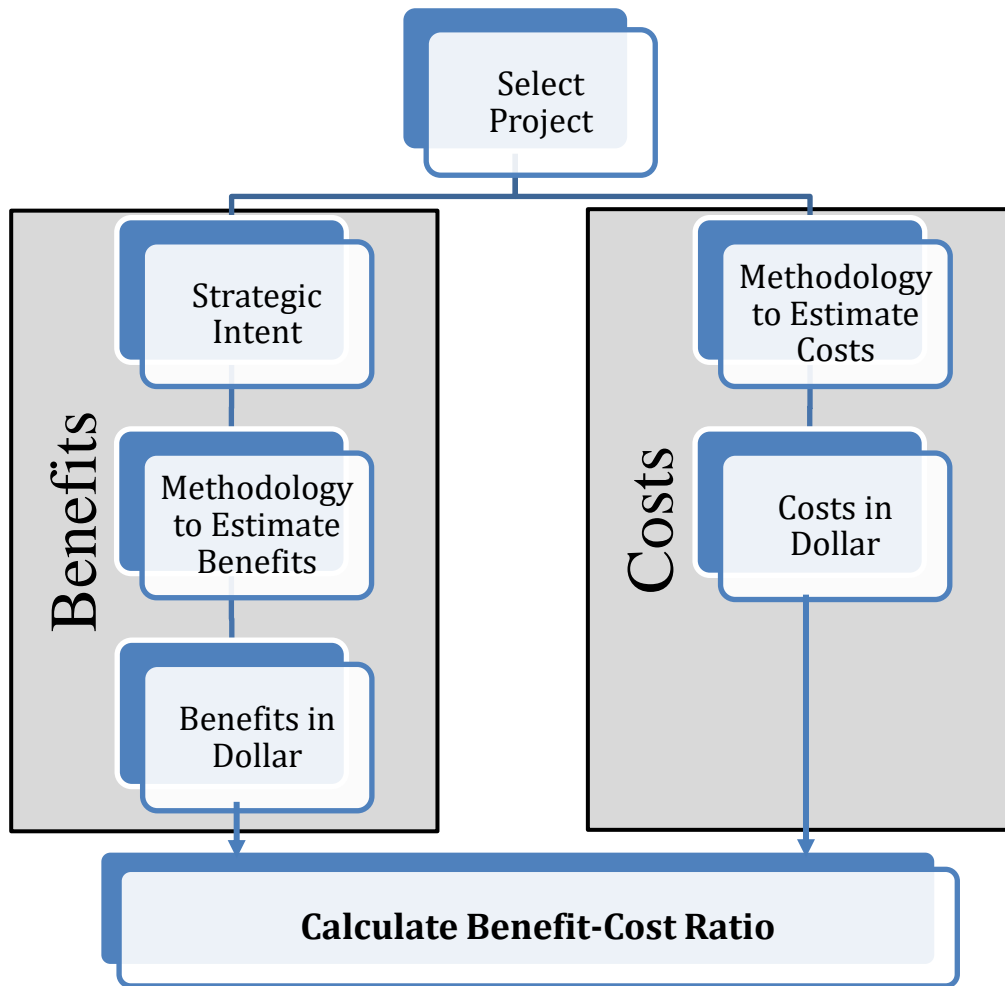


Figure 26. Overall Methodology to Estimate Benefit-Cost Ratio.

Estimation of Costs

The estimation of costs is a relatively simple process, costs associated with projects are similar to each other. The main contribution to costs of a project are costs associated with the research and development, and implementation of the project. The methodology to estimate the costs of a research project can be seen in Figure 27. The costs are divided into two types: research and implementation. In the following sections, these two types of costs are discussed.

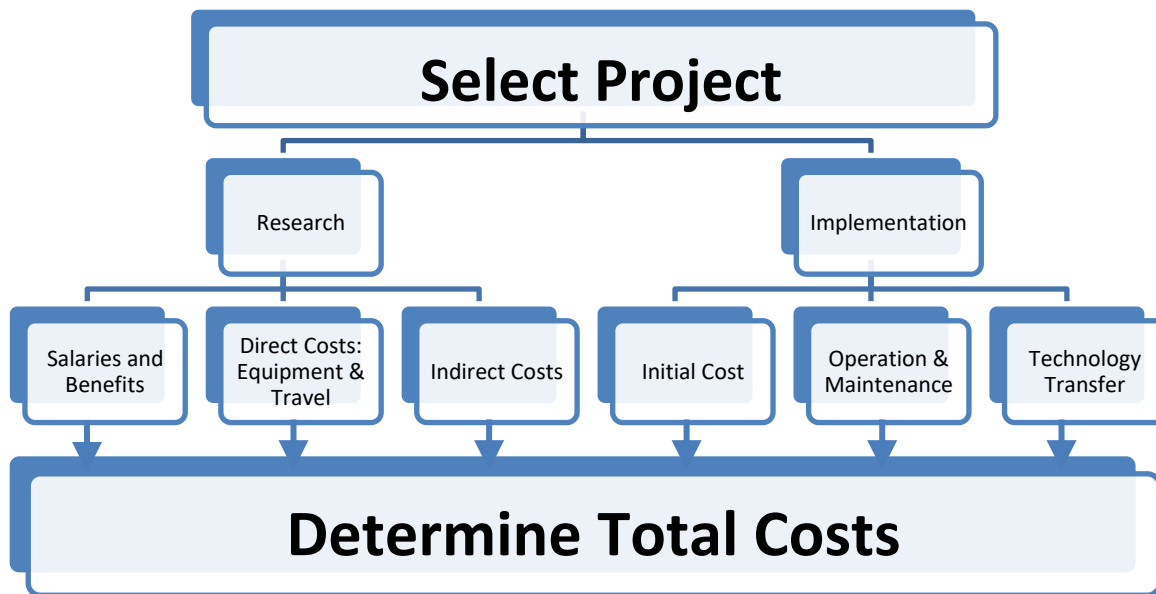


Figure 27. Methodology to Estimate Costs.

Research Costs

Research costs includes any costs associated with the research and development of the project. The main costs of research are salaries, and direct and indirect costs. The research costs of a project are defined in the proposal of the project. Table 27 shows typical costs of a research project. Each type of costs is discussed below:

- **Salaries and Benefits:** The salaries and benefits of a research project are expenses that occur due to costs associated with the salaries of the individuals conducting the research and development. Typically, salaries include those attributed to the Principal Investigator, administrators and individuals assisting the Principal Investigator in the research.
- **Direct Costs:** The direct costs of a research project are the expenses associated directly with the research being conducted. The cost include expense for purchasing equipment, supplies, travel (foreign & domestic), and any other direct costs.
- **Indirect Costs:** The indirect costs of a research project are expense that are not directly related to the research being conducted. Examples of indirect costs related to research projects are maintenance, equipment repair, etc.

Table 27. Example of Typical Costs of a Research Project.

	Category	Budget Amount
Salaries and Benefits	Principal Investigator Salaries	\$ 13,500
	Administrative Salaries	\$ -
	Engineer Salaries	\$ 3,500
	Student Salaries	\$ 28,000
	Staff Salaries	\$ 8,518
	Total Salaries and Benefits	\$ 53,518
Direct Costs	Permanent Equipment	\$ -
	Expendable Property, Supplies, and Services	\$ 3,500
	Domestic Travel	\$ 9,800
	Foreign Travel	\$ -
	Other Direct Costs	\$ 9,000
	Total Other Direct Costs	\$ 22,300
Indirect Costs		\$ 13,181
Total Costs		\$ 89,181

Implementation Costs

The implementation costs depend on the level of implementation: none, partial, or full implementation. The data for the level of implementation for each project should be obtained from the WYDOT Project Champions. Sometimes, there are very few projects which are not fully or partially implemented. So, the implementation costs vary based on the level of implementation. Table 28 shows typical costs associated with implementation of a project.

Table 28. Typical Costs for Implementation of a Project.

	Category
Initial Costs	Equipment Purchases
	Software Purchases
	Education
	Issuing/Updating standards
	Construction
Operational and Maintenance Costs	Staff Salaries
	Maintenance
	Supplies
	Transportation
Technology Transfer Costs:	Copyright
	Licensing
	Patents
	Royalties

- **Initial Costs:** Initial costs are any initial one-time expenditure that is required to implement the project. Examples of initial costs are equipment purchases, software purchases, education related costs, construction costs, etc.
- **Operational and Maintenance Costs:** Operational and maintenance costs are re-occurring expenditures through the implementation of the project. Examples of operational and maintenance costs are staff salaries, maintenance, supplies, transportation.
- **Technology Transfer Costs:** Technology transfer costs are any expenditures related to the transfer of the knowledge or technology from one organization to another. Examples of technology costs are licensing, and patents.

Estimation of Benefits

Quantifying benefits of a project is a complex process. Since the benefits vary significantly among projects, the projects were grouped based on six strategic intent measures: infrastructure upgrades, preservation, safety, wildlife studies, shared knowledge, and public affairs. For each strategic intent measure, a stepwise approach was used to develop a methodology for quantifying the benefits associated with the project.

Benefits for the Infrastructure Upgrade Measure

The purpose of transportation infrastructure measure is to allow for the safe and efficient movement of people and goods. Infrastructure upgrade projects focus on improving the efficiency of transportation infrastructure to better allow for the movement of people and goods. The success of projects is measured by the extent of the improvement on the efficiency of the transportation infrastructure. In identifying the improvement on the transportation infrastructure and savings due to the improvement, a monetary value can be assigned to calculate the benefits.

A benefit of infrastructure upgrade projects is reducing the congestion of transportation infrastructure, or in other words, improving the level of service. The savings contributed to increasing the level of service include reducing the impact of high demand hours on the road network, increasing safety, and increasing the travel time. Another benefit of infrastructure upgrade is reducing the network wide travel time. Reductions in travel time allow for lessening the amount of delays experienced by the transportation infrastructure user resulting in less travel cost for the user. A second benefit of infrastructure upgrade is the savings in vehicle operation costs, which are costs associated with the operation and maintenance of the vehicle (i.e. cost for gasoline, tires, routine maintenance, etc.). A third benefit of infrastructure upgrade projects is the saving incurred due to saving by the DOTs in operational and maintenance due to implementation of the project. Other benefits of infrastructure upgrade projects may include savings in safety transit, and parking, and also generate employment. The methodology developed for evaluating the benefits of a project with a strategic intent measure of infrastructure upgrade is shown in Figure 28.

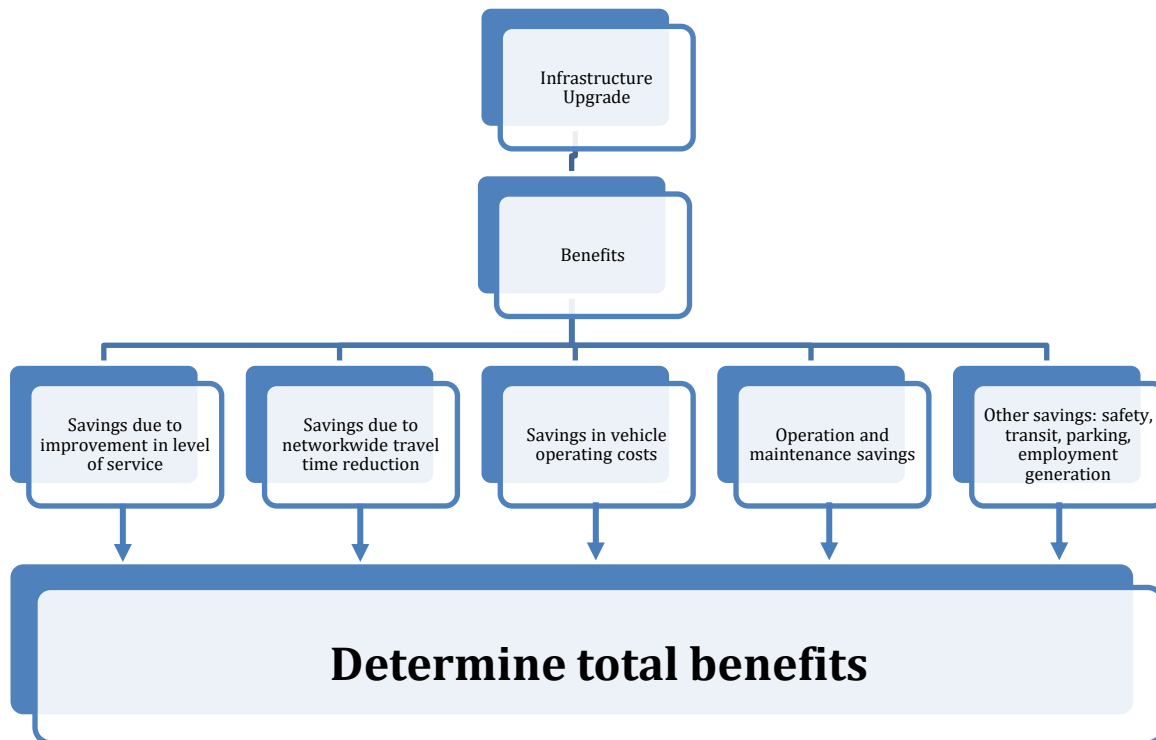


Figure 28. Methodology to Estimate Benefits for Strategic Intent “Infrastructure Upgrade”.

Benefits for the Preservation Measure

With limited amounts of transportation funding, it is necessary to preserve transportation infrastructure to either delay or prevent full replacement of transportation infrastructure. Projects focusing on preservation spotlight preserving the transportation infrastructure. A benefit of preservation projects is increasing the service life of the transportation infrastructure. Savings in increasing the service life are mainly due to preventing rehabilitation / replacement. A second benefit of preservation projects is reducing the travel time due to improved pavement condition, which decreases delays and lowers travel cost for the user. A third benefit of a preservation project is the savings in vehicle operation costs (i.e. cost for gasoline, tires, routine maintenance, etc.). A fourth benefit of preservation projects is the saving in operational and maintenance of the transportation facility. Other benefits of preservation projects are savings in safety and employment generation. Figure 29 shows the methodology for estimating the benefits of projects which fall under the strategic intent measure preservation.

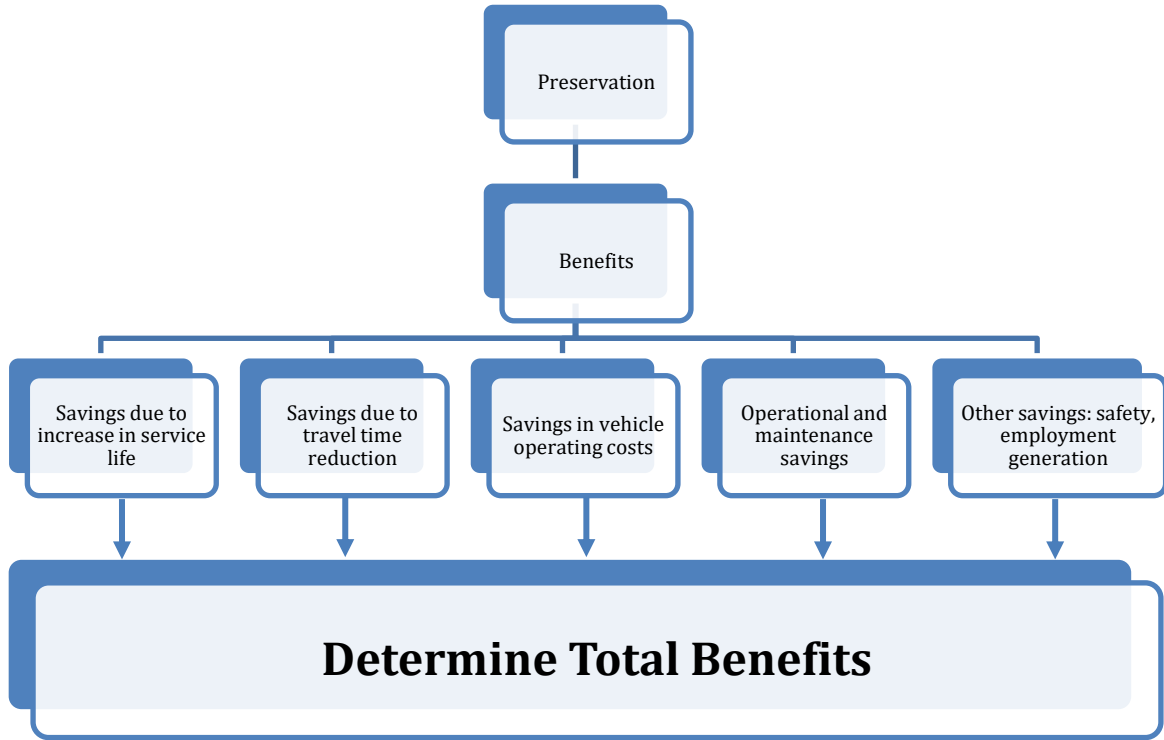


Figure 29. Methodology to Estimate Benefits for Strategic Intent “Preservation”.

Benefits for the Safety Measure

Safety projects allow for enhanced safety for the users of the transportation infrastructure. The main measure used to evaluate the effectiveness of a safety projects is the extent to which the project reduces the number of crashes on the transportation infrastructure. The savings of reducing the number of crashes include the societal cost of the crash (i.e. medical expenses, vehicle repair/replacement, funeral expenses), saved by implementing the safety project, compared to before implementation. Another saving is the expense of repair/replacement of transportation infrastructure elements prevented due to implementation of the safety project. Other savings include the costs for cleanup of the crash prevented by the safety project. Another benefit of a safety project is the extent to which the crash injury severity is reduced. The saving for reducing the crash injury severity include reducing the societal costs of the crash due to the safety project. Other benefits of safety projects can be savings in reducing travel time, vehicle operating costs and employment generation. Figure 30 shows the methodology for estimating the benefits of projects with a strategic intent in safety.

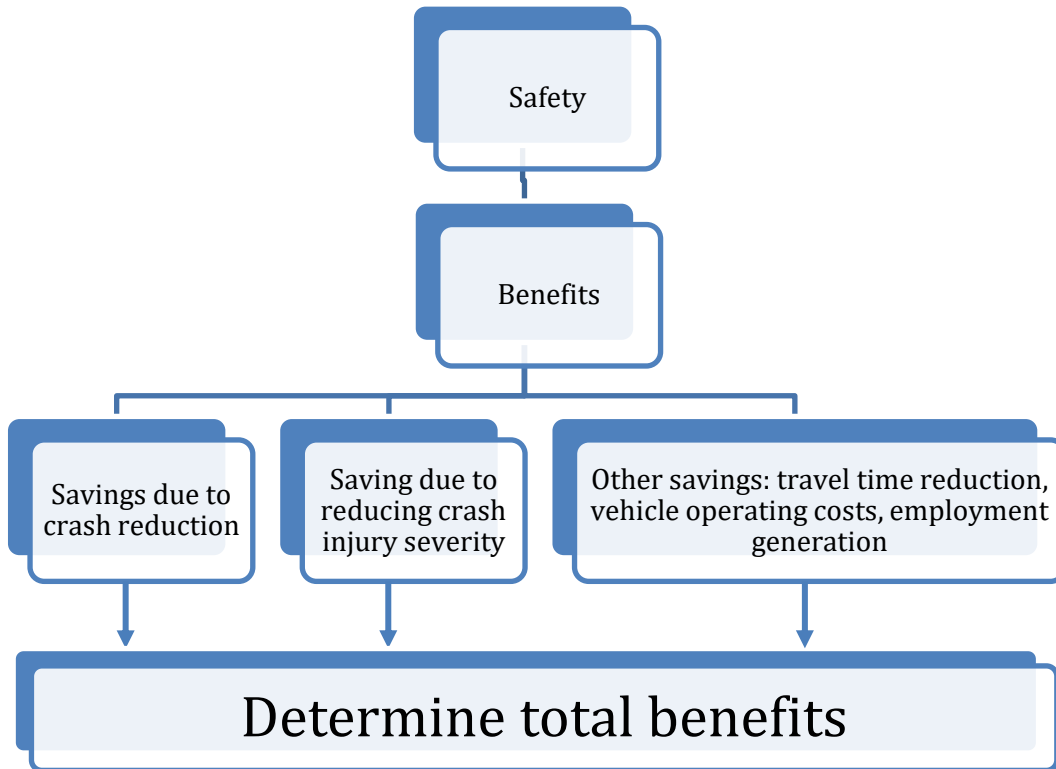


Figure 30. Methodology to Estimate Benefits for Strategic Intent “Safety”.

