



State of Wyoming
Department of
Transportation



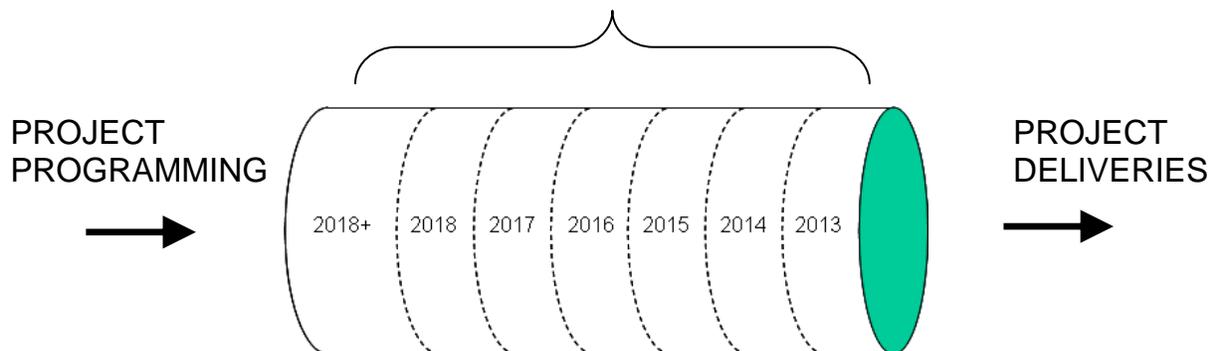
U.S. Department of Transportation
Federal Highway Administration

Final Report

Managing Risks in the Project Pipeline

FHWA 13/06F

Statewide Transportation
Improvement Program (STIP)
"Project Pipeline"



PIPELINE RISKS/UNCERTAINTIES

- *Scope growth and project cost increases*
- *Labor and materials price volatility*
- *Environmental or right-of-way issues*
- *Unplanned political priorities*
- *Construction cost inflation*
- *Uncertain or variable revenue*

BY
Larry Redd, P.E.
Redd Engineering
5302 Golden Willow Drive
Fort Collins, CO 80528

AUGUST 2013

DISCLAIMER

Notice

This document is disseminated under the sponsorship of the U.S. Department of Transportation in the interest of exchange. The U.S. Government assumes no liability for the use of the information contained in this document.

The contents of this report reflect the views of the author(s) who are responsible for the facts and accuracy of the data presented herein. The contents do not necessarily reflect the official views or policies of the Wyoming Department of Transportation (WYDOT) or the Federal Highway Administration (FHWA). This report does not constitute a standard, specification, or regulation.

The United States Government and the State of Wyoming do not endorse products or manufacturers. Trademarks or manufacturers' names appear of this report only because they are considered essential to the objectives of the document.

Quality Assurance Statement

FHWA provides high-quality information to serve Government, industry, and the public in a manner that promotes public understanding. Standards and policies are used to ensure and maximize the quality, objectivity, utility, and integrity of its information. FHWA periodically reviews quality issues and adjusts its programs and processes to ensure continuous quality improvement.

Report No. FHWA-WY-13/06F	Government Accession No.	Recipients Catalog No.	
Title and Subtitle Final Report Managing Risks in the Project Pipeline		Report Date August 2013	Performing Organization Code
Author(s) Larry Redd and Kim Redd		Performing Organization Report No.	
Performing Organization Name and Address Larry Redd, P.E. Redd Engineering 5302 Golden Willow Drive Fort Collins, CO 80528		Work Unit No.	Contact or Grant No.
Sponsoring Agency Name and Address Wyoming Department of Transportation 5300 Bishop Blvd. Cheyenne, WY 82009-3340 WYDOT Research Center (307) 777-4182		Type of Report and Period Covered: Final Report (March 2012 -August 2013) Sponsoring Agency Code	
Supplementary Notes			
<p>Abstract</p> <p>This research focuses on how to manage the risks of project costs and revenue uncertainties over the long-term, and identifies significant process improvements to ensure projects are delivered on time and as intended, thus maximizing the miles paved and minimizing financial risks to the organization. A dynamic simulation model is validated and tested by researching 50 historical projects, collecting data about these projects, and validating the key inputs for the simulation. A variety of parametric studies, including simulating the effects of various revenue scenarios, are performed and conclusive results are reached. Both Core Strategies, focusing on how to load and manage the project pipeline, and System and Organizational Improvement Strategies are identified. By implementing these strategies and minimizing the amount of projects held "on the shelf" and employing practices that minimize the risks of incurring Holding Costs due to revenue shortfalls, savings can be maximized. Applying new strategies and improving processes will allow the department to better manage the risks facing transportation projects in the project pipeline. Estimated cost savings are between 2 and 4 percent of the total budget; this would amount to a total savings of 90 million dollars, for a budget of 3 billion dollars over a ten-year period. The results of the research are enabling WYDOT to maximize the performance benefits from their asset management efforts.</p>			
Key Words WYDOT, Project Pipeline, Financial Risks, Holding Costs, dynamic simulation model, core strategies, process improvement, causal diagramming, revenue uncertainties		Distribution Statement Unlimited	
Security Classif. (of this report) Unclassified	Security Classif. (of this page) Unclassified	No. of Pages 121	Price

SI* (Modern Metric) Conversion Factors

Approximate Conversions from SI Units

Approximate Conversions to SI Units

Symbol	When You Know	Multiply By	To Find	Symbol	Symbol	When You Know	Multiply By	To Find	Symbol
Length					Length				
mm	millimeters	0.039	inches	In	in	inches	25.4	millimeters	mm
m	meters	3.28	feet	Ft	ft	feet	0.305	meters	m
m	meters	1.09	yards	Yd	yd	yards	0.914	meters	m
km	kilometers	0.621	miles	Mi	mi	miles	1.61	kilometers	km
Area					Area				
mm ²	square millimeters	0.0016	square inches	in ²	in ²	square inches	645.2	square millimeters	mm ²
m ²	square meters	10.764	square feet	ft ²	ft ²	square feet	0.093	square meters	m ²
m ²	square meters	1.195	square yards	Yd ²	yd ²	square yards	0.836	square meters	m ²
ha	hectares	2.47	acres	Ac	ac	acres	0.405	hectares	ha
km ²	square kilometers	0.386	squares miles	Mi ²	mi ²	square miles	2.59	square kilometers	km ²
Volume					Volume				
ml	milliliters	0.034	fluid ounces	fl oz	fl oz	fluid ounces	29.57	milliliters	ml
l	liters	0.264	gallons	gal	gal	gallons	3.785	liters	l
m ³	cubic meters	35.71	cubic feet	ft ³	ft ³	cubic feet	0.028	cubic meters	m ³
m ³	cubic meters	1.307	cubic yard	Yd ³	yd ³	cubic yards	0.765	cubic meters	m ³
Mass					Mass				
g	grams	0.035	ounces	Oz	oz	ounces	28.35	grams	g
kg	kilograms	2.202	pounds	Lb	lb	pounds	0.454	kilograms	kg
Mg	megagrams	1.103	short tons (2000 lbs)	T	T	short tons (2000 lbs)	0.907	megagrams	Mg
Temperature (exact)					Temperature (exact)				
°C	Centigrade temperature	1.8C + 32	Fahrenheit temperature	°F	°F	Fahrenheit temperature	5(F-32)/9 or (F-32)/1.8	Celsius temperature	°C
Illumination					Illumination				
lx	lux	0.0929	foot-candles	Fc	fc	foot-candles	10.76	lux	lx
cd/m ²	candela/m ^m	0.2919	foot-Lamberts	Fl	fl	foot-Lamberts	3.426	candela/m ²	cd/m ²
Force and Pressure or Stress					Force and Pressure or Stress				
N	newtons	0.225	pound-force	Lbf	lbf	pound-force	4.45	newtons	N
kPa	kilopascals	0.145	pound-force per square inch	psi	psi	pound-force per square inch	6.89	kilopascals	kPa

Acknowledgements

The author wishes to acknowledge the active support and valuable input from many people, without which this project would not have been possible.

Gregg Fredrick, Assistant Chief Engineer at Wyoming Department of Transportation, is the overall sponsor of this project and provided invaluable support.

The author would also like to acknowledge the following individuals who have made generous contributions to the project:

Martin Kidner, State Planning Engineer
Tim McDowell, State Programming Engineer
Lowell Fleenor, District Engineer, District 2, WYDOT
Pat Persson, District Engineer, District 1, WYDOT
Shelby Carlson, District Engineer, District 5, WYDOT
Tony Laird, Program Manager, Project Development
Ken Spear, Program Manager, Contracts and Estimates
Rick Harvey, State Materials Engineer
Joe McCarthy, Safety Analysis Consultant to WYDOT
Christy Stone, STIP Specialist
Christine Grant, ERP Specialist
Heather Robinson, Project Control System (PCS) Administrator

Table of Contents

EXECUTIVE SUMMARY	1
WHAT THIS RESEARCH SHOWS.....	1
SIMULATION MODEL.....	2
WHY THESE FINDINGS ARE IMPORTANT.....	2
HOW TO PROCEED FROM HERE.....	3
Core Strategies.....	3
System and Organizational Improvement Strategies	4
Recommended Further Research	5
IN SUMMARY	5
CHAPTER 1 OVERVIEW OF THE PROJECT PIPELINE: CONCEPT, GOALS, APPROACH, AND SIMULATION MODEL DEVELOPMENT.....	7
1.1 INTRODUCTION.....	7
1.2 BACKGROUND.....	7
1.3 STUDY APPROACH.....	9
1.4 SIMULATION MODEL.....	11
1.4.1 Results of Simulation Runs.....	11
1.5 LAYING THE FOUNDATION	12
1.5.1 Early Analysis Results in Developing the Model.....	12
1.5.2 Sensitivity of Long-term Paving Deliveries to Project Pipeline Cost Factors.....	13
1.5.3 Bumpy Versus Flat or Smooth Funding Profiles.....	16
1.6 SYNOPSIS	16
CHAPTER 2 TOOL CONFIGURATION: VALIDATING AND MODIFYING THE SIMULATION TOOL FOR WYDOT.....	17
2.1 INTERVIEWS.....	17
2.2 DATA GATHERED FOR MODEL CONFIGURATION	17
2.2.1 Holding Costs.....	18
2.2.2 Hurry-Up Costs	18
2.3 IDEAS AND SUGGESTIONS FOR MANAGING RISKS AND LOWERING COSTS	18
2.3.1 Critical Project Method Concepts	18
2.3.2 Pipeline Loading.....	19
2.3.3 Reducing Design Time and Design Cost = Increased Responsiveness to Changing Revenue Balance.....	19
2.3.4 Project Control System (PCS) Opportunities.....	19
2.3.5 Revenue Smoothing.....	20
2.3.6 Organization Responses which may be Counterproductive.....	20
2.3.7 TAM (Transportation Asset Management)/Planning Process Trends/Issues	20
2.3.8 Other Systemic Issues, Ideas, Suggestions, and Questions from the Interviews ..	23
2.4 MAJOR SIMULATION TOOL MODIFICATIONS.....	24
2.4.1 Major Candidate Strategies for Using Funding Projections and Loading the Pipeline	24
2.4.2 Project Pipeline Draining Strategies.....	26
2.5 SIMULATION RUNS COMPARING ALTERNATE STRATEGIES.....	28
2.5.1 Funding Scenarios	28

2.6 ANALYSES AND RESULTS OF FUNDING SCENARIOS AND PIPELINE LOADING/DRAINING STRATEGIES	31
2.6.1 Results of HighLow and LowHigh Funding Scenario Analyses	31
2.6.2 Results of WYDOT Funding Scenario Analysis	32
2.7 CONCLUSIONS – FROM THESE PRELIMINARY RESULTS.....	32
CHAPTER 3 HISTORICAL PROJECT RESEARCH	35
3.1 PROJECT TABLES	35
3.2 INFORMATION GATHERED ON HISTORICAL PROJECTS.....	38
CHAPTER 4 HISTORICAL PROJECT ANALYSIS RESULTS	41
4.1 STIP DATA NEEDS LIST	41
4.2 RESEARCH PERFORMED ON EACH PROJECT.....	41
4.3 NARRATIVES REFERENCE (IN APPENDICES A AND B).....	42
4.4 ANALYSIS TOOL FOR TRACKING PROJECT ESTIMATES, INFLATION, AND FINAL PROJECT COSTS.....	42
4.5 HOW TO VIEW INFLATION	44
4.6 ANALYSIS OF PROJECT COST ESTIMATES	46
4.7 OUTCOMES FOR DELAYED PROJECTS.....	48
4.7.1 Net Escalation	48
4.7.2 Splits.....	50
4.7.3 Redesign Costs	52
4.8 SUMMARY CHARTS.....	52
CHAPTER 5 CANDIDATE STRATEGIES: DEVELOPMENT OF STRATEGIES AND QUANTIFYING THEIR BENEFITS	57
5.1 CAUSAL DIAGRAM	57
5.2 CANDIDATE STRATEGY IDENTIFICATION	58
5.3 SENSITIVITY STUDIES OF THE CANDIDATE STRATEGIES	60
5.4 OBSERVATIONS	62
CHAPTER 6 STUDY CONCLUSIONS AND RECOMMENDATIONS	63
6.1 COHERENT STRATEGY APPROACHES	63
6.2 ADDITIONAL SUB-STRATEGIES	66
6.3 CONCLUSIONS.....	67
6.4 KEY OPPORTUNITIES – PROCESS IMPROVEMENTS AND RECOMMENDED RESEARCH.....	67
6.4.1 Process Improvements:	67
6.4.2 Research:	67
6.5 CONTINUING RESEARCH AND DEVELOPMENT OF THE SIMULATION MODEL.....	68
CHAPTER 7 STRATEGY IMPLEMENTATION — MODEL, MEASURE, MANAGE ..	69
7.1 MODEL, MEASURE, MANAGE AND CONTINUOUS IMPROVEMENT	69
7.2 REVIEW OF RECOMMENDED STRATEGIES	69
7.2.1 Core Strategies.....	70
Model	70
The Case for Measures.....	71
Manage	76
7.2.2 System and Organizational Improvement Strategies	76
Model	76

Measure and Manage	81
7.3 CONTINUOUS IMPROVEMENT RESEARCH: VERIFYING ASSUMPTIONS ...	81
7.4 PRACTICES ALREADY PUT INTO PLACE--MONITOR, MEASURE, MANAGE ON-GOING PERFORMANCE	81
7.5 SUMMARY	82
APPENDIX A PROJECT NARRATIVES – LARGE PROJECTS (10 MILLION DOLLARS OR MORE)	83
APPENDIX B PROJECT NARRATIVES – MEDIUM PROJECTS (5 TO 10 MILLION DOLLARS)	99
REFERENCES	111

Table of Figures

Figure 1. Graph. Over-Programming and Under-Programming of Projects	1
Figure 2. Illustration. Overall Context of the Project Pipeline Problem.....	8
Figure 3. Graph. Tradeoff between “Hurry-Up Costs” and “Holding Costs”	10
Figure 4. Illustration. Simulation Model Illustration	11
Figure 5. Illustration. Simulation Run – Typical Results	12
Figure 6. Illustration. Two Representative Revenue Profiles, “LowHigh” and “HighLow” Scenarios.....	14
Figure 7. Illustration. Project Pipeline Costs Corresponding to Accelerated and Delayed Projects	14
Figure 8. Graph. Comparison of Amounts Paved for Three Revenue Scenarios	15
Figure 9. Illustration. Simulation Model Basic Structure	24
Figure 10. Illustration. LowHigh and HighLow Funding Scenarios	29
Figure 11. Graph. WYDOT Funding Profile	29
Figure 12. Illustration. Comparison of Projects On-the-Shelves.....	30
Figure 13. Graph. Project Cost Estimate History Model	44
Figure 14. Graph. Addition of Roundabouts to the Original Project Scope	45
Figure 15. Graph. Scope Changes throughout the Development of a Project	46
Figure 16. Graph. Accuracy of Project Cost Estimates for Medium Size Projects	47
Figure 17. Graph. Project Cost Estimate Accuracy Using Scope Statements Only	48
Figure 18. Graph. Escalation Rate (Percent Over Inflation) for Medium Size Projects.....	49
Figure 19. Graph. Escalation Rate (Percent Over Inflation) for Large Size Projects	50
Figure 20. Graph. Illustration of the “Split Penalty” for Delayed Projects	51
Figure 21. Graph. Split Penalty Versus Overall Project Size (in Millions of Dollars).....	52
Figure 22. Chart. Breakout of Delayed Medium Size (5 to 10 Million Dollars) Projects	53
Figure 23. Chart. Breakout of Delayed Large Size (10 Million Dollars or More) Projects	53
Figure 24. Illustration. Causal Diagram of Project Delivery Dynamics.....	57
Figure 25. Graph. Over-Programming and Under-Programming of Projects	63
Figure 26. Graph. Components of Holding Costs and Hurry-Up Costs	64
Figure 27. Graph. Strategies that Reduce Holding Costs and Hurry-Up Costs.....	65
Figure 28. Illustration. Causal Diagram of Project Delivery Dynamics.....	72
Figure 29. Graph. Project Cost Estimate Tracking Tool	74
Figure 30. Illustration. Examples of Lagging Indicators	75

List of Tables

Table 1. Chart. Results for the HighLow and LowHigh Funding Scenarios..... 31

Table 2. Chart. Results for the WYDOT Funding Scenario 32

Table 3. Chart. Medium Projects (5 to 10 Million Dollars)..... 36

Table 4. Chart. Large Projects (10 Million Dollars or More)..... 37

Table 5. Chart. Construction Cost Inflation Index..... 43

Table 6. Chart. Summary Table of Results 54

Table 7. Chart. Strategy Development Tool 59

Table 8. Chart. Sensitivity Study Results 61

Table 9. Chart. Sensitivity Study Results 66

Table 10. Chart. Strategy Development Tool 70

Table 11. Chart. Percentage of Large Projects (10 Million Dollars or More) Delayed 8 years or More* 75

Table 12. Chart. Percentage of Medium Projects (5 to 10 Million Dollars) Delayed 8 years or More* 76

Table 13. Chart. System and Organizational Trends/Issues, Potential Problems, 77

MANAGING RISKS IN THE PROJECT PIPELINE

EXECUTIVE SUMMARY

WHAT THIS RESEARCH SHOWS

Research on how highway projects are loaded into the “project pipeline” and delivered has shown that mismatches between available funding and the number of projects that are “ready to go” can result in significant financial costs to a Department Of Transportation. These costs have been defined as “Holding Costs” if there are too many projects on hand and “Hurry-Up Costs” if there are too few projects ready to go. The goal of the research was to identify significant process improvements to ensure projects are delivered on time and as intended, thus maximizing the miles paved and minimizing financial risks to the organization.

As shown in figure 1, there are costs in programming either too many projects or too few projects. Having too many projects ready to go is referred to as being “over-programmed.” This means there is not enough money to fund projects that are ready to be delivered and there are significant holding costs when projects sit on the shelf. When there are not enough projects ready to go, this is called being “under-programmed.” This means there is an excess of available funds relative to the projects that are ready to go. Similar to being over-programmed, there are costs to being under-programmed; accelerating project design in order to “use or lose” funding that is available is just one of the hurry-up costs. Between Holding Costs and Hurry-Up Costs, the bottom line is that this money could have been utilized on actual “on the ground” projects and if these costs are minimized, more projects can be delivered.

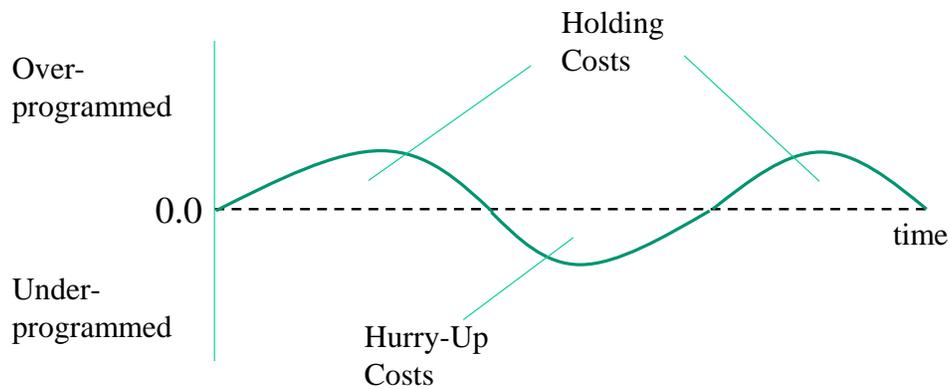


Figure 1. Graph. Over-Programming and Under-Programming of Projects

When there are revenue shortfalls year after year, the research has shown that the organization can see significant cost impacts due to project delays. Holding or delaying projects and not being able to deliver them as originally intended often results in project splits, cost escalation during delays, project redesign, and down-scoping of projects (resulting in lower performance than originally anticipated). Likewise, when there is an unexpected influx of money, perhaps due to stimulus funds or extra highway funds, there are costs of accelerating projects if there aren't enough projects ready to go.

Overall, a balance between Holding Costs and Hurry-Up Costs or inefficiencies must be maintained in order to deliver the maximum amount of projects over time. In order to explore

MANAGING RISKS IN THE PROJECT PIPELINE

the various aspects of this problem, a simulation tool was developed to perform scenario analyses to help balance the project pipeline.

SIMULATION MODEL

The choice of using dynamic simulation was based on the complexity of the problem and the objectives of the analysis. A spreadsheet approach was not adequate for the type of analysis required. The basic structure of the model is to use a “conveyor belt” to simulate projects moving through time, after they are programmed; one conveyor belt for each type of project. In this study, the two types of projects analyzed were minor and major pavement rehabilitation projects, however, the model is expandable to other types of transportation projects as well as construction projects in other industries.

In the simulation, the projects move through design, development, and then are held “on-the-shelf” until they are delivered, assuming funding is available and depending upon the logic for pulling them from the “shelf” for delivery. The model then tracks the dollar amount of projects that are delivered, given the actual funding available and considering the money wasted on project delays and the inefficiencies of accelerating projects. The simulation is built on a PowerSim platform, which runs on a standard PC.

The simulation tool was validated by researching 50 historical projects, collecting data about these projects, and developing and validating the key inputs for the simulation. As a result, a variety of parametric studies, including simulating the effects of various revenue scenarios, have been performed and conclusive results have been reached.

WHY THESE FINDINGS ARE IMPORTANT

The results of the study show that implementing new strategies and improving processes can have a significant effect on paving outcomes. For example, it is estimated that the total benefits of applying new strategies and improving processes could result in an increase in actual paving by between 2 and 4 percent. Thus, for the same amount of available revenue, a significant increase in paving could be expected.

This project pipeline study allowed the researchers to find ways to manage the risks in the delivery of transportation projects. One outcome was the realization of how future uncertainties in costs and revenue are impacting project delivery performance. With this understanding, we were able to determine methods for shifting these impacts to other components of the project pipeline that are better able to absorb those impacts. For example, the annual variability in revenue for highway projects is costly when major rehabilitation projects are affected. Alternatively, minor rehabilitation projects, which are cheaper to develop and modify, are affected in less costly ways when there are fluctuations in available revenue.

Summary of what we have seen:

- Several parameters, which can be controlled or improved to some extent, may increase paving accomplishments significantly, with initial estimates of between 2 and 4 percent.
- The “Critical Project” focus in project pipeline management, which shelters major projects from pipeline uncertainties, is an important core strategy to consider adopting.

MANAGING RISKS IN THE PROJECT PIPELINE

- Utilization of funding projections in the logic for “loading the pipeline” can significantly improve the overall balance of projects through time and maximize deliveries.
- Reducing Hurry-Up costs and inefficiencies for minor rehabilitation projects can save money and increase annual paving accomplishments significantly.
- Smooth funding is strongly preferred over “Bumpy” funding. In a perfect world, where revenue is constant from year to year, there would be few losses related to delivering projects, since there should not be revenue mismatches with projects that are ready to be delivered.
- Amount of savings are revenue profile dependent and therefore process improvement strategies should consider a wide range of potential revenue scenarios.
- This analysis could not have been accomplished with a spreadsheet approach. Using the dynamic simulation tool was critical for this study.