Benefits for the Wildlife Studies Measure

Wyoming has a rich diverse wildlife population that inhabits all of the state. Projects with a strategic intent measure in wildlife studies are concerned with studying Wyoming wildlife to improve the interaction between the wildlife and traveling public. A benefit of wildlife study projects are the savings for reducing the number of crashes, include the societal cost of the crash (i.e. medical expenses, vehicle repair/replacement, funeral expenses) saved by implementing the wildlife studies project compared to before implementation. Another saving is the quantifiable benefits for the impact on wildlife due to implementation of the wildlife studies project. Other savings include the travel time reduction, vehicle operating costs, employment generation, and any industry related benefits. Figure 31 shows the methodology for estimating the benefits of projects with a strategic intent in wildlife studies.

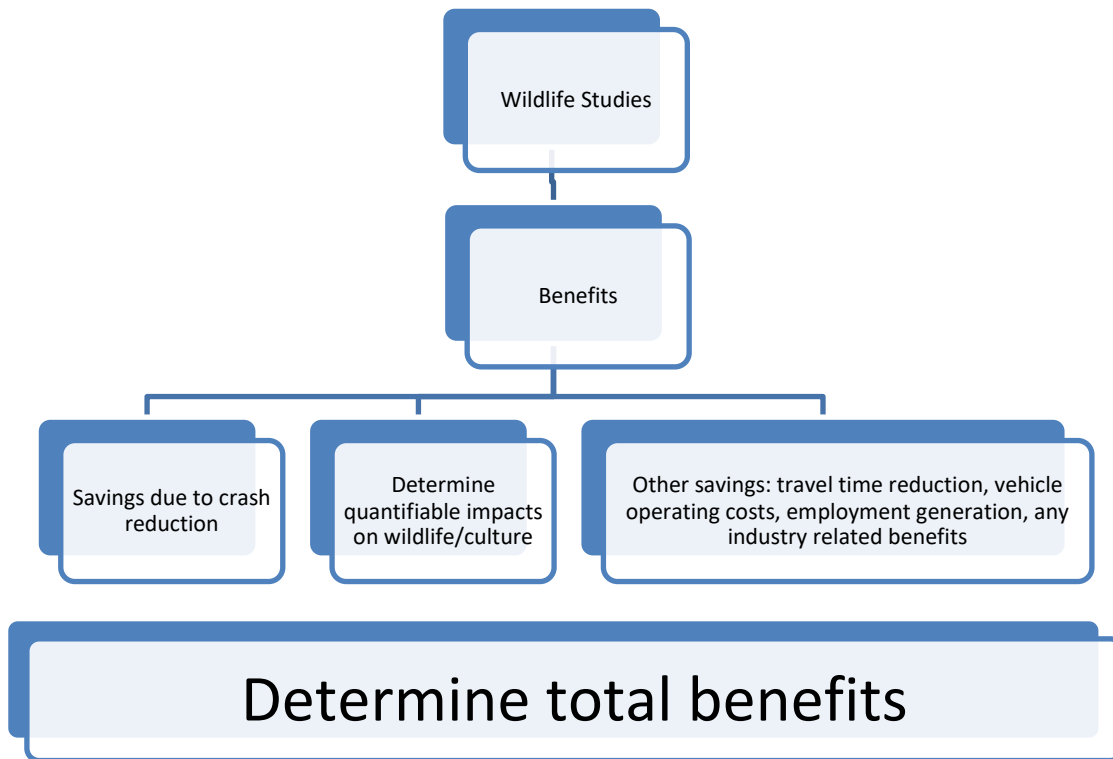


Figure 31. Methodology to Estimate Benefits for Strategic Intent “Wildlife Study”.

Benefits for the Shared Knowledge Measure

In the transportation community, the transfer of knowledge from one organization to another is an important process. The projects with a strategic intent measure of shared knowledge are concerned with the transfer of knowledge developed by an organization and implementing that knowledge within another organizations. The savings for shared knowledge projects are any savings due to enhancement in effectiveness. Other benefits of shared knowledge projects can be savings due improving research funding allocation, and any user savings. Figure 32 shows the methodology for estimating the benefits of projects with a strategic intent in shared knowledge.

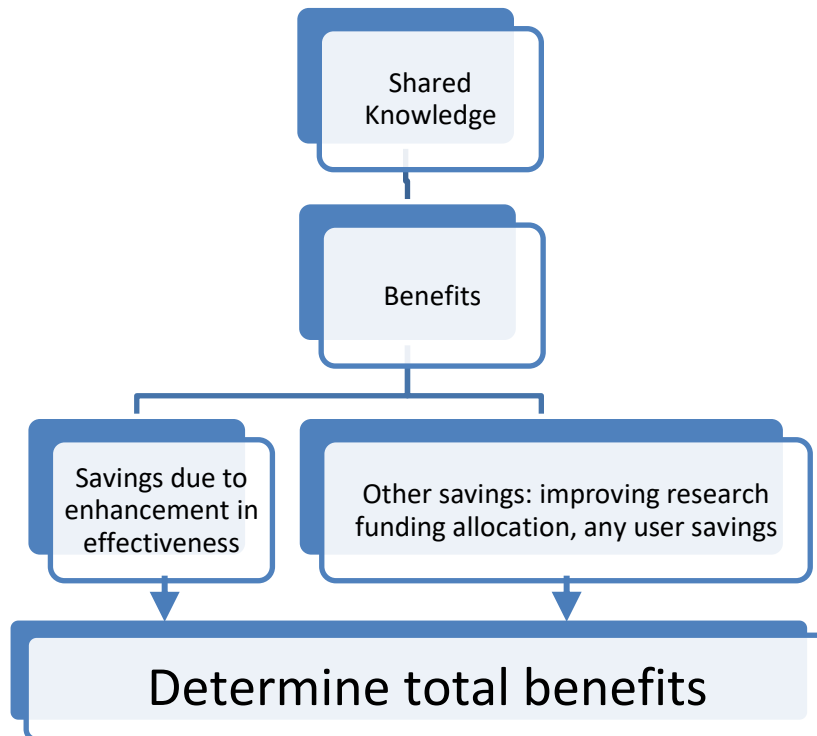


Figure 32. Methodology to Estimate Benefits for Strategic Intent “Shared Knowledge”.

Benefits for the Public Affairs Measure

To promote the safe and efficient flow of travel on the transportation infrastructure it is important to provide information relevant to the infrastructure to the public. Projects in public affairs are concerned with interacting with the public. The savings for public affair projects are any quantifiable benefits for the smother interaction with the driving public. Other benefits projects can be savings due to the improvement of safety, reduced travel time, and vehicle operating costs. Figure 33 shows the methodology for estimating the benefits of projects with a strategic intent in public affairs.

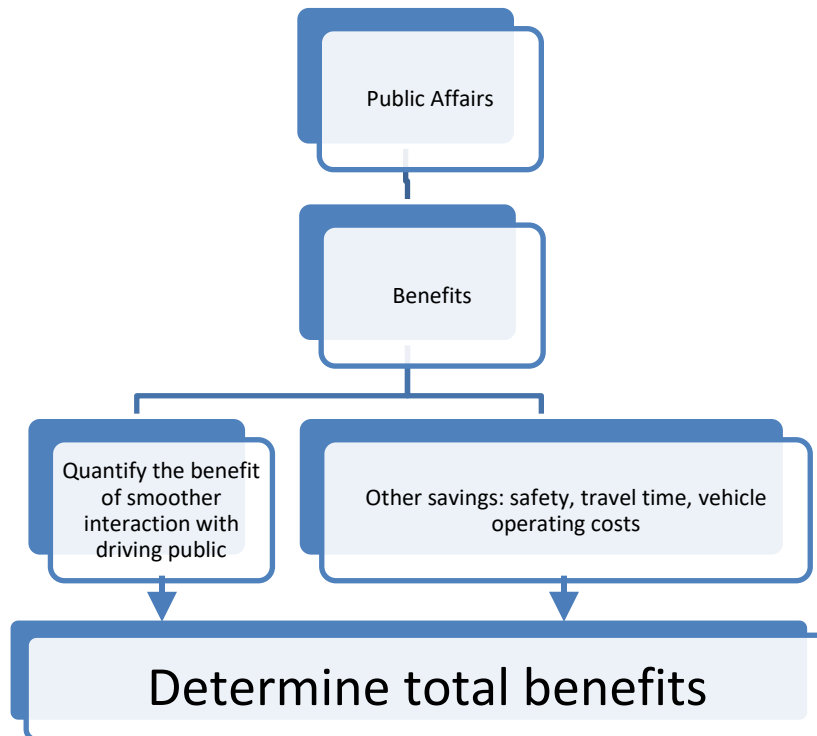


Figure 33. Methodology to Estimate Benefits for Strategic Intent “Public Affairs”.

Approaches to Estimate Benefits

Various approaches to estimate different types of benefits are listed in Table 29. Most of the benefits including crash reduction, travel time savings, estimated change in vehicle operation costs, estimated change in level of service, estimated increase in service life will contribute to the benefits of research projects. Several other benefits such as community impact, and impact on wildlife can be assessed by conducting surveys and wildlife movement studies. Each type of benefits is discussed below:

Table 29. Approaches to Estimate Benefits

Type of Benefits	Approaches to Estimate
Crash reduction	Use state traffic model, safety performance functions and crash modification factors or conduct a before-after study.
Travel time savings	Follow the U.S Department of Transportation’s publication “Departmental Guidance on Valuation of Travel Time in Economic Analysis”
Estimate change in vehicle operation costs	Use simulation model like Cal-B/C (Caltrans)
Estimate change in level of service	Use simulation model like VISSIM™, Synchro™.
Estimate increase in service life	Use pavement deterioration model.
Determine community impact	Conduct satisfaction surveys, hold public meetings and/or interviews.
Impact on wildlife	Conduct wildlife population, movement and location studies.

- **Crash Reduction:** For estimating the benefits of a crash reduction there are multiple approaches that can be used. One approach is to use a state traffic model or safety performance functions to predict the number of crashes prior to and after implementation of the project. Another approach is to use crash modification factors to estimate the number of crashes. A final approach is to conduct a before after study to determine the crash reduction.
- **Travel time savings:** Estimating the savings due to a decrease in travel time requires that the average travel time be calculated before and after implementation of the project. To estimate dollar savings for the reduction in travel time, the principal investigator should follow the most up to date version of the U.S Department of Transportation’s publication, *Departmental Guidance on Valuation of Travel Time in Economic Analysis*. The publication provides tables that indicate the recommended hourly values of travel time savings in dollars per person hour for multiple types of travel time. The travel time savings per person is determined by multiplying the travel time in hours by the estimate travel time saving (dollar per person-hour) resulting in the travel time saving per person. Then, multiply dollar savings per person by the total number of users for the particular type of transportation infrastructure to determine the total travel time saving.
- **Estimate change in vehicle operation costs:** For estimating a change in vehicle operation costs use a simulation model similar to the Cal-B/C. The simulation model was developed for Caltrans for conducting a benefit-cost analysis on highway transportation projects. The model provides an appropriate and easy way to estimate the cost savings associated with vehicle operating costs.
- **Estimate change in level of service:** To estimate the change in level of service, use a simulation model similar to PTM VISSIM™ or Synchro™. The simulation models

utilized a methodology for estimating the level of service presented in the Highway Capacity Model. The programs provided an easy process for estimating the level of service for a transportation facility.

- Estimate increase in service life: To estimate the benefits due to the increase in service life, calculate the condition of the pavement after implementation of the project, and the projected condition pavement, if the project was not implemented. Utilize a pavement deterioration model to estimate the service life of the pavement. Utilize a treatment process decision tree from a pavement or asset management system to determine the recommended treatment type for the pavement. The estimated benefits for increased service life will be the cost of the treatment for the pavement, if the project was not implemented.
- Determine community impact: The approach for estimating benefits for community impacts of a project is to receive feedback from the community impacted. An effective approach to gathering feedback is to conduct satisfaction surveys targeting communities directly impacted by the implementation of the project. The surveys can be simple multiple choice or question requiring detailed explanations. It is most effective if the survey is easy to follow and not time consuming. Another feedback response is to hold public meetings. Public meeting are effective in receiving detailed comments on the community impacts that paint a better picture of the impacts than comments from surveys. An approach to gathering information of the community impacts is to interview community leaders.
- Impact on wildlife: An approach to estimating the benefits due to impacts on the wildlife populations is to conduct studies on movement and location. A wildlife population study will indicate the impact on the population that the implementation of a project will have. Wildlife movement studies indicate impact on the movement routes of the wildlife due to the implementation of the project.

Templates to Estimate BCR

Six templates were developed to estimate BCR for the six strategic intent measures: infrastructure upgrades, preservation, safety, wildlife studies, shared knowledge, and public affairs (see Appendix 6). Each template provides costs and benefits in dollar value for each research study. These costs and benefits were used to estimate BCR. An example of a template for strategic intent measure safety can be seen in Figure 34.

Template to Calculate Benefits-to-Cost Ratio (BCR) for Strategic Intent “Safety”

Project Title:	_____
Name:	_____
Organization:	_____
Date:	_____



Costs Input Table	
Research Costs:	_____
<i>Estimated Split Among Types:</i>	
Salaries and Benefits	_____
Direct Costs	_____
Indirect Costs	_____
Other	_____

Implementation Costs:	_____
<i>Estimated Split Among Types:</i>	
Initial Costs	_____
Operation and Maintenance	_____
Technology Transfer	_____
Other	_____

GRAND TOTAL:	_____

Benefits Input Table	
Total Savings:	_____
<i>Estimated Savings Split Among Following:</i>	
Crash Reduction	_____
Travel Time	_____
Vehicle operating Costs	_____
Employment generation	_____
Other	_____

GRAND TOTAL:	_____

$$\text{Overall Benefits-to-Costs Ratio (BCR)} = \frac{\text{Total Benefits}}{\text{Total Costs}}$$

Figure 34. Template to Estimate BCR, Strategic Intent “Safety”

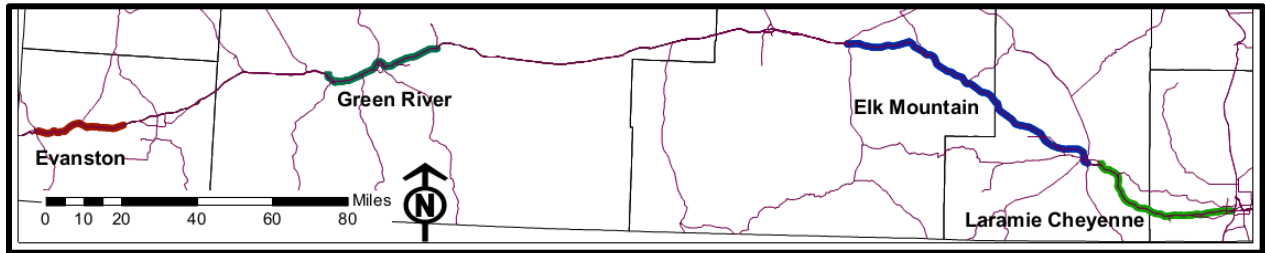
Benefit-to-Cost (Analysis), Case Studies

Three research projects were evaluated to estimate the BCR. Two of the projects were recently approved for funding, and one was completed. The templates proposed in this study, as shown in Appendix 6, were used to estimate the BCR. The Principal Investigators were requested to provide the itemized costs and benefits for each project. The detail data can be seen below:

Case Study 1: Completed Research Study

The methodology developed to estimate BCR was implemented as a case study on a WYDOT research study titled *Rural Variable Speed Limit Systems: Phase II*. The study was started in 2010 and completed in 2013. In this study, four corridors located on Interstate 80 in Wyoming, totaling 143 miles, were studied to determine ways to mitigate weather related crashes and road

closures (see Figure 35). To reduce crashes and road closures, WYDOT installed variable speed limit (VSL) systems along these corridors, in 2009. The VSL systems changed the speed limit based on real-time conditions in these corridors. One of the objectives of this study was to evaluate the effectiveness of VSL in terms of reducing crash frequency and road closures (Saha 2015). A before-after study was conducted to estimate the reduction of crashes and road closures after the installation of VSL systems. The reduction of crashes and road closures were converted into monetary value to be represented as benefits of this study.



Source: Saha, P. 2015. *Modeling Effectiveness of Variable Speed Limit (VSL) Corridors on Crashes and Road Closures*. University of Wyoming.

Figure 35. Map of Wyoming VSL Corridors.

In order to measure the performance of this research study in terms of BCR, this study can be categorized under strategic intent measure safety, and the methodologies were presented to estimate the costs and benefits, in Figure 27 and Figure 30 respectively. According to these methodologies, the estimated costs and benefits were estimated to determine BCR. In the following subsections, the costs and benefits estimated are discussed.

Costs Estimation: The methodology to estimate costs (see Figure 27) provided different types of costs that should be included to estimate overall costs. The costs were primarily divided into research and implementation. The research costs include salaries and benefits; direct costs of equipment and travel; and indirect costs. The implementation costs include initial cost, operation and maintenance costs and technology transfer. Table 30 provides the costs for research and implementation of this case study separately. The total research costs was estimated as \$182,403, and the implementation costs was \$4,000,000. In total, the overall costs was estimated as \$4,182,403.

Table 30. Costs Estimation, Case Study.

Type of Costs	Costs
Research Costs	\$182,403
Implementation Costs	\$ 4,000,000
Total Costs	\$ 4,182,403

Benefits Estimation: The methodology to estimate benefits for strategic intent measure safety (see Figure 30) provided the types of benefits be included in estimating benefits. In this study, two major benefits were estimated: benefits by reducing crash frequency, and benefits by

reducing road closure frequency due to severe weather conditions. Two models were developed to estimate the crashes and road closures reduced after the VSL implementations. The safety model estimated that 27.8 crashes were reduced per year after implementing the system. To monetize the safety benefits, estimates of both the crash severity distribution and costs by crash severity were calculated based on historic values from the VSL corridors in Wyoming. The crash cost values were obtained from WYDOT (see Table 31) and represent statewide averages. Winter data from October 2001 through April 2012 on the VSL corridors has been used to determine crash severity distribution. Using these values and the crash reduction estimate the monetized annual safety benefit due to VSL implementation is approximately \$2.8 million per year (see Table 32). The road closure model concluded that the actual closures for calculating benefits were reduced to 4.69. The average delay due to a winter road closure was estimated as 8 hour and 25 minutes, a cumulative impact of \$11.68 million is estimated. Using these values and the reduction of road closure, the monetized road closure benefit in a winter due to implementation is approximately \$54.7 million. The total benefits including crash and road closure reduction was estimated as \$57.5 million as shown in Table 33. It is important to note that the benefits estimated in Table 33 represents annual benefits.

Table 31. Wyoming Comprehensive Crash Cost

Crash Severity	Cost
Critical (Fatal and Incapacitating)	\$3,350,649
Serious (non-incapacitating and possible injury)	\$44,918
Damage (PDO)	\$13,900

Table 32. Annual VSL Safety Benefits

	Rural Interstate	Crashes	Cost	Total
Critical, K & A	2.3	0.6	\$ 3,350,649	\$ 2,145,231
Serious, B & C	34.9	9.7	\$ 44,918	\$ 436,378
PDO, O	62.8	17.5	\$ 13,900	\$ 242,992
Sum	100	27.8		\$ 2,824,601

Table 33. Benefits Estimation, Case Study.

Type of Benefits	Benefits
Crash Reduction, Annual	\$2,824,601
Other Benefits: Road Closure Reduction annually	\$ 54,700,000
Total Costs	\$ 57,524,601

Benefits-to-Costs Ratio (BCR): The total costs for this research project was estimated approximately \$4.1 million, whereas the benefits were estimated as \$54.7 million annually. So, the BCR can be calculated as 13.02 in the first year of implementation. Considering the benefits

due to crash reduction only, the benefits for the VSL corridor implementation is about 75 percent of the costs in the first year of system use. There is ongoing operation and system maintenance costs also associated with VSL use but these costs would very likely be less than the estimated safety benefits each year showing that the benefits of the system will likely outweigh the costs.