This Project Pipeline study has provided data and rationale to develop realistic and powerful strategies for process improvements. In addition, it has enabled the organization to identify and challenge current practices that may be counterproductive, such as policies that encourage putting projects on the shelf or incentives in the system to increase project scope or beef up projects that are already in the pipeline. Furthermore, during the research several organizational patterns were identified that can have negative effects on project delivery, such as chronically low project cost estimates and outdated inflation estimates. Both of these factors can cause delays in project delivery due to unanticipated cost escalation. By changing or altering these practices, the organization can realize significant cost savings. It is estimated that the cost savings from implementing the strategies recommended by this research could be on the order of 90 million dollars for a total highway project budget of 3 billion dollars, or about 3 percent.

HOW TO PROCEED FROM HERE

Review of Recommended Strategies

There are two major categories of strategies to be implemented: the Core Strategies and the System and Organizational Improvement Strategies. In order to reap the benefits of these strategies, the implementation of the new strategies should be managed properly. The approach suggested for this effort is the Model, Measure, Manage process which is a very useful management practice that guides an organization through process changes and towards continuous improvement. In this process, the “model” provides the framework for analyzing the situation and the “measures” allow the analyst to monitor what the various indicators are showing. According to what is learned, process improvement strategies can be adjusted or modified over time, thus effectively “managing” the implementation.

Core Strategies

One of the key strategy recommendations is to manage major rehabilitation (3R4R) projects using the Critical Project Method. This would involve a shift from current business practices, known in this study as the “Baseline Case.” In the Baseline Case, an optimized mix of projects is targeted annually and projects are kept on the shelf and ready to go. The goal of the Critical Project Method is for 3R4R projects to never sit on the shelf; this approach assures that the 3R4R projects, which are usually higher cost and have a longer lead time, are delivered as

MANAGING RISKS IN THE PROJECT PIPELINE

originally intended and on time. Thus, this strategy minimizes the amount of 3R4R projects that are on the shelf by pulling 3R4R projects out of the project pipeline for delivery on time. Letting “critical projects” (3R4Rs) to contract when they are ready to go, and not holding them for any reason, allows the 1R2R (minor rehabilitation) projects to absorb the variability and uncertainty in available revenue.¹

The recommended new Core Strategies are as follows:

- Utilize the Critical Project Method as the core strategy for defining the overall operation policies for the Project Pipeline.
- Maintain a list of minor rehabilitation projects (1R2R) that are “ready to go”.
- Reduce design and development cycle time, especially for 1R2R projects:
 - Reduces the costs of accelerating 1R2R projects (Hurry-Up Costs).
 - Would provide large benefits in supporting the Critical Project Method.
- Use projected revenue in loading the project pipeline:
 - Strive to make accurate revenue projections from one to two years out.
 - Load the pipeline accordingly, reducing the time delays in the project pipeline.
 - Make accurate projections of inflation and update these projections regularly.
- Ensure project cost estimates are sound and are monitored and updated, especially within the three to four year window prior to the intended year of delivery.

By combining these strategies as part of the Critical Project approach, the total estimated losses can be reduced by approximately 2 to 4 percent of the total budget.

System and Organizational Improvement Strategies

The other recommended strategies to be implemented are in the category of System and Organizational Improvement Strategies. These strategies help support the Core Strategies and can be implemented at the same time. They also can be managed using the Model, Measure, Manage process.

There are several areas that were identified for potential system and organizational improvement. Trends and issues were documented as research on historical projects was done and as interviews were conducted within the organization. The recommended improvement strategies fall into five categories: Organizational, Transportation Asset Management, Funding, Economic, and Project Management Software.

Once management selects and prioritizes what processes they want to change or improve, decisions can be made about what measures to put in place to track outcomes. By monitoring system changes and outcomes, managers can determine what additional modifications are needed to strategies or processes to maximize positive outcomes.

¹ WYDOT uses the term 1R2R to define projects that are usually under 10 million dollars and involve minor pavement rehabilitation including chip sealing, crack sealing, and thin overlays and uses the term 3R4R to define projects that are usually over 10 million dollars and involve major pavement rehabilitations including removal and replacement of the current surface and reconstruction of the roadway.

MANAGING RISKS IN THE PROJECT PIPELINE

Recommended Further Research

There are several areas of further work and research that were out of the scope of this study but could provide additional cost savings and strategy improvement. Recommended further research includes:

- Determine whether project cost estimates and revenue projections are getting better:
 - Examine what's been done to date; model, measure, and manage progress.
- Analyze cost estimating/updating processes, and revenue and inflation projection methods.
- Determine if the lowest risk and highest payoff approach is one-year revenue projections and a one-year design time for 1R2Rs.
- Examine the components of project cost escalation (bad cost estimates, scope creep that is useful, scope creep that is not useful, inaccurate inflation predictions or revenue projections, no updates of inflation or cost estimates, etc.) and determine improvement strategies.
- Research project splits – examine economy of scale inefficiencies, cost escalation components, consider corridor plans and impacts, study optimum project length/cost (analyze tradeoffs between spreading fixed costs versus incurring the risks of being split), and explore historical projects for “post-split scope growth”.
- Perform Uncertainty Factor analysis and Monte Carlo algorithm development -- analyze price volatility, inflation, political priorities, legal issues, regulatory issues, etc. and the impacts of these uncertainties on project deliveries.
- Study and better quantify the impacts of Hurry-Up projects – study the impacts of accelerating 1R2R projects and the resulting delay risks for 3R4R projects.
- Redesign costs – gather historical information and financial data on redesign costs.

IN SUMMARY

Significant savings in delivering highway projects can be possible by implementing the recommendations from this research. A 3 percent savings is representative based on the findings of the analysis. This would amount to a total savings of 90 million dollars, for example, for a budget of 3 billion dollars over a 10-year period.

By minimizing the amount of projects held “on the shelf” and employing practices that minimize the risks of incurring Holding Costs due to revenue shortfalls, these savings can be maximized. Furthermore, using the Critical Project Method shifts the impact of revenue uncertainties from major rehabilitation projects to minor rehabilitation projects and provides a sound, core strategy for managing the risks in the project pipeline.

After considering both the recommended Core Strategies and the System and Organizational Improvement Strategies, management can decide what processes they want to change or improve. Then, the Model, Measure, Manage approach can be used to guide the organizational change process and help the organization move towards a state of continuous improvement.

Finally, plans can be outlined for additional research which may be needed to support the new strategies and process improvements.

MANAGING RISKS IN THE PROJECT PIPELINE

MANAGING RISKS IN THE PROJECT PIPELINE

CHAPTER 1 OVERVIEW OF THE PROJECT PIPELINE: CONCEPT, GOALS, APPROACH, AND SIMULATION MODEL DEVELOPMENT

1.1 INTRODUCTION

The Project Pipeline study focuses on optimizing the delivery of highway projects at the Wyoming Department of Transportation (WYDOT). Specifically, the research involves identifying and determining how to manage the risks associated with revenue fluctuations and uncertainties in project delivery over the long-term. The goal is to maximize the successful delivery of projects that have been planned six to eight years in advance by delivering projects on time and as intended. The results of this work will provide WYDOT and other transportation agencies with great leverage in achieving performance targets by delivering more projects on time and with the performance benefits anticipated in the initial selection of the projects.

This study considers various funding scenarios, such as high amounts of funding followed by low amounts, flat funding, and low funding followed by high funding. The study considers plausible uncertainties in funding profiles, and examines methods to mitigate the impacts of these uncertainties. For example, due to mismatches between projected and actual funding in the intended years of delivery, some projects may suffer costly delays due to a lack of funding. On the other hand, projects may need to be accelerated in order to spend excess revenue. Analyzing and understanding these potential outcomes has enabled process improvements to be developed.

The results of the process improvements will enable WYDOT to maximize the performance benefits anticipated in their asset management efforts. The department will now be able to better manage the amount and mix of transportation projects in the project pipeline, with estimated overall cost savings of between 2 and 4 percent annually. In summary, this work provides information that transportation agency planners can now use to improve on-time project deliveries and maximize their achievement of performance targets over the long-term.

1.2 BACKGROUND

WYDOT schedules highway projects into a multi-year Statewide Transportation Improvement Program (STIP) using thorough asset management and project selection processes. Some of these processes deal with uncertainty, such as variability in inflation rates or asphalt price volatility. However, even with current processes there are still project pipeline risks that affect the department's ability to deliver projects on time and as intended. As illustrated in figure 1, Figure 1 projects that have been programmed, shown moving toward delivery from left to right, may encounter delays and other significant cost impacts due to many factors.

Uncertainty Factors Include: Uncertainties in available revenue, scope growth, labor or materials price volatility, regulatory issues, other infrastructure priorities, design times, and political influences.

Cost Impacts Include: Holding costs for keeping delayed projects ready, the need to hurry-up projects, loss of funds, obsolete projects, non-optimum advanced construction, redesign and development, and wasted efforts related to right-of-way issues, environmental assessments, etc.

The Problem: To better manage these uncertainties and deliver projects on time and within the budget, achieving the benefits that were intended when the projects were selected.

MANAGING RISKS IN THE PROJECT PIPELINE

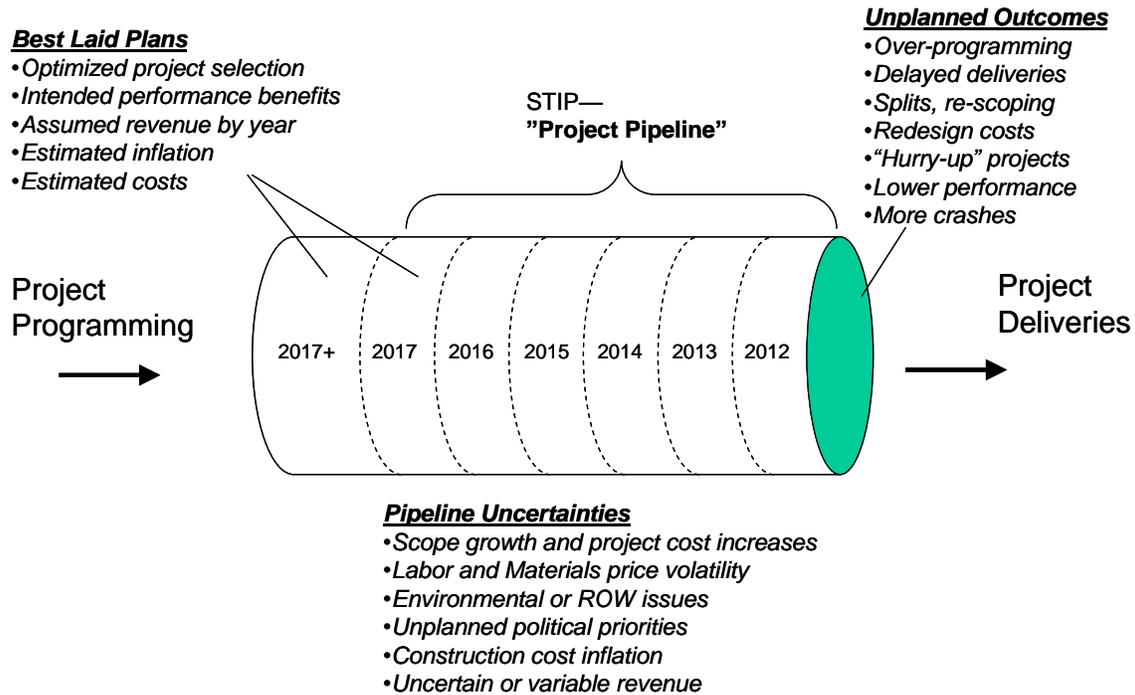


Figure 2. Illustration. Overall Context of the Project Pipeline Problem

The Goal: Save the transportation agency as much money as possible while maximizing overall long-term project delivery performance by addressing the following problems:

- Too few projects on the shelf and ready to go, limiting delivery flexibility.
- Too many projects on the shelf, racking up holding costs due to project delays.
- An inflexible mix of project types—again, limiting delivery flexibility.
- Unmitigated factors of uncertainty with chronic variability and/or large impact such as scope creep, design delays, materials price volatility, uncertain revenue, and political or local priorities.

The Solution -- ***IF*** a DOT can maintain an optimum number of projects in the pipeline, through time, with a flexible mix of project types (such as preservation versus major rehabilitation), ***THEN*** the savings over the long-term can be quite significant.

Why: Because the cost and performance impacts associated with project pipeline uncertainties are estimated to be significant---up to 4 or 5 percent of the overall project budget or more.

How to Work the Problem: Perform targeted risk management by using a customized simulation tool to perform scenario analyses around anticipated funding profiles, including realistic ranges of uncertainty. In general, it is expected that process improvements in planning, design, and project development will help significantly. In addition, process improvements across the organization are likely to provide opportunities to mitigate key elements of these uncertainties and improve organizational functioning.

MANAGING RISKS IN THE PROJECT PIPELINE

In the past, some studies have addressed the risks associated with individual projects, but typically have not addressed the overall management of risks associated with delivering projects over the long-term and reaping the anticipated performance benefits. (1) Other studies have addressed parts of this problem, such as scope growth, but once again analysis of the long-term impacts on project deliveries has been lacking to date. (2)

The authors have made contributions to analyzing long term impacts on project deliveries previously up through 2011. (3,4) With results from this study, WYDOT will be able to utilize the new simulation tool, specifically designed to model the project pipeline, to analyze project delivery risks and costs and develop effective planning strategies. Through the analysis of a range of funding scenarios and potential operating parameters, WYDOT will be able to determine the most effective strategies to employ. By actively managing risks in the project pipeline, WYDOT will be able to minimize the costs of project delivery and maximize the performance of transportation projects over the long-term.

1.3 STUDY APPROACH

The overall objectives of this study are to understand the uncertainties and risks related to project deliveries for projects that are planned years in advance. Often, actual funding that is available in the future may not match up with the funding levels that were assumed when projects were scheduled and committed to the design and development process. Hence, the best laid plans for project deliveries may not always come true.

Due to mismatches between anticipated funding and actual funding available in each of the intended years of project delivery, some projects may need to be delayed until adequate funding is available. This results in Holding Costs for these projects in order to keep them ready to go. If excess revenue becomes available, projects may need to be accelerated through design and development in order to spend stimulus money or other additional funds. This results in inefficiencies in these accelerated or hurry-up project deliveries that typical projects would not experience. Therefore, reducing the effects of Holding Costs and Hurry-Up Costs over the planning time horizon will minimize the cost impacts that result from variable or uncertain funding.

One strategy to address uncertain funding is to optimize the amount of projects loaded into the pipeline over time, in order to balance the pipeline and minimize the cost impacts. Balancing the pipeline means finding the best tradeoff between Hurry-Up and Holding costs, given a range of funding scenarios. Figure 3 shows the tradeoffs between having “too few” projects in the pipeline versus having “too many”. Some of the impacts of having too few or too many projects in the pipeline are listed at each end of the curve. Specifically, the Hurry-Up Costs or inefficiencies of having too few projects and being Too Lean are on the left side. On the right side are Holding Costs which are costs of having too many projects in the pipeline, resulting in projects being delayed and not delivered on time.

MANAGING RISKS IN THE PROJECT PIPELINE

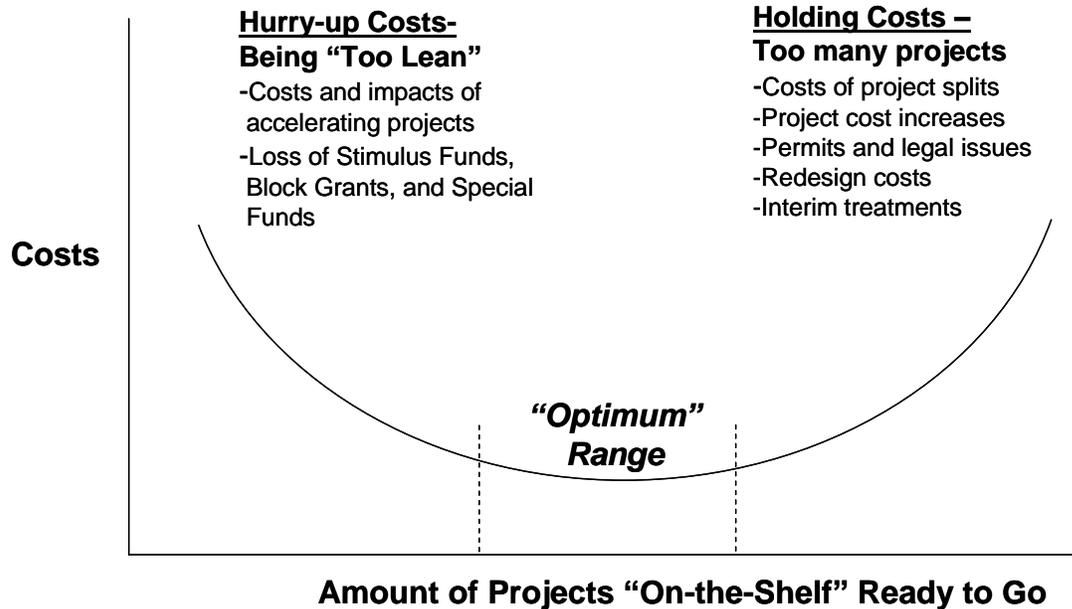


Figure 3. Graph. Tradeoff between "Hurry-Up Costs" and "Holding Costs"

For instance, for the low end or "too lean" case on the left side of the spectrum there may be dollars that are left on the table if there are not enough projects to pull forward to deliver. Thus, there could be a dollar-for-dollar penalty for not using the available money. To avoid this, projects can be accelerated and delivered "just to spend the money", but there may be penalties that should be assessed for doing that. Thus, at the high end or "too lean" end, there is a lack of projects ready to go, and hence Hurry-Up costs or inefficiencies may result when trying to accelerate projects so they can be delivered in order to use up available revenue.

At the high end, there are too many projects in the pipeline and Holding Costs can be incurred. One type of Holding Cost is a project split which can occur when there is a revenue shortfall relative to the projects that are "ready to go". When there isn't enough money to deliver all the projects scheduled for a particular year, large projects are often split in half or even more pieces in order to deliver at least part of the original project. There are also costs of redesign or redevelopment as projects wait for delivery, otherwise performance impacts result from eventually delivering a non-optimum or stale project. In addition, there can be other costs related to delaying projects such as interim treatments that may be necessary, regulatory and legal issues that may appear, or crashes that may occur due to the current roadway design or condition and the roads not being fixed when originally intended.

Optimizing the mix of project types, whether major or minor transportation projects, is also necessary in order to further balance the pipeline. Ensuring a good project mix will provide delivery flexibility each year and increase the ability to hit intended performance targets. Finally, it is important to mitigate other uncertainties such as scope growth, design delays, local priorities, political influences, etc., that may increase Holding Costs and Hurry-Up inefficiencies.

Parallels to the manufacturing world were important in the formulation of the solution concept. (5,6) For example, the concepts of Just-in-Time (JIT) delivery of parts and minimum inventory costs are important in manufacturing and the similarities with the highway project

MANAGING RISKS IN THE PROJECT PIPELINE

pipeline are significant and worth exploiting. Specifically, there are costs of running too “lean” in terms of inventory in a manufacturing operation and there are also costs of carrying too much inventory. A major premise of this research is that there is an optimum operating point in the project pipeline somewhere between being too lean and being over-programmed. Therefore a key objective of highway project pipeline management should be to optimize the number of projects to maintain in inventory, or “on-the-shelf”, and thus minimize long-term costs.

Overall, a balance between Holding Costs and Hurry-Up inefficiencies must be maintained in order to deliver the maximum amount of projects over time. This optimization has been performed using a simulation tool that was specially developed for this situation. Using the simulation tool, scenario analyses can be performed by an agency to maximize performance in project deliveries.

1.4 SIMULATION MODEL

The choice of using dynamic simulation is based on the complexity of the problem and the objectives of the analysis. A spreadsheet approach is not adequate for the type of analysis required. The basic structure of the model is to use a “conveyor belt” to simulate projects moving through time, after they are programmed; one conveyor belt for each type of project as shown in Figure 4. In this research, the two types of projects studied are minor and major pavement rehabilitation projects (1R2R and 3R4R projects, respectively). However, the model is expandable to other types of projects. The simulation is built on a PowerSim platform, which runs on a standard PC.

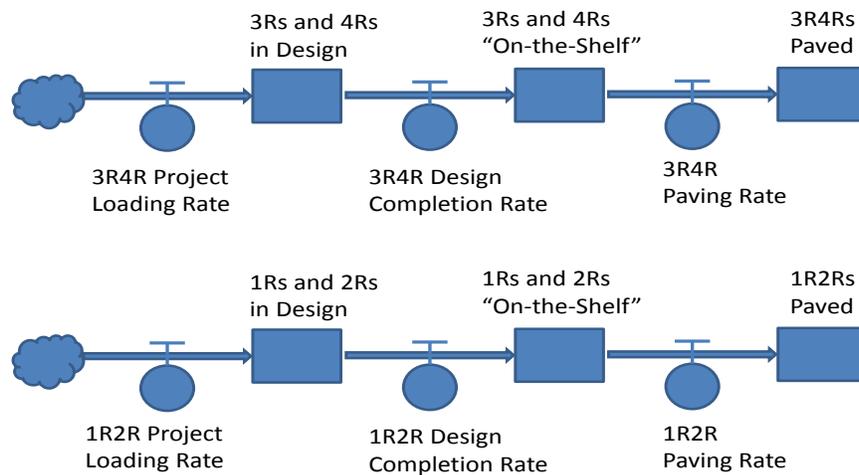


Figure 4. Illustration. Simulation Model Illustration

1.4.1 Results of Simulation Runs

Figure 5 shows some of the results and dynamics of the project pipeline simulation for a potential funding scenario. The various charts portray the amount of projects in design and the amount of projects on-the-shelf (projects in inventory and ready to go) in the project pipeline. The charts reflect both minor (1R2Rs) and major (3R4Rs) pavement rehabilitations. In addition, the two charts on the right show the annual amounts of paving that are being accomplished over time. By understanding the step-by-step calculations going on within the simulation, the analyst

MANAGING RISKS IN THE PROJECT PIPELINE

can gain insight and make decisions regarding strategies that might lower the risks in the project pipeline. The graphs illustrate how these variables change year-by-year.

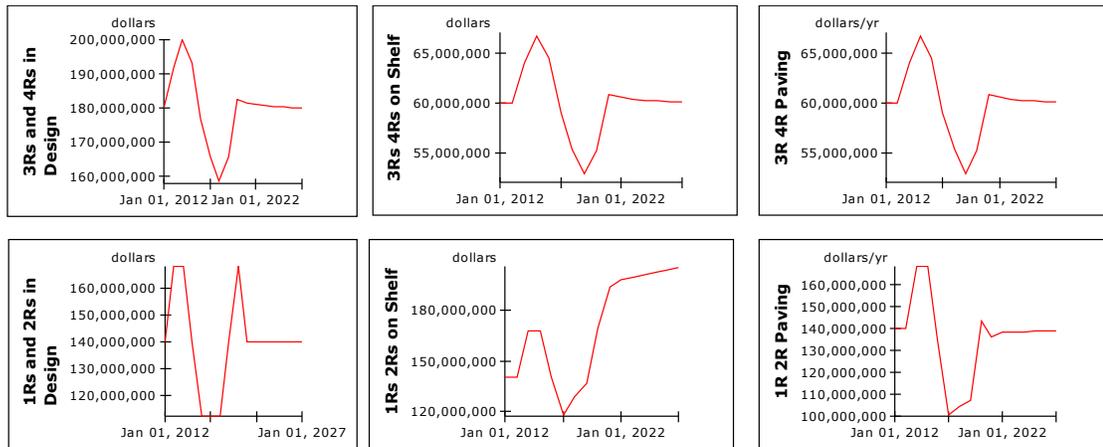


Figure 5. Illustration. Simulation Run – Typical Results

In the simulation, the projects move through design, development, and are then held on-the-shelf until they are delivered, assuming funding is available, and depending upon the logic for pulling them from the “shelf” for delivery. The model then tracks the dollar amount of projects that are delivered, given the actual funding available and considering the money wasted on project delays and the inefficiencies of accelerating projects.

Key Modeling Assumptions and Inputs:

- Scenarios for available funding are input at the end of the pipeline.
- Total dollar amount/year of projects is fed into the pipeline (i.e. fed into the design phase).
- Holding costs are assessed for excess projects held on the shelf.
- Hurry-Up Costs are assessed for a lack of projects ready to go (i.e. the costs of “late entry” 1R2Rs).
- 1R2R and 3R4R shelves are drained proportionately according to amount of funding available.

1.5 LAYING THE FOUNDATION

1.5.1 Early Analysis Results in Developing the Model

A few historical projects were examined early in the study to quickly garner the needed inputs for the simulation model (e.g. costs of project delays, inefficiencies of accelerating projects, ranges of actual funding versus what was originally anticipated, etc.). In parallel, the development of the simulation tool enabled parametric sensitivity analyses of projected outcomes as a function of key inputs and assumptions.

The analysis results produced early in the study enabled better targeting of the follow-up research into model inputs, assumptions, and project pipeline uncertainties. Following this first round of scoping analysis and parametric (sensitivity) studies, it was possible to perform deeper research into historical data, which included examining actual projects and the resulting

MANAGING RISKS IN THE PROJECT PIPELINE

outcomes. This effort validated and upgraded the assumptions used to date and helped determine ranges of uncertainties to utilize in developing a Monte Carlo analysis capability going forward. The historical research included identifying not only factors for holding costs (project delays) and hurry-up (accelerated) project inefficiencies, but also uncertainty factors such as political priorities, scope growth, inflation, regulatory or legal issues, etc. The research ultimately enabled the refinement of the simulation model, thus improving the analysis for testing various risk management strategies and making credible projections of paving outcomes.

1.5.2 Sensitivity of Long-term Paving Deliveries to Project Pipeline Cost Factors

The first effort in the analysis was to determine the sensitivities of project delivery performance to the project pipeline cost factors discussed above (i.e. being too lean or too heavy). Depending upon the funding scenario, including the variability of funding, either Holding Costs or Hurry-Up Costs or both could become significant factors. This analysis was intended to not only determine the overall impact of these two cost elements, but whether they are significant in general, and if so, which one is the most dominant.

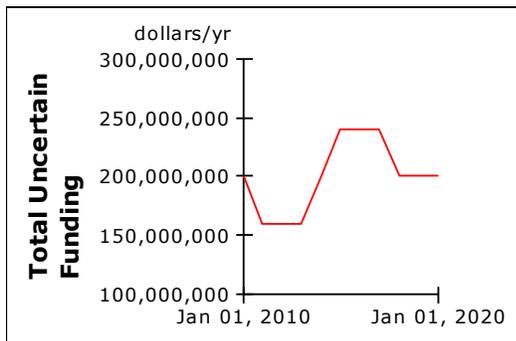
In order to answer these questions it was decided that two dissimilar scenarios would be important to examine. The scenarios were designed to provide variability in funding (for each scenario) and also provide diversity in funding variability between the scenarios. The premise behind this is that Holding Costs and Hurry-Up Costs arise when there is a funding mismatch between the projects that are ready to go in any given year and the actual funding that is available in that year.

The funding scenarios shown in figure 6 were chosen for examination as “actual funding” profiles and were named the “LowHigh” and “HighLow” scenarios. They have some similarities, but also some important differences. For example, these scenarios each have the same TOTAL funding amount of 2 billion dollars over a 10-year planning time period. They differ, however, in terms of when the funding is high and when the funding is low. The importance here is to be able to consider generic revenue profiles that provide fluctuations between plausible bounds of long-term funding amounts, with reasonable variation, and yet are characteristically different from each other in terms of impacts on the project pipeline.

In determining the impacts of these variable funding profiles, it was assumed that the anticipated funding for programming projects into the pipeline would be the coming year’s revenue. Since no one knows the future, it was assumed, for the purposes of this analysis, that the dollar amount of projects added to the project pipeline per year would be equal to the revenue of the coming construction season. Depending upon the actual funding when the projects are ready for delivery, there could be Holding Costs or Hurry-Up Costs and possibly both if there is large enough variability in the mismatch between anticipated funding and actual funding.

MANAGING RISKS IN THE PROJECT PIPELINE

“LowHigh” Funding Scenario



“HighLow” Funding Scenario

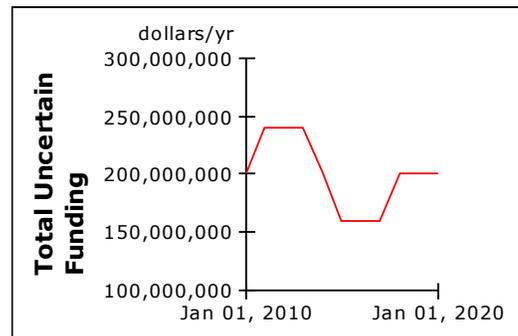


Figure 6. Illustration. Two Representative Revenue Profiles, “LowHigh” and “HighLow” Scenarios

Figure 7 shows how Holding Costs and Hurry-Up Costs apply to specific situations, in this example for the HighLow funding case. Funding exceeds the amount of projects that are ready to go for the first few years and therefore there are Hurry-Up Costs for those years, where projects need to be accelerated in order to spend all of the money available. Then in the latter years of this scenario, when projects exceed the amount of revenue available, there are Holding Costs. Note: Hurry-Up 1R2Rs are accelerated minor pavement rehabilitations.

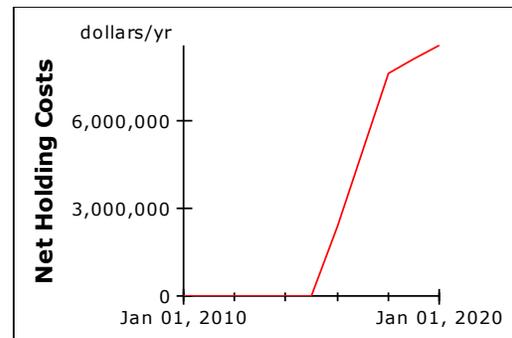
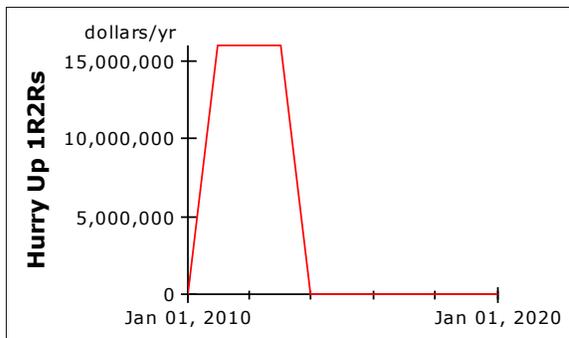


Figure 7. Illustration. Project Pipeline Costs Corresponding to Accelerated and Delayed Projects

The simulation model was then used to analyze the three funding scenarios (Flat, LowHigh, and HighLow) in order to quantify the resulting project deliveries that were possible for each scenario and for the “Bad” or “Good” cost factor assumptions.

Some additional definitions are important to provide at this point in order to interpret the figures that are to follow:

- A Flat funding scenario is used for comparison with the HighLow and LowHigh funding cases. Flat funding means that the actual funding is a constant 200 million dollars per year. In this case, since there is no variation in the available

MANAGING RISKS IN THE PROJECT PIPELINE

funding each year, there are no Holding Costs or Hurry-Up Costs, because there are no mismatches in any year between projects that are ready to be delivered and actual available funding.

- “Bad” refers to assumptions for the cost factors for calculating Holding Costs and Hurry-Up Costs which are the most pessimistic. For example, the range of the Holding Cost factor is from 2 to 6 percent of the initial project cost to be charged on an annual basis for delays. Thus the Bad case is 6 percent. For Hurry-Up Costs, the cost penalty of accelerating a 1R2R project is a range from 20 percent to 60 percent. Hence the Bad case would be a 60 percent inefficiency associated with under-programming. “Good” in this case means 2 percent for annual Holding Costs, and 20 percent for Hurry-Up Costs.

The results of the funding scenario analyses are shown in the figure 8. As shown, the Flat funding cases, as expected, have no penalty in terms of reduced project deliveries. Specifically, 200 million dollars per year, times the 10 years of the planning horizon, results in 2,000 million or 2 billion dollars in total project deliveries. However, due to the mismatches in actual funding versus ready-to-go projects, the other scenarios result in some penalties. Also, due to the Bad versus Good assumptions there are dramatic differences in penalties.

Same Total Dollars Spent Over 10 Years

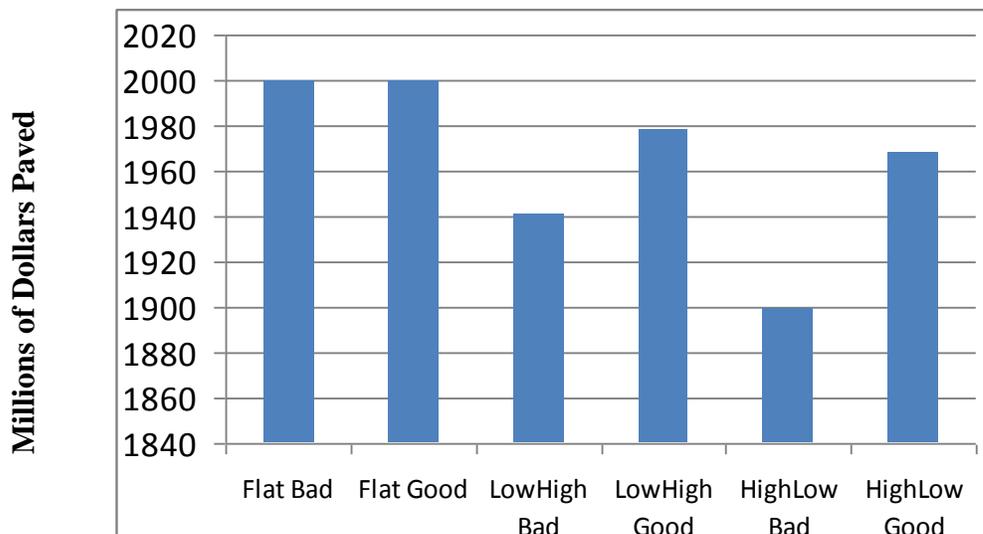


Figure 8. Graph. Comparison of Amounts Paved for Three Revenue Scenarios

Based upon this analysis, it appears that the potential savings in using the optimistic assumptions over the pessimistic ones for Holding Costs and Hurry-Up inefficiencies is between 2 and 4 percent of total projects that could be delivered, given the total amount of revenue over the time period.

As an example, for the LowHigh funding case, the additional project potential is approximately 2 percent (or 1,980 dollars minus 1,940 million dollars and then divided by 2 billion dollars in revenue). In contrast, for the HighLow funding case, the additional project potential is about 3.5 percent. This is a good example of how the variability of a funding scenario can affect the

MANAGING RISKS IN THE PROJECT PIPELINE

amount of projects that can be delivered and also how the two cost factors illustrated here can affect deliveries. The key conclusion is that these cost factors can affect the total amounts of delivered projects by a few percent, depending upon the actual cost factor values. To put this into perspective, a 3 percent difference on 2 billion dollars over a ten year period is 60 million dollars. Therefore, there is a strong incentive to minimize and/or manage these cost factors in the project pipeline.

As a side note, the relative magnitudes of the impacts of Holding Costs and Hurry-Up Costs were found, by additional analysis, to be similar for both scenarios. Therefore, both scenarios are recommended subjects of further investigation regarding the potential for minimizing their impacts.

1.5.3 Bumpy Versus Flat or Smooth Funding Profiles

In addition to the sensitivity study of key cost factors, a comparison of the Flat versus “Bumpy” (LowHigh and HighLow) revenue profiles is possible. The Flat scenario contains the same total funding over the time period as the Bumpy ones, but the Bumpy scenarios result in more losses than having more consistent funding from year to year. Note that the worst-case “losses” from figure 8 are approximately 100 million dollars or 5 percent of the 2 billion dollars over the time horizon. Therefore, the benefits of the Flat funding versus the LowHigh and HighLow funding (or Bumpy profiles) is between 2.0 and 3.25 percent, based on using average assumptions for the cost factors described above.

When examining even more dramatic variations in funding over time, such as steep increases in funding or more volatile changes from year-to-year, the effects can become even more pronounced. There are considerable opportunities to smooth out funding; whether it means working with the state legislature to smooth out funding over the years or determining if the transportation agency has the ability to hold over funds from year-to-year and thus provide a virtual smoothing effect for programming projects over time. These options should be explored due to the potential, lucrative payoffs. With a multi-billion dollar program over a 10 to 15 year time horizon, the savings can easily be in the tens of millions of dollars.

1.6 SYNOPSIS

Once the Project Pipeline concept, goals, and approach were determined, then the focus was on how to design and use a model to simulate various funding scenarios and different pipeline loading strategies. A preliminary list of cost factors including Hurry-Up and Holding Costs were generated. Initial runs of the dynamic simulation model showed the effects of Bumpy versus Flat or Smooth funding and indicated that tens of millions of dollars could be saved by smoothing out funding. The next step was to validate and modify the Simulation Tool for WYDOT.

MANAGING RISKS IN THE PROJECT PIPELINE

CHAPTER 2 TOOL CONFIGURATION: VALIDATING AND MODIFYING THE SIMULATION TOOL FOR WYDOT

After the simulation model was designed and the initial simulation runs were performed, the research focused on validating and modifying the simulation tool for usage by WYDOT. The goal was to be able to model the WYDOT situation overall, regarding the key types of transportation projects delivered. Specifically, the general types of projects to be modeled were either minor pavement rehabilitations or major highway rehabilitations, including periodic reconstruction projects. The simulation tool also had to be able to model the amount of time projects needed to spend in their design phase, which can be up to several years for major rehabilitation projects. Thus, WYDOT preferences and constraints shaped how the simulation tool was modified for WYDOT usage.

2.1 INTERVIEWS

Various managers and engineers from the Districts and WYDOT headquarters were interviewed in order to collect input from WYDOT personnel regarding the modification of the overall simulation tool configuration. These interviews involved the following people:

- Pat Persson, District 1 Engineer, and his staff
- Shelby Carlson, District 5 Engineer, and her staff
- Lowell Fleenor, District 3 Engineer, and his staff
- Rick Harvey, State Materials Engineer
- Ken Spear, Program Manager of Contracts and Estimates
- Martin Kidner, State Planning Engineer
- Gregg Fredrick, Assistant Chief Engineer
- Tim McDowell, State Programming Engineer

2.2 DATA GATHERED FOR MODEL CONFIGURATION

Based upon these interviews, a wealth of information and suggestions were collected that provided important data that was used in configuring and inputting the simulation tool. This information included how to model the following items:

- The components of Holding Costs.
- The components of Hurry-Up Costs.
- Design times for 1R2R and 3R4R projects.
- How to account for inflation and historical cost inflation for construction.
- How to program projects into the pipeline given revenue projections.
- How to drain the pipeline in order to help manage risks.
- Percentage mix of 1R2R projects versus 3R4R projects, and how to manage the mix.

MANAGING RISKS IN THE PROJECT PIPELINE

2.2.1 Holding Costs

Holding Costs were defined as costs associated with the following:

- Escalation of project costs over and above inflation.
- Costs of splitting projects.
- Sunk design costs prior to redesign, for a delayed project.
- Crashes that have occurred during a delay that may have been precluded with the intended project/treatment.
- Interim treatment costs that are not fully recovered.
- Costs to other entities (cities, counties) due to delays.
- Costs of stockpiling material during the delay.
- Costs of churning projects, switching them in and out, etc.
- Regulatory and/or legal costs that would have been avoided.

2.2.2 Hurry-Up Costs

Similarly, the consensus on the Hurry-Up Costs associated with accelerating projects included:

- Costly accelerated design and development, due to need for consultants to augment staff.
- Due to the American Recovery Act (ARA) and the Hurry-Up projects, attention was taken away from early activities on 3R4R jobs, and some of these projects were delayed accordingly.
- Non-optimum early or light pavement treatments – an estimated 25 percent of treatment is lost in missing the delivery date by two years (1R2Rs). Treatments may have been applied early in some cases, and hence a partial loss of treatment effectiveness.
- Due to ARA, the increased funding may have lifted the prices of contracting and materials due to increased demand, with the same supply (this needs more research).

With these lists of potential contributors to the costs of delaying or accelerating projects, the task of quantifying these cost factors could begin. Chapters 3 and 4 will cover how these factors were quantified.

2.3 IDEAS AND SUGGESTIONS FOR MANAGING RISKS AND LOWERING COSTS

During the interviews, discussions regarding strategies to manage risks and lower costs in project delivery were very important. Below is a fairly complete listing of the ideas and suggestions that came directly from the interview process:

2.3.1 Critical Project Method Concepts

- Assure that high-priority (and high cost, high risk) projects move through the project pipeline on schedule.
- Have a pool of 1R2Rs ready to go to handle surges of funding.
- See detailed bullets later in this chapter under Critical Project Method.

MANAGING RISKS IN THE PROJECT PIPELINE

2.3.2 Pipeline Loading

- Project cost estimating accuracy, consistency, and formality is important.
- Inflation projections – need to monitor inflation in real time, since projected values now may be much different in the years ahead; and projections need to be re-estimated during times of rapidly changing inflation.
- Revenue projections – techniques to improve these should be explored.
- Use of projections in order to synch up “ready” projects with available revenue.
- Optimize size(s) of projects, balance economy of scale benefits with risks of being split.
- Move from having projects ready to go to a strategy of just in time delivery. In other words, instead of having too many projects on the shelf, which is costly, work toward managing the project pipeline in order to have them ready when needed.

2.3.3 Reducing Design Time and Design Cost = Increased Responsiveness to Changing Revenue Balance

- Reducing time delays in design enables a more adaptive project pipeline.
- Continuous design of 1R2R projects would increase ability to handle a rush for projects from a pool of projects, when accelerating projects is necessary.
- Hire consultants for the 1R2R excess (leave the 3R4R design efforts alone).
- Have dedicated design team(s) for 1R2R jobs.
- Have different design procedures for 3R4R jobs versus 1R2R jobs.
- Shared accountability between resident engineer and designer on projects.
- It is important for districts to make their expectations and priorities clear.
- Designers need better visibility of the tradeoffs in the critical path and the results of decisions to be made; and thus develop an ability to advise the districts on their options.
- Provide the critical path of a project within PCS (Project Control System), readily visible to the designer, so they can make the best choices on priorities.
- Define or clarify decision rights during the project development process.
- Reduce time from project commitment to delivery through streamlining and optimizing design process flow.
- Define triggers/alerts for intervention by executive staff, and make them clear.
- Prevent bottlenecks for future excess funding (e.g. stimulus).
- Identify best practices and employ whatever was successful during the Stimulus era.
- How to manage the “emergency projects”? There are no procedures for these currently.

2.3.4 Project Control System (PCS) Opportunities

- Opportunity to shorten up design times.
- Better communication and transparency will lead to shorter schedules.
- Primavera, PeopleSoft, and Oracle – opportunity for integration; need to eliminate double-entry of data in PeopleSoft and Primavera both.
- Project templates – flexibility, fit – are useful for defining projects.
- Upgrade of Primavera (PCS software) and ensure continuity of knowledge during and after.

MANAGING RISKS IN THE PROJECT PIPELINE

- Reduction of schedule “float” during stimulus periods, and the impact on 3R and 4R projects.
- Training on Primavera’s capabilities (who, what, when, where, how often, etc.).
 - E.g. Primavera could be possibly used for setting priorities and schedules statewide, defining overall critical path, etc.
- Overall roles, responsibilities, expectations, processes related to PCS.
- Upgrade of PCS software (Primavera) may provide good timing for integration with PeopleSoft.
- Oracle has purchased Primavera – additional incentive to integrate Primavera with PeopleSoft.

2.3.5 Revenue Smoothing

- There are benefits of consistent funding from the state including minimizing the mismatches of funding with the number of projects that are ready to go. Smooth, consistent funding makes it much easier to plan and deliver projects on time and as intended.

2.3.6 Organization Responses which may be Counterproductive

- Early PCS can lead to putting more projects on the shelf, incurring more Holding Costs. Need to rethink the PCS template or perhaps get rid of “early PCS” process/concept and reduce the “gaming of the system”.
- Tendency to grow or add scope for programmed projects.
- Tendency to low-ball estimates of new or anticipated projects.

2.3.7 TAM (Transportation Asset Management)/Planning Process Trends/Issues

1. STIP information availability –
 - Within hard copy files in the past 10 years, there has been a tendency for email to be used to document changes in project scope, estimated cost increases/decreases, splits, etc. rather than using hard copy forms (Scope Amendments, Scope Addendums) that require signatures. Potential problems with this trend are:
 - The lack of a formal process (Scope Amendments) can cause system issues including:
 - Easier to change projects, which can cause increased volatility in project planning/design/delivery.
 - Less able to track why projects change.
 - Decreased traceability regarding project cost fluctuations (without a Scope Amendment, no rationale for increase/decrease in cost estimates is apparent).
 - Less documentation on changes in cost estimates. Sometimes project changes are documented in an email but no change in the cost estimate is given; if cost changes are recorded in the STIP/PCS then the “why” of the cost change may not be documented, thus creating a fragmented picture of the project and elements of the project.

MANAGING RISKS IN THE PROJECT PIPELINE

- Unclear what cost escalation might be due to:
 - Scope growth (undocumented in Scope Statements/Amendments).
 - Bad estimates (unclear if estimates are based on simple road reconstruction and then it becomes more complicated or why estimates are “off”—usually low).
- Unclear at the end of a project whether any increase or decrease in scope was done; only that the Let price was much higher/lower than previous estimates.
- Less able to compare data/information later between projects.
- Unexplained project changes cause ripples throughout planning and design organizations.

2. Formality, rigor, and consistency of Program Study Report (PSR) & Scope Statements/Amendments. Tracking changes in cost estimates or changes in the scope of the project regularly/ and/or periodically during delays is important.

- Project scope changes:
 - Scope seems to change according to perceived or actual changes in available funding.
 - When scope is amended or changed three to five or more years from Let, it is often unclear why a project was amended. Some possible reasons for amending scope include:
 - Scope creep: combining projects (adding/increasing mileage) is most often the biggest change in project cost (and is done when additional funds become available or when justifying the need for more funding).
 - De-scope: splitting projects appears to be the fastest way to cut project cost in the near term to get a project “out the door” quickly.
 - Long term costs for a corridor can greatly increase if projects are split—especially when they are split into multiple small segments.
 - Effects of multiple scope changes (increase and/or decrease).
 - Need to research what the ripple effects are for the organization of multiple scope changes;
 - For one project,
 - For multiple projects in one district (district system effects),
 - Or for multiple projects in multiple districts (large system effects).
 - Multiple changes in scope can be evident in PCS notes but no official Scope Amendment or other documentation may be on file.
 - Urban reconstruction seems especially prone to multiple scope changes including:
 - Intersection modifications.
 - Revised recon reports mentioned.
 - Cost of interacting with city and/or county entities for:
 - Sewer, drainage, lighting, other modifications.
 - Scope changes by city and/or county.
 - ROW issues.