Case Study 2: Recently Approved for Funding

A recently approved research study titled: Safety and Operational Analysis with Mitigation Strategies for Freeway Truck Traffic in Wyoming was evaluated to estimate the BCR, as shown in Figure 36. The total costs and benefits were estimated as approximately \$25 million and \$36 million, which results with a BCR as 1.42. A 20-year planning horizon was considered to estimate the costs and benefits. The following list of assumptions were made to estimate the costs and benefits:

- Annual inflation rate: 2.1 percent (averaged from the Bureau of Labor Statistics).
- Annual traffic growth rate on I-80: 2.0 percent (previous studies).
- Construction happening in year 10 (estimated average).
- Construction cost per mile for potential roadway improvements: \$3,000,000 for current year.
- Estimated additional Operations and Maintenance (O & M) costs: \$6,500,000 (Years 10 – 20).
- Estimated length of roadway construction along critical segments: 5 miles.
- Main analysis roadway segments: vertical grade >4 percent.
- Current year crash frequency for selected critical segments: 25 truck crashes, 66 car crashes.
- Average crash cost for current year: \$183,000 per truck crash, \$9,000 per car crash (weighted from the national data according to the crash severity on I-80).
- Crash reduction for potential improvements along critical segments: 30 percent (based on nationwide studies for these types of improvements, which range between 30 percent and 50 percent).
- Value of time for current year: \$29.85 for trucks, \$13.55 for cars.
- Travel time savings for the critical segments: 0.15 min per truck, 0.3 min per car.
- Vehicle operating cost savings: \$0.25 per hour.

Template to Calculate Benefits-to-Cost Ratio (BCR) for Strategic Intent "Safety"

Project Title:	Safety and Operational Analysis with Mitigation Strategies for Freeway Truck Traffic in Wyoming
Name:	Milan Zlatkovic & Khaled Ksaibati
Organization:	University of Wyoming
Date:	01/24/2018



Costs Input Table	
Research Costs:	\$143,184
<i>Estimated Split Among Types:</i>	
Salaries and Benefits	\$88,670
Direct Costs	\$33,640
Indirect Costs	\$20,874
Other	
Implementation Costs:	\$25,400,000*
<i>Estimated Split Among Types:</i>	
Initial Costs	\$18,500,000
Operation and Maintenance	\$6,500,000
Technology Transfer	\$400,000
Other	N/A
GRAND TOTAL:	\$25,543,184*

Benefits Input Table	
Total Savings:	\$36,300,000*
<i>Estimated Savings Split Among Following:</i>	
Crash Reduction	\$31,600,000
Travel Time	\$4,400,000
Vehicle operating Costs	\$50,000
Employment generation	\$250,000
Other	N/A
GRAND TOTAL:	\$36,300,000*

*The implementation costs and benefits are estimated for a 20-year period

$$\text{Overall Benefits-to-Costs Ratio (BCR)} = \frac{\$36,300,000}{\$25,543,184} = 1.42$$

Figure 36. Estimated BCR for a Safety Project, Case Study 2

Case Study 3: Recently Approved for Funding

Case Study 3 was for the recently approved proposal for funding Safety and Operational Analysis with Mitigation Strategies for Freeway Truck Traffic in Wyoming. Figure 37 provides the estimated costs and benefits which resulted in BCR of 4.83. In this study, benefits were estimated based on crash reduction for one year only.

Template to Calculate Benefits-to-Cost Ratio (BCR) for Strategic Intent “Safety”

Project Title:	Human Machine Interface for Connected Vehicle: Requirements, Development and Assessment
Name:	Mohamed M. Ahmed
Organization:	University of Wyoming
Date:	February 1, 2018



Costs Input Table	
Research Costs:	\$228,720
<i>Estimated Split Among Types:</i>	
Salaries and Benefits	\$154,766
Direct Costs	\$36,000
Indirect Costs	\$37,954
Other	
Implementation Costs:	
<i>Estimated Split Among Types:</i>	
Initial Costs	
Operation and Maintenance	
Technology Transfer	
Other	
GRAND TOTAL:	\$228,720

Benefits Input Table	
Total Savings:	
<i>Estimated Savings Split Among Following:</i>	
† Crash Reduction	\$1,107,000/ year
Travel Time	
Vehicle operating Costs	
Employment generation	
Other	
GRAND TOTAL:	\$1,107,000/ year

$$\text{Overall Benefits-to-Costs Ratio (BCR)} = \frac{1,107,000}{228,720} = 4.83$$

† Crash reduction is estimated based on the elimination of distraction related crashes due to ill-designed In-vehicle technology in Connected Vehicles on I-80 for various severity levels. The benefits are calculated for 1-year only.

Figure 37. Estimated BCR for a Safety Project, Case Study 3

Chapter Summary

This chapter introduced the methodology for implementing a BCA for evaluating proposed as well as completed research projects. Two types of costs were included in the methodology to estimate the costs of research and implementation. The detailed benefits for each type of projects were listed in this chapter. As the benefits depend on the type of strategic intent measure, a strategic-intent-specific methodology was developed for estimating benefits. A template was developed for calculating the BCR for each type of study based on strategic –intent.

CHAPTER 8. CONCLUSIONS AND RECOMMENDATIONS

This chapter summarizes the conclusions and recommendations of this study. In this study, the performance measures for the research projects from 2010 to 2016 were reviewed and compared with the Phase II Study completed in 2012. Feedback surveys and performance evaluation surveys were completed by Principle Investigators and WYDOT Project Champions respectively. A methodology for conducting BCA was also developed in this study.

Data Analysis

The following eight performance measurements were included when the 64 research proposals submitted to the WYDOT RAC from 2011 to 2016:

- Number of projects and amount of funding per project by strategic intent.
- Number of proposals responding to the Research Center solicitations.
- Number of needs statements submitted by the agency's programs.
- Outcomes of a project: specifications revised, new methodologies implemented, dollars saved/costs avoided, facilities with extended life, crashes reduced, fatalities reduced, new products evaluated and implemented, policy/legislative impacts, etc.
- Number of research reports completed each year and number of research reports not completed within three years.
- Percentage of administrative costs to overall program funding.
- Funds requested by research community versus funds available.
- Percentage of projects completed on-time and within budget.

These performance measures assess the direction that the Research Center has been moving towards during the time period analyzed. The performance measures demonstrates how the Research Center is responsive to the research needs of WYDOT. The performance measures concentrated on: ng the number of research reports that are created each year, the administrative costs of the program, the funding capabilities of the program with respect to the needs of the program, and the percentage of projects that are completed on-time and within their proposed budget. All of these measures are critical for a DOT Research Center to be an effective and relevant asset. The following conclusions were developed after implementing the evaluation methodology on the WYDOT Research Center:

- The top three sponsoring organizations that submitted proposals from 2011 to 2016 were the University of Wyoming, Inter Alpine, and the Teton Science School. These institutions have the relevant expertise to conduct the required research for WYDOT.
- A significant percentage of the proposal submitted are approved for funding due to the requirement that each proposal should have a WYDOT champion. This would ensure that only proposals that are relevant to the mission of WYDOT are considered for funding.
- Strategic intent measures in: infrastructure upgrade, safety, and wildlife studies received the highest amount of funding with approximately \$1.4 million, \$1.39 million, and \$1.2 million respectively. The least funded strategic intent was public affairs with approximately \$40,000.

- The overall average funding per project is \$53,605 with an average duration of 2 years. The strategic intent measure with the largest amount of funding per project was wildlife studies with \$84,020. On the other hand, the least funding per project was preservation with \$34,779.
- The project areas with the most approved funding was bridge with approximately \$1.2 million, District 3 with approximately \$1 million, and materials with approximately \$900,000. The WYDOT project areas with the least amount of approved funding were: Maintenance, with \$170,000, Geology with \$160,000, and Environment Studies with \$87,000.
- Out of the five Districts, Districts 3, 4, and 5 received 31 percent of total funding (approximately \$2.1 million). Districts 1 and 2 did not submit any proposals during the analysis period. So, they should be encouraged to submit proposals that are relevant to their needs.
- The project areas with the most proposals approved were Bridge (9), District 5 (8), and materials (8). The project areas with the least number of approved projects were Geology (2), Traffic (2) and Environment Studies (1).
- The total amount of funding requested from 2011 to 2016 was approximately \$6.8 million, only \$5.7 million was approved due to the limited availability of funds or quality of proposals.
- During the analysis period, 29 projects were completed with strategic intent measures in infrastructure upgrade, preservation, safety, shared knowledge, and wildlife study.
- During the analysis period, approximately 89 percent of the total projects were completed on time and within budget. Only three projects were not completed on time or within budget.

Comparison with the Phase II Study

The performance measures from this Phase III study were compared with the Phase II Study which was completed in June 2012. The following list of performance measures were compared:

- Amount of funding per project by strategic intent
- Outcomes of the research projects
- Number of research reports completed each year
- Funds requested by the research community versus funds available
- Percentage of projects completed on-time and within budget

The following conclusions were developed after comparing the performance measures from the two phases.

- The number of proposals submitted in Phases II and III were 65 and 64 respectively. The number of proposals funded were 55 in Phase III and 54 in Phase II. This indicates that there has been no significant change in this performance measure.
- The funding for wildlife studies in Phase III was double the funding in Phase II. Also, the funding for shared knowledge in Phase III increased from \$61,150 to \$695,454. This might be due to the shifting needs of WYDOT or the type of proposals presented to the RAC.

- The rate of completion of projects in Phase III is higher than Phase II. On average, Phase III has one additional project completed each year when compared to Phase II.
- In Phase III, approximately \$6.7 million were requested and only \$5.7 million were approved which represents 85 percent approval rate. On the other hand, in Phase II, approximately \$5.2 million were approved out of \$7.2 million of requested fund which represent 73 percent approval rate.
- The percentage of pooled fund allocation decreased from 16.8 percent in Phase II to only 9% in Phase III. This might be due to a strategic decision by the RAC.
- The percentage of administrative costs was estimated as 9 percent in both Phases. This shows that the Research Center is still very efficient in managing projects.
- About 90 percent of all projects were completed on time and within budget in Phases II and III. This is a very high completion rate.

Benefit-to-Cost Analysis

This study developed a methodology for implementing a BCA for evaluating research projects. Based on this methodology, a template was developed to calculate the BCR for each strategic intent. It is recommended that every PI should use this template to estimate the BCR in the proposal stage and after completion of the study. Two types of costs are included in the methodology to estimate costs: research and implementation. As the benefits depend on the type of strategic intent measure, a strategic-intent-specific methodology was developed. The types of benefits included in the methodology are:

- **The benefits of infrastructure upgrade** which include savings in vehicle operation costs including operation and maintenance of the vehicle, savings due to improvements, savings due to network travel time reduction, savings in operation and maintenance, and other savings.
- **The benefits of a preservation project** include savings in vehicle operation costs, savings due to improvements, savings in operational and maintenance of the transportation facility, and savings in safety and employment generation.
- **The benefits of a safety project** include savings due to crash reduction, savings due to reducing crash injury severity, and other savings.
- **The benefits of wildlife studies** include savings due to crash reduction, knowledge in quantifiable impacts on wildlife/culture, and other savings.
- **The benefits of a shared knowledge project** include savings due to enhancement in effectiveness and other savings, such as improving research funding allocation and savings by users.
- **The benefits of a public affair project** include knowledge in quantifying the benefit of smoother interaction with driving public and savings in safety, travel time, and vehicle.

Surveys

In addition to developing performance measurements, three different surveys were conducted for 29 research projects which were started and completed between January 2011 and July 2017. Twenty-eight surveys were received from the Principal Investigators. 18 and 10 surveys were received from WYDOT Project Champions for Level I and Level II surveys respectively. The

following conclusions were developed after the Principal Investigators and Project Champions completing the surveys:

- Sixty-seven percent of the Principal Investigators were very satisfied with the proposals process while 33 percent were satisfied with the proposal process. None of the Principal Investigators were dissatisfied with the proposal process.
- Out of the feedback surveys received from the Principal Investigators, 21 provided positive comments on the proposal process. The majority of the comments complimented the involvement and feedback of the RAC during the proposal process, as well as the transparency of the proposal process.
- Eighty-two percent of the Principal Investigators were very satisfied with the WYDOT Research Center staff while 18 percent of the Principal Investigators were satisfied with the WYDOT Research Center staff. None of the Principal Investigators were dissatisfied with the WYDOT Research Center staff.
- Eighty-nine percent of the Principal Investigators were very satisfied with the WYDOT Project Champions, while 11 percent of Principal Investigators were satisfied with the WYDOT Project Champions. None of the Principal Investigators were dissatisfied with the WYDOT Project Champions.
- Seventy-eight percent of the Project Champions indicated that all objectives of the research project were fulfilled while 22 percent indicated that only some of the objectives of the research project were fulfilled.
- Forty-four percent of the Project Champions indicated that the research projects expected full future implementation, 50 percent expected partial implementation within WYDOT, and only 6 percent of the Project Champions expected no implementation within WYDOT.
- Eighty-three percent of the Project Champions indicated that the research projects were completed within their proposed timeline, while 11 percent indicated the research projects were completed one month after its proposed timeline. Six percent of the Project Champions indicated the project was not completed within its proposed timeline.
- Project Champion indicated that 33 percent of the research projects had resulted in additional research, and 67 percent indicated that the research projects did not result in additional research.

Recommendations for the WYDOT Research Center

The following recommendations are proposed based on the performed analyses:

- WYDOT should continue funding research projects that advance the overall goals of their mission statement.
- WYDOT should continue evaluating the research projects on a regular basis to understand which types of research are the most effective. In addition, it is important to determine if the right level of funding is being dedicated to each research project.

- The research projects with the highest potential to produce significant benefits are those which should be funded in the future. The benefit cost analysis proposed in this study should be implemented to identify research proposals with the highest benefits.
- WYDOT should implement the BCA methodology to estimate BCR for every project. It is recommended that BCR should be estimated in the proposal stage and after the completion of the studies.
- WYDOT should utilize the results from the surveys to gather benefit information related to the implementation of research projects.
- Some survey results from the Project Champions indicated that the project deliverables needed additional implementation effort. It is recommended that a formal process should be created to monitor the implementation of research findings. An implementation meeting should be held at least once a year to discuss the progress of implementation of completed research studies.
- It is recommended that the WYDOT Research Center should continue to implement the performance evaluations developed in this study as well as the Phase II study. Such implementation will ensure that the Research Center is effective in addressing the needs of WYDOT.
- Projects resulting in the strategic intent measures, preservation and shared knowledge had an overall lower level of implementation within WYDOT. When such projects are presented to the RAC, it is recommended that the results and outcomes of the projects be identified to ensure implementable results are produced.

Implementing the Methodology for Other DOT Research Centers

Any other DOTs interested in evaluating their Research Centers can implement the performance evaluation measures and benefit-to-cost methodology developed in this study. This methodology provides DOTs with a framework, direction, and specific procedures for evaluating their Research Center based on their particular needs. The case study presented in this report shows how DOT Research Centers can gather the necessary information and conduct evaluations of the research they complete as well as their Research Center.

Overall Conclusions

In this study, the effectiveness of the WYDOT Research Center was investigated by evaluating several performance measures and conducting surveys. Based on the analysis, it can be concluded that the WYDOT Research Center is very effective and moving into the right direction. It was found that the research funding were allocated consistently on various strategic intents and projects areas. A few performance measures, such as the number of projects completed and implemented every year, increased in this evaluation period when compared to the period before. In addition, a new methodology for benefit-to-cost analysis was developed in this study and recommended to be included as one of the future performance measures.

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APPENDIX 1. LIST OF THE PROPOSALS, 2011- 2016

No	Proposal date	Project I.D.	Project Title	Project Type	Strategic Intent	Principal Investigator	Sponsoring Organization	WYDOT Champion	Project Area	Funding	Decision
1	1/12/2011	TPF-5(253)	Pooled Fund TPF-5(253): Member-level Redundancy in Built-up Steel Members	Proposal [C]	Preservation	Tommy Nantung	Indiana DOT (Lead Agency)	Keith Fulton	Bridge	\$75,000	Forward Request to Executive Session for Approval
2	4/13/2011	RS04211	Investigation of Silica Fume Concrete Bridge Overlay Failures	Proposal [C]	Infrastructure Upgrade	Kim Basham	KB Engineering	Bob Rothwell	Materials	\$99,500	Forward Request to Executive Session for Approval
3	4/13/2011	RS05211	Instrumentation and Analysis of Frost Heave Mitigation on WY 70, Encampment, WY	Proposal [C]	Preservation	Thomas Edgar	University of Wyoming	Tim McGary	Maint.	\$127,856	Forward Request to Executive Session for Approval
4	4/13/2011	TPF-5(193)	Pooled Fund TPF-5(193): Midwest States Regional Pooled Fund Project	Increased Funding	Shared Knowledge	Amy Starr	Nebraska DOR (Lead Agency)	Bill Wilson, Keith Fulton	Bridge	\$195,000	Forward Request to Executive Session for Approval
5	4/13/2011	RS03211	Evaluation of the Wyoming Research Center and Research Center (Phase II)	Proposal [C]	Shared Knowledge	Khaled Ksaibati	University of Wyoming	Tim McDowell	Planning	\$37,680	Forward Request to Executive Session for Approval
6	4/13/2011	Solicitation 1297	Pooled Fund Solicitation 1297: 2012 Multi-State Asset Management Implementation	Proposal	Shared Knowledge				Standards	\$10,000	NOT Forwarded to Executive Session for Approval
7	7/13/2011	RS08211	Evaluating Base Widening Methods	Proposal [C]	Infrastructure Upgrade	Khaled Ksaibati Rhonda Young	University of Wyoming	Bob Rothwell	Bridge	\$139,134	Forward Request to Executive Session for Approval
8	7/13/2011	RS07211	Improving Traveler Information on Rural Corridors in Wyoming through the Use of Intelligent Transportation Systems	Proposal [C]	Safety	Rhonda Young	University of Wyoming	Vince Garcia	Traffic	\$130,730	Forward Request to Executive Session for Approval
9	7/13/2011	RS06211	Comprehensive Technology Assessment for Avalanche Hazard Management	Proposal [C]	Safety	Rand Decker	InterAlpine	John Eddins	District 3	\$294,428	Forward Request to Executive Session for Approval
10	7/13/2011	RS09211	Developing a Roadway Safety Improvement Program for Indian Reservations	Proposal [C]	Safety	Khaled Ksaibati	University of Wyoming	Matt Carlson	Safety	\$77,934	Forward Request to Executive Session for Approval
11	7/13/2011	RS10211	Criteria for a WYDOT Culvert Selection Policy	Proposal [C]	Shared Knowledge	John Turner Ryan Kobbe	University of Wyoming	Bill Wilson	Standards	\$76,492	Forward Request to Executive Session for Approval
12	7/13/2011	RS11211	Pronghorn and Mule Deer Use of Underpasses along US Highway 191	Proposal [C]	Wildlife Study	Hall Sawyer	Western Ecosystems Technology	John Eddins	District 3	\$139,833	Forward Request to Executive Session for Approval
13	10/19/2011	TPF-5(054)	Pooled Fund TPF-5(054): Maintenance Decision Support System	Increased Funding	Preservation	Dave Huft	South Dakota DOT (Lead Agency)	Jeff Frazier	Maint.	\$25,000	Forward Request to Executive Session for Approval
14	1/11/2012	RS02212	Managing Risks in the Project Pipeline - Minimizing the Impacts of Highway Funding Uncertainties	Proposal [C]	Shared Knowledge	Larry Redd	Larry Redd, LLC	Tim McDowell	Planning	\$162,600	Forward Request to Executive Session for Approval
15	4/11/2012	RS03209	Implementation of the Mechanistic-Empirical Pavement Design Guide in WYDOT	Increased Funding	Infrastructure Upgrade		Applied Research Associates, Inc.	Bob Rothwell	Materials	\$35,000	Forward Request to Executive Session for Approval
16	4/11/2012	RS03212	Structural Health Monitoring of Highway Bridges Subject to Overweight Trucks, Phase - - Structural Health Monitoring of Highway Bridge Subject to Overweight Trucks, Phase I	Proposal [C]	Preservation	Richard Schmidt	University of Wyoming	Keith Fulton	Bridge	\$152,863	Forward Request to Executive Session for Approval
17	4/11/2012		Evaluating the Effects of Deer Delineators in Wildlife-Vehicle Collisions in Northwest Wyoming	Pre-Proposal	Wildlife Study	Morgan Graham Corinna Riginos	Teton Science School	Shelby Carlson	District 5	\$116,544	Approved to Submit Proposal