MANAGING RISKS IN THE PROJECT PIPELINE

3. Update of estimates (for programming) during periods of steep inflation or changes in material costs is important.
 - Accuracy of Estimates:
 - Trends
 - Project cost estimates are low, especially PSR and early Scope.
 - PR 714 Estimates are usually higher than Let price (PR 714 estimates are conservative).
 - Estimates trend low until one to two years from Let and then may jump dramatically (possibly become more accurate?) and then a project may be split as a result.
 - Estimates are done via a PSR six to 10 years or even 20 years before Let and this can lead to problems such as:
 - Without an update, early/low estimates can skew how the STIP is loaded, which would tend to:
 - Overload the pipeline with too many projects (since they don't appear to cost as much as they really will cost),
 - Encourage scope creep (since cost looks low);
 - Encourages combining projects on same road,
 - Encourages adding bridge work, interchange work, slide area work, and
 - Encourages adding side roads or adjacent projects to the main project.
 - Scope creep can lead to:
 - Additional design work.
 - Additional recon work.
 - Additional ROW.
 - Additional aerial mapping.
 - Additional environmental studies.
 - If accurate estimates do not come in until one to three years before Let, the pipeline can:
 - Become congested/overloaded with too many projects which puts pressure on the pipeline/districts to:
 - Hold/shelve/delay projects.
 - Split projects.
 - De-scope projects.
 - Which can cause:
 - Wasted design work.
 - Wasted recon.
 - Cost per mile escalation in construction costs for the corridor.
 - Updated Estimates within two to three years of Let would give Planning a better idea of real cost, at a critical time in the design of major rehabilitation projects.
 - Currently, updated estimates often are not in the project file. Could they be found somewhere else?

MANAGING RISKS IN THE PROJECT PIPELINE

- Characteristics of “Black Hole Projects”—projects that get pushed out 10-20-30 years into the future include:
 - Very difficult to tell what is going on with some projects that get pushed out so far into the future.
 - Often, no notes can be found in the file.
 - STIP information may keep changing but no reasons as to why the estimated cost keeps increasing. (Is it inflation projections only?)
 - PCS notes only keep record of how far out the project keeps getting delayed.
 - Question why a project still resides in the STIP if the project is getting further and further delayed?
 - No evident design costs or design work in file.
- 4. Program Study Report: Improvements in the PSR process are now underway, and should be monitored in on-going efforts (similar to the new processes for project cost estimating).

2.3.8 Other Systemic Issues, Ideas, Suggestions, and Questions from the Interviews

- The organization could benefit from reviewing what happened during the Stimulus era. How were priorities handled? What “worked” during the stimulus era?
- Would modeling events and outcomes during the Stimulus timeframe be useful?
- How do Districts communicate their priorities/expectations?
- Are there any duplicate efforts across the organization? Or unclear roles?
- How valuable would shared accountability between the resident engineer and designer be?
- Is Project Development organized to be adaptable?
- Major rehabs, if late summer, are a real worry; if they get pushed back, money may go elsewhere; so the lesson is to quit scheduling for late summer.
- Use District PCS notes as test scenarios for who provides what to whom, and how these scenarios affect critical path.
- Right of Way’s (ROW) processes: what affects their processes and what are the impacts to the critical path?
- Resident engineers are busy in summer, who owns projects in the pipeline?
- Start a “Statewide AFE” for a pool of 1R2R jobs as the buffer for the Critical Project approach and pull these projects from the “candidate list” as needed.
- Need to reduce how teams are away from their home offices during the paving season.
- Different process template for larger versus smaller projects.

After gathering information from the interviews and then organizing and categorizing the feedback, the ideas and suggestions for managing risks and lowering costs were used to later develop the Core Strategies and the System and Organizational Improvement Strategies. These are covered in detail in chapters 5, 6, and 7.

2.4 MAJOR SIMULATION TOOL MODIFICATIONS

Modifying the simulation tool was necessary in order to test significant strategy changes proposed by WYDOT personnel. These included major strategies for loading the project pipeline and for draining the pipeline. The first one presented here is related to loading the pipeline.

2.4.1 Major Candidate Strategies for Using Funding Projections and Loading the Pipeline

It is important to address the methods by which the project pipeline can be “loaded”. Depending upon the anticipated future revenue, there are multiple methods the planner or analyst can use in terms of programming projects from year to year. Figure 9 shows a diagram of the basic structure of the simulation model. The loading of the project pipeline is shown at the left end of the diagram, where the 3R4R and 1R2R project loading rates are shown, and illustrates feeding projects into their respective design phases. These loading rates may be constant, or perhaps a function of anticipated future funding. But these rates are important to consider in the eventual matching up of projects that are ready to go with available funding.

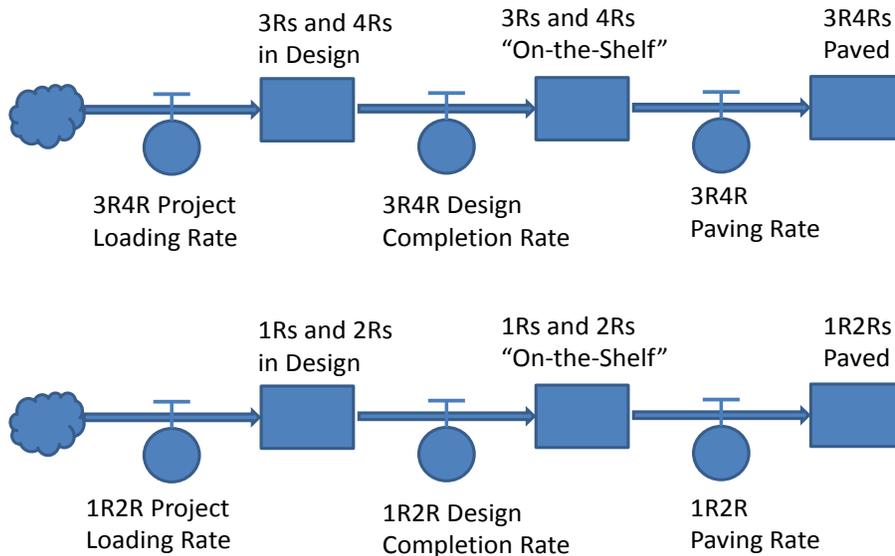


Figure 9. Illustration. Simulation Model Basic Structure

Constant Versus Tracked Versus Projected Schemes for Loading the Project Pipeline

Multiple strategies were considered for loading the pipeline to determine what magnitude of savings might be possible by using projections of available revenue. The following is a description of the three methods for loading the pipeline that have been examined in this study: Constant versus Tracked versus Projected Strategies.

The Constant strategy assumes that one knows nothing about the future; and hence a constant dollar amount of projects is loaded into the project pipeline each year. Basically the Constant approach is where a planner can estimate the available funding over the next several years, and

MANAGING RISKS IN THE PROJECT PIPELINE

then use an assumed average of constant annual available funding over the time horizon. For example, if the planner is fairly certain that the total amount of available funding over the next ten years will be about 2 billion dollars they might assume the average will be 200 million dollars per year. This example actually represents the numbers used in this study of one option for loading the project pipeline. This option is known as the Constant loading option.

A second strategy was entitled the Tracked approach. This approach involves adding an amount of projects into the pipeline each year that are the same value as the actual revenue expected for the coming year. This scheme is to simply use the known amount of available funding for the coming paving season, and plug this amount of projects into the pipeline. This option is referred to as the Tracked option where the available funding only needs to be known in the short term, and is used to load the pipeline. Use of this approach would suffer the design time delays, and may incur either Hurry-Up or Holding Costs or both. In other words, with variable revenue amounts from year to year, the amount of projects ready to go in any given year may or may not match the available revenue due to design time delays. If, for example, the funding for the coming paving season is known to be 230 million dollars for that year then this amount of projects would be loaded into the pipeline, even though the amount being loaded may not result in projects ready for delivery for several years due to the time spent in project design.

The third scheme is referred to as the Projected loading option. This option uses a projection of available revenue for the next two years, for example, and this amount of projects, anticipated two years ahead, is loaded into the pipeline. In this manner, projected revenue information is used as a means to fast-forward the project pipeline, so that the design time delays can be better managed and brought into synch with the actual funding that may be available.

Myriad options exist regarding how to use projected funding estimates for determining the amount of projects to be loaded into the pipeline. For the Projected approach in this study, projections of available funding from two years ahead were used for loading the pipeline each year. It was assumed that the available revenue could be projected with fairly good accuracy up to two years into the future and commensurate amounts of projects could be loaded into the pipeline in order to better phase with design times and thus minimize the impacts of the time delays inherent in the project pipeline.

In future studies, assessing various strategies that agencies might wish to use in loading the pipeline is a strong candidate for more quantitative research. For example, using revenue projections in general may create additional uncertainties or risks. These uncertainties could impact the paving results and thus imply a tradeoff between the benefits of using projections versus suffering the inaccuracies of those projections. Therefore, this topic deserves additional research beyond the analysis that is presented here.

Results were generated per the three pipeline loading strategies outlined above. Based upon the anticipated funding for the next construction season as well as two years out, projects were loaded into the project pipeline accordingly, and included for comparison with the Flat approach. These three strategies have been tested using the simulation analysis, using multiple funding profiles. The results are calculated in terms of the amounts of total surfacing accomplished.

MANAGING RISKS IN THE PROJECT PIPELINE

In summary, the three project pipeline loading schemes are:

- Constant Loading
 - Assumes a constant dollar amount of projects loaded per year over the timeframe but this may be a BIG assumption (i.e. having that knowledge).
 - This assumption is used for loading the pipeline EVERY year over the timeframe.
 - Typically the results are not bad; but once again, knowing the average dollar amount over the time horizon may be an optimistic assumption.
- Tracked Loading
 - Assumes that next season's available revenue should be the amount of projects loaded per year, year-by-year.
 - No projections of future revenues are used and no assumptions are made regarding average dollar amount of revenue over time.
 - Typically this does not provide very good results.
- Projected Revenue Loading
 - Utilizes projected amounts of available revenue for loading the pipeline, such as two years ahead (used in this study), to minimize time delays caused by time spent in design.
 - Typically very good results (but assumes accuracy of the projection).
 - Assumptions or projections are only made for two years into the future.

2.4.2 Project Pipeline Draining Strategies

The second set of major strategies examined in the study was how projects are selected for delivery or “drained” from the project pipeline, depending upon how much revenue is available year-by-year. Two project pipeline draining strategies were proposed, a Traditional strategy and an alternative strategy, referred to as the Critical Project method. First the concept and configuration of the Traditional case will be described and then compared to the Critical Project method.

The Traditional Method

In the Traditional approach, a targeted mix of projects is selected to proportionally drain the 3R4R and 1R2R shelves, so that the projects actually delivered will match a desired mix each year. For example, if the mix of projects loaded into the pipeline is 70/30 (70 percent 1R2R projects and 30 percent 3R4R projects), then the simulation uses this split to determine what the respective amount of each type of treatment should be drained from the shelves of projects ready to go, totaling up to the amount of revenue available for paving in that year. These amounts of each treatment type are then removed from their respective shelves and are the amounts that are paved in the simulation.

If, however, there are not enough of a certain type of project on the shelf (either minor or major rehabilitation projects) to fulfill this algorithm, then the simulation will remove all of the project value that it can from that shelf; and then remove as much from the other shelf in order to use up all of the revenue for that year, if possible. Therefore, even though the drained amounts of each project type are supposed to equal the target mix of project types, the result may not be that desired mix. This can be due to the flow of projects through the pipeline, variable funding, different design time delays for 1R2Rs versus 3R4Rs, etc.

MANAGING RISKS IN THE PROJECT PIPELINE

As an example, if there is 200 million dollars in available revenue and the desired mix of minor rehabilitations (1R2Rs) to major rehabilitations (3R4Rs) is 70/30, then the amount drained from each of the respective shelves would be 140 million dollars worth of projects from the minor rehabilitation shelf and 60 million dollars worth of projects from the major rehabilitation (3R4R) shelf. If, for instance, there is not 60 million dollars worth of 3R4Rs on that shelf, then the simulation takes as much as it can (say 45 million dollars worth of 3R4Rs) from that shelf and then takes 155 million dollars worth from the 1R2R shelf. If additional projects need to be accelerated in order to spend all available revenue, then this process is also accommodated by the simulation. In this manner, the simulation uses ALL of the available revenue and, thereby, does not leave any funds on the table.

The Critical Project Method

Shelby Carlson, District Engineer of District 5 in Wyoming, suggested an alternate strategy for draining the shelves of projects. Carlson's premise is that major rehabilitation projects are more costly to delay than minor rehabilitation projects. The costs of delays and revenue shortfalls are key topics of this study and include the costs of project splits, inaccurate estimates, scope increases, redesign, updating permits, and other cost elements related to revenue mismatches and delayed project deliveries. In addition, Carlson made the case that other entities (cities, counties, etc.) also have a vested interest in major rehabilitation projects being delivered on time. Therefore, the overall costs of delayed 3R4R projects are more than simply the increased costs the state DOT experiences, and could include impacts to city governments, county governments, negative public perception, etc.

District 5 suggested that the major rehabilitation projects (3R4Rs) be held at a higher priority level in the project pipeline. Specifically, it was suggested that the 3R4R projects be kept on a predictable timeline; when these projects are put into the pipeline they are designed and delivered in a specific timeframe from when they entered the pipeline. Thus, when 3R4R projects reach the originally designated delivery date, those projects are delivered as intended and on time; they are not allowed to be delayed.

This strategy assumes there is enough available revenue to deliver ALL 3R4R projects intended for a given year, even if some 1R2Rs that are planned have to be delayed. If there is not enough revenue, then the available revenue is used to deliver as many 3R4R projects as there is money available. If there is more money than 3R4R projects intended for delivery in that year, then additional 1R2R projects are delivered in order to use up all available revenue for that year. Specifically, the additional 1R2Rs are pulled from a list of projects that are in a 1R2R pool of ready-to-go projects.

Again, in the Traditional (proportional draining) approach, the targeted project mix is used to assign the paving rates for 3R4Rs and 1R2Rs as described above. For the Critical Project draining approach, the complete amount of 3Rs and 4Rs that are on-the-shelf and ready to go are drained each year of the simulation if possible, and the 1Rs and 2Rs are drained to the extent that there is additional revenue available.

MANAGING RISKS IN THE PROJECT PIPELINE

The following attributes describe some of the specifics of the Critical Project approach:

- Once critical projects are programmed, do not move them forward or back in the schedule.
- Critical projects are 30 percent of total projects loaded each year in a 70/30 mix.
- Critical projects may include 3R4Rs or complex, high-cost projects.
- Critical projects may involve local funding.
- Right-of-way acquisition may be involved or difficult geologic issues.
- These projects may involve materials source concerns, or major utility relocation (e.g. quality of material, volume, time of year, and the ability to give the landowner a date that is fairly certain).
- May involve funding challenges, and/or are regionally significant projects.
- 1R2Rs take up the slack if excess funding appears, and are pulled from a pick list of ready projects.
- 1R2Rs are identified more than two years in advance, but no specific year for delivery is assigned to each project – a candidate list of projects is identified.
- 1R2Rs are cut back if funding is reduced, and critical projects proceed as scheduled per available funding.
- Allows flexibility in design time opportunities (i.e. when to work 1R2Rs into the other priorities).
- Priorities of 1R2R projects are set in the district, and are chosen according to factors such as crew manageability for the season, and in sync with pavement treatment performance.
- Meet public expectations and public notice deadlines regarding delivery dates of critical projects.

2.5 SIMULATION RUNS COMPARING ALTERNATE STRATEGIES

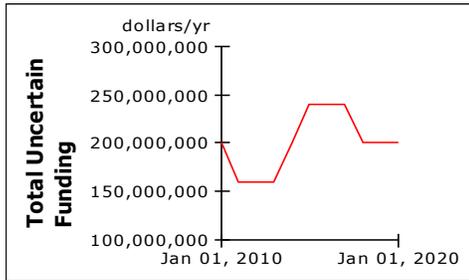
The simulation tool was used for comparing the Traditional and the Critical Project pipeline draining methods. The tool was also used to compare the pipeline loading methods of Constant, Tracked, and Projected. Results were generated and compared for three funding profiles – HighLow, LowHigh, and WYDOT.

2.5.1 Funding Scenarios

Three funding scenarios were used in this study. Two of them are shown in figure 10. These two are the LowHigh and HighLow scenarios as introduced in chapter 1. Again, these funding profiles were chosen due to the plausible variations and magnitude of the variations of available revenue over time. Specifically, for each of these scenarios, the average funding level is 200 million dollars per year, with a variation of plus or minus 20 percent (or 40 million dollars per year).

MANAGING RISKS IN THE PROJECT PIPELINE

“LowHigh” Funding Scenario



“HighLow” Funding Scenario

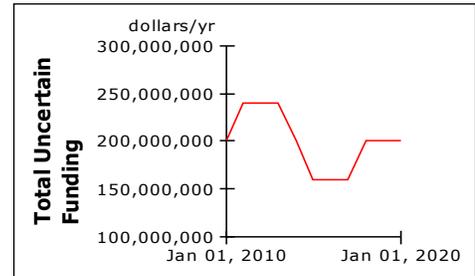


Figure 10. Illustration. LowHigh and HighLow Funding Scenarios

The third funding scenario used in this analysis is the WYDOT Funding Scenario which is a sample, possible funding profile. This is shown below in figure 11. This funding profile spends the same amount of money over the time horizon (200 million dollars per year) as the HighLow and LowHigh scenarios. Note also that this funding scenario is very bumpy over the time period of the analysis.

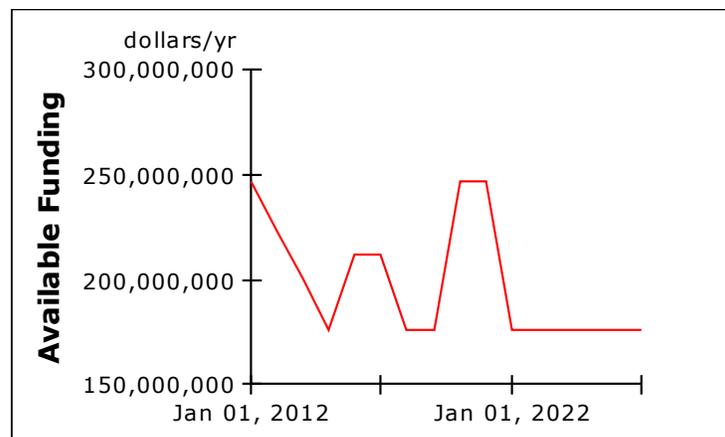


Figure 11. Graph. WYDOT Funding Profile

Assumptions used in the analysis are as follows:

- Factors used for Holding Costs
 - 2 percent per year of initial project cost for 1R2R projects.
 - 5 percent per year of initial project cost for 3R4R projects.
- Hurry-Up inefficiencies for 1R2R projects
 - 40 percent inefficiencies for accelerated projects (i.e. 60 percent of the funds are effectively spent on the projects).
- Design times for 1R2Rs and 3R4Rs
 - Two years for 1R2Rs.
 - Five years for 3R4Rs.
- Input mix of 70 percent for minor rehabilitations (1R2Rs) and 30 percent for major rehabilitations (3R4Rs).

MANAGING RISKS IN THE PROJECT PIPELINE

- Timeframe of 15 years for the simulation.
- Same total dollar amounts used for all three funding scenarios.

Comparing the Traditional to the Critical Project Pipeline Draining Approach

Figure 12 shows some sample results of running the simulation for the HighLow case. The purpose of the comparison is to show some of the differences between the Traditional versus the Critical Project pipeline draining approaches. The results were generated using the Tracked loading scheme. Notice that the amount of projects that end up on the shelf differ between the two approaches. It appears that when using the Critical Project Method, the 3R4R projects are more under control versus the Traditional case where the amount of projects on the shelf is less in control. Specifically, for the Critical Project approach, there are significantly less 3R4R projects on the shelf and a few more 1R2R projects on the shelf. Since the Holding Costs for 3R4R projects are greater than the Holding Costs for 1R2R projects, this represents a favorable tradeoff in terms of the amount of projects held on the shelf for each type of project. In other words, with more 1R2R projects on the shelf, and less 3R4R projects, presumably there will be less overall Holding Costs.

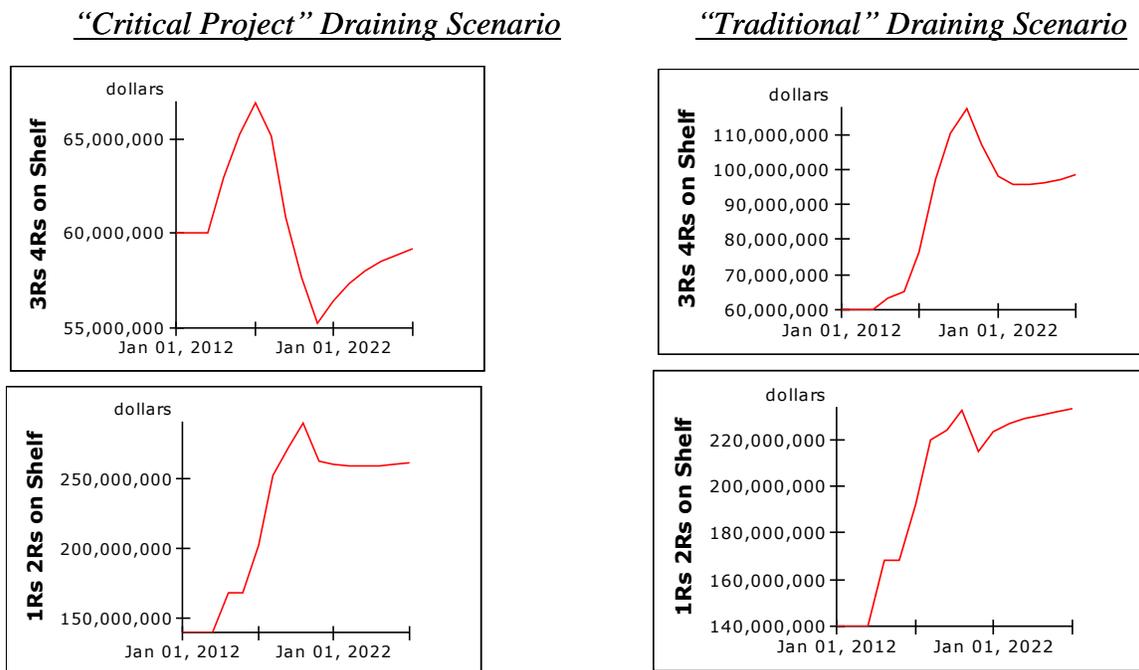


Figure 12. Illustration. Comparison of Projects On-the-Shelves for the Two Draining Approaches

MANAGING RISKS IN THE PROJECT PIPELINE

2.6 ANALYSES AND RESULTS OF FUNDING SCENARIOS AND PIPELINE LOADING/DRAINING STRATEGIES

2.6.1 Results of HighLow and LowHigh Funding Scenario Analyses

The results for the HighLow and LowHigh funding scenarios are shown in table 1. The individual cases are shown in each column of the table.

The general observations are as follows:

- Total losses from Holding Costs and Hurry-Up Inefficiencies for these nominal cases can be on the order of 2.0 to 3.0 percent.
- The LowHigh funding scenarios did not result in very high overall losses, and only the results for the Constant loading approach are shown in table 1.
- The HighLow funding scenario has much greater losses, and results for all three pipeline loading methods are shown in table 1.
- The Constant as well as the Tracked loading methods show the greatest amount of total losses.
- For the Constant and Tracked cases, the Critical Project Method case reduces the losses significantly; both in terms of Total Losses and Holding Losses.
- The Projected cases have significantly less losses over the time horizon, compared to the other two cases.
- The Projected case virtually eliminates the benefits of the Critical Project method for draining the pipeline; but of course this assumes accurate projections.
- In all cases, the target project mix of 70/30 is fairly closely matched by the resulting mix.
- Hurry-Up costs are not a factor regarding these particular funding scenarios.

Table 1. Chart. Results for the HighLow and LowHigh Funding Scenarios

<i>Funding Scenarios & Pipeline Loading Strategies</i>	HighLow/Constant		HighLow/Projected		HighLow/Tracked		LowHigh/Constant	
	Critical	Traditional	Critical	Traditional	Critical	Traditional	Critical	Traditional
<i>Pipeline Draining Method</i>	Critical	Traditional	Critical	Traditional	Critical	Traditional	Critical	Traditional
Total Paved (\$ millions)	2931	2921	2971	2970	2936	2924	2988	2982
3R4Rs Paved (\$ millions)	900	855	898	874	903	864	900	895
1R2Rs Paved (\$ millions)	2031	2066	2072	2096	2033	2060	2088	2087
Resulting % of Minor Rehabs (70% as Target)	69.3	70.7	69.8	70.6	69.2	70.4	69.9	70
Holding Costs (\$ millions)	21	31	8	9	28	40	12	18
Hurry Up Costs (\$ millions)	48	48	21	21	36	36	0	0
Total Losses (\$ millions)	69	79	29	30	64	76	12	18

MANAGING RISKS IN THE PROJECT PIPELINE

2.6.2 Results of WYDOT Funding Scenario Analysis

Table 2 shows the results for the three WYDOT funding scenarios. The general observations are very similar to the HighLow cases, and are as follows:

- Total losses from Holding Costs and Hurry-Up Costs for these nominal cases can be on the order of 2 percent.
- The Constant as well as the Tracked loading methods show the greatest amount of total losses.
- For the Constant and Tracked cases, the Critical Project method reduces the losses significantly; both in terms of Total Losses and Holding Losses; and more significantly for the Tracked case by these measures.
- The Projected cases have significantly fewer losses over the time horizon, compared to the other two cases.
- The Projected case virtually eliminates the benefits of the Critical Project method for draining the pipeline; but once again, assumes accurate projections.
- In all cases the target project mix of 70/30 is fairly closely matched by the resulting mix.
- Hurry-Up Costs are not a factor regarding these particular funding scenarios.
- There is little variation in the final delivered mix of project types.

Table 2. Chart. Results for the WYDOT Funding Scenario

<i>Pipeline Loading Strategies</i>	WYDOT Constant		WYDOT Projected		WYDOT Tracked	
<i>Pipeline Draining Method</i>	Critical	Traditional	Critical	Traditional	Critical	Traditional
Total Paved (\$ millions)	2946	2943	2959	2958	2943	2937
3R4Rs Paved (\$ millions)	900	862	891	882	920	869
1R2Rs Paved (\$ millions)	2046	2081	2067	2076	2023	2068
Resulting % of Minor Rehabs (70% as Target)	69.4	70.7	69.9	70.2	68.8	70.4
Holding Costs (\$ millions)	8	12	10	11	26	34
Hurry Up Costs (\$ millions)	46	45	31	31	31	29
Total Losses (\$ millions)	54	57	41	42	57	63

2.7 CONCLUSIONS – FROM THESE PRELIMINARY RESULTS

Please note that these analyses are preliminary, and are primarily used here to illustrate two major strategy candidates, three pipeline loading approaches, and a few future revenue (funding) profiles. These results are preliminary because the cost factors for Holding Costs related to

MANAGING RISKS IN THE PROJECT PIPELINE

project delays, and Hurry-Up Costs for accelerating projects are only rough estimates at this point.

Nonetheless, these early results have helped increase understanding of the order-of-magnitude of what potential losses in the project pipeline could amount to. In addition, this early analysis has been useful in determining what the potential savings might be in employing one strategy versus another. For instance:

- Nominal assumptions (used in this analysis) for these losses/costs suggest the losses are over 2.5 percent per year.
- Multiple methods have been shown to be effective in cutting these losses:
 - Using (accurate) forward projections of available revenue or reducing design times in the pipeline (especially design times of 3R4R projects).
 - Using the Critical Project Method to stabilize the major projects in the pipeline.
- Projecting revenue out two years (accurately) and/or reducing design times similarly in the pipeline are significant. Reduces losses by approximately 30 percent over simply Tracking revenue on a year-to-year basis to load the pipeline.
- Requires good short-term forecasting of available revenue.
- The Critical Project approach reduces losses from 10 to 30 percent (for Holding Cost Losses), and an average of 13 percent (for overall losses) for a variety of funding scenarios.
- Critical Project approach also keeps 3R4R jobs under control.

Further Conclusions:

- Additional research to verify assumptions on Holding Costs and Hurry-Up inefficiencies is needed.
- The Critical Project approach appears to have a significant role in reducing losses in the project pipeline and should be considered further as a candidate core strategy.
- Using the Projected method for pipeline loading reduces losses compared to the Tracked approach and should be maintained as a key candidate solution.
- It is further anticipated that if design cycle time can be reduced then additional reductions in losses are also possible.

The following chapters will cover the research done regarding input parameter assumptions such as Holding Cost factors, Hurry-Up Cost factors, and the costs of splitting projects as well as the potential benefits of implementation of some of the candidate solutions previously noted.

MANAGING RISKS IN THE PROJECT PIPELINE

MANAGING RISKS IN THE PROJECT PIPELINE

CHAPTER 3 HISTORICAL PROJECT RESEARCH

The main purposes of the research and analysis of historical WYDOT highway projects was to determine the cost factors associated with project delays and to challenge, validate, or update the previous assumptions to the simulation model as well as validate the model in general. Following the initial interviews with various people within the department and after the initial modifications were made to the simulation tool, it was necessary to perform in-depth research on historical highway projects to satisfy these objectives.

The approach to this research was to examine historical highway projects that had delays from a few years up to ten or more years. Specifically, the projects selected were ones that were delivered more than seven years after their entry into the STIP.

Two groups of projects were selected – medium size projects between 5 million dollars and 10 million dollars and large projects that were over 10 million dollars. In order to provide a statistically significant analysis, at least 20 projects were analyzed in each group. Due to limited information on certain projects and the need to have a minimum amount of data to perform the analyses, the total number of projects examined was approximately 50 projects.

3.1 PROJECT TABLES

A partial list of the data collected on the medium and large projects which were selected for analysis is found in table 3 (Medium Size Projects) and table 4 (Large Size Projects). The information listed in the tables includes: each project's District number, Project Number, Description of the Project, Reason (widen/overlay, reconstruction, etc.), R Level (1R, 2R, 3R, 4R), Project Location (physical location of the project with a description and mileposts), STIP Entry Date (date the project was entered into the State Transportation Improvement Program schedule), Delivery Date (year the project was delivered or the anticipated Let year), and the Let Cost (the cost of the project when it was delivered) or Latest Cost Estimate (for projects not yet delivered, the latest cost estimate found in the STIP at the time of the research).

MANAGING RISKS IN THE PROJECT PIPELINE

Table 3. Chart. Medium Projects (5 to 10 Million Dollars)

District	Project Number	Description (e.g. Rawlins to Walcott Jct)	Reason (e.g. Widen/Overlay)	R Level (e.g. 3R)	Project Location (Rt, MP1, MP2)	STIP Entry Date	Delivery Date (Let yr, STIP yr)	Let Cost (or Latest Cost Estimate)
1	804228	Rock Springs -- Rawlins	Mill/level/overlay WBL	2R	I-80, 199.05 - 210.98	2/3/2003	2012	\$9,580,128.00
1	251147	CHEY MARG, VANDEHEI INTERCHANGE	widen structure, roundabouts	4R	I-25, MP 13.83	10/1/1999	2011	\$6,501,643.00
1	805129	WALC-LARA/QUEALY DOME/WBL	resurfacing and rehabilitation	3R	I-80, MP 282.65 - 291.1 (8.45 mi)	3/1/1993	2009	\$7,659,157.00
1	I251156	chey -- chug, whitaker section	resurfacing	2R (final)	I-25, 24.2 - 30.75	3/31/2003	2012	\$5,280,000.00
1	212001	Chey/College/BNRR-Ave C/01	widening and resurfacing	3R (?)	MP 0.17 - 3.58 (was 0.28 - 3.28)	10/1/1991	2001	\$6,541,000.00
2	1002014	KAYC-SUSX/15 MI DRW/00	resurface/minor wide/chip seal	3R (?)	MP 6.8 - 11.6	1989	2000	\$5,114,000.00
2	253085	DOUG-GLNK/DOUG WEST/EAST SEC SBL	widen & overlay/ISO-reconstruction	4R	MP 141.37 - 145.6 (4.2 mi)	1993	2011	\$7,106,052.00
2	S805006	SUGR/E SEC	Reconstruction	4R	MP 0.25 - 7.0	10/1/1998	2011	\$9,607,016.00
2	1401007	MNVL-LNCE/WYATTE CR	Reconstruction	4R	MP 104.34 - 107.9 (3.56)	10/1/1996	2012	\$6,096,577.00
2	1600006	WHTL/HIGHTOWER RD&WYO 311 SPUR	widen & overlay/ISO-reconstruction	3R (was 4R)	MP 4.5 - 7.5 plus 2 mi spur	10/1/1996	2012	\$5,106,294.00
3	2100020	EVAN-UTAH/EVAN SO/04	widen & overlay	4R	12.84 - 23.25	10/1/1991	2004	\$8,384,000.00
3	N132076	DANL-HOBK/PFISTR CR/05	reconstruction		MP 136.37 - 142.75	3/1/1992	2005	\$6,781,000.00
3	1906018	GRRV-FONT/FONTENLE	reconstruction	3R	MP 33.7 - 40.29	10/1/1998	2008	\$6,115,403.00
3	1903022	HIAW/SALT WELLS CR	widen & overlay	3R	MP 5.95 - 16.06	7/1/1998	2010	\$5,741,997.00
4	2302011	UPTON SO/JCT 450 NO SEC	widen & overlay	3R	MP 25.17 - 32.46	6/1/1998	2009	\$7,703,148.00
4	901094	ER/SHER-BUFF-MARSHALL HILL	resurface	2R	MP 28.29 - 33.6	10/1/1994	2010	\$7,577,326.00
4	255098	KAYC-BUFF/MDL FK INT SEC	widen & resurface	3R	MP 279.71 - 289.6	7/1/1998	2011	\$9,821,465.00
4	P433035	GILL-MONT/WESTON SEC	widen & overlay	3R	MP 142.05 - 148.6	1/1/1990	2012	\$9,600,000.00
4	600016	SUND-UPTON/CO LN SO	widen & overlay	3R	MP 16.6 - 22.51	7/1/1998	2011	\$6,148,337.00
5	333012	CODY-MONT/CLARKS FK R	widening & resurfacing		MP-127.95 - 133.0	8/12/1997	2007	\$7,605,433.00
5	N331021	TMOP-MEET/TMOP NW	widen, overlay, ISO reconstruction	3R	MP 0.94 - 4.21	10/1/2001	2012	\$6,771,879.00
5	N361053	WORL-TENS/WORLE	reconstruction	4R	MP 1.52 - 4.84	7/1/1998	2012	\$7,662,254.00
5	N361055	TENS-BUFF/CO LN W	Rock fall mitigation	4R	MP - 41.74 - 44.04	10/1/2001	2012	\$9,071,899.00

MANAGING RISKS IN THE PROJECT PIPELINE

Table 4. Chart. Large Projects (10 Million Dollars or More)

District	Project Number	Description (e.g. Rawlins to Walcott Jct)	Reason (e.g. Widen/Overlay)	R Level (e.g. 3R)	Project Location (Rt, MP1, MP2)	STIP Entry Date (year entered)	Delivery Date FY (Let yr, STIP yr)	Let Cost (or Latest Cost Estimate)
1	P231022	MEDBOW-BOSL/MEDB E	(Scope change from reconstruction)		US HWY 30 MP 272.19-283.69	10/1/1994	2009	\$11,453,884
1	109021	BOSL-WHTL/NO SYBILLE CR	RECONSTRUCTION		STATE HWY 34 MP 22.36-28.38	10/1/1989	2011	\$11,598,230
1	251141	COLO-CHEY/ST LN NO/SBL/05	RECON SBL/OVLY NBL/OE/PULL O		I-25 MP 0.00-7.36 SBL	10/1/1997	2005	\$13,434,000
1	251158	COLO-CHEY/ST LN NO/NBL	CONCR RECON +POE		I-25 MP 0.00-7.36 NBL	10/1/1997	2008	\$15,839,123
1	N211056	RAWL-MUDG/BEL SPRG	WIDEN & OVERLAY+LANES		HWY 287 MP 12.55 - 22.89	10/1/1999	2013	\$10,669,471
2	254138	GLNK-CASP/CASP E	WIDEN/OVERLAY	4R/ITS	I-25 MP <u>174.89-180.77</u>	3/1/1993	2007	\$15,966,269
2	N212084	CASP/W BELT LOOP/SEC 1	BELTLOOP/GRADING/STRUCTURES		Casper West Belt Loop	12/1/1997	2012	\$21,333,718
2	252140	DWYR-GLEN/EL RANCHO/NBL	WIDEN/OVERLAY w/ISOL RECON	4R	I-25 MP <u>94.18-97.50 NBL only</u>	10/1/1990	TBL: 2013	\$11,539,749
2	253094	DOUG-GLNK/GLNK E/05	WIDEN & OVERLEY	4R	I25 MP 150.0-160.5	10/1/1997	2005	\$19,323,000
2	P581013	STREETS/YELLOW STONE HWY	Widen/Overlay and Br Replc) CSA/RECON & BR		HWY 20-26 MP 139.07-140.45	10/1/1996	2008	\$18,010,543
3	803135	RKSP-RAWL/WAMS W	RESURF/RECON/ITS		I-80 MP 162.0-173.41	10/1/2001	2008	\$50,386,438
3	N104006 +N104065	ALPN-HOBK/SNAK SEC	WC/Bridge Replacement Snake R.	4R	Hoback Jct MP 140.69-142.51	10/1/1981	2010	\$26,962,812
3	P132064	HOBK/DELL CR SEC/NHS	RECONSTRUCTION		WY191 MP 142.75-147.60	3/1/1992	2010	\$10,389,918
3	N104066	JACK/SNAK SEC/PHASE 3	RECON/ITS/TURNOUT	4R	US HWY 26/89 MP 141.7-145.5	10/1/1995	TBL: 2018	\$32,943,876
3	N104083	JACK/SNAK SEC/PHASE 4	RECONSTRUCTION	4R	US HWY 26/89 MP 145.5-148.6	4/6/2006	TBL: 2019	\$28,834,467
3	SLIDE) AND N104088 (MUNGER MTN	JACK/SNAK SEC/PHASE 1 & 2	TWO SLIDE MITIGATIONS	1R	HOBACK N-141.7	5/9/2011	(N104087) & TBL: 2016	\$12,000,000
4	w/complications P432032	GILL-DOUG/I-90-US14	CSA/RECONSTRUCTION		WY HWY 59 MP <u>112.26-113.10</u>	4/1/1993	2008	\$12,074,035
4	P601023 (urban road) + P01024 (sidewalk)	SHERIDAN/MAIN NO SEC/PAV	RESURFACE/STRUCTURE		SHERIDAN MP: 21.65-22.90	10/1/1991	2010	\$12,149,989
4	N362013 (+ N362015)	TENS-BUFF/BUFF W/03	RECONSTRUCTION		US HWY 16 MP: 79.58-88.40	10/1/1989	2003	\$19,966,000
4	N362015	TENS-BUFF/BUFF W/03	RECONSTRUCTION		US HWY 16 MP: 83.5-88.4	1988 (?)	2003	
4	N362025	BUFF-UCRS/BUFF E SEC	CSA/RECONSTRUCTION		HWY 16 MP 100.03-102.20	10/1/1996	2009	\$11,749,105
5	301018	DUBO/TOGWOTE E PASS	RECONSTRUCTION		US Hwy 26-287 MP <u>14.47-30.75</u>	10/1/1998	2008	\$49,459,699
5	N301016	MRAN-DUBO/4 MI MEADOWS	RECONSTRUCTION		Final: <u>14.47-30.75</u>	10/1/1998	2008	\$22,118,000
5	N291036	POWL/CODY NE/PHS1	RECONSTRUCTION/5 LANE		Final MP <u>10.05-13.90</u>	10/1/1996	2009	\$14,641,000
5	N301013	DUBO/BUFF FORK RIVER SEC	RECONSTRUCTION/BRD GS		US HWY 26/287 MP 3.00-7.83	6/1/1992	2006	\$18,479,938
5	N301015	DUBO/ROSIES RDGE/RECONST	RECONSTRUCTION		US HWY 26/287 MP 7.83-14.47	10/1/1998	2011	\$25,617,837

MANAGING RISKS IN THE PROJECT PIPELINE

While these tables include all of the projects researched, not all projects could be analyzed due to lack of information in the files on some projects.

3.2 INFORMATION GATHERED ON HISTORICAL PROJECTS

Researchers looked through paper files, electronic databases, and electronic records to gather pertinent information about each project. In addition, WYDOT personnel were interviewed about various projects as needed. The following information and factors were included in the research. Project spreadsheets were used to record information that was gathered about specific projects.

Overall Project Management:

- Original project purpose.
- Project changes, when & why, change orders.
- Impacts of project changes on other projects/programs (if known).
- Scope changes, when, why.
- Projects during Stimulus era; how many were delayed?
- Project components, anticipated costs, bid items, complexity.
- Nature of project – regular, emergency, etc.
- Legal challenges, impacts.

Overall Project Timeline:

- Project origination date – when project was entered into STIP.
- Original project delivery date (planned).
- Current anticipated project delivery date (if applicable).
- Schedule changes & why.
- Delays – when, why including:
 - Crashes that occurred during delays (from Safety Management System).
 - Redesign required due to the delay.
 - Inflation that occurs during delays.
 - Interim treatments that are wasted (i.e. a major rehab quickly follows).
 - Stockpiling of materials (How tight is the lead time for materials on average?).
 - Crew inefficiencies due to delays compounding the problem of locating the work.
- Project accelerations – when, why including:
 - Non-optimum early or light treatments (estimated 25 percent loss for two year date mismatch).
 - Expensive acceleration of design and development (change orders during Stimulus).
 - Impacts on other projects (e.g. major jobs delayed during Stimulus).
 - Stimulus effects on bid prices in the market (i.e. same supply, but more demand).
 - Bid items – compare with weighted average of change orders.

MANAGING RISKS IN THE PROJECT PIPELINE

Budget/Financial Issues:

- Original budget projection when the project was programmed.
- Budget changes.
- Final project Cost.
- Inflation, price changes, projected versus actual over the past several years including:
 - Labor.
 - Materials.
 - Other.

Design:

- Design start date – original.
- Anticipated design start date.
- Actual design start date (if design has begun).
- Anticipated design complete date.
- Design timeline, and any changes, and causes of these changes.
- Key milestones in design and development, and any changes in these.
- Design changes, when, why.
- Why crews were not working at home.
- Redesign information (costs, changes, dates, etc.).
- Materials changes.
- Personnel or squad(s) involved in the project.

Right-of-Way (ROW):

- Right-of-way changes, issues, additional acquisitions, delays.
- ROW and their window of time for their activities.

Environmental:

- Environmental requirements changes, issues, permitting changes, delays.

Geologic:

- Geological requirements changes, issues, delays.

Photogrammetry:

- Their place on the critical path of project development.

Sources of Information:

- STIP
- Budget Office
- PCS (Primavera)
- Design system (Bentley)
- As-Built records
- ROW
- Geology
- Environmental

MANAGING RISKS IN THE PROJECT PIPELINE

- Contracts and Estimates
- PMS

SUMMARY

Approximately 50 projects were reviewed and at least 20 large projects (over 10 million dollars) and 20 medium projects (between 5 and 10 million dollars) were analyzed for this study.

MANAGING RISKS IN THE PROJECT PIPELINE

CHAPTER 4 HISTORICAL PROJECT ANALYSIS RESULTS

4.1 STIP DATA NEEDS LIST

During the research of historical projects, it was determined that there were several data elements that were not always available that would have been useful to have. These include:

- Program Study Reports (PSR) on every project as a starting point to clearly define: the Location (length of project, mileposts, defined beginning and end points), Purpose and Need (defining the scope—reconstruction, widen/overlay, resurfacing), Construction Year (anticipated Let year), and Estimated Cost.
- Scope Statement on every project (done after the Reconnaissance Report) to clearly define any changes from the PSR in location, length, scope, purpose, construction year, or cost.
- Scope Amendment/Addendum on every project whenever there is a change in location, length, scope, purpose, construction year, or cost. The trend since 2000 has been for emails or PCS notes to often serve as the documentation of scope changes for projects. This leads to lack of uniformity and clarity regarding why project changes occur, what the scope of the change is, and whether there is a change in the cost estimate. It is often difficult to determine exactly what the final Let project included or did not include as far as scope and why costs may have significantly increased or decreased. In addition, how projects were split and what happened to all of the pieces of the split project are difficult to track. This makes analysis of split projects difficult.
- Within the Enterprise Resource Planning (ERP) PeopleSoft STIP system, it would be good to maintain historical information about cost estimates and changes that are made to projects in order to analyze what happens to a project. Large projects, especially over 20 million dollars, tend to be delayed and have changes in scope if there is a revenue shortfall. When information is entered into the STIP, it can overwrite the last information that was in the system thus losing the historical record. This is particularly important for changes in cost estimates and tracking when the estimates were changed. In addition, tracking why cost estimates change is important to determine the rationale and accuracy of the estimates and to make changes if the estimation process appears to not be working well.

4.2 RESEARCH PERFORMED ON EACH PROJECT

A systematic approach was developed early-on for investigating each historical project. As part of this, a summary matrix was constructed in order to store pertinent information about each project. The summary matrix for both Medium Projects (less than 10 million dollars) and Large Projects (over 10 million dollars) included:

- Project Number.
- Project Description.
- Reason or Type of Rehabilitation/Roadwork (e.g. Widen/Overlay, Reconstruction, Resurface, etc.).
- R Level (1R, 2R, 3R, 4R, ITS, etc.).

MANAGING RISKS IN THE PROJECT PIPELINE

- Project Location (Highway/Road number, mileposts, road description, etc.).
- Year Project was entered into the STIP.
- Delivery Date Fiscal Year (Let Year).
- Let Cost (or Latest Cost Estimate).
- Program Study Report –PSR Year (or E-113), original estimated construction (let) year and original project cost estimate.
- Scope Statement – Scope Statement date, estimated construction year, Scope cost estimates based on recon reports, Scope comments or changes from PSR.
- Scope Amendments/Addendums – changes/updates to the original Scope Statement including Scope Amendment Date, Change in Construction Year, Change in Cost, and Reasons for Changes.
- PR714 – Information from PR714 including PR 714 date, Engineer’s construction estimate date, PR714 Cost Estimate.
- Final Cost Amount (Actual).

These pieces of information enabled a high degree of analysis to be performed involving project estimates, the effects of inflation, and the accuracy of project cost estimates over the timeframe of project delays.

4.3 NARRATIVES REFERENCE (IN APPENDICES A AND B)

In working through the analysis of each project, a narrative was developed for each project. These narratives contain the highlights of each project and the final analysis of each project, including how it affects the simulation model. These narratives are included in the appendices A and B.

4.4 ANALYSIS TOOL FOR TRACKING PROJECT ESTIMATES, INFLATION, AND FINAL PROJECT COSTS

A useful tool has been created that enables the tracking of project cost estimates, the effects of inflation, and the eventual project let cost. This tool allows the comparison of the project cost estimates with the project let cost, adjusted back through time based on construction cost inflation. Table 5 shows the inflation index used for the study. This table is historical information provided by the Contracts and Estimates Program at WYDOT.