18	4/11/2012	RS04212	Evaluation of a Mitigation Site: Amphibian Population	Proposal [C]	Wildlife Study	Maggie Schilling		Bob Bonds	Environ.	\$86,562	Forward Request to Executive Staff for Approval
19	7/11/2012	RS08211	Evaluating Base Widening Methods	Increased Funding	Infrastructure Upgrade	Khaled Ksaibati Rhonda Young	University of Wyoming	Bob Rothwell	Bridge	\$39,300	Forward Request to Executive Staff for Approval
20	7/11/2012	RS07212	Jackson South Snow Supporting Structures Proposed Performance and Health Monitoring at WYDOT Project No. N104085, Teton County, Jackson, WY	Proposal [C]	Infrastructure Upgrade	Josh Hewes	InterAlpine	Jamie Yount	District 5	\$104,566	Forward Request to Executive Staff for Approval
21	7/11/2012		Snow Fence Design Evaluation	Proposal	Infrastructure Upgrade		University of Wyoming		Maint.	\$153,134	Forward Request to Executive Staff for Approval NOT Funded
22	7/11/2012	RS04211	Investigation of Silica Fume Concrete Bridge Overlay Failures	Increased Funding	Infrastructure Upgrade	Kim Basham	KB Engineering	Bob Rothwell	Materials	\$30,000	Forward Request to Executive Staff for Approval
23	7/11/2012	RS06212	Evaluating the Risk of Alkali Silica Reaction in Wyoming	Proposal [C]	Preservation	Jennifer Tanner	University of Wyoming	Bob Rothwell	Materials	\$103,283	Forward Request to Executive Staff for Approval
24	7/11/2012	RS08212	Multi-Measure Performance Assessment and Benchmarking of the Divisions of the Wyoming Highway Patrol	Proposal [C]	Shared Knowledge	Mehmet Ozbek	Colorado State University	Derek Mickelson	Standards	\$173,452	Forward Request to Executive Staff for Approval
25	7/11/2012		Developing a Database and Web Viewing tool for Ungulate Migrations in Wyoming	Pre-Proposal	Wildlife Study	Bill Rudd	Wyoming Migration Initiative		District 3		Approved to Submit Proposal
26	7/11/2012	RS05212	Evaluating the Effects of Deer Delineators in Wildlife-Vehicle Collisions in Northwest Wyoming	Proposal [C]	Wildlife Study	Morgan Graham Corinna Riginos	Teton Science School	Shelby Carlson	District 5	\$234,303	Forward Request to Executive Staff for Approval
27	10/10/2012	RS01213	Developing a Database and Web Viewing tool for Ungulate Migrations in Wyoming	Proposal [C]	Wildlife Study	Bill Rudd	Wyoming Migration Initiative		District 3	\$152,677	Forward Request to Executive Staff for Approval
28	1/9/2013	RS05213	A Literature Review of Approach Slab and its Settlement for Roads and Bridges in Wyoming	Proposal [C]	Infrastructure Upgrade	Kam Ng	University of Wyoming	Jim Coffin	Bridge	\$69,466	Forward Request to Executive Staff for Approval
29	1/9/2013	RS04213	Characterization of Material Properties for Mechanistic-Empirical Pavement Design in Wyoming	Proposal [C]	Infrastructure Upgrade	Khaled Ksaibati	University of Wyoming	Bob Rothwell	Materials	\$317,759	Forward Request to Executive Staff for Approval
30	1/9/2013		Hands-free and Eyes-free Travel Information System for Smart Phones	Proposal	Public Affairs	Daleynn Polson		Vince Garcia	Traffic	\$6,000	NOT Forwarded Executive Staff Approval
31	4/15/2013		A Comparative Review of Rippability Factors and Characteristics of Rock Cuts	Pre-Proposal	Infrastructure Upgrade		University of Wyoming	Blaine Smith	Geology		Approved to Submit Proposal
32	4/15/2013	RS06213	Wyoming Low Volume Roads Traffic Volume Estimation	Proposal [C]	Safety	Khaled Ksaibati	University of Wyoming	Martin Kidner	Traffic	\$148,945	Forward Request to Executive Staff for Approval
33	10/9/2013		A Comparative Review of Rippability Factors and Characteristics of Rock Cuts	Proposal	Infrastructure Upgrade	Kam Ng	University of Wyoming	Blaine Smith	Geology	\$77,011	NOT Forwarded Executive Staff Approval
34	10/9/2013	RS03214	Assessment and Evaluation of I-80 Truck Loads and their Load Effects	Proposal [C]	Preservation	Jay Puckett	BridgeTech	Keith Fulton	Bridge	\$206,931	Forward Request to Executive Staff for Approval
35	10/9/2013		Investigation of Ground Level Wind Factors and Blowing Snow Conditions	Proposal	Safety	Noriaki Ohara	University of Wyoming	Kent Ketterling	Maint.	\$105,803	NOT Forwarded Executive Staff Approval
36	10/9/2013	RS02214	Developing an Effective Shoulder and Centerline Rumble Strip Policy to Accommodate All Roadway Users	Proposal [C]	Safety	Khaled Ksaibati	University of Wyoming	Matt Carlson	Safety	\$89,672	Forward Request to Executive Staff for Approval
37	10/9/2013		A Framework of Optimizing Moose-Vehicle Collisions;	Proposal	Wildlife Study	Corinna Riginos	Teton Science Schools	Tom Hart	District 5	\$197,340	NOT Forwarded Executive Staff Approval

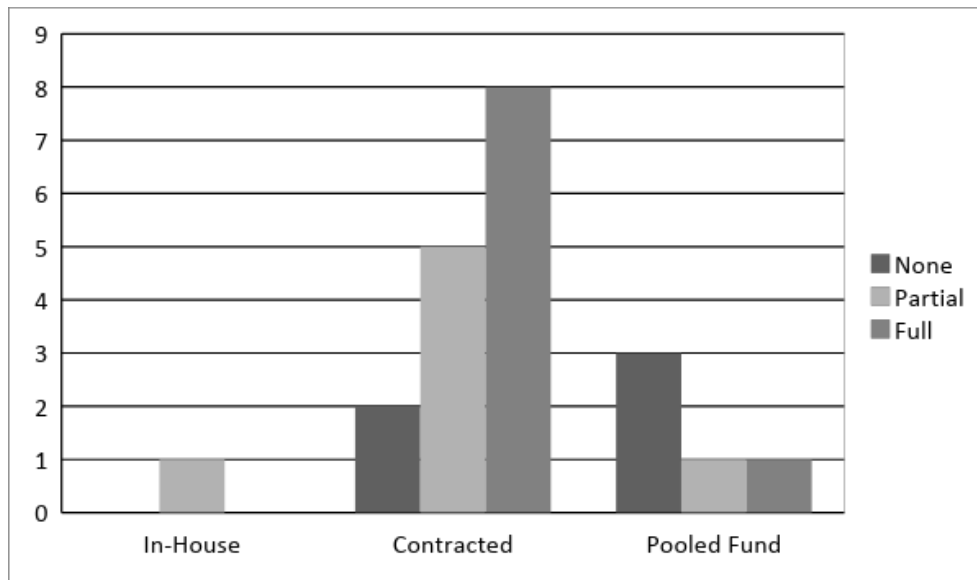
			Mitigation Measures in Teton County									
38	1/8/2014	RS04212	Evaluation of a Mitigation Site: Amphibian Population	Increased Funding	Wildlife Study	Maggie Schilling		Bob Bonds	Environ.	\$44,500	NOT Forwarded to Executive Staff for Approval	
39	4/7/2014	RS04214	Developing Wyoming Specific Bridge Deterioration Models for Bridge Management	Proposal [C]	Preservation	Marc Mcquire	Utah State University	Keith Fulton	Bridge	\$82,973	Forward Request to Executive Staff for Approval	
40	4/7/2014	RS05214	Safety Effectiveness of Regulatory Headlights Signs in Wyoming (Phase I)	Proposal [C]	Safety	Mohamed Ahmed Khaled Ksaibati	University of Wyoming	Matt Carlson	Safety	\$95,592	Forward Request to Executive Staff for Approval	
41	10/8/2014	RS02215	Fly Ash to Mitigate ARS	Proposal [C]	Infrastructure Upgrade	Jennifer Tanner Eisenhart	University of Wyoming	Chris Romo Bob Rothwell	Materials	\$65,975	Forward Request to Executive Staff for Approval	
42	10/8/2014	RS05216	Low Volume Study, Phase 2	Proposal [C]	Safety	Khaled Ksaibati	University of Wyoming	Mark Wingate	Planning	\$119,100	Forward Request to Executive Staff for Approval	
43	10/8/2014	RS03215	Planning-Support for Mitigation of Wildlife Vehicle Collisions and Highway Impacts on Migration Routes in Wyoming	Proposal [C]	Wildlife Study	Corinna Riginos	Teton Science School	Tom Hart	District 5	\$29,201	Forward Request to Executive Staff for Approval	
44	4/14/2015	RS05215	Developing Mitigation Strategies to Reduce Truck Crash Rates in Wyoming Highways	Proposal [C]	Safety	Khaled Ksaibati	University of Wyoming	Matt Carlson	Safety	\$89,181	Forward Request to Executive Staff for Approval	
45	7/8/2015	RS06215	Historic Winter Weather Assessment for Snow Fence Design using a Numerical Weather Model	Proposal [C]	Infrastructure Upgrade	Noriaki Ohara	University of Wyoming	Kathy Ahlenius	Maint.	\$19,178	Forward Request to Executive Staff for Approval	
46	7/8/2015	TPF-5(317)	Pooled Fund TPF-5(317): Evaluation of Low Cost Safety Improvements	Proposal [C]	Safety	Roya Amjadi	FHWA (Lead Agency)	Joel Meena	District 4	\$30,000	Forward Request to Executive Staff for Approval	
47	10/7/2015	RS02216	Characterization of Crushed Bases	Proposal [C]	Infrastructure Upgrade	Kam Ng and Khaled Ksaibati	University of Wyoming	Ryan Steinbrenner Mike Farrar	Materials	\$64,577	Forward Request to Executive Staff for Approval	
48	10/7/2015	TPF-5(337)	Pooled Fund TPF-5(337): Avalanche Research Pooled Fund	Proposal [C]	Safety	Jaime Yount David Reeves	Wyoming DOT (Lead Agency)	Jamie Yount	District 5	\$75,000	Forward Request to Executive Staff for Approval	
49	10/7/2015	RS03216	Calibrating Crash Modification Factors for Wyoming	Proposal [C]	Safety	Mohamed Ahmed	University of Wyoming	Matt Carlson	Safety	\$79,234	Forward Request to Executive Staff for Approval	
50	10/7/2015	TPF-5(193)	Pooled Fund TPF-5(193): Midwest States Regional Pooled Fund Project	Increased Funding	Shared Knowledge	Amy Starr	Nebraska DOR (Lead Agency)	Bill Wilson, Keith Fulton	Bridge	\$195,000	NOT Forwarded to Executive Staff for Approval	
51	10/7/2015	RS04216	Traffic Thresholds in Deer Road Crossing Behavior	Proposal [C]	Wildlife Study	Corinna Riginos	Northern Rockies Conservation Cooperative	Tom Hart	District 5	\$36,960	Forward Request to Executive Staff for Approval	
52	1/18/2016	RS06216	Development of Load and Resistance Factor Design Procedure for Driven Piles of Soft	Proposal [C]	Infrastructure Upgrade	Kam Ng	University of Wyoming	Jim Coffin	Geology	\$160,372	Forward Request to Executive Staff for Approval	
53	1/18/2016	TPF-5(310)	Pooled Fund TPF-5(310): Peer Exchange	Proposal [C]	Shared Knowledge	Leslie Wright Michael Bufalino	Oregon DOT (Lead Agency)		Standards	\$5,902	Forward Request to Executive Staff for Approval	
54	4/8/2016	RS07212	Jackson South Snow Supporting Structures Proposed Performance and Health Monitoring at WYDOT Project No. N104085, Teton County, Jackson, WY	Increased Funding	Infrastructure Upgrade	Josh Hewes	InterAlpine	Jamie Yount	District 5	\$9,020	Forward Request to Executive Staff for Approval	
55	4/8/2016	RS09216	Design and Performance Evaluation of a Semi Flexible Snow Barrier for Avalanches	Proposal [C]	Infrastructure Upgrade	Josh Hewes	InterAlpine	Jamie Yount	District 5	\$138,781	Forward Request to Executive Staff for Approval	
56	4/8/2016		Climate Change, Snowpack Distribution and Highway Winter Maintenance	Proposal	Preservation	Rand Decker	InterAlpine	Kathy Ahlenius	Maint.	\$188,200	NOT Forwarded to Executive Staff for Approval	

57	4/8/2016	RS06211	Comprehensive Technology Assessment for Avalanche Hazard Management	Increased Funding	Safety	Rand Decker	InterAlpine	John Eddins	District 3	\$50,000	NOT Forwarded to Executive Staff for Approval
58	4/8/2016	RS08216	Updating and Implementing the Grade Severity Rating System for Wyoming	Proposal [C]	Safety	Khaled Ksaibati	University of Wyoming	James Evensen Joel Meena Matt Carlson	District 4	\$157,004	Forward Requested to Executive Staff for Approval
59	7/20/2016	RS10216	Last Mile Commercial Package Delivery as a Revenue Generation Tool for Rural Public Transportation Systems in Wyoming	Proposal [C]	Public Affairs	Jaydeep Chaudhari	WTI, Montana State University	Talbot Hauffe	Planning	\$40,143	Forward Requested to Executive Staff for Approval
60	7/20/2016	RS11216	Effectiveness of Nighttime Speed Limit Reduction in Reducing Wildlife Vehicle Collisions	Proposal [C]	Wildlife Study	Corinna Riginos Marcel Huijser	Northern Rockies Conservation Cooperative	Keith Compton	District 3	\$320,226	Forward Requested to Executive Staff for Approval
61	10/12/2016	RS03217	Development of an Ultra Accelerated Test to Evaluate ASR Potential in Concrete	Proposal [C]	Infrastructure Upgrade	Jennifer Tanner	University of Wyoming	Chris Romo, Bob Rothwell, Greg Milburn	Materials	\$142,880	Forward Requested to Executive Staff for Approval
62	10/12/2016	RS02217	Structural Health Monitoring of Highway Bridges Subject to Overweight Vehicles, Phase II - Field Deployment	Proposal [C]	Preservation	John Judd Michael Barker	University of Wyoming	Paul Cortez	Bridge	\$220,374	Forward Requested to Executive Staff for Approval
63	10/12/2016	RS04217	Evaluation of the Wyoming Research Center and Research Center (Phase III)	Proposal [C]	Shared Knowledge	Khaled Ksaibati	University of Wyoming	Tim McDowell	Planning	\$44,328	Forward Requested to Executive Staff for Approval
64	10/12/2016	RS11216	Effectiveness of Nighttime Speed Limit Reduction in Reducing Wildlife Vehicle Collisions	Increased Funding	Wildlife Study	Corinna Riginos Marcel Huijser	Northern Rockies Conservation Cooperative	Keith Compton	District 3	\$70,200	Forward Requested to Executive Staff for Approval

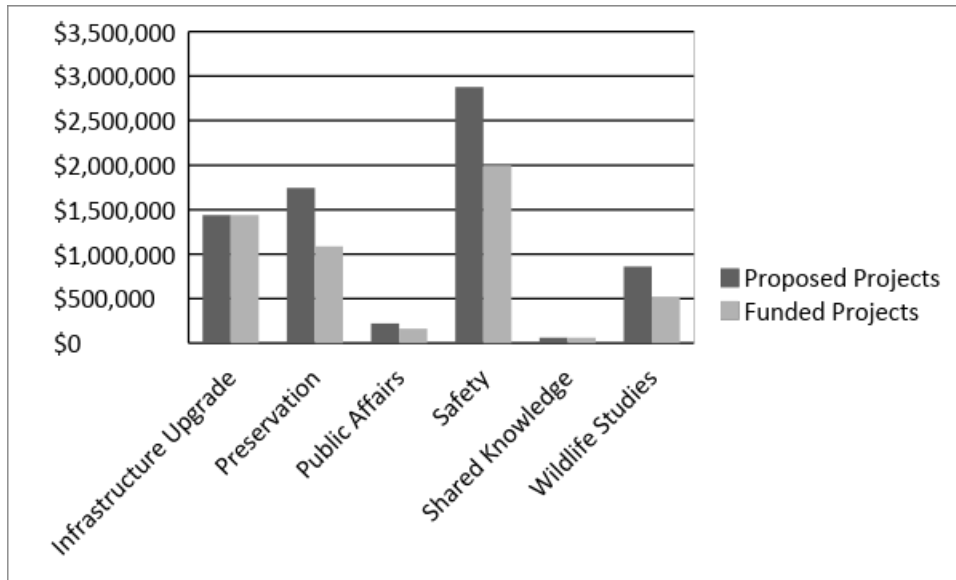
APPENDIX 2. TABLES AND FIGURES FROM PHASE II STUDY

Appendix 2.1: Breakdown of Project Types Proposed to the RAC.

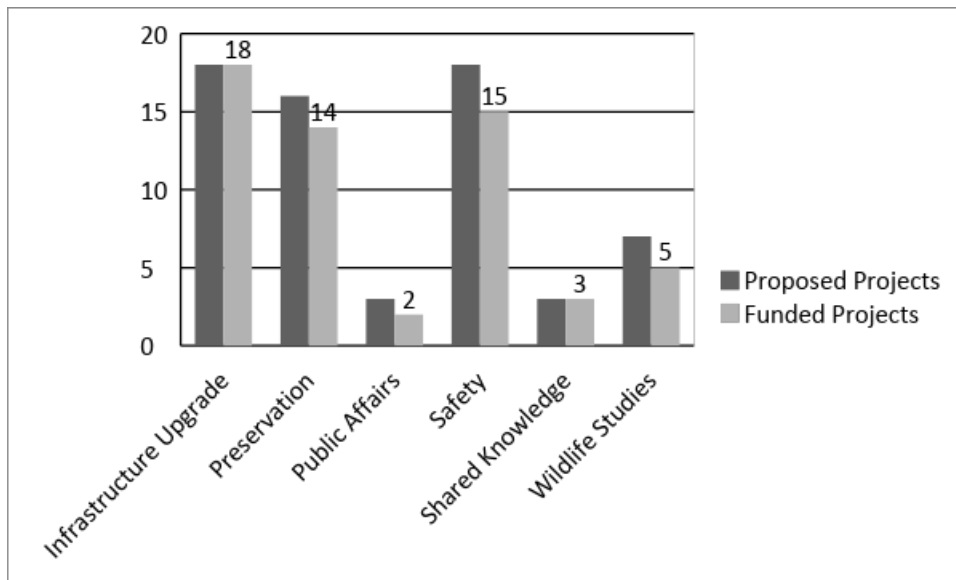
Project Type	2005	2006	2007	2008	2009	2010	Totals
Proposals	10	12	6	8	5	9	50
Approved Proposals	8	10	6	7	5	8	44
Proposals w/ Amendments	4	0	1	2	0	2	9
Requests for Increased Funding	1	1	3	1	2	2	10
Approved Increased Funding	1	1	1	3	1	1	8
Requests for Increased Funding with Amendments	0	0	1	0	0	0	1
Pre-proposals	0	0	1	3	1	0	5
Approved Pre-Proposals	0	0	1	3	1	0	5
Pre-proposals w/ Amendments	0	0	0	3	0	0	3
Total Projects for Analysis =							65



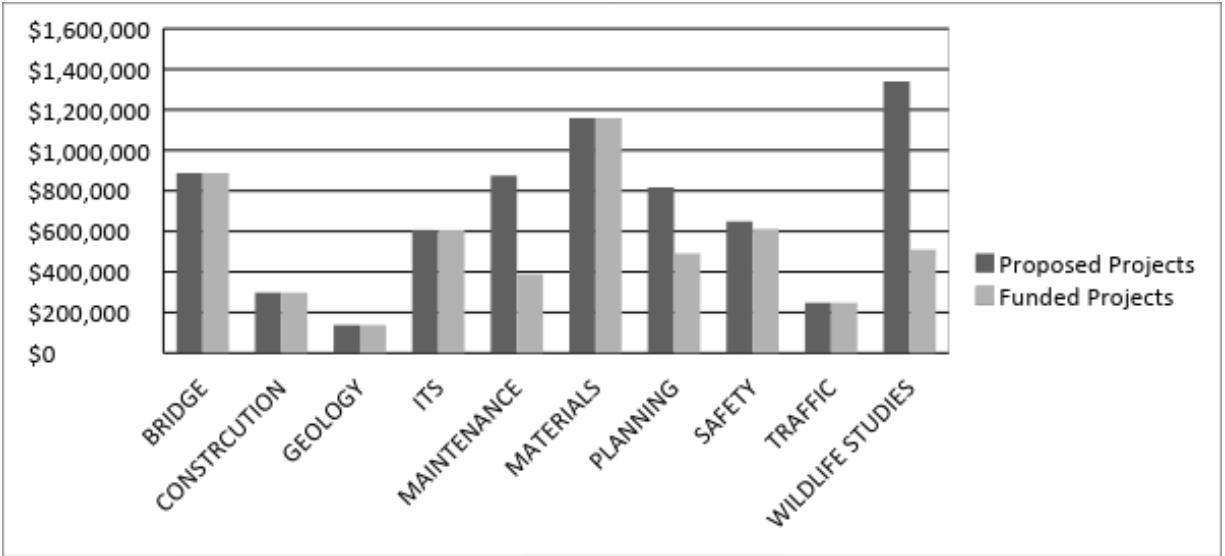
Appendix 2.2: Level of Implementation by Project Category.



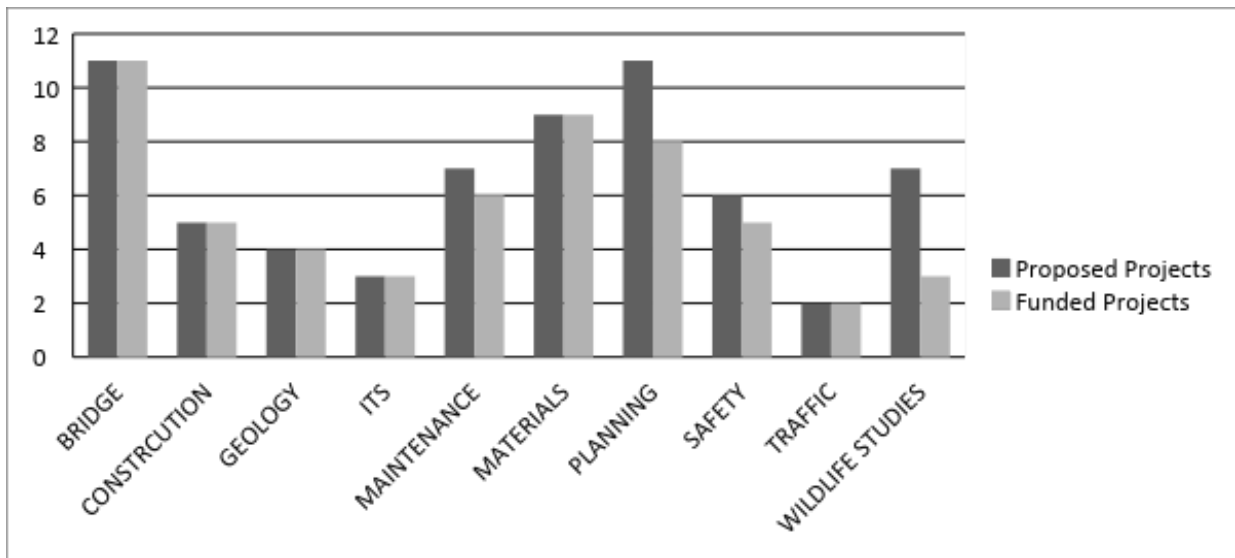
Appendix 2.3: Funding by Strategic Intent.



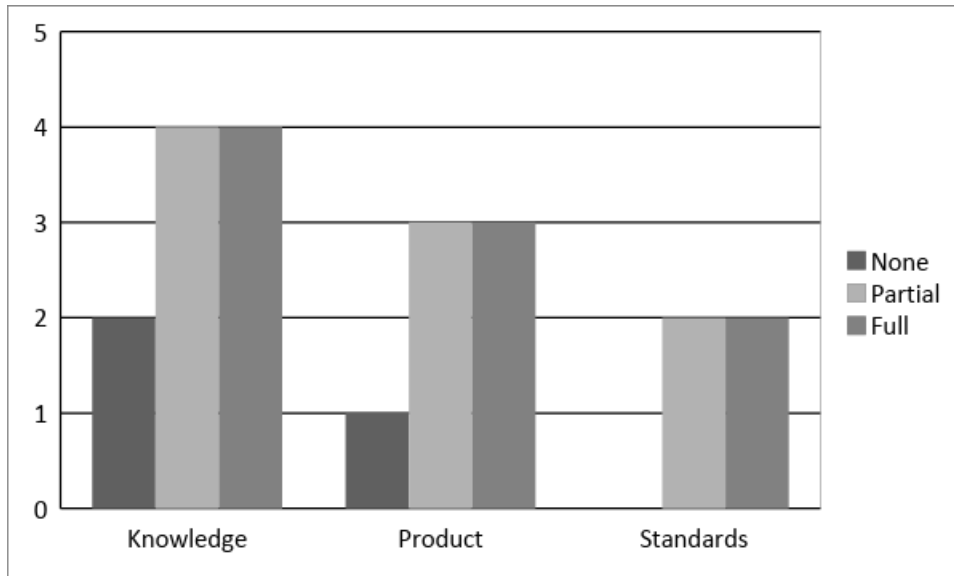
Appendix 2.4: Number of Projects by Strategic Intent.



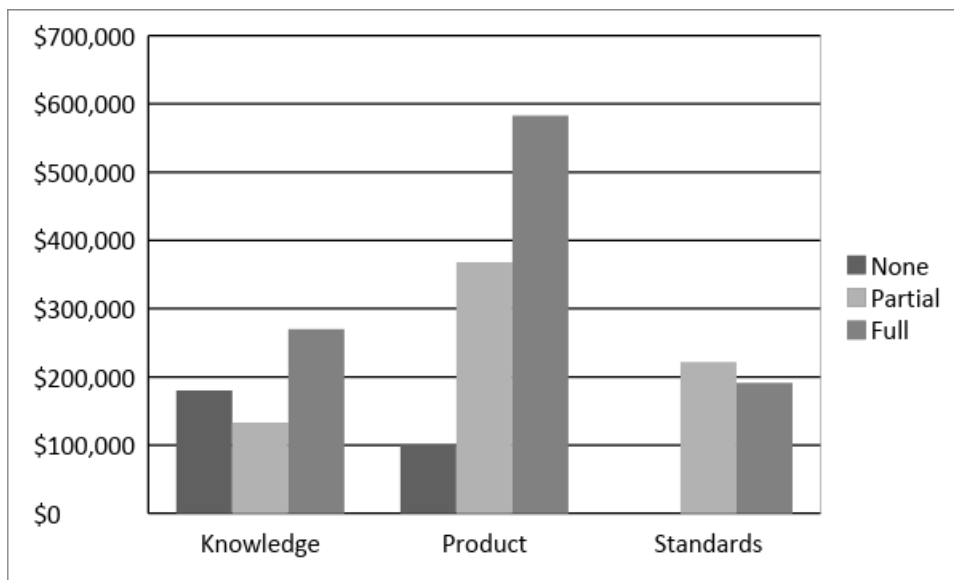
Appendix 2.5: Funding by WYDOT Program.



Appendix 2.6: Number of Projects by WYDOT Program.



Appendix 2.7: Level of Implementation by Project Outcome.



Appendix 2.8: Level of Implementation by Funds Proposed by Project Outcome.

Appendix 2.9: Total Funds Directed to Administrative Costs per Year.

	2005	2006	2007	2008	2009	2010	2011	Averages
Administrative Costs	\$16,360	\$69,433	\$103,993	\$81,877	\$118,183	\$118,642	\$118,642	\$89,590
Overall Research Budget	\$923,795	\$1,061,660	\$559,716	\$628,172	\$1,212,314	\$1,375,280	\$1,359,808	\$1,017,249
Percent Admin. Costs	1.8%	6.5%	18.6%	13.0%	9.7%	8.6%	8.7%	9.57%

Appendix 2.10: Funds Obligated per Year for Pooled Fund Studies vs. Research Center Budget.

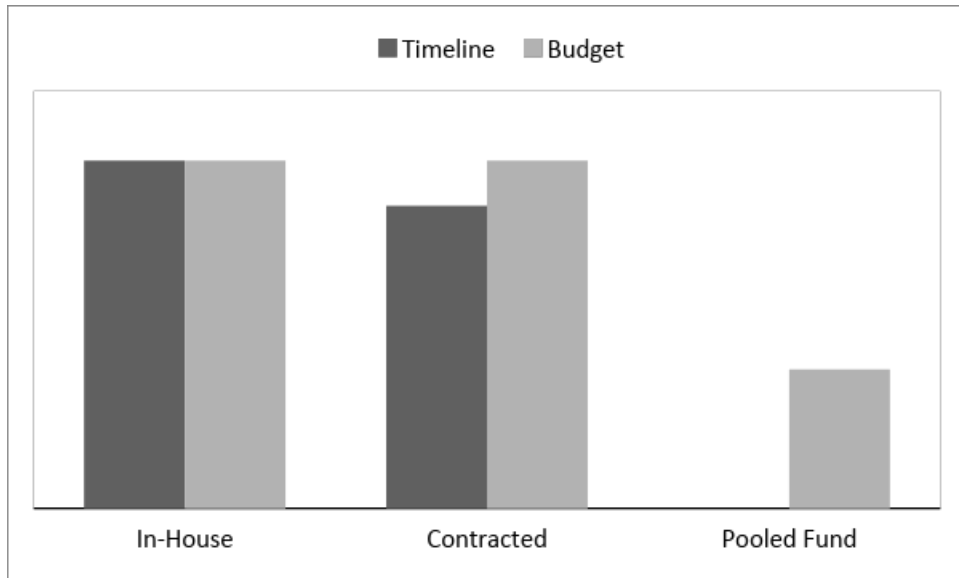
	2005	2006	2007	2008	2009	2010	2011	Averages
Pooled Fund Studies	\$170,000	\$108,000	\$170,000	\$297,000	\$85,000	\$140,000	\$140,000	\$158,571
Overall Research Budget	\$923,795	\$1,061,660	\$559,716	\$628,172	\$1,212,314	\$1,375,280	\$1,359,808	\$1,017,249
Percent Pooled Funds	18.4%	10.2%	30.4%	47.3%	7.0%	10.2%	10.3%	19.10%

Appendix 2.11: Summary of Proposed Projects from 2005-2010.

Project Area	Total Requested Funding				Total Number of Requested Projects			
	Contract	Pooled Fund	In-house	Total	Contract	Pooled Fund	In-house	Total
Infrastructure Upgrade	\$742,147	\$575,000	\$120,000	\$1,437,147	7	10	1	18
Preservation	\$1,354,300	\$392,000	\$0	\$1,746,300	8	8	0	16
Public Affairs	\$220,972	\$0	\$0	\$220,972	3	0	0	3
Safety	\$2,644,705	\$232,500	\$0	\$2,877,205	16	2	0	18
Shared Knowledge	\$61,150	\$0	\$0	\$61,150	3	0	0	3
Wildlife Studies	\$860,549	\$0	\$0	\$860,549	7	0	0	7
Totals	\$5,883,823	\$1,199,500	\$120,000	\$7,203,323	44	20	1	65

Appendix 2.12: Summary of Funded Projects from 2005-2010.

Project Area	Total Approved Funding				Total Number of Approved Projects			
	Contract	Pooled Fund	In-house	Total	Contract	Pooled Fund	In-house	Total
Infrastructure Upgrade	\$742,147	\$575,000	\$120,000	\$1,437,147	7	10	1	18
Preservation	\$695,450	\$392,000	\$0	\$1,087,450	7	7	0	14
Public Affairs	\$162,972	\$0	\$0	\$162,972	2	0	0	2
Safety	\$1,764,287	\$232,500	\$0	\$1,996,787	13	2	0	15
Shared Knowledge	\$61,150	\$0	\$0	\$61,150	3	0	0	3
Wildlife Studies	\$514,849	\$0	\$0	\$514,849	5	0	0	5
Totals	\$3,940,855	\$1,199,500	\$120,000	\$5,260,355	37	19	1	57



Appendix 2.13: Percentage of Projects Completed on time and on Budget.

APPENDIX 3. SURVEY RESPONSES

Appendix 3.1: Researcher Feedback Survey Response 1.

Project Title: Developing a Database and Web Viewing Tool for Ungulate Migrations in Wyoming

Proposal Process:

1. Rate your satisfaction with the proposal process? *Satisfied*
2. What did you like / dislike about the proposal process?
I appreciated the help I got from Enid and the flexibility given in the process. If process is too involved and too rigid it makes it difficult for all parties. It is important to be accountable but better to flexible.

Research Center Staff:

3. Rate your satisfaction with the WYDOT research center staff? *Very satisfied*
4. As a researcher, what suggestions can you provide to improve the management and administration of the center?
Perhaps a FAQ for submitters might help reduce questions to staff. Final report is fairly rigid in requirements and direction. I prefer a more flexible process and more leeway with format.
5. Rate your satisfaction with WYDOT champion / sponsor? *Very satisfied*
6. What suggestions can you provide to improve the interaction with the WYDOT champion / sponsor?
Relationship worked well.

Lessons Learned:

7. Briefly, what are the most important and transferrable lessons learned from this project?
 1. *Takes patience and persistence to get cooperation from other researchers to share data*
 2. *Sharing and archiving data is an important aspect of research. To ensure that the data is captured in a way that it can be used and shared and archived for the future.*
 3. *Takes flexibility and patience when working with multiple partners and multiple datasets. It is also difficult to predict time frames as we were dependent on others to respond and share information.*

Follow-up research:

1. Is follow-up research warranted? If yes, please explain why?
Not specifically for this project although by building a legacy project like this there will always be new datasets acquired and entered. Additionally, as managers and others use the migration viewer they often request enhancements that allow new data to be added and viewed in new ways. These enhancements will only happen if there is interest in funding these.
2. Please provide other suggestions to improve the research center?
I think that much of the rank and file of WYDOT is not engaged in the RAC process and of course with large workloads etc. it is not always possible. I believe the research should be tailored (where applicable) to the needs of the folks who work at WYDOT and so the communication between folks in the field and the researchers is important.

Appendix 3.2: Researcher Feedback Survey Response 2.

Project Title: Managing Risks in the Project Pipeline - Minimizing the Impacts of Highway Funding Uncertainties

Proposal Process:

1. Rate your satisfaction with the proposal process? *Very satisfied*
2. What did you like / dislike about the proposal process? *It was important to have discussed the topic and the need for the research beforehand, and so we knew what to propose.*

Research Center Staff:

3. Rate your satisfaction with the WYDOT research center staff? *Satisfied*
4. As a researcher, what suggestions can you provide to improve the management and administration of the center? *If there was any way to identify the research needs of the transportation department that would be great. Perhaps they are doing this now, and so that is a good thing.*
5. Rate your satisfaction with WYDOT champion / sponsor? *Very satisfied*
6. What suggestions can you provide to improve the interaction with the WYDOT champion / sponsor? *It would be good to have a follow-up meeting a couple of years after each project (if applicable) to discuss a quick status of how or where the research results were used.*

Lessons Learned:

7. Briefly, what are the most important and transferrable lessons learned from this project?
 1. *We identified root causes of unsatisfactory project delivery*
 2. *The support of the broader organization was important*
 3. *The research recommended process AND behavior changes*

Follow-up research:

8. Is follow-up research warranted? If yes, please explain why? *We identified additional research objectives and tasks at the end of the original project. It would be good to look at those recommendations now (2017) and identify needs.*
9. Please provide other suggestions to improve the research center? *The involvement of key DOT resources was fairly good, but not perfect (nothing is). But a little more encouragement would have been very good.*

Appendix 3.3: Researcher Feedback Survey Response 3.

Project Title: Developing an Effective Shoulder and Centerline Rumble Strip Policy to Accommodate All Roadway Users

Proposal Process:

1. Rate your satisfaction with the proposal process? *Very satisfied*
2. What did you like / dislike about the proposal process? *Skipped*

Research Center Staff:

3. Rate your satisfaction with the WYDOT research center staff? *Very satisfied*
4. As a researcher, what suggestions can you provide to improve the management and administration of the center? *Skipped*
5. Rate your satisfaction with WYDOT champion / sponsor? *Very satisfied*
6. What suggestions can you provide to improve the interaction with the WYDOT champion / sponsor? *Nothing*

Lessons Learned:

7. Briefly, what are the most important and transferrable lessons learned from this project?
 1. *A guide was prepared for selecting rumble strips.*
 2. *WYDOT has implemented the recommendations of the study.*
 3. *Rumble strips are effective in reducing crashes.*

Follow-up research:

8. Is follow-up research warranted? If yes, please explain why? *No, since the study findings have been implemented.*
9. Please provide other suggestions to improve the research center? *Skipped*

Appendix 3.4: Researcher Feedback Survey Response 4.

Project Title: Evaluation of the Wyoming Research Center and Research Center (Phase II)

Proposal Process:

1. Rate your satisfaction with the proposal process? *Very satisfied*
2. What did you like / dislike about the proposal process? *Smooth process*

Research Center Staff:

3. Rate your satisfaction with the WYDOT research center staff? *Very satisfied*
4. As a researcher, what suggestions can you provide to improve the management and administration of the center? *It was easy to work with the center staff.*
5. Rate your satisfaction with WYDOT champion / sponsor? *Very satisfied*
6. What suggestions can you provide to improve the interaction with the WYDOT champion / sponsor? *The WYDOT champion was very supportive of this effort.*

Lessons Learned:

Briefly, what are the most important and transferrable lessons learned from this project?

1. *Performance measures were established*
2. *Surveys to researchers will help enhance the operation*
3. *Additional surveys will help in quantifying the benefits of research*

Follow-up research:

7. Is follow-up research warranted? If yes, please explain why? *The Third phase is needed in a few years to implement the performance measures.*
8. Please provide other suggestions to improve the research center? *skipped*

Appendix 3.5: Researcher Feedback Survey Response 5.

Project Title: Structural Health Monitoring of Highway Bridges Subject to Overweight Trucks, Phase - Structural Health Monitoring of Highway Bridge Subject to Overweight Trucks, Phase I

Proposal Process:

1. Rate your satisfaction with the proposal process? *Very satisfied*
2. What did you like / dislike about the proposal process?
The following elements were effective:
 1. Working with WYDOT staff to develop project concept and scope.
 2. Proposal requirements are modest with a focus on application of research findings.
 3. Feedback from the RAC was timely.

I have no "dislikes."

Research Center Staff:

3. Rate your satisfaction with the WYDOT research center staff? *Very satisfied*
4. As a researcher, what suggestions can you provide to improve the management and administration of the center? *None. There were some contractual issues that needed to be managed with the Contracts and Grants office, but they had little or no impact on me.*
5. Rate your satisfaction with WYDOT champion / sponsor? *Very satisfied*
6. What suggestions can you provide to improve the interaction with the WYDOT champion / sponsor? *None. The research champion was cooperative, helpful and responsive.*

Lessons Learned:

7. Briefly, what are the most important and transferrable lessons learned from this project?
 1. Quarterly reports are not burdensome, but they are important for accountability.
 2. WYDOT has high standards for the quality of its research deliverables.
 3. Frequent interaction with WYDOT staff is important to assure the utility of the research outcome.

Follow-up research:

8. Is follow-up research warranted? If yes, please explain why? *Yes, and it is currently underway.*
9. Please provide other suggestions to improve the research center? *Skipped.*

Appendix 3.6: Researcher Feedback Survey Response 6.

Project Title: Assessment and Evaluation of I-80 Truck Loads and their Load Effects

Proposal Process:

1. Rate your satisfaction with the proposal process? *Very satisfied*
2. What did you like / dislike about the proposal process? *Straightforward, much better than other agencies.*

Research Center Staff:

3. Rate your satisfaction with the WYDOT research center staff? *Very satisfied*
4. As a researcher, what suggestions can you provide to improve the management and administration of the center? *The center runs fine. I appreciated the editorial review of our final report.*
5. Rate your satisfaction with WYDOT champion / sponsor? *Very satisfied*
6. What suggestions can you provide to improve the interaction with the WYDOT champion / sponsor? *Bridge group is always helpful. They could consider being proactive in sharing this work with SCOBS technical committee the might be affected.*

Lessons Learned:

7. Briefly, what are the most important and transferrable lessons learned from this project?
 1. *I-80 loads are higher than specifications for expected level of safety*
 2. *Road closures create atypical loading compared with other regions*
 3. *This work should be debated at the national level and it has significant implications to modifications to our present design specifications.*

Follow-up research:

8. Is follow-up research warranted? *It really is. I hope to find time! The service load limit states should be evaluated using the tools developed in this project. Also, we now have one of the best routing and rating system around for rigorous analysis of bridges for permits loads, etc. The combination of the software tools, the outstanding bridge data in the WyDOT inventory and analysis tools now developed, we can move to compute reliability indices for each limit state for a large number of loads and bridges. This combination is a large "big data" research opportunity that simply does not exist anywhere else. If our time permits, we will be following up with a RAC proposal. I find this follow up really exciting and quite novel. WyDOT software efforts lead the country in many areas.*
9. Please provide other suggestions to improve the research center? *I have not reviewed the distribution methods for products, but my feeling is the WYDOT research successes are often undertold.*

Appendix 3.7: Researcher Feedback Survey Response 7.