MANAGING RISKS IN THE PROJECT PIPELINE

Table 5. Chart. Construction Cost Inflation Index

Inflation Index	Year
100	1997
98	1998
100	1999
107	2000
110	2001
112	2002
111	2003
112	2004
130	2005
162	2006
212	2007
234	2008
224	2009
200	2010
218	2011
232	2012

The graphic shown in figure 13 illustrates how the tool works. Key cost elements of each project are plotted on a graph. These may include cost estimates from Scope Statements, Scope Amendments, as well as the actual Let cost at the time of project delivery. In the example below, the Scope Statements in 1993 and 1996 are the project costs estimates in “then-year” dollars. The final project delivery Let Cost is shown at the right-hand side, in the 2001 year of delivery. The diamond shaped dots that are to the left of the Let Cost are the dollar value of the Let Cost adjusted for inflation, leading back in time to when the original cost estimate was made. As you can see, the 1993 and 1996 Scope Statement estimates are both lower than the inflation adjusted values of the Let Cost, in their respective years. As it turns out, most of the projects examined during this study exhibited a similar trend of “low estimates” in terms of how Scope Statement estimates compared with Let cost.

MANAGING RISKS IN THE PROJECT PIPELINE

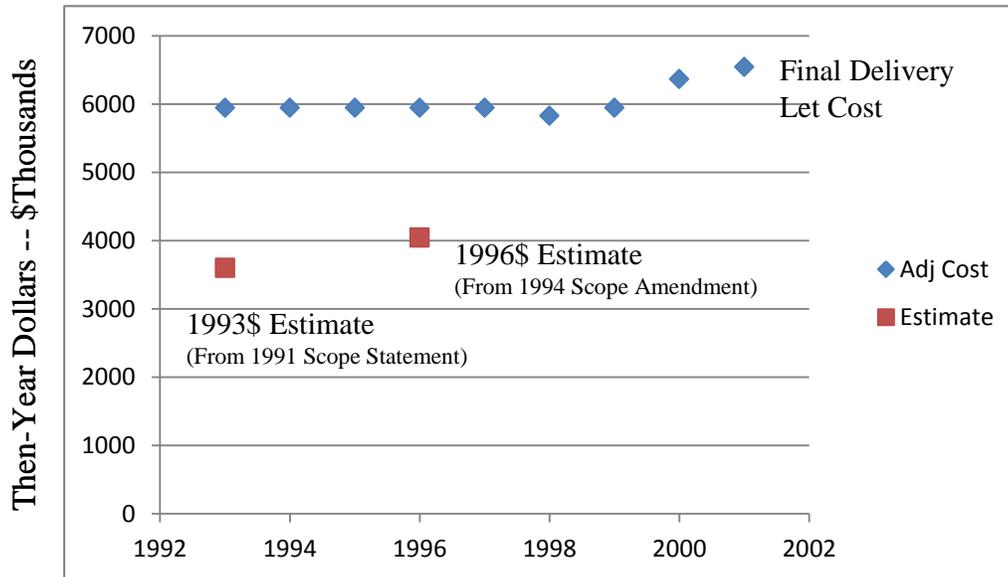


Figure 13. Graph. Project Cost Estimate History Model

Notes:

- If the DOT had made a perfect estimate years earlier, then the estimate along with the actual inflation over the years would follow the diamond shaped dots.
- Cost estimates (square shaped dots) were plotted according to what year dollars the estimate was calculated in; thus a Scope Statement from 1991 might have the project estimated in 1993 dollars and therefore, the Estimate would be located on the graph in 1993.

4.5 HOW TO VIEW INFLATION

At this point it is important to discuss aspects of inflation. There has been some confusion regarding how to view inflation as it pertains to project costs and revenue available for delivering projects. The following list helps in defining the approach to analyzing inflation:

- Inflation may be a “cause” of a delay (i.e. over-programming can result if inflation sets in unexpectedly, and hence there can be more projects than there is money).
- Inflation is not a “cost” of a delay per se; inflation affects ALL projects whether they are delayed or not.
- Greater than expected inflation means that fewer than expected projects can be funded and delivered, as mentioned earlier.
- While the “risk” of inflation cannot be controlled by the organization, the organization can estimate or project what inflation will be. Revenues also need to be estimated or projected in order to program an appropriate number of projects.

As part of the objective to understand and portray the history of each project, in the context of inflation, the tool described above was very useful.

MANAGING RISKS IN THE PROJECT PIPELINE

Figure 14 shows another example of a project, progressing from an initial Program Study Report (PSR) to a Scope Statement and then final delivery. Note that in 2004 there was an addition of roundabouts to the scope of the project. Then the final delivery took place in 2011.

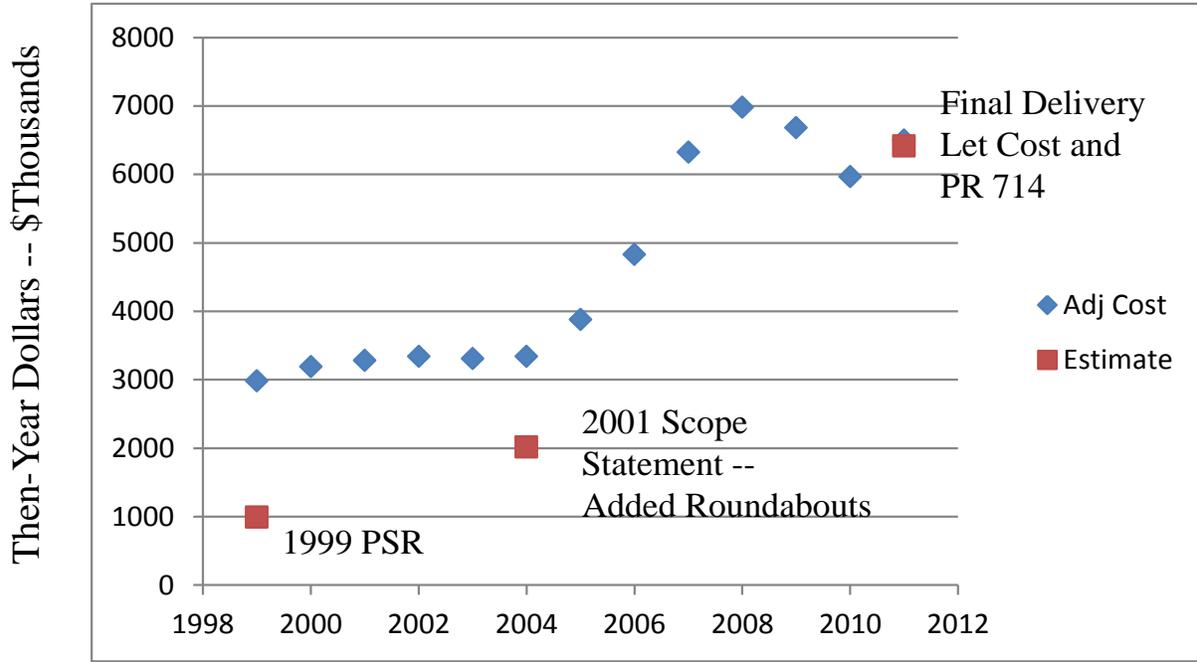


Figure 14. Graph. Addition of Roundabouts to the Original Project Scope

As depicted on the graph, the cost estimates from the PSR and Scope Statement were quite low compared to the final delivery cost. When adjusted for inflation, the diamond dots indicate where the cost estimates should have been if the organization was accurately predicting both the inflation rate and the project costs that led to the final Let cost. The further away estimates are from the diamonds, the more inaccurate the estimate is. Inaccurate, low estimates can lead the organization to over-programming since they are unaware that their estimates are low. Thus the organization plans to deliver more projects; but due to higher actual cost, they will be forced to deliver fewer projects or will need to split or down-scope the projects.

Similarly, inaccurate high project cost estimates can lead to under-programming. The lesson here is that during times of fluctuating inflation (high and low), it is important to update cost estimates at least annually. If this is not done, the DOT will run the risk of being unable to deliver projects efficiently and having to rearrange projects in the STIP continually.

Other projects were even more complicated in their evolution through time. Figure 15 shows a project that was originally scoped in 1998 to cover 6.5 miles of roadway. Then a 2007 Scope Statement indicated the length of the project was changed to 5.0 miles. The project was eventually delivered for 5.0 miles of road. This type of scenario was not uncommon in the projects that were examined, and hence these situations presented the need to do some additional analysis in order to keep “apples and apples” through time so that meaningful conclusions could

MANAGING RISKS IN THE PROJECT PIPELINE

be made regarding project cost estimating, scope growth, and other changes to the project over time.

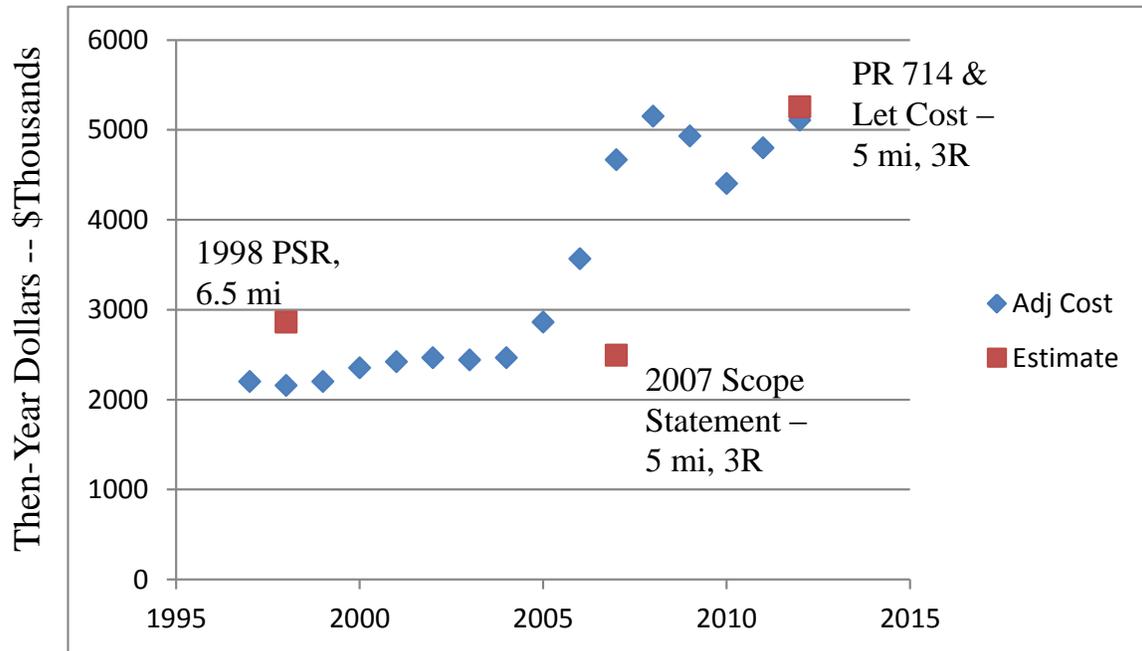


Figure 15. Graph. Scope Changes throughout the Development of a Project

4.6 ANALYSIS OF PROJECT COST ESTIMATES

In general, the historical project information included PSRs, Scope Statements, and Amendments or Addenda to the Scope Statements. These data were utilized in order to perform an analysis of the accuracy of the project cost estimates. Medium size projects were used for this analysis due to their greater simplicity and the greater confidence in “apples and apples” continuity throughout the life of the project from PSR to Letting in terms of project scope, fewer splits, etc.

Figure 16n figure 16, the accuracy/inaccuracy of estimates is presented. For this analysis, both the PSR and Scope Statement estimates were used. On the X axis is the number of years ahead of project delivery that the estimate was made. On the Y axis is the percent difference from the Let Amount that the project cost estimate was, when adjusted for inflation to the year of project delivery. The “0” line indicates a perfectly accurate estimate in relation to the Let price at delivery. As shown, there is a great degree of variation in the accuracy of project cost estimates from the projects examined when using both PSR and Scope Statement estimates.

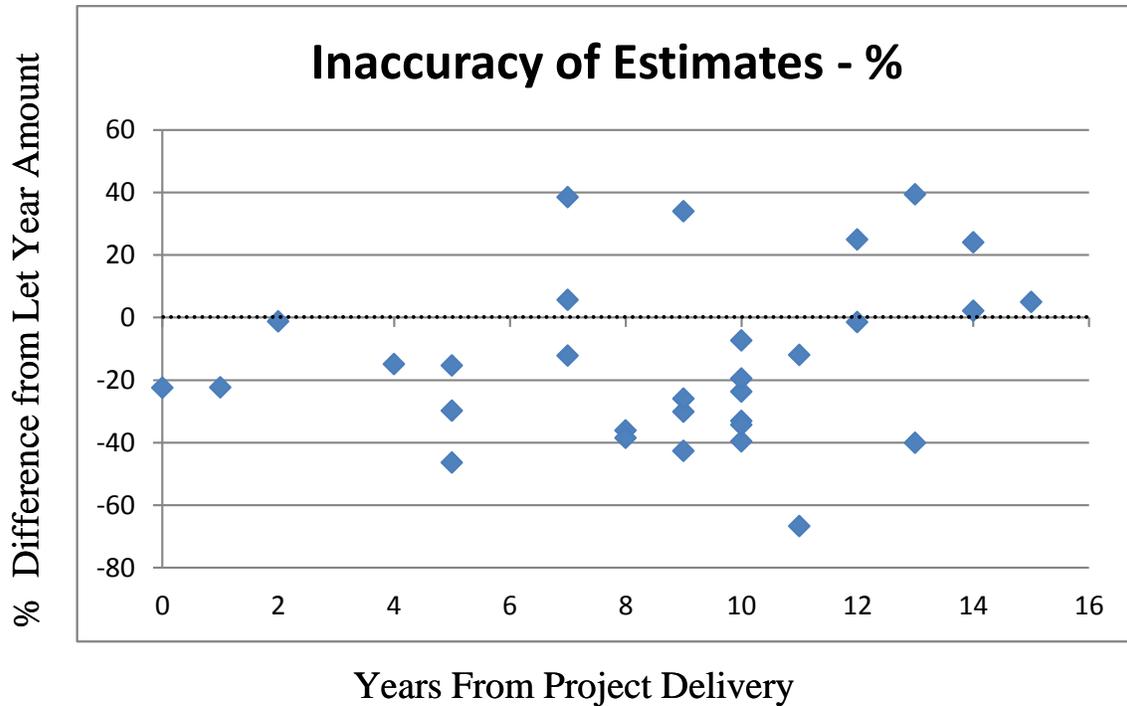


Figure 16. Graph. Accuracy of Project Cost Estimates for Medium Size Projects

Following this analysis, it was decided that if Scope Statements were available, then those would be used for the purposes of determining the accuracy of project cost estimates before a project is delivered. For example, a PSR cost estimate that was 20 years ahead of a project’s delivery year would probably be quite inaccurate both in the eventual scope and cost of the final project. The rationale for using Scope Statements versus PSRs is: projects are usually assigned their final year of delivery date within the final three to five years, and hence, at that time the project cost estimates become a critical part of whether the STIP will become over-programmed or under-programmed. Thus, the decision was made to primarily use Scope Statements for the remainder of the analysis.

Criteria for using best project cost estimates:

- Use Scope Statements/Amendments only, if they are available.
- Use estimates between three and 10 yrs out from delivery and no further out.
- Use the PSR if it meets the above criteria, and if no Scope Statement is available.
- Use Let Cost for value at delivery (although Engineer’s estimates on PR714 are typically higher).

By using the above criteria, and repeating the analysis, the results indicate chronically low project estimates. All of the projects examined provided low cost estimates except for one outlier project. Thus there is a clear pattern in figure 17 of low project cost estimates.

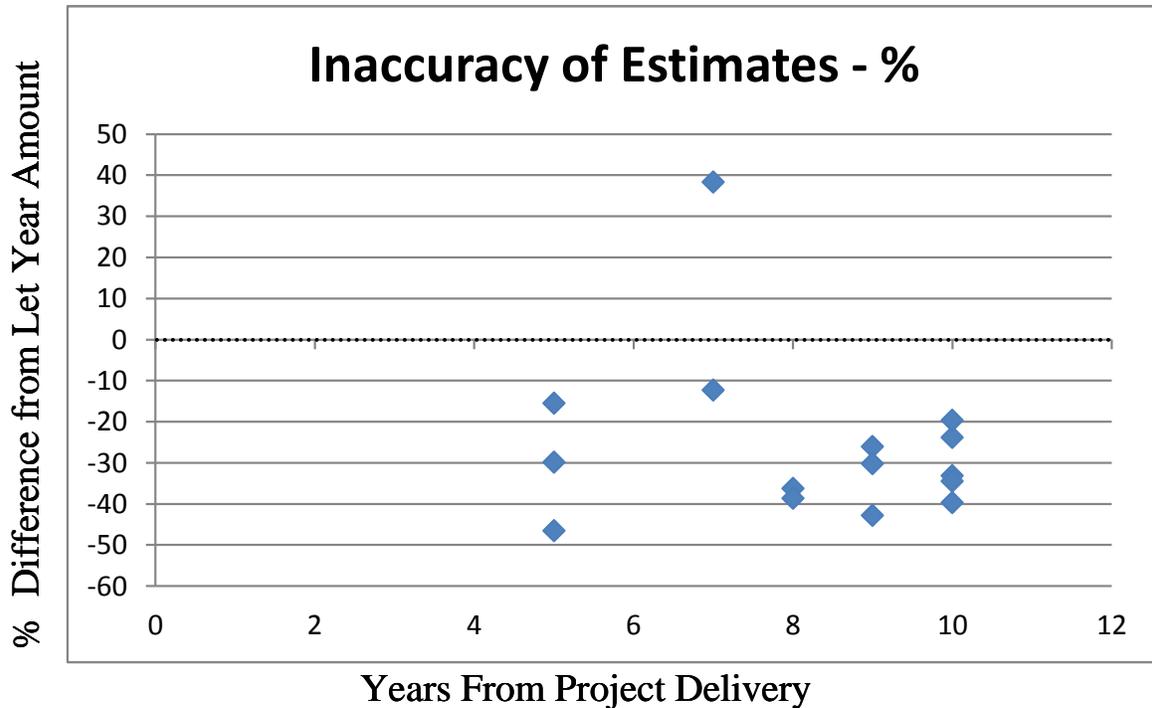


Figure 17. Graph. Project Cost Estimate Accuracy Using Scope Statements Only

4.7 OUTCOMES FOR DELAYED PROJECTS

The main question during the analysis of delayed projects was, “If a project is delayed, what would the costs be?” In this research, the costs of delayed projects are referred to as Holding Costs and the research focused on determining which holding costs are predominant, and how to quantify them.

There are three holding costs that became apparent early in the research. They are:

- Net Escalation: rising project costs, over and above inflation.
- Splits: costs of splitting projects.
- Redesign Costs: redesign costs that are non-applicable, sunk costs that occurred during the delay—usually due to down-scoping.

4.7.1 Net Escalation

Rising projects costs, over and above inflation, were observable by tracking the Scope Statement estimate and then determining how much cost escalation per year was necessary in order to match the eventual Let Cost. A “net” escalation cost was determined in order to set aside the concerns of inflation. Thus, total escalation was initially calculated and then the inflation rate over the time period being analyzed was subtracted from total escalation in order to determine the net escalation cost. The result of the Net Escalation calculation for medium size projects is shown in figure 18.

MANAGING RISKS IN THE PROJECT PIPELINE

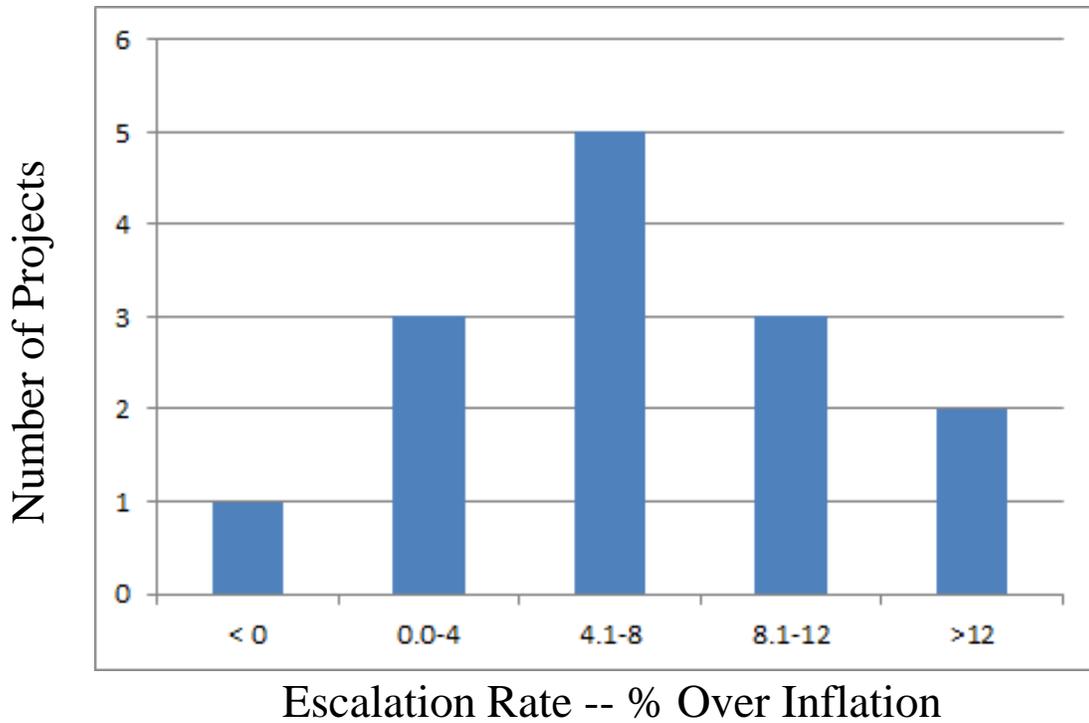


Figure 18. Graph. Escalation Rate (Percent Over Inflation) for Medium Size Projects

For medium size projects, the average Net Escalation required across projects is 5.5 percent per year, over and above the annual inflation rate, in order for the Scope Statement estimates to match the Let Cost in the year of delivery.

Similar calculations were performed for the large size projects, and the results are shown in figure 19.

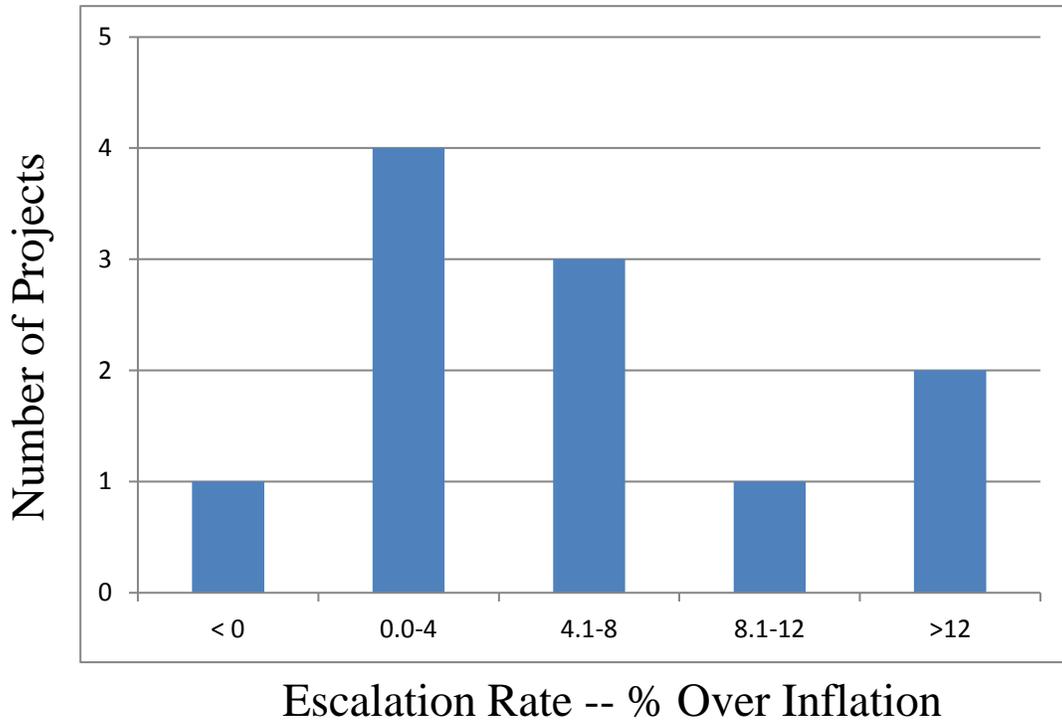


Figure 19. Graph. Escalation Rate (Percent Over Inflation) for Large Size Projects

The average Net Escalation required for large projects is 5.8 percent; thus, the results were very similar to those for the medium size projects.