Project Title: Planning-Support for Mitigation of Wildlife Vehicle Collisions and Highway Impacts on Migration Routes in Wyoming

Proposal Process:

1. Rate your satisfaction with the proposal process? *Very satisfied*
2. What did you like / dislike about the proposal process? *The proposal process has been streamlined; I appreciated having a relatively short (5-10 page) proposal and short presentation. Having to travel to Laramie to make the presentation was a little bit of a hindrance.*

Research Center Staff:

3. Rate your satisfaction with the WYDOT research center staff? *Very satisfied*
4. As a researcher, what suggestions can you provide to improve the management and administration of the center? *Enid is extremely helpful and responsive. I can't really think of anything she could do better in running the research center.*
5. Rate your satisfaction with WYDOT champion / sponsor? *Very satisfied*
6. What suggestions can you provide to improve the interaction with the WYDOT champion / sponsor? *As noted in the other survey I completed, it would be helpful to have some guidelines about what a good level of interaction with the champion is. It is sometimes hard to know how often the champion wants an update.*

Lessons Learned:

7. Briefly, what are the most important and transferrable lessons learned from this project?
 1. *There are places in WY with a wildlife warning sign that don't merit one, and other places without a sign that should have one*
 2. *The combination of WVC data and animal movement data provide powerful insights into the relationships between wildlife and roads and how best to mitigate them*
 3. *Deer-vehicle collisions tend to occur where there is moderate-high traffic volume through deer migration and winter use areas.*

Follow-up research:

8. Is follow-up research warranted? If yes, please explain why? *Yes, I am currently working to understand better the relationship between traffic and deer road crossing behavior to understand when traffic creates a partial or complete barrier to deer movement.*
9. Please provide other suggestions to improve the research center? *None other than already stated.*

Appendix 3.8: Researcher Feedback Survey Response 8.

Project Title: Calibrating Crash Modification Factors for Wyoming

Proposal Process:

1. Rate your satisfaction with the proposal process? *Very satisfied*
2. What did you like / dislike about the proposal process? *Skipped*

Research Center Staff:

3. Rate your satisfaction with the WYDOT research center staff? *Very satisfied*
4. As a researcher, what suggestions can you provide to improve the management and administration of the center? *Skipped*
5. Rate your satisfaction with WYDOT champion / sponsor? *Very satisfied*
6. What suggestions can you provide to improve the interaction with the WYDOT champion / sponsor? *Skipped*

Lessons Learned:

7. Briefly, what are the most important and transferrable lessons learned from this project?
Skipped

Follow-up research:

8. Is follow-up research warranted? If yes, please explain why? *Skipped*
9. Please provide other suggestions to improve the research center? *Skipped*

Appendix 3.9: Researcher Feedback Survey Response 9.

Project Title: Investigation of Silica Fume Concrete Bridge Overlay Failures

Proposal Process:

1. Rate your satisfaction with the proposal process? *Very satisfied*
2. What did you like / dislike about the proposal process? *The requirements and format were clearly identified and an example proposal was provided for review.*

Research Center Staff:

3. Rate your satisfaction with the WYDOT research center staff? *Very satisfied*
4. As a researcher, what suggestions can you provide to improve the management and administration of the center? *It would have been beneficial if the WYDOT Research Staff provided updated financial statements for the project. We kept a spreadsheet of funds/expenditures for the project but at the end of the project, WYDOT's figures did not match ours. There was also confusion as to how and when WYDOT billed the project for laboratory work performed by the Materials Lab. Had WYDOT provided a financial summary sheet every quarter, these discrepancies could have been avoided or at least fixed before the end of the project.*
5. Rate your satisfaction with WYDOT champion / sponsor? *Very satisfied*
6. What suggestions can you provide to improve the interaction with the WYDOT champion / sponsor? *None. Robert Rothwell was a great sponsor.*

Lessons Learned:

7. Briefly, what are the most important and transferrable lessons learned from this project?
 1. *Premature silica fume bridge deck overlay failures were caused by weak (microcracked) substrate concrete and cracking, curling and debonding of the overlay due to high drying shrinkage characteristics of the silica fume concrete.*
 2. *Service life including bonding of silica fume overlays are highly dependent on several factors including: soundness of the concrete substrate and surface preparation, drying shrinkage characteristics of the silica fume concrete and crack resistance of the silica flume concrete overlay.*
 3. *Specifying, measuring and using a very low-shrinkage concrete as verified by ASTM C157 is critical to extending the surface life of silica flume bridge deck overlays.*

Follow-up research:

8. Is follow-up research warranted? If yes, please explain why? *Yes, verifying and perhaps modifying the detailed recommendations of the original research would be beneficial to the State of Wyoming and the traveling public.*
9. Please provide other suggestions to improve the research center? *Obtain more funding and funding sources.*

Appendix 3.10: Researcher Feedback Survey Response 10.

Project Title: Evaluation of a Mitigation Site: Amphibian Population

Proposal Process:

1. Rate your satisfaction with the proposal process? *Satisfied*
2. What did you like / dislike about the proposal process? *Skipped*

Research Center Staff:

3. Rate your satisfaction with the WYDOT research center staff? *Very satisfied*
4. As a researcher, what suggestions can you provide to improve the management and administration of the center? *Skipped*
5. Rate your satisfaction with WYDOT champion / sponsor? *Very satisfied*
6. What suggestions can you provide to improve the interaction with the WYDOT champion / sponsor?

Lessons Learned:

7. Briefly, what are the most important and transferrable lessons learned from this project?
 1. *Good collaborative effort*
 2. *Interest of wydot cooperators*
 3. *Broadened scope of the use of the data*

Follow-up research:

8. Is follow-up research warranted? If yes, please explain why? *it depends on the question wydot wants to answer*
9. Please provide other suggestions to improve the research center? *Skipped*

Appendix 3.11: Researcher Feedback Survey Response 11.

Project Title: Characterization of Material Properties for Mechanistic-Empirical Pavement Design in Wyoming

Proposal Process:

1. Rate your satisfaction with the proposal process? *Very satisfied*
2. What did you like / dislike about the proposal process? *The project was funded in a timely manner.*

Research Center Staff:

3. Rate your satisfaction with the WYDOT research center staff? *Very satisfied*
4. As a researcher, what suggestions can you provide to improve the management and administration of the center? *Skipped*
5. Rate your satisfaction with WYDOT champion / sponsor? *Very satisfied*
6. What suggestions can you provide to improve the interaction with the WYDOT champion / sponsor? *Skipped*

Lessons Learned:

7. Briefly, what are the most important and transferrable lessons learned from this project?
 1. *A process for selecting materials properties was established.*
 2. *WYDOT was presented with multiple ways to select aggregate strength.*
 3. *The study will facilitate the full implementation of the MEPDG.*

Follow-up research:

8. Is follow-up research warranted? If yes, please explain why? *Yes, WYDOT funded a study to calibrate the base materials.*
9. Please provide other suggestions to improve the research center? *Skipped*

Appendix 3.12: Researcher Feedback Survey Response 12.

Project Title: Developing Wyoming Specific Bridge Deterioration Models for Bridge Management

Proposal Process:

1. Rate your satisfaction with the proposal process? *Satisfied*
2. What did you like / dislike about the proposal process? *Skipped*

Research Center Staff:

3. Rate your satisfaction with the WYDOT research center staff? *Very satisfied*
4. As a researcher, what suggestions can you provide to improve the management and administration of the center? *Skipped*
5. Rate your satisfaction with WYDOT champion / sponsor? *Very satisfied*
6. What suggestions can you provide to improve the interaction with the WYDOT champion / sponsor? *Skipped*

Lessons Learned:

7. Briefly, what are the most important and transferrable lessons learned from this project?
 1. *LASSO regression, a form of penalized linear regression, can remove human influence from the selection of explanatory variables.*
 2. *While deterministic and stochastic models can be made for various subsets, bridge managers should be careful about implementing models developed from small datasets, and engineering judgment should be applied.*
 3. *Several deterministic and stochastic bridge deterioration models were developed to predict future bridge service life.*

Follow-up research:

8. Is follow-up research warranted? If yes, please explain why? *Yes, improvements can be made to modeling techniques, collected inspection data and life cycle cost analysis could be performed.*
9. Please provide other suggestions to improve the research center? *Skipped*

Appendix 3.13: Researcher Feedback Survey Response 13.

Project Title: Instrumentation and Analysis of Frost Heave Mitigation on WY 70, Encampment, WY

Proposal Process:

1. Rate your satisfaction with the proposal process? *Very satisfied*
2. What did you like / dislike about the proposal process? *I received a lot of support from WYDOT during its preparation.*

Research Center Staff:

3. Rate your satisfaction with the WYDOT research center staff? *Very satisfied*
4. As a researcher, what suggestions can you provide to improve the management and administration of the center? *The research report writing requirements changed during the writing process. It required considerable rewriting for which I eventually hired a PhD graduate to complete the reformatting.*
5. Rate your satisfaction with WYDOT champion / sponsor? *Very satisfied*
6. What suggestions can you provide to improve the interaction with the WYDOT champion / sponsor? *Everyone I worked with at WYDOT was helpful and understanding.*

Lessons Learned:

7. Briefly, what are the most important and transferrable lessons learned from this project?
 1. *The injectable polymer foam stabilized the frost heave.*
 2. *The process was rapid and provided many safety benefits over conventional reconstruction methods.*
 3. *The thickness of polymer can be predicted using a modification of a procedure developed by the US military.*

Follow-up research:

8. Is follow-up research warranted? If yes, please explain why? *This was a pilot project to verify a procedure. Subsequent testing would provide further verification of the procedure and the polymer injection thickness.*
9. Please provide other suggestions to improve the research center? *Micheal Pattrich and Enid White were very supportive before, during and after the proposal and final report stages. That support needs to be continued.*

Appendix 3.14: Researcher Feedback Survey Response 14.

Project Title: Evaluating the Effects of Deer Delineators in Wildlife-Vehicle Collisions in Northwest Wyoming

Proposal Process:

1. Rate your satisfaction with the proposal process? *Satisfied*
2. What did you like / dislike about the proposal process? *I was actually not part of the proposal process; I inherited the project from the original proposer*

Research Center Staff:

3. Rate your satisfaction with the WYDOT research center staff? *Very satisfied*
4. As a researcher, what suggestions can you provide to improve the management and administration of the center? *Enid does a fantastic job.*
5. Rate your satisfaction with WYDOT champion / sponsor? *Very satisfied*
6. What suggestions can you provide to improve the interaction with the WYDOT champion / sponsor? *The project champion was very engaged. However, some guidelines for researchers on how much / how often to engage with the project champion might be helpful for the future.*

Lessons Learned:

7. Briefly, what are the most important and transferrable lessons learned from this project?
 1. *Deer reflectors have some limited effectiveness in reducing WVC*
 2. *White bags on posts worked better than reflectors and further technology should be explored*
 3. *Before-after collision data are not very useful for testing the effectiveness of WVC mitigations unless their effectiveness is extremely high*

Follow-up research:

8. Is follow-up research warranted? If yes, please explain why? *Yes, I think more research on the potential for white reflective surfaces to deter deer from unsafe road crossings is warranted.*
9. Please provide other suggestions to improve the research center? *None*

Appendix 3.15: Researcher Feedback Survey Response 15.

Project Title: A Literature Review of Approach Slab and its Settlement for Roads and Bridges in Wyoming

Proposal Process:

1. Rate your satisfaction with the proposal process? *Very satisfied*
2. What did you like / dislike about the proposal process? *Skipped*

Research Center Staff:

3. Rate your satisfaction with the WYDOT research center staff? *Very satisfied*
4. As a researcher, what suggestions can you provide to improve the management and administration of the center? *Skipped*
5. Rate your satisfaction with WYDOT champion / sponsor? *Very satisfied*
6. What suggestions can you provide to improve the interaction with the WYDOT champion / sponsor? *Skipped*

Lessons Learned:

7. Briefly, what are the most important and transferrable lessons learned from this project?
 1. *Engage with WYDOT especially the champion as early as possible*
 2. *Seek assistance from the champion*
 3. *Understand the needs and deliverables of the project*

Follow-up research:

8. Is follow-up research warranted? If yes, please explain why? *Yes, the proposed research outcomes may need verification from field experiments and implementation.*
9. Please provide other suggestions to improve the research center? *Allocate some funding for innovative research ideas.*

Appendix 3.16: Researcher Feedback Survey Response 16.

Project Title: Developing Mitigation Strategies to Reduce Truck Crash Rates in Wyoming Highways

Proposal Process:

1. Rate your satisfaction with the proposal process? *Very satisfied*
2. What did you like / dislike about the proposal process? *The study got funded in a timely manner.*

Research Center Staff:

3. Rate your satisfaction with the WYDOT research center staff? *Very satisfied*
4. As a researcher, what suggestions can you provide to improve the management and administration of the center? *Skipped*
5. Rate your satisfaction with WYDOT champion / sponsor? *Very satisfied*
6. What suggestions can you provide to improve the interaction with the WYDOT champion / sponsor? *Skipped*

Lessons Learned:

7. Briefly, what are the most important and transferrable lessons learned from this project?
 1. *Enforcement impacts crashes.*
 2. *Enforcement agencies in Wyoming have similar resources to other agencies in the region.*
 3. *Specific recommendations were provided to the trucking industry, WYDOT, and Wyoming Highway Patrol.*

Follow-up research:

8. Is follow-up research warranted? If yes, please explain why? *There will be several studies in the future tackling this major challenge.*
9. Please provide other suggestions to improve the research center? *Skipped*

Appendix 3.17: Researcher Feedback Survey Response 17.

Project Title: Comprehensive Technology Assessment for Avalanche Hazard Management

Proposal Process:

1. Rate your satisfaction with the proposal process? *Very satisfied*
2. What did you like / dislike about the proposal process? *Hardly anything. WYDOT Research and the RAC process is agile and complete. I wish there were more choices for restaurants in Cheyenne...*

Research Center Staff:

3. Rate your satisfaction with the WYDOT research center staff? *Very satisfied*
4. As a researcher, what suggestions can you provide to improve the management and administration of the center? *These guys are 'top drawer'. Tight technically. Approachable. Agile. Sound info flow.*
5. Rate your satisfaction with WYDOT champion / sponsor? *Very satisfied*
6. What suggestions can you provide to improve the interaction with the WYDOT champion / sponsor? *Because this project is multi-year, it has 'outlived' a couple of champions. Perhaps with projects like this, the next potential champion could shadow the existing champion in anticipation of the day that they'll have to pick that role up.*

Lessons Learned:

7. Briefly, what are the most important and transferrable lessons learned from this project?
 1. *WYDOT met its strategic goal of moving their avalanche hazard management program out of using military weapons to accomplish it.*
 2. *The 'modern (French) technology' for avalanche initiating shock sources is effective, reliable and perhaps most importantly fast. This provides additional flexibility in scheduling avalanche control activities and reduces delay on the roadway.*
 3. *There is a caveat associated with 'in house' installation of this modern technology associated with the mountain side footers and foundations. At present, the gear come in a (big) box with an ISO spec for the foundations. As a consequence, quite often they're getting installed (not just at WYDOT) without much, if any, QA/QC on the critical foundation elements, including test pins and their requisite pull tests. Almost any engineer, and especially a DOT one would recognize this as 'bad form'.*

Follow-up research:

8. Is follow-up research warranted? If yes, please explain why? *Yes.. The quality of a hazard reduction program, avalanche and otherwise, is the sum of its hardware and its (human) procedures. We should make sure that our decision making environment, procedures, and checks/balances is as tuned-up as our technology.*
9. Please provide other suggestions to improve the research center? *Continue to engage the transportation communities 'Peer Exchange' activity for the guys working the line (the non gender specific 'guy'..) and also similar peer opportunities for Research staff. It's*

only by measuring your progress and outcomes against other programs of the same ilk that you get to know if you're doing well or really have a long ways to go in improving yourself.

Appendix 3.18: Researcher Feedback Survey Response 18.

Project Title: Evaluating the Risk of Alkali Silica Reaction in Wyoming

Proposal Process:

1. Rate your satisfaction with the proposal process? *Satisfied*
2. What did you like / dislike about the proposal process? *I enjoyed working with WYDOT.*

Research Center Staff:

3. Rate your satisfaction with the WYDOT research center staff? *Satisfied*
4. As a researcher, what suggestions can you provide to improve the management and administration of the center? *It would be nice to see more transparency in the process of available funds.*
5. Rate your satisfaction with WYDOT champion / sponsor? *Satisfied*
6. What suggestions can you provide to improve the interaction with the WYDOT champion / sponsor? *I enjoyed working with Bob Rothwell. He was responsive without becoming overly involved.*

Lessons Learned:

7. Briefly, what are the most important and transferrable lessons learned from this project?
 1. *Reactivity of Wyoming Aggregates*
 2. *Data on local materials*
 3. *Field site to provide long term data*

Follow-up research:

8. Is follow-up research warranted? If yes, please explain why? *Yes, but additional projects have been proposed.*
9. Please provide other suggestions to improve the research center? *Skipped.*

Appendix 3.19: Researcher Feedback Survey Response 19.

Project Title: Wyoming Low Volume Roads Traffic Volume Estimation

Proposal Process:

1. Rate your satisfaction with the proposal process? *Very satisfied*
2. What did you like / dislike about the proposal process? *There were no issues associated with the proposal process.*

Research Center Staff:

3. Rate your satisfaction with the WYDOT research center staff? *Very satisfied*
4. As a researcher, what suggestions can you provide to improve the management and administration of the center? *None, at this point.*
5. Rate your satisfaction with WYDOT champion / sponsor? *Very satisfied*
6. What suggestions can you provide to improve the interaction with the WYDOT champion / sponsor? *The Planning program was very supportive of the study.*

Lessons Learned:

7. Briefly, what are the most important and transferrable lessons learned from this project?
 1. *Traffic volumes on LVR can be predicted in three different ways.*
 2. *The regression modeling is the easiest to implement.*
 3. *The TDM is the most accurate.*

Follow-up research:

8. Is follow-up research warranted? If yes, please explain why? *Yes, a second phase has been funded to develop a state wide TDM for LVRs.*
9. Please provide other suggestions to improve the research center? *Skipped*

Appendix 3.20: Researcher Feedback Survey Response 20.

Project Title: Historic Winter Weather Assessment for Snow Fence Design using a Numerical Weather Model

Proposal Process:

1. Rate your satisfaction with the proposal process? *Satisfied*
2. What did you like / dislike about the proposal process? *It was just fine with me.*

Research Center Staff:

3. Rate your satisfaction with the WYDOT research center staff? *Satisfied*
4. As a researcher, what suggestions can you provide to improve the management and administration of the center? *I do not have any good idea.*
5. Rate your satisfaction with WYDOT champion / sponsor? *Satisfied*
6. What suggestions can you provide to improve the interaction with the WYDOT champion / sponsor? *The communication was smooth.*

Lessons Learned:

7. Briefly, what are the most important and transferrable lessons learned from this project?
 1. *Updated wind field data for snow fence design*
 2. *Model verified snow data for snow fence design*
 3. *Blowing snow remains a major hazard during winter in Wyoming*

Follow-up research:

8. Is follow-up research warranted? If yes, please explain why? *Skipped*
9. Please provide other suggestions to improve the research center? *I have no suggestion. It was a good experience.*

Appendix 3.21: Researcher Feedback Survey Response 21.

Project Title: Improving Traveler Information on Rural Corridors in Wyoming through the Use of Intelligent Transportation Systems

Proposal Process:

1. Rate your satisfaction with the proposal process? *Very satisfied*
2. What did you like / dislike about the proposal process? *Like the fast response in knowing whether a project is moving forward.*

Research Center Staff:

3. Rate your satisfaction with the WYDOT research center staff? *Very satisfied*
4. As a researcher, what suggestions can you provide to improve the management and administration of the center? *Skipped*
5. Rate your satisfaction with WYDOT champion / sponsor? *Very satisfied*
6. What suggestions can you provide to improve the interaction with the WYDOT champion / sponsor? *Skipped*

Lessons Learned:

7. Briefly, what are the most important and transferrable lessons learned from this project?
 1. *Bluetooth/wifi sensors not a good technology for I-80 corridor due to low penetration rates.*
 2. *Travel time index gives a consistent and reliable measure of condition severity.*
 3. *Use of travel time reporting likely would enhance WYDOT's traveler information system.*

Follow-up research:

8. Is follow-up research warranted? If yes, please explain why? *No*
9. Please provide other suggestions to improve the research center? *Skipped*

Appendix 3.22: Researcher Feedback Survey Response 22.

Project Title: Developing Mitigation Strategies to Reduce Truck Crash Rates in Wyoming Highways

Proposal Process:

1. Rate your satisfaction with the proposal process? *Very satisfied*
2. What did you like / dislike about the proposal process? *The study got funded in a timely manner.*

Research Center Staff:

3. Rate your satisfaction with the WYDOT research center staff? *Very satisfied*
4. As a researcher, what suggestions can you provide to improve the management and administration of the center?
5. Rate your satisfaction with WYDOT champion / sponsor? *Very satisfied*
6. What suggestions can you provide to improve the interaction with the WYDOT champion / sponsor?
- 7.

Lessons Learned:

Briefly, what are the most important and transferrable lessons learned from this project?

1. *Enforcement impacts crashes.*
2. *Enforcement agencies in Wyoming have similar resources to other agencies in the region.*
3. *Specific recommendations were provided to the trucking industry, WYDOT, and Wyoming Highway Patrol.*

Follow-up research:

8. Is follow-up research warranted? If yes, please explain why? *There will be several studies in the future tackling this major challenge.*
9. Please provide other suggestions to improve the research center?

Appendix 3.23: Researcher Feedback Survey Response 23.

Project Title: Evaluating Base Widening Methods

Proposal Process:

1. Rate your satisfaction with the proposal process? *Very satisfied*
2. What did you like / dislike about the proposal process? *Skipped*

Research Center Staff:

3. Rate your satisfaction with the WYDOT research center staff? *Very satisfied*
4. As a researcher, what suggestions can you provide to improve the management and administration of the center? *Skipped*
5. Rate your satisfaction with WYDOT champion / sponsor? *Very satisfied*
6. What suggestions can you provide to improve the interaction with the WYDOT champion / sponsor? *Skipped*

Lessons Learned:

7. Briefly, what are the most important and transferrable lessons learned from this project?
 1. *Vertical pavement widening joining preferred method in region due to constructability even though they have higher costs due to increased base material usage.*
 2. *Tapered base widening joining have better strength and less longitudinal cracking when compared to vertical joints.*

Follow-up research:

8. Is follow-up research warranted? If yes, please explain why? *No*
9. Please provide other suggestions to improve the research center? *Skipped*

Appendix 3.24: Researcher Feedback Survey Response 24.

Project Title: Multi-Measure Performance Assessment and Benchmarking of the Divisions of the Wyoming Highway Patrol

Proposal Process:

1. Rate your satisfaction with the proposal process? *Very satisfied.*
2. What did you like / dislike about the proposal process? *Skipped.*

Research Center Staff:

3. Rate your satisfaction with the WYDOT research center staff? *Very satisfied.*
4. As a researcher, what suggestions can you provide to improve the management and administration of the center? *Skipped.*
5. Rate your satisfaction with WYDOT champion / sponsor? *Very satisfied.*
6. What suggestions can you provide to improve the interaction with the WYDOT champion / sponsor? *Skipped.*

Lessons Learned:

7. Briefly, what are the most important and transferrable lessons learned from this project? *Skipped.*

Follow-up research:

8. Is follow-up research warranted? If yes, please explain why? *Yes, the research was not completed in its entirety as originally planned.*
9. Please provide other suggestions to improve the research center? *Skipped.*

Appendix 3.25: Researcher Feedback Survey Response 25.

Project Title: Developing a Roadway Safety Improvement Program for Indian Reservations

Proposal Process:

1. Rate your satisfaction with the proposal process? *Very satisfied*
2. What did you like / dislike about the proposal process? *The RAC was very supportive.*

Research Center Staff:

3. Rate your satisfaction with the WYDOT research center staff? *Very satisfied*
4. As a researcher, what suggestions can you provide to improve the management and administration of the center? *The Research Center staff provided the needed support promptly.*
5. Rate your satisfaction with WYDOT champion / sponsor? *Very satisfied*
6. What suggestions can you provide to improve the interaction with the WYDOT champion / sponsor? *Matt was extremely supportive and the Safety Office of WYDOT implemented the findings immediately.*

Lessons Learned:

7. Briefly, what are the most important and transferrable lessons learned from this project?
 1. *A systematic process should be implemented when evaluating safety on tribal lands.*
 2. *Lots of coordination is needed among stakeholder to make sure that the safety projects are successful.*
 3. *DOTs should work closely with tribal representatives to enhance roadway safety on tribal roads.*

Follow-up research:

8. Is follow-up research warranted? If yes, please explain why? *Additional work would be warranted on livability on tribal lands.*
9. Please provide other suggestions to improve the research center? *Skipped.*

Appendix 3.26: Researcher Feedback Survey Response 26.

Project Title: Criteria for a WYDOT Culvert Selection Policy

Proposal Process:

1. Rate your satisfaction with the proposal process? *Satisfied*
2. What did you like / dislike about the proposal process? *Skipped*

Research Center Staff:

3. Rate your satisfaction with the WYDOT research center staff? *Satisfied*
4. As a researcher, what suggestions can you provide to improve the management and administration of the center? *Skipped*
5. Rate your satisfaction with WYDOT champion / sponsor? *Satisfied*
6. What suggestions can you provide to improve the interaction with the WYDOT champion / sponsor? *Skipped*

Lessons Learned:

7. Briefly, what are the most important and transferrable lessons learned from this project?
Skipped

Follow-up research:

8. Is follow-up research warranted? If yes, please explain why? *Skipped*
9. Please provide other suggestions to improve the research center? *Skipped*

Appendix 3.27: Researcher Feedback Survey Response 27.

Project Title: Pronghorn and Mule Deer Use of Underpasses along US Highway 191

Proposal Process:

1. Rate your satisfaction with the proposal process? *Very satisfied*
2. What did you like / dislike about the proposal process? *Clear yes or no answers to funding and straight-forward contracting process.*

Research Center Staff:

3. Rate your satisfaction with the WYDOT research center staff? *Very satisfied*
4. As a researcher, what suggestions can you provide to improve the management and administration of the center? *Skipped.*
5. Rate your satisfaction with WYDOT champion / sponsor? *Very satisfied*
6. What suggestions can you provide to improve the interaction with the WYDOT champion / sponsor? *None. We have good relationship.*

Lessons Learned:

7. Briefly, what are the most important and transferrable lessons learned from this project?
 1. *Wildlife crossing structures work*
 2. *Pronghorn prefer to move over roadways*
 3. *Mule deer can move under or over roadways*

Follow-up research:

8. Is follow-up research warranted? If yes, please explain why? *Yes, our initial research suggested crossing structures encouraged animals to move back and forth across roadways more often, which has important biological implications. We have GPS radio-collar data for the project area that could be used to quantify whether this is indeed occurring and if so, to what degree in both pronghorn and mule deer.*
9. Please provide other suggestions to improve the research center? *Seems like a great program to me.*

Appendix 3.28: Researcher Feedback Survey Response 28.

Project Title: Pronghorn and Mule Deer Use of Underpasses along US Highway 191

Proposal Process:

1. Rate your satisfaction with the proposal process? *Satisfied*
2. What did you like / dislike about the proposal process? *RAC involvement and feedback.*

Research Center Staff:

3. Rate your satisfaction with the WYDOT research center staff? *Very satisfied, the program works well.*
4. As a researcher, what suggestions can you provide to improve the management and administration of the center? *Very satisfied*
5. Rate your satisfaction with WYDOT champion / sponsor? *Very satisfied*
6. What suggestions can you provide to improve the interaction with the WYDOT champion / sponsor?

Lessons Learned:

7. Briefly, what are the most important and transferrable lessons learned from this project?
 - 1) *Maintain database*
 - 2) *Project support from resident engineer.*
 - 3) *Publish results in journa."*

Follow-up research:

8. Is follow-up research warranted? If yes, please explain why? *May be, there is interest in revisiting this monitoring a future, when ADT reates increase..*
9. Please provide other suggestions to improve the research center?

Researcher Feedback Form

Researcher: _____
Organization: _____
Project Title: _____

WYDOT Sponsor: _____
Survey Date: _____



	<input type="checkbox"/> Very Satisfied

Proposal Process	Rate your satisfaction with the proposal process:	<input type="checkbox"/> Satisfied <input type="checkbox"/> Dissatisfied
	What did you like about the proposal process?	
	What did you dislike about the proposal process?	
Research Center Staff	Rate your satisfaction with the Research Center staff:	<input type="checkbox"/> Very Satisfied <input type="checkbox"/> Satisfied <input type="checkbox"/> Dissatisfied
	As a researcher, what suggestions can you provide to improve the management and administration of the program?	
Project Sponsor	Rate your satisfaction with the Research Center staff:	<input type="checkbox"/> Very Satisfied <input type="checkbox"/> Satisfied <input type="checkbox"/> Dissatisfied
	What suggestions can you provide to improve the interaction with the program sponsor?	

Lessons Learned	<p>Briefly, what are the three most important and transferrable lessons learned from this project?</p> <p>1.</p> <p>2.</p> <p>3.</p>	
Follow-up Research	<p>Is follow-up research warranted?</p>	<p><input type="checkbox"/> Yes <input type="checkbox"/> No</p>
	<p>If yes, please explain why:</p>	
Continuous Improvement	<p>Please provide other suggestions to improve the Research Center.</p>	

APPENDIX 4. PHASE I PERFORMANCE EVALUATION

Appendix 4.1: Phase I Performance Evaluation, Response 1.

Project Title: Managing Risks in the Project Pipeline – Minimizing the Impacts of Highway Funding Uncertainties

1. Were all of the proposed objectives of the research project fulfilled? *Some objectives were fulfilled*
2. Expected future level of implementation within WYDOT. *Partial implementation*
3. External technology transfer. *Some national, regional, or local presentations, publications, etc.*
4. Internal technology transfer. *Research findings were presented to relevant departments within WYDOT*
5. Was a research project created? *A professional and concise research report was created, meeting WYDOT's expectations*
6. Was the research project completed within its proposed timeline? *The project was completed within its proposed timeline or within approved extensions*
7. Was the project completed within its proposed budget? *The project was completed within its proposed budget or within an approved funding increase.*

Appendix 4.2: Phase I Performance Evaluation, Response 2.

Project Title: Developing an Effective Shoulder and Centerline Rumble Strip Policy to Accommodate All Roadway Users

1. Were all of the proposed objectives of the research project fulfilled? *Some objectives were fulfilled*
2. Expected future level of implementation within WYDOT. *Partial implementation*
3. External technology transfer. *Some national, regional, or local presentations, publications, etc.*
4. Internal technology transfer. *Research findings were presented to relevant departments within WYDOT*
5. Was a research project created? *A professional and concise research report was created, meeting WYDOT's expectations*
6. Was the research project completed within its proposed timeline? *The project was completed within its proposed timeline or within approved extensions*
7. Was the project completed within its proposed budget? *The project was completed within its proposed budget or within an approved funding increase.*

Appendix 4.3: Phase I Performance Evaluation, Response 3.

Project Title: Implementation and Local Calibration of the MEPDG Transfer Functions in Wyoming

1. Were all of the proposed objectives of the research project fulfilled? *All objectives were fulfilled*
2. Expected future level of implementation within WYDOT. *Partial implementation*
3. External technology transfer. *Some national, regional, or local presentations, publications, etc.*
4. Internal technology transfer. *Research findings were presented to relevant departments within WYDOT*
5. Was a research project created? *A professional and concise research report was created, meeting WYDOT's expectations*
6. Was the research project completed within its proposed timeline? *The project was completed within its proposed timeline or within approved extensions*
7. Was the project completed within its proposed budget? *The project was completed within its proposed budget or within an approved funding increase.*

Appendix 4.4: Phase I Performance Evaluation, Response 4.

Project Title: Structural Health Monitoring of Highway Bridges Subject to Overweight Trucks, Phase - Structural Health Monitoring of Highway Bridge Subject to Overweight Trucks, Phase I

8. Were all of the proposed objectives of the research project fulfilled? *All objectives were fulfilled*
9. Expected future level of implementation within WYDOT. *Partial implementation*
10. External technology transfer. *Some national, regional, or local presentations, publications, etc.*
11. Internal technology transfer. *No internal technology transfer*
12. Was a research project created? *A professional and concise research report was created, meeting WYDOT's expectations*
13. Was the research project completed within its proposed timeline? *The project was completed after one month of its proposed timeline.*
14. Was the project completed within its proposed budget? *The project was completed within its proposed budget or within an approved funding increase.*

Appendix 4.5: Phase I Performance Evaluation, Response 5.

Project Title: Assessment and Evaluation of I-80 Truck Loads and their Load Effects

1. Were all of the proposed objectives of the research project fulfilled? *All objectives were fulfilled*
2. Expected future level of implementation within WYDOT. *Partial implementation*
3. External technology transfer. *No external technology transfer*
4. Internal technology transfer. *Research findings were presented to relevant departments within WYDOT*
5. Was a research project created? *A professional and concise research report was created, meeting WYDOT's expectations*
6. Was the research project completed within its proposed timeline? *The project was completed after one month of its proposed timeline.*
7. Was the project completed within its proposed budget? *The project was completed within its proposed budget or within an approved funding increase.*

Appendix 4.6: Phase I Performance Evaluation, Response 6.

Project Title: Calibrating Crash Modification Factors for Wyoming

1. Were all of the proposed objectives of the research project fulfilled? *Some objectives were fulfilled*
2. Expected future level of implementation within WYDOT. *Full implementation*
3. External technology transfer. *Some national, regional, or local presentations, publications, etc.*
4. Internal technology transfer. *Research findings were presented to relevant departments within WYDOT*
5. Was a research project created? *A professional and concise research report was created, meeting WYDOT's expectations*
6. Was the research project completed within its proposed timeline? *The project was completed after one month of its proposed timeline.*
7. Was the project completed within its proposed budget? *The project was completed within its proposed budget or within an approved funding increase.*

Appendix 4.7: Phase I Performance Evaluation, Response 7.

Project Title: Characterization of Material Properties for Mechanistic-Empirical Pavement Design in Wyoming

1. Were all of the proposed objectives of the research project fulfilled? *All objectives were fulfilled*
2. Expected future level of implementation within WYDOT. *Full implementation*
3. Internal technology transfer. *Research findings were presented to relevant departments within WYDOT*
4. External technology transfer. *No external technology transfer*
5. Was a research project created? *A professional and concise research report was created, meeting WYDOT's expectations*
6. Was the research project completed within its proposed timeline? *The project was completed after one month of its proposed timeline.*
7. Was the project completed within its proposed budget? *The project was completed within its proposed budget or within an approved funding increase.*

Appendix 4.8: Phase I Performance Evaluation, Response 8.

Project Title: Developing Wyoming Specific Bridge Deterioration Models for Bridge Management

1. Were all of the proposed objectives of the research project fulfilled? *All objectives were fulfilled*
2. Expected future level of implementation within WYDOT. *Partial implementation*
3. Internal technology transfer. *No internal technology transfer*
4. External technology transfer. *No external technology transfer*
5. Was a research project created? *A professional and concise research report was created, meeting WYDOT's expectations*
6. Was the research project completed within its proposed timeline? *The project was completed after one month of its proposed timeline*
7. Was the project completed within its proposed budget? *The project was completed within its proposed budget or within an approved funding increase.*

Appendix 4.9: Phase I Performance Evaluation, Response 9.

Project Title: Instrumentation and Analysis of Frost Heave Mitigation on WY-70

1. Were all of the proposed objectives of the research project fulfilled? *All objectives were fulfilled*
2. Expected future level of implementation within WYDOT. *Partial implementation*
3. Internal technology transfer. *Research findings were presented to relevant departments within WYDOT*

4. External technology transfer. *Some national, regional, or local presentations, publications, etc.*
5. Was a research project created? *A professional and concise research report was created, meeting WYDOT's expectations*
6. Was the research project completed within its proposed timeline? *The project was completed within its proposed timeline or within approved extensions*
7. Was the project completed within its proposed budget? *The project was completed within its proposed budget or within an approved funding increase.*

Appendix 4.10: Phase I Performance Evaluation, Response 10.

Project Title: Effects of wildlife warning reflectors (“deer delineators”) on wildlife-vehicle collisions in central Wyoming ALSO KNOW AS Evaluating the Effects of Deer Delineators on Wildlife-Vehicle Collisions in Northwest Wyoming

1. Were all of the proposed objectives of the research project fulfilled? *All objectives were fulfilled*
2. Expected future level of implementation within WYDOT. *Full implementation*
3. Internal technology transfer. *Skipped*
4. External technology transfer. *Some national, regional, or local presentations, publications, etc.*
5. Was a research project created? *A professional and concise research report was created, meeting WYDOT's expectations*
6. Was the research project completed within its proposed timeline? *The project was completed within its proposed timeline or within approved extensions*
7. Was the project completed within its proposed budget? *The project was completed within its proposed budget or within an approved funding increase.*

Appendix 4.11: Phase I Performance Evaluation, Response 11.

Project Title: Investigation of Approach Slab and its Settlement for Roads and Bridges OR CALLED A Literature Review of Approach Slab and Its Settlement for Roads and Bridges in Wyoming

1. Were all of the proposed objectives of the research project fulfilled? *All objectives were fulfilled*
2. Expected future level of implementation within WYDOT. *Full implementation*
3. Internal technology transfer. *Skipped*
4. External technology transfer. *Some national, regional, or local presentations, publications, etc.*

5. Was a research project created? *A professional and concise research report was created, meeting WYDOT's expectations*
6. Was the research project completed within its proposed timeline? *The project was completed within its proposed timeline or within approved extensions*
7. Was the project completed within its proposed budget? *The project was completed within its proposed budget or within an approved funding increase.*

Appendix 4.12: Phase I Performance Evaluation, Response 12.

Project Title: Developing Mitigation Strategies to Reduce Truck Crash Rates in Wyoming Highways

1. Were all of the proposed objectives of the research project fulfilled? *All objectives were fulfilled*
2. Expected future level of implementation within WYDOT. *Partial implementation*
3. Internal technology transfer. *Research findings were presented to relevant departments within WYDOT*
4. External technology transfer. *Some national, regional, or local presentations, publications, etc.*
5. Was a research project created? *A professional and concise research report was created, meeting WYDOT's expectations*
6. Was the research project completed within its proposed timeline? *The project was completed within its proposed timeline or within approved extensions*
7. Was the project completed within its proposed budget? *The project was completed within its proposed budget or within an approved funding increase.*

Appendix 4.13: Phase I Performance Evaluation, Response 13.

Project Title: Comprehensive Technology Assessment for Avalanche Hazard Management

1. Were all of the proposed objectives of the research project fulfilled? *All objectives were fulfilled*
2. Expected future level of implementation within WYDOT. *Partial implementation*
3. Internal technology transfer. *Research findings were presented to relevant departments within WYDOT*
4. External technology transfer. *Some national, regional, or local presentations, publications, etc.*
5. Was a research project created? *A professional and concise research report was created, meeting WYDOT's expectations*
6. Was the research project completed within its proposed timeline? *The project was completed within its proposed timeline or within approved extensions*

7. Was the project completed within its proposed budget? *The project was completed within its proposed budget or within an approved funding increase.*

Appendix 4.14: Phase I Performance Evaluation, Response 14.

Project Title: Wyoming Low Volume Roads Traffic Volume Estimation

1. Were all of the proposed objectives of the research project fulfilled? *All objectives were fulfilled*
2. Expected future level of implementation within WYDOT. *Full implementation*
3. Internal technology transfer. *Research findings were presented to relevant departments within WYDOT*
4. External technology transfer. *Some national, regional, or local presentations, publications, etc.*
5. Was a research project created? *A professional and concise research report was created, meeting WYDOT's expectations*
6. Was the research project completed within its proposed timeline? *The project was completed within its proposed timeline or within approved extensions*
7. Was the project completed within its proposed budget? *The project was completed within its proposed budget or within an approved funding increase.*

Appendix 4.15: Phase I Performance Evaluation, Response 15.