4.7.2 Splits

Another Holding Cost resulting from delaying projects is the cost of splitting projects. In the research, it was determined that the cost penalties of splitting projects were NOT simply due to a loss of economy of scale due to the project being broken into smaller pieces. A “split penalty” cost was calculated by including scope growth after the split and cost escalation over and above inflation. Ultimately, the split penalty was defined as the percentage amount that the original whole project (before the split) would have to increase in order to equal the total cost of the parts from the split.

Figure 20 shows an illustration of a split project. Note that the Scope Statement of 2007 reflects the delivery of the project in one piece. By adjusting that estimate to the year of delivery, the “whole package” refers to the cost of the project if it had been delivered in one piece. However, after 2007 the project was split into two pieces and delivered, most probably in two different years. But when these two deliveries are compared in a common Let Year, in this case 2011, then the costs of the split can be compared. The split penalty, therefore, has been defined as the percentage amount that the whole package would have to increase in order to equal the total of the parts that resulted from the split.

Split Project Example

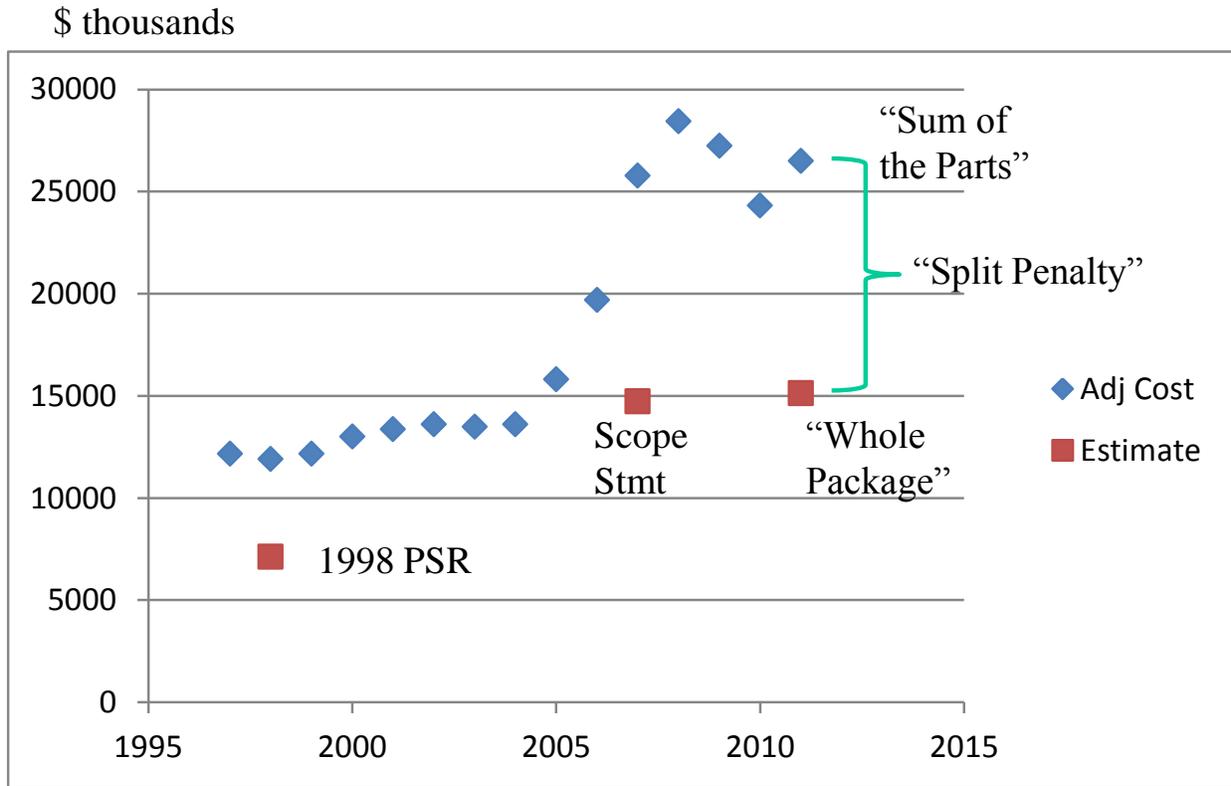


Figure 20. Graph. Illustration of the “Split Penalty” for Delayed Projects

The average split penalty for the medium size projects was 85 percent and the average split penalty for the large projects was 103 percent. The project split cost factor or split penalty appears to be quite significant and therefore splits should be avoided if at all possible.

Another analysis was performed to determine whether there was a correlation between the project size and the percentage of the split penalty. Figure 21 shows the percentage of the split penalty versus project size. The number of data points related to project splits probably does not suffice as a statistically significant set. This makes it hard to make the case that larger projects generally trend toward higher split penalties than smaller projects. Although, as indicated in figure 20, the average medium project split penalty is less than the average large project split penalty.

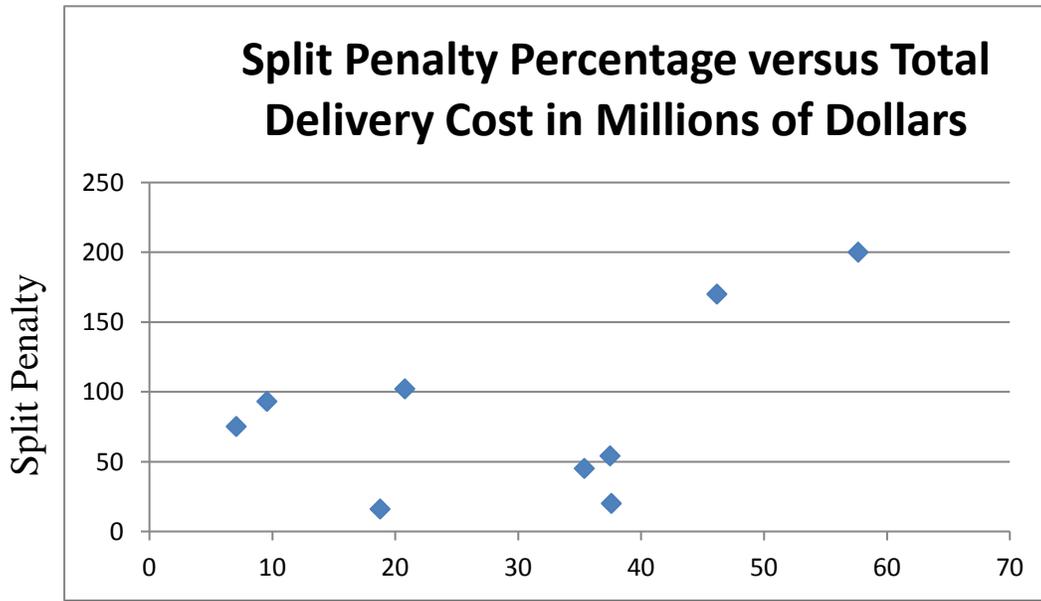


Figure 21. Graph. Split Penalty Versus Overall Project Size (in Millions of Dollars)

Further evaluation of more split projects may provide additional clarity about the penalties of splitting projects. One trend is clear, that split penalties are highly dependent on the situation and the design/scope of the project and therefore have a wide range of costs associated with the splits. In addition, when a project is split there appear to be additional cost factors which drive the cost higher than if the project was done as a whole. If the split penalty is shown to be a much higher percentage for large projects, this could change management decision making processes for large projects to ensure corridors are planned and managed more effectively in order to realize significant cost savings.

4.7.3 Redesign Costs

The third category of holding costs is related to projects that have been redesigned, often due to down-scoping of the project. These are sunk design costs which are wasted when a project has to be redesigned due to a scope change. This area is being recommended for further investigation and the impacts have not yet been quantified. This will be discussed later in the Future Research Efforts section.

4.8 SUMMARY CHARTS

The overall percentage of each type of holding cost has been calculated for both the medium and large size projects. Figure 22 shows the percent breakouts for the medium projects. Note that the predominant holding cost that medium size delayed projects exhibited was cost escalation over inflation. There were some projects that had changed in scope and a few splits. But for the most part, the costs of delays were mostly related to cost escalation.

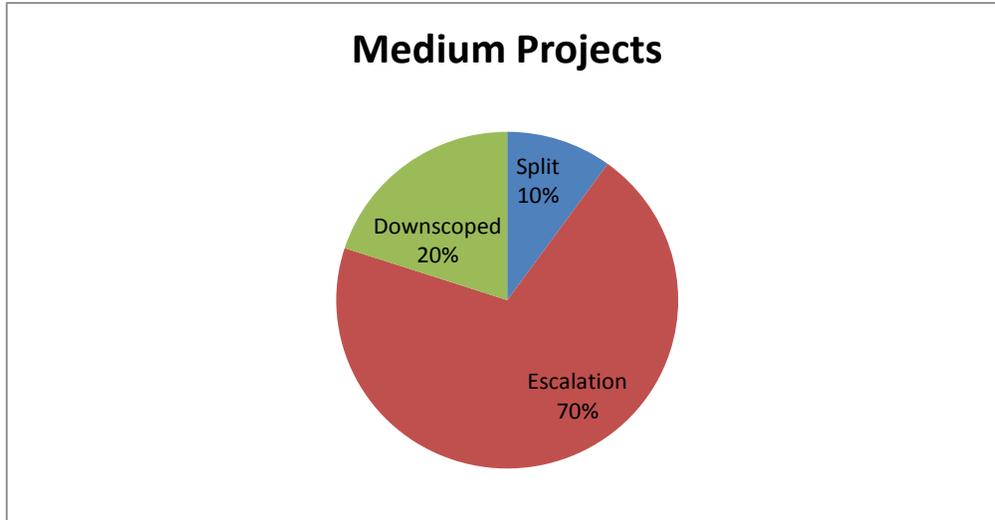


Figure 22. Chart. Breakout of Delayed Medium Size (5 to 10 Million Dollars) Projects

For the large size projects there is a different story. Per figure 23, the larger projects had a significant number of projects that were split. This is attributable, mostly, to the higher costs inherent in a larger project and thus the inclination to split those costs up.

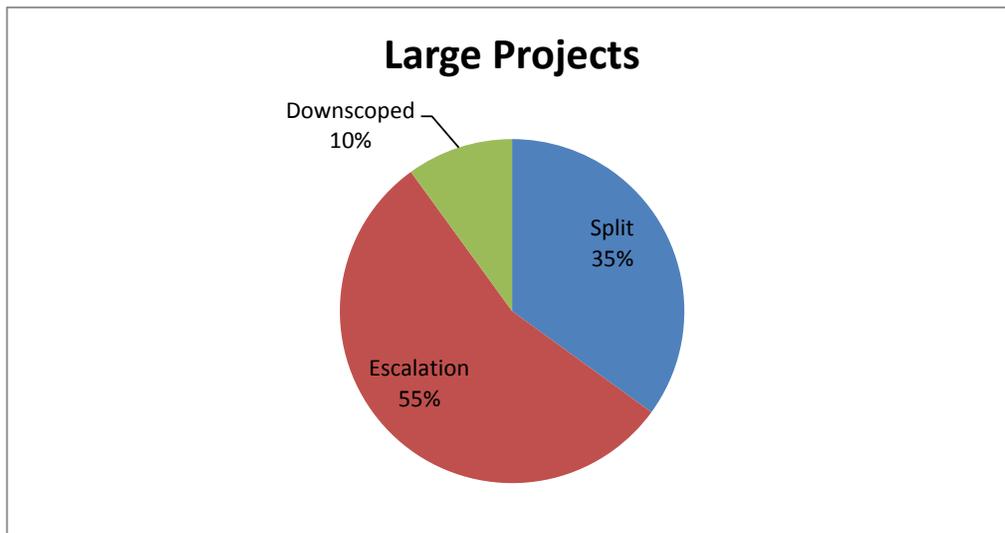


Figure 23. Chart. Breakout of Delayed Large Size (10 Million Dollars or More) Projects

When analyzing the large projects, it became apparent that as projects were delayed for 12, 15, or 20 years and as project cost estimates increased significantly by tens of millions of dollars, there was a strong tendency to split projects in half or even in quarters. Most often, road projects were split into northbound and southbound or eastbound and westbound lanes. Sometimes, as scope grew and side-road projects were added, the “add-ons” were later taken off. With each of these changes, the reduced cost of the split project helped balance the STIP in the short-term but had long-term cost impacts for the DOT. Thus, the split “penalty” appears to be a significant factor to consider when planning and making decisions about splitting large projects.

MANAGING RISKS IN THE PROJECT PIPELINE

In summary, table 6 shows the results that have been outlined above. In addition, the costs of crashes that occurred during the delays have also been calculated. Costs of crashes refers to when a highway project is delayed there are presumably crashes that can be attributable to that road treatment not being in place as anticipated. Hence, those costs have been calculated and are shown in table 6. Note that these costs have not been used subsequently in the simulation tool but, nonetheless, these are significant in the overall scheme of things as a societal cost of having projects delayed.

Table 6. Chart. Summary Table of Results

Costs of Revenue Shortfalls	Medium Size Projects	Large Size Projects	Remarks
Cost Escalation*	5.5%/yr (70% wt.)	5.8%/yr (55% wt.)	% over inflation
Split Penalties	85% (10% wt.)	103% (35% wt.)	% of total projects
Downscoped	TBD (20% wt.)	TBD (10% wt.)	Performance loss
Redesign Costs	TBD	TBD	Additive costs
Crashes -- costs per mi per year	\$33,800/mi/yr	\$42,500/mi/yr	Societal cost, not a direct paving loss
Interim Treatments	TBD	TBD	Additive cost
Other Costs **	TBD	TBD	Additive costs

* Average annual cost (% of project cost), usually from Scope Statement to Delivery, normalized into a per-yr cost over and above inflation (initial overall assumption was 5%)

** Regulatory, legal, ROW, stockpiling material, costs to other entities, etc.

The To Be Determined (TBD) cost factors for Down-scoped projects, Redesign Costs, Interim Treatments, and Other Costs are not able to be calculated currently due to lack of information available from internal tracking systems. These are costs that could be further tracked and analyzed if WYDOT would like to do so. Down-scope costs may include the cost of doing a less comprehensive treatment in the short term (resurfacing versus widen and overlay) and what the long term cost would be of not doing a more comprehensive road reconstruction or treatment.

Redesign Costs can also be a factor in delayed and/or split projects. When a project is delayed, there often appear to be new permits needed because they have expired or new environmental or other regulations that can come into play and increase costs. When a project is split, the PCS notes sometimes indicate that there is a new Reconnaissance Report needed or a delay occurs due to redesign issues. These could all be Redesign Cost factors.

Interim Treatment costs, when a project is delayed 10-15-20 or more years and needs interim treatments to keep the road condition stable, can also be calculated as a Holding Cost if the information is available.

MANAGING RISKS IN THE PROJECT PIPELINE

Components of the Split Penalty are worth examining, due to the high costs of delivering split projects. Costs that could perhaps be quantified for split projects include the cost of multiple manpower and equipment deployments when projects are split. In addition, the cost of increasing the scope on split projects should be considered. For example once a project is split, if additional revenue becomes available there appears to be a tendency to add-on to the split project with everything from Intelligent Transportation Systems (ITS) to bridge work to widening a road or adding a lane.

Other Costs, listed in table 6, were also identified as important, but difficult to quantify. These costs, along with all of the other costs identified here, could be significant factors to consider when updating the simulation and using the simulation to make future transportation planning decisions. These costs and components of cost are also topics of potential future research, due to the limitations of the present study.

MANAGING RISKS IN THE PROJECT PIPELINE

CHAPTER 5 CANDIDATE STRATEGIES: DEVELOPMENT OF STRATEGIES AND QUANTIFYING THEIR BENEFITS

5.1 CAUSAL DIAGRAM

Following the research on historical projects, it was necessary to step back and understand what the results of the research were portraying. Due to the complexities of project delivery dynamics, it was decided that a deeper understanding of the situation was needed. Therefore, based on the researchers’ experience in other complicated organizational systems, it was determined that there would be great value in constructing a “causal diagram” in order to dissect the various types of cause and effect relationships that might exist in this system. Figure 24 illustrates the cause and effect interactions that seem to create problems in delivering projects on time and as intended.

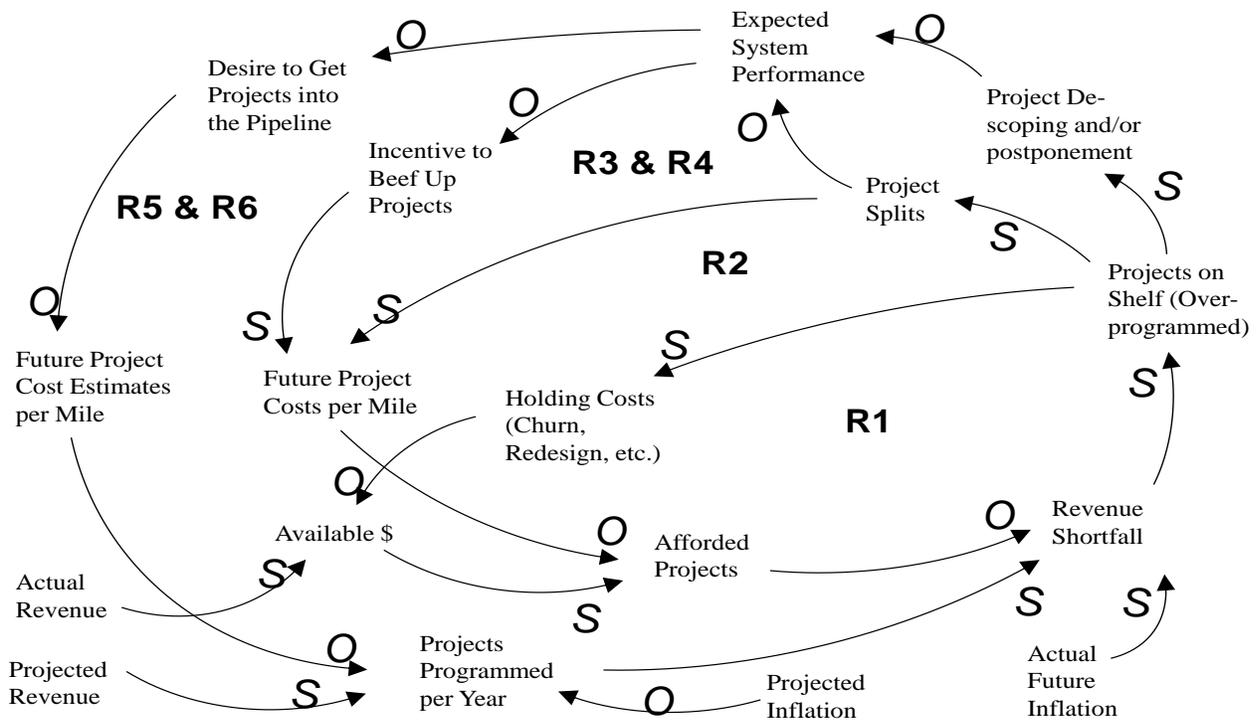


Figure 24. Illustration. Causal Diagram of Project Delivery Dynamics

The convention for the causal diagram is as follows:

- “S” means that the entity at the end of the arrow moves in the “same” way that the entity at the front end of the arrow does, such as “revenue shortfalls increase as actual future inflation increases”.
- “O” means that the entity at the end of the arrow moves in the “opposite” way that the entity at the front end of the arrow does, such as “projects programmed per year decrease as projected inflation increases”.

MANAGING RISKS IN THE PROJECT PIPELINE

- The “R” designation is when there is a “reinforcing loop”. In other words, the causality around a continuous loop works to strengthen the loop, rather than dissipate the influences around the loop. As you can see there are several R (reinforcing) loops at work in this diagram.

In examining the diagram, starting with “Revenue Shortfall” (on the right side of the diagram), this indicates that Revenue Shortfall can lead to projects building up on the shelf. When this happens, multiple changes can occur including project splits, project de-scoping, or postponement of projects. For example, projects are sometimes split in order to get the critical parts of key projects delivered. If projects are delayed, this often results in higher risks of scope growth which not only results in higher costs for the delayed projects but as these project costs increase, the delayed project is likely to bump additional projects and thus delay them as well. Another outcome is that projects can become obsolete and, due to their delay, may require redesign. This impacts costs because some of the design effort originally performed may not be entirely applicable anymore; hence there is a lost, sunk cost associated with a large percentage of redesigned projects.

The above mentioned outcomes from Revenue Shortfalls are validated by the research findings presented in the previous chapter. However, from this point on in the influence diagram several things can happen that have been observed by department personnel over the long-term, but were not researched in-depth as part of this study. It is believed that the effects of splitting projects, redesign, scope growth, and/or delaying projects may result in additional impacts such as: a) lower system performance over time, b) the incentive to beef up projects that have been committed to, and c) the incentive to keep early project cost estimates low so that these projects will have a better chance of getting the go-ahead. These dynamics, which involve human decision making and responses to events, may lead to fewer projects that can be afforded and more over-programming of projects. This, in turn, leads us back to where we started with revenue shortfalls.

Overall, these reinforcing dynamics appear to be quite strong. One can discuss or even dispute the relative strength of each causal link in the diagram, and this is where the analysis would naturally lead to next. Unfortunately, the scope of this study did not allow for further study of the human reactions and responses to the causal factors. Instead, the study effort moved on to identifying potential strategies to test with the simulation modeling tool.

5.2 CANDIDATE STRATEGY IDENTIFICATION

In an effort to distill the causal analysis and the results of the historical project research into a format that would be useful for strategy identification and development, it was decided that it would be helpful to “linearize” the causal diagram. The main objective for developing a cause, effect, results, and strategy table included the need to explain this complex subject matter and thus lay it out in a traditional manner that most people could understand and appreciate.

To begin the analysis, the causal diagram was utilized to identify entities or causes that would lead to results such as over-programming and revenue shortfalls. These entities include items such as inaccurate inflation projections, low project cost estimates, escalating project scope and cost, variable or uncertain funding, and inaccurate revenue projections. These items are found in the left-hand column of table 7 and are thus defined as Causes. The “Effects” of these causes are

MANAGING RISKS IN THE PROJECT PIPELINE

found in the next column; based on the causal diagram, this list includes items such as revenue shortfalls, project delays, and over-programming. Finally, these causes and effects lead to “Results”, which are shown in the third column.

Table 7. Chart. Strategy Development Tool

Causes	Effects	Results	Candidate Strategies
<p><u>Root Causes of Delays --</u></p> <p>Low project cost estimates Inaccurate revenue projections Inaccurate inflation projections Uncertain funding</p>	<p>Revenue shortfalls. Over-programming of projects</p>	<p>Project splits Cost Escalation Downscoping Project Delays Increased crashes Redesign costs Lower performance</p>	<p><u>Pipeline loading</u> Cost estimates (and updates) Projections (Inflation, Rev) Project mix and project size Project volume -- "go leaner" Use of projections (volume and timing of loading)</p>
<p><u>"Hurry Up" Projects --</u></p> <p>Volatile funding, Stimulus funds, "One-Time" infusions from the State, etc.</p>	<p>1R2Rs get attention and get delivered. 3R4Rs pile up on the shelf and risk being delayed</p>		<p><u>Design time reduction</u> Pipeline adaptability <u>"Critical Project" method</u> 3R4Rs held sacred "Pool" of 1R2Rs ready to go</p>
<p><u>Organizational Responses --</u></p> <p>Beefing up projects already in the pipeline Tendency to provide low estimates "Early PCS" approach</p>	<p>Continued over-programming and project delays</p>		<p><u>TAM process improvements</u> Formality, rigor, consistency. STIP information availability. Corridor plans, designs <u>Revenue "smoothing"</u> Fewer losses from volatility <u>Org. response fixes</u> Stop the systemic feedback <u>PCS enhancements</u> PeopleSoft integration</p>

The Results are the items that this study has focused on quantifying due to their costs and other impacts they have on the project pipeline. Therefore, the Results are the entities that are: a) simulated and quantified in the simulation tool – including delays, cost escalation and scope growth, and splits, or b) quantified separately by supporting analysis, such as the safety analysis for crashes, or c) were not analyzed during this study due to a shortage of time, and/or scarce or unavailable data.