Project Title: Multi-Measure Performance Assessment and Benchmarking of the Divisions of the Wyoming Highway Patrol

1. Were all of the proposed objectives of the research project fulfilled? *Some objectives were fulfilled*
2. Expected future level of implementation within WYDOT. *No implementation*
3. Internal technology transfer. *No internal technology transfer*
4. External technology transfer. *Some national, regional, or local presentations, publications, etc.*
5. Was a research project created? *A professional and concise research report was created, meeting WYDOT's expectations*
6. Was the research project completed within its proposed timeline? *The project was not completed*
7. Was the project completed within its proposed budget? *The project was completed within its proposed budget or within an approved funding increase.*

Appendix 4.16: Phase I Performance Evaluation, Response 16.

Project Title: INDIAN RESERVATION SAFETY IMPROVEMENT PROGRAM: A METHODOLOGY AND CASE STUDY or Developing a Roadway Safety Improvement Program for Indian Reservations-

1. Were all of the proposed objectives of the research project fulfilled? *All objectives were fulfilled*
2. Expected future level of implementation within WYDOT. *Full implementation*
3. Internal technology transfer. *Research findings were presented to relevant departments within WYDOT*
4. External technology transfer. *Some national, regional, or local presentations, publications, etc.*
5. Was a research project created? *A professional and concise research report was created, meeting WYDOT's expectations*
6. Was the research project completed within its proposed timeline? *The project was completed within its proposed timeline or within approved extensions*
7. Was the project completed within its proposed budget? *The project was completed within its proposed budget or within an approved funding increase.*

Appendix 4.17: Phase I Performance Evaluation, Response 17.

Project Title: Criteria for WYDOT Culvert Selection Policy

1. Were all of the proposed objectives of the research project fulfilled? *All objectives were fulfilled*
2. Expected future level of implementation within WYDOT. *Full implementation*
3. Internal technology transfer. *Research findings were presented to relevant departments within WYDOT*
4. External technology transfer. *No external technology transfer*
5. Was a research project created? *A professional and concise research report was created, meeting WYDOT's expectations*
6. Was the research project completed within its proposed timeline? *The project was completed within its proposed timeline or within approved extensions*
7. Was the project completed within its proposed budget? *The project was completed within its proposed budget or within an approved funding increase.*

Appendix 4.18: Phase I Performance Evaluation, Response 18.

Project Title: Pronghorn and Mule Deer Use of Underpasses along US Highway 191

8. Were all of the proposed objectives of the research project fulfilled? *All objectives were fulfilled*
9. Expected future level of implementation within WYDOT. *Full implementation*
10. Internal technology transfer. *Research findings were presented to relevant departments within WYDOT*
11. External technology transfer. *Some national, regional, or local presentations, publications, etc.*
12. Was a research project created? *A professional and concise research report was created, meeting WYDOT's expectations*
13. Was the research project completed within its proposed timeline? *The project was completed within its proposed timeline or within approved extensions*
14. Was the project completed within its proposed budget? *The project was completed within its proposed budget or within an approved funding increase.*

APPENDIX 5. PHASE II PERFORMANCE EVALUATION

Appendix 5.1: Phase II Performance Evaluation, Response 1.

Project Title: Managing Risks in the Project Pipeline - Minimizing the Impacts of Highway Funding Uncertainties

1. Have the results of this research project contributed to WYDOT's mission? *Yes, it has allowed WYDOT to optimize its resources more efficiently and allowed WYDOT to impact performance better.*
2. Have the results of this research project been implemented within WYDOT? *Full, WYDOT has incorporated the results into its business practice. Large more complex projects for the most part are kept in the project schedule in order not to incur greater costs. The risk assessment of moving smaller lower impact projects has been considered and these are moved if needed.*
3. What is the cost/benefit associated with this project? *Benefits associated with results of project exceeds cost of project.*
4. Please fill in costs and benefits if possible.

<i>Total Project Costs:</i>	<i>Approximately \$150,000</i>
<i>Estimated dollar savings or benefits associated with implementation of the project:</i>	
<i>Benefit-to-Cost Ratio</i>	<i>Benefits estimated now at 6:1</i>

5. Have the results of the project had any impacts on national, regional, or local organizations or agencies? *Yes, In a roundabout way it has contributed to the management of assets and also allowed our designers to focus resources better.*
6. Has additional research been pursued or conducted as a result of this project within WYDOT. *No*

Appendix 5.2: Phase II Performance Evaluation, Response 2.

Project Title: Evaluation of the Wyoming Research Center and Research Center (Phase II)

1. Have the results of this research project contributed to WYDOT's mission? *Yes, I believe it has allowed the Research Center to better focus its energies on more productive mission based research.*
2. Have the results of this research project been implemented within WYDOT? *Partial*
3. What is the cost/benefit associated with this project? *Benefits of project cannot be identified*
4. Please fill in costs and benefits if possible.

<i>Total Project Costs:</i>	
<i>Estimated dollar savings or benefits associated with implementation of the project:</i>	
<i>Benefit-to-Cost Ratio</i>	

5. Have the results of the project had any impacts on national, regional, or local organizations or agencies? *Yes, Because of the improvements suggested and implemented, it has been shared on a regional and national level. Results sharing has helped other agencies to tweak their programs and has allowed WYDOT to learn more from others to improve our program even more.*
6. Has additional research been pursued or conducted as a result of this project within WYDOT. *Yes, a phase 3 project is in progress.*

Appendix 5.3: Phase II Performance Evaluation, Response 3.

Project Title: Investigation of Silica Fume Concrete Bridge Overlay Failures

1. Have the results of this research project contributed to WYDOT's mission? *Yes, The silica fume modified concrete overlay specifications have been modified based on the research*
2. Have the results of this research project been implemented within WYDOT? *Full, As stated our specifications have been changed and we plan to monitor performance based on these changes*
3. What is the cost/benefit associated with this project? *Benefits of project cannot be identified*
4. Please fill in costs and benefits if possible.

<i>Total Project Costs:</i>	
<i>Estimated dollar savings or benefits associated with implementation of the project:</i>	<i>The anticipated benefit is to decrease the amount of debonding of the overlays and thereby extend the life of the overlay</i>
<i>Benefit-to-Cost Ratio</i>	

5. Have the results of the project had any impacts on national, regional, or local organizations or agencies? *No*
6. Has additional research been pursued or conducted as a result of this project within WYDOT. *No*

Appendix 5.4: Phase II Performance Evaluation, Response 4.

Project Title: Evaluation of a Mitigation Site: Amphibian Population

1. Have the results of this research project contributed to WYDOT's mission? *Yes, one of the goals to fulfill mission: exercise good stewardship of our resources - this research project assisted in evaluating effective wetland creation; first time we studied effects on amphibians and reptiles.*
2. Have the results of this research project been implemented within WYDOT? *No, We have not had the opportunity yet*
3. What is the cost/benefit associated with this project? *Benefits associated with results of project exceeds cost of project*
4. Please fill in costs and benefits if possible.

<i>Total Project Costs:</i>	
<i>Estimated dollar savings or benefits associated with implementation of the project:</i>	
<i>Benefit-to-Cost Ratio</i>	

5. Have the results of the project had any impacts on national, regional, or local organizations or agencies? *Yes, research on the apex herp community has been promulgated to ngo's and federal agencies. the bridger-teton national forest has recognized this site as an important area to protect and study the long term effects*
6. Has additional research been pursued or conducted as a result of this project within WYDOT. *Yes, i believe the geologic survey is continuing research at this site.*

Appendix 5.5: Phase II Performance Evaluation, Response 5.

Project Title: Instrumentation and Analysis of Frost Heave Mitigation on WY 70, Encampment, WY

1. Have the results of this research project contributed to WYDOT's mission? *Yes, This research project give WYDOT another option in dealing with proplem frost heaves on roadways.*
2. Have the results of this research project been implemented within WYDOT? *No, I do not know of any other area WYDOT has used the methods in this research project.*
3. What is the cost/benefit associated with this project? *Benefits of project cannot be identified*
4. Please fill in costs and benefits if possible.

<i>Total Project Costs:</i>	<i>Unknown by me</i>
<i>Estimated dollar savings or benefits associated with implementation of the project:</i>	<i>Unknown by me</i>
<i>Benefit-to-Cost Ratio</i>	

5. Have the results of the project had any impacts on national, regional, or local organizations or agencies? *No, I do not know of any impacts*
6. Has additional research been pursued or conducted as a result of this project within WYDOT. *No.*

Appendix 5.6: Phase II Performance Evaluation, Response 6.

Project Title: Instrumentation and Analysis of Frost Heave Mitigation on WY 70, Encampment, WY

1. Have the results of this research project contributed to WYDOT's mission? *Yes, The way that approach backfill is constructed has been improved.*
2. Have the results of this research project been implemented within WYDOT? *Partial, To my knowledge, changing the backfill gradation for approach was one of the main recommendations of this research. This change in gradation has been implemented and the limited feedback that I have received from the construction inspectors is that the material with the new gradation compacts well.*
3. What is the cost/benefit associated with this project? *Benefits of project cannot be identified*
4. Please fill in costs and benefits if possible.

<i>Total Project Costs:</i>	
<i>Estimated dollar savings or benefits associated with implementation of the project:</i>	
<i>Benefit-to-Cost Ratio</i>	

5. Have the results of the project had any impacts on national, regional, or local organizations or agencies? *No, I am not aware of other organizations that have implemented any of the recommendations of this research to date.*
6. Has additional research been pursued or conducted as a result of this project within WYDOT. *I do not know if any further research has been pursued or approved.*

Appendix 5.7: Phase II Performance Evaluation, Response 7.

Project Title: Evaluating the Risk of Alkali Silica Reaction in Wyoming

1. Have the results of this research project contributed to WYDOT's mission? *Yes, WYDOT is continually trying to find or develop better methods for evaluating aggregates for alkali silica reaction. The ideal test has not been developed and research is ongoing.*
2. Have the results of this research project been implemented within WYDOT? *Partial, The long term alkali silica reaction test results for specific aggregate sources is utilized, however our specs at this time is still based on ASTM C1260.*
3. What is the cost/benefit associated with this project? *Benefits of project cannot be identified*
4. Please fill in costs and benefits if possible.

<i>Total Project Costs:</i>	
<i>Estimated dollar savings or benefits associated with implementation of the project:</i>	<i>The more we know about alkali silica reaction the better, however further research is needed in order to have significant changes to our specifications.</i>
<i>Benefit-to-Cost Ratio</i>	

5. Have the results of the project had any impacts on national, regional, or local organizations or agencies? *No.*
6. Has additional research been pursued or conducted as a result of this project within WYDOT. *Yes, RS03217 Development of an Ultra Accelerated test to Evaluate ASR Potential in Concrete.*

Appendix 5.8: Phase II Performance Evaluation, Response 8.

Project Title: Evaluating the Risk of Alkali Silica Reaction in Wyoming

1. Have the results of this research project contributed to WYDOT's mission? *Yes, It has helped us evaluate the different geometric options for base widening of roadways.*
2. Have the results of this research project been implemented within WYDOT? *Partial, On at least one project, we have specified a tapered widening versus a vertical cut based on the research.*
3. What is the cost/benefit associated with this project? *Benefits of project cannot be identified*
4. Please fill in costs and benefits if possible.

<i>Total Project Costs:</i>	
-----------------------------	--

<i>Estimated dollar savings or benefits associated with implementation of the project:</i>	<i>Having a better understanding of the potential long term performance of the different base widening options is beneficial</i>
<i>Benefit-to-Cost Ratio</i>	

5. Have the results of the project had any impacts on national, regional, or local organizations or agencies? *No.*
6. Has additional research been pursued or conducted as a result of this project within WYDOT. *No.*

Appendix 5.9: Phase II Performance Evaluation, Response 9.

Project Title: Evaluating the Risk of Alkali Silica Reaction in Wyoming

1. Have the results of this research project contributed to WYDOT's mission? *Yes, Improving safety by reducing pavement settlements over culverts. Increasing efficiency by allowing more competition of pipe products.*
2. Have the results of this research project been implemented within WYDOT? *Partial, We have constructed a few pilot projects with new specifications developed out this research. We are preparing to incorporate these new specifications on all future projects.*
3. What is the cost/benefit associated with this project? *Benefits associated with results of project exceeds cost of project*
4. Please fill in costs and benefits if possible.

<i>Total Project Costs:</i>	
<i>Estimated dollar savings or benefits associated with implementation of the project:</i>	
<i>Benefit-to-Cost Ratio</i>	

5. Have the results of the project had any impacts on national, regional, or local organizations or agencies? *Yes, The project was recognized as a model for other Safety planning efforts on other Reservations throughout the US.*
6. Has additional research been pursued or conducted as a result of this project within WYDOT. *No.*

Appendix 5.10: Phase II Performance Evaluation, Response 10.

Project Title: Evaluating the Risk of Alkali Silica Reaction in Wyoming

1. Have the results of this research project contributed to WYDOT's mission? *Yes, Improving safety by reducing pavement settlements over culverts. Increasing efficiency by allowing more competition of pipe products.*
2. Have the results of this research project been implemented within WYDOT? *Partial, We have constructed a few pilot projects with new specifications developed out this research. We are preparing to incorporate these new specifications on all future projects.*
3. What is the cost/benefit associated with this project? *Benefits associated with results of project exceeds cost of project.*
4. Please fill in costs and benefits if possible.

<i>Total Project Costs:</i>	
<i>Estimated dollar savings or benefits associated with implementation of the project:</i>	
<i>Benefit-to-Cost Ratio</i>	

5. Have the results of the project had any impacts on national, regional, or local organizations or agencies? *No, however, at least one other state is reviewing our new specifications for possible inclusion into their specifications.*
6. Has additional research been pursued or conducted as a result of this project within WYDOT. *No.*

APPENDIX 6. TEMPLATES TO ESTIMATE BCR

**Template to Calculate Benefits-to-Cost Ratio (BCR) for Strategic Intent
“Infrastructure Upgrade”**

Project Title:	_____
Name:	_____
Organization:	_____
Date:	_____



Costs Input Table	
Research Costs:	_____
<i>Estimated Split Among Types:</i>	
Salaries and Benefits	_____
Direct Costs	_____
Indirect Costs	_____
Other	_____
Implementation Costs:	_____
<i>Estimated Split Among Types:</i>	
Initial Costs	_____
Operation and Maintenance	_____
Technology Transfer	_____
Other	_____
GRAND TOTAL:	_____

Benefits Input Table	
Total Savings:	_____
<i>Estimated Savings Split Among Following:</i>	
Improvement in Level of Service	_____
Travel Time Reduction	_____
Vehicle operating Costs	_____
Operational and Maintenance Savings	_____
Other	_____
GRAND TOTAL:	_____

$$\text{Overall Benefits-to-Costs Ratio (BCR)} = \frac{\text{Total Benefits}}{\text{Total Costs}}$$

Appendix 6. 1: Template to Estimate BCR, Strategic Intent “Infrastructure Upgrade”

**Template to Calculate Benefits-to-Cost Ratio (BCR) for Strategic Intent
“Preservation”**

Project Title:	_____
Name:	_____
Organization:	_____
Date:	_____



Costs Input Table	
Research Costs:	_____
<i>Estimated Split Among Types:</i>	
Salaries and Benefits	_____
Direct Costs	_____
Indirect Costs	_____
Other	_____

Implementation Costs:	_____
<i>Estimated Split Among Types:</i>	
Initial Costs	_____
Operation and Maintenance	_____
Technology Transfer	_____
Other	_____

GRAND TOTAL:	_____

Benefits Input Table	
Total Savings:	_____
<i>Estimated Savings Split Among Following:</i>	
Increase in Service Life	_____
Travel Time Reduction	_____
Vehicle operating Costs	_____
Operational and Maintenance Savings	_____
Other	_____

GRAND TOTAL:	_____

$$\text{Overall Benefits-to-Costs Ratio (BCR)} = \frac{\text{Total Benefits}}{\text{Total Costs}}$$

Appendix 6. 2: Template to Estimate BCR, Strategic Intent “Preservation”

Template to Calculate Benefits-to-Cost Ratio (BCR) for Strategic Intent “Safety”

Project Title:	_____
Name:	_____
Organization:	_____
Date:	_____



Costs Input Table	
Research Costs:	_____
<i>Estimated Split Among Types:</i>	
Salaries and Benefits	_____
Direct Costs	_____
Indirect Costs	_____
Other	_____

Implementation Costs:	_____
<i>Estimated Split Among Types:</i>	
Initial Costs	_____
Operation and Maintenance	_____
Technology Transfer	_____
Other	_____

GRAND TOTAL:	_____

Benefits Input Table	
Total Savings:	_____
<i>Estimated Savings Split Among Following:</i>	
Crash Reduction	_____
Travel Time	_____
Vehicle operating Costs	_____
Employment generation	_____
Other	_____

GRAND TOTAL:	_____

$$\text{Overall Benefits-to-Costs Ratio (BCR)} = \frac{\text{Total Benefits}}{\text{Total Costs}}$$

Appendix 6.3: Template to Estimate BCR, Strategic Intent “Safety”

Template to Calculate Benefits-to-Cost Ratio (BCR) for Strategic Intent “Wildlife Studies”

Project Title:	_____
Name:	_____
Organization:	_____
Date:	_____



Costs Input Table	
Research Costs:	_____
<i>Estimated Split Among Types:</i>	
Salaries and Benefits	_____
Direct Costs	_____
Indirect Costs	_____
Other	_____

Implementation Costs:	_____
<i>Estimated Split Among Types:</i>	
Initial Costs	_____
Operation and Maintenance	_____
Technology Transfer	_____
Other	_____

GRAND TOTAL:	_____

Benefits Input Table	
Total Savings:	_____
<i>Estimated Savings Split Among Following:</i>	
Crash Reduction	_____
Impacts on Wildlife/Culture	_____
Other	_____

GRAND TOTAL:	_____

$$\text{Overall Benefits-to-Costs Ratio (BCR)} = \frac{\text{Total Benefits}}{\text{Total Costs}}$$

Appendix 6. 4: Template to Estimate BCR, Strategic Intent “Wildlife Studies”

Template to Calculate Benefits-to-Cost Ratio (BCR) for Strategic Intent “Shared Knowledge”

Project Title:	_____
Name:	_____
Organization:	_____
Date:	_____



Costs Input Table	
Research Costs:	_____
<i>Estimated Split Among Types:</i>	
Salaries and Benefits	_____
Direct Costs	_____
Indirect Costs	_____
Other	_____

Implementation Costs:	_____
<i>Estimated Split Among Types:</i>	
Initial Costs	_____
Operation and Maintenance	_____
Technology Transfer	_____
Other	_____

GRAND TOTAL:	_____

Benefits Input Table	
Total Savings:	_____
<i>Estimated Savings Split Among Following:</i>	
Enhancement of Effectiveness	_____
Other	_____

GRAND TOTAL:	_____

$$\text{Overall Benefits-to-Costs Ratio (BCR)} = \frac{\text{Total Benefits}}{\text{Total Costs}}$$

Appendix 6. 5: Template to Estimate BCR, Strategic Intent “Shared Knowledge”

Template to Calculate Benefits-to-Cost Ratio (BCR) for Strategic Intent “Public Affairs”

Project Title:	_____
Name:	_____
Organization:	_____
Date:	_____



Costs Input Table	
Research Costs:	_____
<i>Estimated Split Among Types:</i>	
Salaries and Benefits	_____
Direct Costs	_____
Indirect Costs	_____
Other	_____
Implementation Costs:	_____
<i>Estimated Split Among Types:</i>	
Initial Costs	_____
Operation and Maintenance	_____
Technology Transfer	_____
Other	_____
GRAND TOTAL:	_____

Benefits Input Table	
Total Savings:	_____
<i>Estimated Savings Split Among Following:</i>	
Benefit of smoother interaction with driving public	_____
Other	_____
GRAND TOTAL:	_____

$$\text{Overall Benefits-to-Costs Ratio (BCR)} = \frac{\text{Total Benefits}}{\text{Total Costs}}$$

Appendix 6. 6: Template to Estimate BCR, Strategic Intent “Public Affairs”