In lieu of a full analysis of the Results items during this study, a set of applicable strategies or “Candidate Strategies” were identified as shown in the final column. This set of strategies was checked against the potential strategies identified in chapter 2, based upon the discussions with various stakeholders throughout the department. This comparison allowed the researchers to do a thorough assessment of the Candidate Strategies by using the earlier suggestions from the interviews.

In summary, building the Cause and Effect table yielded a credible list of candidate strategies to consider. Additional analysis was needed to determine what the benefits would be for each of

MANAGING RISKS IN THE PROJECT PIPELINE

the strategies, or which strategies would combine best with other strategies to provide the best overall system improvements.

5.3 SENSITIVITY STUDIES OF THE CANDIDATE STRATEGIES

Once the Baseline Case was defined, sensitivity analyses were performed by altering the strategies for draining the pipeline, loading the pipeline using different revenue projections, and altering design times for both 1R2R and 3R4R projects.

The following is the Baseline Case including cost factor and design time assumptions:

- Pipeline draining logic based upon delivering the 70/30 project mix in each year (70 percent minor rehabilitations (1R2Rs) and 30 percent major rehabilitations (3R4Rs)).
- Loading the pipeline using “Tracking” or actual funding for the next season.
- Design times for 1R2Rs and 3R4Rs:
 - Two years for 1R2Rs.
 - Four years for 3R4Rs.
- Factors used for Holding Costs:
 - 2 percent per year of the project cost for 1R2R projects.
 - 5.65 percent per year of the project cost for escalation costs for 3R4R projects.
 - 94 percent split penalty for 3R4R projects.
 - 60 percent of delayed 3R4R projects have cost escalation, and 40 percent are split projects.
- Hurry-Up inefficiencies for 1R2R projects:
 - 40 percent inefficiencies for accelerated projects (i.e. 60 percent of the funds are effectively spent on the projects).

The sensitivity analyses involved altering the following strategies:

- Draining the pipeline using the Critical Project Method versus using the Traditional Method of draining the pipeline proportionally (70/30 project mix). The Critical Project Method means paving the “critical projects” (3R4Rs) when they are ready to go and not holding them for any reason, and letting the 1R2R projects absorb the uncertainties in available revenue.
- Loading the pipeline using revenue projections of two years out versus simply “tracking” the available revenue for the next season and plugging in the corresponding amount of projects into the pipeline.
- Lowering the 3R4R design time from four years to two years.
- Explore a sensitivity of Hurry-Up costs, comparing results from 40 percent inefficiency with results from using 20 percent inefficiency.
- Penalty associated with holding 10 percent additional projects on the shelf. (This portion of the study is TBD).

The results for a High/Low funding scenario are as follows:

As shown in table 8, the “Baseline” case has almost 100 million dollars in losses over a 15 year period (97 million dollars). This is relative to an overall budget of 3 billion dollars over the

MANAGING RISKS IN THE PROJECT PIPELINE

15 year period. By reducing the design time of 3R4R projects from four years to two years, the result is a reduction in losses by 11 million dollars (or about 11 percent). The use of projected revenue (two years out), assuming the revenue projections and cost estimates are accurate, and that the projections are truly used in “loading the pipeline”, enables the greatest reduction in losses for the Baseline case. Of course, these assumptions are optimistic and would have to be carefully monitored and managed. Finally, for the Baseline case, if the inefficiencies for accelerating projects (Hurry-Up Costs) are reduced from a loss factor of 40 percent to just 20 percent, then the result is an overall loss of 80 million dollars.

Table 8. Chart. Sensitivity Study Results

Model Configuration	Option(s)	Losses in \$Millions
Baseline	none	97
Baseline	3R4R design time – 2 yrs	86
Baseline	Use of 2 yr projections	44
Baseline	Hurry Up Costs of 20%	80
Critical Project Method	none	68
Critical Project Method	3R4R design time – 2 yrs	68
Critical Project Method	Use of 2 yr projections	37
Critical Project Method	Hurry Up Costs of 20%	51
Critical Project Method	Projections and Hurry Up	27

Now compare the benefits of the Critical Project Method to the Baseline case. Just employing the Critical Project Method by itself results in about a 30 percent reduction in losses to 68 million dollars. Notice that the reduction in design time for 3R4R projects does not reduce the losses further. This is due to the inherent benefits of putting 3R4R projects on a “treadmill” and delivering them after four years, no matter what. This aspect of the Critical Project Method appears to decouple the design time from variations in funding for 3R4R projects for this particular funding profile and thus, there are no Holding costs associated with the 3R4R projects.

The use of two-year revenue projections enables the Hurry-Up costs to be reduced because of the advanced warning of funding fluctuations being in tune with the time delays associated with having 1R2R projects ready to go (e.g. from one to two years maximum). In summary, by combining all the strategies that are not overlapping in terms of benefits, the result is a loss of 27 million dollars versus 97 million dollars, or a total reduction of 70 million dollars (about 72 percent) in losses from the initial Baseline Case.

These results show that altering key strategy parameters can have a significant effect on surfacing outcomes and are worth considering in planning and managing risks in the project

MANAGING RISKS IN THE PROJECT PIPELINE

pipeline. For example, it is estimated that the total benefits of applying these strategies could enable an increase in surfacing by several percent. In other words, for the same amount of money a significant increase in surfacing could be accomplished.

5.4 OBSERVATIONS

What researchers observed:

- Altering several parameters, which can be controlled or improved to some extent, may increase surfacing accomplishments significantly with initial total estimates of between 2 and 4 percent.
- Reducing project design time is a significant strategy to consider even if no other new strategies are employed.
- Reducing Hurry-Up costs could allow more miles to be surfaced per year or more projects to be completed per year, especially during times of sudden, temporary increases in available funding (stimulus funds, federal or state special project funds, etc.).
- Utilizing funding projections in the logic for loading the pipeline and managing the overall balance of projects in the pipeline through time is fertile ground for significant improvements.
- The Critical Project Method is an important core strategy to consider in managing the project pipeline overall.
- Smooth funding is strongly preferred over Bumpy funding. In a perfect world where revenue streams are always constant, there would be no inefficiencies or losses due to too much or too little revenue and all projects that are ready to be delivered would be delivered on time. Taking steps to smooth out funding from year to year would allow the DOT to significantly increase miles paved and number of projects accomplished per year.
- Modeling different funding scenarios is very important for planning since the savings (above) are scenario dependent.
- Process improvement opportunities are numerous and need to be prioritized and implemented over time.
- Developing and using a dynamic simulation tool has been critical to this study and will be very important to use in planning and managing the project pipeline now and in the future.

CHAPTER 6 STUDY CONCLUSIONS AND RECOMMENDATIONS

6.1 COHERENT STRATEGY APPROACHES

Based upon the candidate strategies developed in chapter 5 and the results of the sensitivity study, a core strategic approach is presented and examined in this chapter, as well as recommendations for further research that were out of scope for the current study.

In chapter 5, a series of strategies were identified and explored, but no coherent overall strategy was presented. Such a core strategy would be useful in making comparisons with the current Baseline approach to operating the project pipeline. A core strategy would involve tying together the somewhat separate strategies presented in the previous chapter and capitalizing on their combined effects.

As shown in figure 25, there are costs in programming either too many projects or too few projects. Having too many projects ready to go is referred to as being “over-programmed.” This means there is not enough money to fund projects that are ready to be delivered and there are significant Holding Costs when projects sit on the shelf. When there are not enough projects ready to go, this is called being “under-programmed.” This means there is an excess of available funds relative to the projects that are ready to go. Similar to being over-programmed, there are costs to being under-programmed. For example, accelerating project design in order to “use or lose” funding is just one of the Hurry-Up Costs.

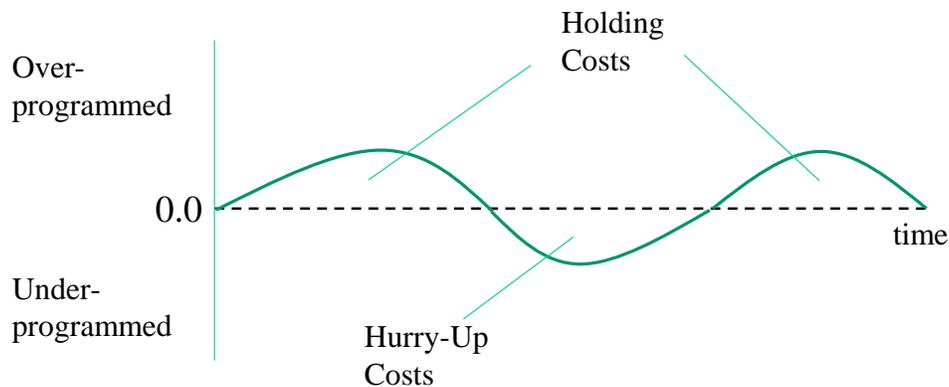


Figure 25. Graph. Over-Programming and Under-Programming of Projects

The costs illustrated in figure 25 are typical of what is referred to as the Baseline Case. In this case, Holding Costs are historically high due to shortfalls in revenue and the resulting project delays, split projects, scope growth, and project redesigns. The causes of these shortfalls in revenue include low project cost estimates, inaccurate projections of inflation and available revenue, and volatility of available revenue from year to year. In addition, policies regarding the loading and management of the project pipeline can also be a factor, such as having somewhat arbitrary targets that promote or encourage keeping projects on the shelf.

MANAGING RISKS IN THE PROJECT PIPELINE

The following list contains attributes of the Baseline Case:

- Target dollar amounts of projects to keep on the shelf.
- Draining the pipeline in order to deliver a target mix of minor versus major rehabilitations each year (such as enforcing a 70/30 ratio for annual dollars spent on minor versus major rehabilitations according to recommendations from the pavement analysis).
- Acceleration of 1R2Rs driven by an influx of excess funds and the need to spend the additional funds.
- Project management practices prior to 2009 at WYDOT and hence losses from inaccurate cost estimates and significant penalties from project splits, scope growth, project redesign, etc.
- Loading the pipeline per practices up until 2009 (involving how projected revenue is utilized in pipeline loading, how inflation rates are projected and updated, and how project cost estimates are made and updated).

The outcomes from following the practices related to the Baseline Case are illustrated in figure 26. The primary costs related to Holding Costs and Hurry-Up Costs are listed. As an example, the costs associated with project splits are significant. Therefore, when there is a shortfall of revenue in a given year, the splitting of projects can be a very costly choice.

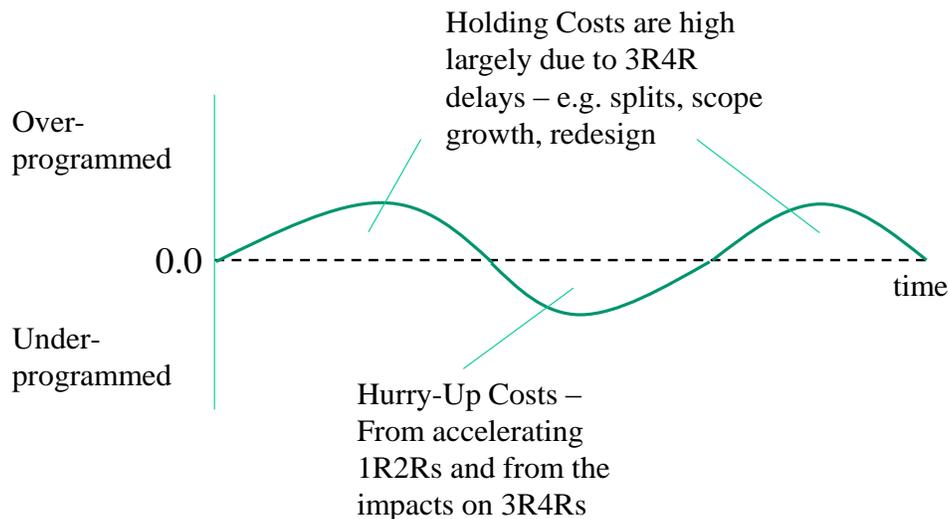


Figure 26. Graph. Components of Holding Costs and Hurry-Up Costs

As a result of this study, alternative strategies to manage the project pipeline are being recommended. A core part of these strategies is to use what is referred to as the Critical Project approach, which utilizes a radically different philosophy that minimizes the amount of 3R4R projects that are on the shelf. The Critical Project Method accomplishes this by keeping 3R4R projects “sacred” and pulling these projects out of the project pipeline for delivery on time and as originally intended. This is an alternative to enforcing a desired project mix target on an annual basis. Instead, this approach assures that the higher cost and longer lead time projects are

MANAGING RISKS IN THE PROJECT PIPELINE

delivered as originally intended and on time. The Critical Project policy reinforces that 3R4R projects should never sit on the shelf. Thus the attributes of the Critical Project approach are as follows:

- Keep the major rehabilitation projects (3R4Rs) sacred.
- Keep the 3R4Rs on schedule and deliver them on time and as intended when they were originally programmed (same scope, objectives, and same delivery date).
- Maintain a pool of 1R2Rs ready to go in order to backfill any shortage in projects that are ready for delivery.
- Do not keep or plan to keep 3R4R projects on the shelf, as these are costly in terms of Holding Costs.
- 1R2R projects are much better suited, due to their cheaper design and development costs, to bear the brunt of funding uncertainties.

The results from utilizing the practices associated with the Critical Project approach are illustrated in figure 27. The primary cost savings are related to the reduction in Holding Costs due to lower costs of projects that are delayed, split, or redesigned.

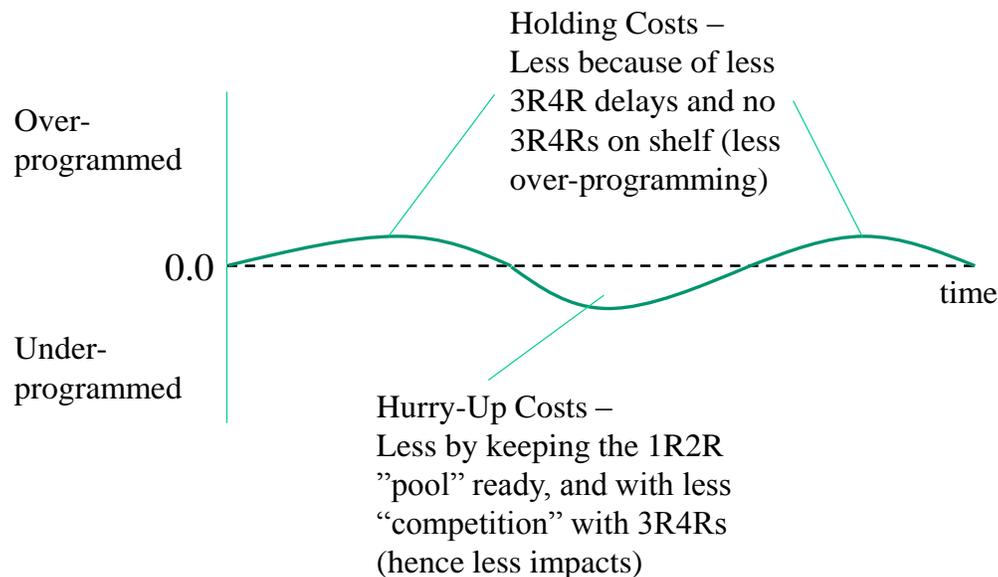


Figure 27. Graph. Strategies that Reduce Holding Costs and Hurry-Up Costs

In table 9 (shown also in chapter 5), the benefits of adopting an alternative strategy from the Baseline Case are shown. The data are for a 15-year scenario and the losses that occur during that timeframe are listed. Specifically, for a 3 billion dollar overall budget for the 15-year period, and for a HighLow revenue profile, these "losses" are the dollar amounts of projects that do not get delivered due to the Holding and Hurry-Up costs described earlier. In other words, the losses are the amounts of paving that could have been accomplished if there were no Holding or Hurry-Up costs.

MANAGING RISKS IN THE PROJECT PIPELINE

Note that for the Baseline Case, and a representative funding scenario, the losses over the 15 years amount to 97 million dollars. Compare that to the Critical Project Method, where the losses are two-thirds as much or 68 million dollars. The savings are about 30 million dollars.

Table 9. Chart. Sensitivity Study Results

Model Configuration	Option(s)	Losses in \$Millions
Baseline	none	97
Baseline	3R4R design time – 2 yrs	86
Baseline	Use of 2 yr projections	44
Baseline	Hurry Up Costs of 20%	80
Critical Project Method	none	68
Critical Project Method	3R4R design time – 2 yrs	68
Critical Project Method	Use of 2 yr projections	37
Critical Project Method	Hurry Up Costs of 20%	51
Critical Project Method	Projections and Hurry Up	27

6.2 ADDITIONAL SUB-STRATEGIES

Since the Critical Project Method appears to provide the foundation of a valuable core strategy, the question becomes, “Which other sub-strategies would complement this core strategy?” It does not appear that shortening the 3R4R design time cycle would be a significant benefit, at least not for this particular revenue profile. The other two sub-strategies would, however, complement the core strategy significantly. By making use of the two year projections and by lessening the Hurry-Up cost inefficiency from 40 to 20 percent (if possible) this would reduce the overall losses considerably and result in a total loss that is only a fraction of the Baseline Case (i.e. 27 million dollars for this revenue profile).

To summarize, the core strategy that is recommended is as follows:

- Utilize the Critical Project Method for defining the overall operation policies for the project pipeline.
- Strive to make accurate revenue projections out two years and load the pipeline accordingly. This approach also entails making good projections of inflation and updating these projections. Finally, project cost estimates must be sound, and be monitored and updated, especially within the three to four year window prior to the year of project delivery.

MANAGING RISKS IN THE PROJECT PIPELINE

- Lowering the costs of accelerating projects (Hurry-Up Costs) from 40 percent of the accelerated project values to 20 percent by maintaining a pool of prioritized 1R2R projects that are ready to go.

By combining these strategies as part of the Critical Project approach, the total estimated losses can be reduced to less than 30 million dollars. This represents a 67 million dollar savings over 15 years, or about 2.2 percent of the overall budget.

6.3 CONCLUSIONS

Significant savings in delivering highway projects can be possible by implementing the recommendations from this research. By minimizing the amount of projects held on the shelf, and employing practices that minimize the risks of incurring Holding Costs due to revenue shortfalls, these savings can be maximized. Shifting the burden of impacts due to revenue uncertainties from major rehabilitation projects to minor rehabilitation projects can provide a sound and powerful method for improving the risk management of the project pipeline.

In addition to the conclusions provided above, there are several areas of further work and research that are recommended. These are listed below.

6.4 KEY OPPORTUNITIES – PROCESS IMPROVEMENTS AND RECOMMENDED RESEARCH

6.4.1 Process Improvements:

- Critical Project Method implementation.
- Design process improvement—cycle time reduction for 3R4R projects.
- Explore options for smoothing out Bumpy funding.
- Run “what if” scenarios (and create tradeoff parametrics):
 - To prioritize and support implementation of process improvements and on-going planning activities.
- Analyze and improve PCS integration with PeopleSoft.
- Optimize loading of the pipeline:
 - Cost estimating/updates, revenue and inflation projections, use of projections, trade off loading the shelf versus running leaner, etc.
- Multi-program process improvements and implementations (overall organizational):
 - PCS, Design, TAM/Planning, Districts, ROW, Materials Lab, etc.
- Minimize negative feedback in the system (organization responses).

6.4.2 Research:

- Research project splits—the inefficiencies, cost escalation component, corridor plans and impacts, optimum project length/cost (tradeoff spreading fixed costs versus the risks of being split), and scope growth post-split.
- Examine the components of project cost escalation (inaccurate project cost estimates, scope creep that is useful, scope creep that is not useful, bad inflation predictions, no updates of inflation or cost estimates, etc.).

MANAGING RISKS IN THE PROJECT PIPELINE

- Uncertainty Factor Analysis and Monte Carlo Algorithm—price volatility, inflation, political priorities, legal issues, regulatory issues, etc.).
- Simulation tool—add capability into model regarding uncertainty factors.
- Conduct pipeline loading analysis and use of revenue projections.
- Impacts of Hurry-Up projects—1R2Rs and the delay risks for 3R4Rs.
- Determine whether project cost estimates are getting better:
 - What has been done to date, can we measure progress/accuracy of estimates, etc.
- Explore adding other conveyor belts to model (design’s list, emergency projects)
- Crashes—deeper analysis of the components of each project, and what dollars were for safety (crash reductions).
- Follow up on the causal analysis by examining the human responses to project delays and revenue shortfalls, project splits, and redesigns. Research the effects on cost estimates and scope growth among committed projects.
- Redesign costs—gather and analyze historical information on these costs.

6.5 CONTINUING RESEARCH AND DEVELOPMENT OF THE SIMULATION MODEL

The following is a more detailed description of the two recommended research and development areas to be done on the simulation model.

Monte Carlo Addition to the Model – Determine the historical ranges of Uncertainty Factors and their impacts on project deliveries. These factors include political priorities, material cost volatility, labor cost variability, legal challenges, right-of-way, and environmental issues. The overall future research would enable the calculations and results from the simulation tool to become more reliable and accurate.

In order to appropriately include the Uncertainty Factors into the analysis and to provide for a confidence level around the results of the overall analysis, a Monte Carlo routine is being prepared for the pipeline cost calculations for projects that are either delayed or accelerated. The various factors of uncertainty will be considered together in the simulation and the results of this will be an overall range of uncertainty in pipeline costs, and also a range of uncertainty in the amount of projects that can be delivered per each funding scenario. For example, the results will be displayed with a statistical range, with a percent confidence in the results; such as “a 90 percent confidence level that the resulting projects delivered will be between X and Y over a ten year period”.

Use of Revenue Projections – It will be important to tie projected funding and what is known about it to the amount of projects loaded into the pipeline year-by-year. Initial analyses have shown that using two-year projections instead of one-year projections for loading the pipeline can provide significant benefits. Therefore, this topic should be further explored. Other aspects of Revenue Projection strategies also need to be explored regarding project cost estimates, updates of these estimates, inflation predictions, updates of these predictions, and other factors including data that are available, or should be made available, to all segments of the organization.

CHAPTER 7 STRATEGY IMPLEMENTATION — MODEL, MEASURE, MANAGE

The recommended strategies defined in chapters 2, 5, and 6 should provide significant improvement in project deliveries over time. However, in order to reap these benefits with confidence, the implementation of the new strategies should be managed properly. The process suggested for this effort is “Model, Measure, Manage”. This approach has been used extensively by the authors in the past, including the implementation of new strategies at Fortune 500 companies. Model, Measure, Manage considers the recommended strategies, the anticipated benefits, and connects these strategies with actual results over time. This process not only measures success, but maximizes the ability to retarget, adjust, or change strategies as appropriate.

7.1 MODEL, MEASURE, MANAGE AND CONTINUOUS IMPROVEMENT

The Model, Measure, Manage process is a very useful management practice that guides an organization towards continuous improvement. By modeling a situation and then measuring how things are progressing over time, it is then possible to “manage” accordingly. The “model” provides the framework for analyzing the situation and the “measures” allow the analyst to monitor what the various indicators are showing. If the indicators do not match what the model has predicted, then there is room for learning and improving the model. According to what is learned, process improvement strategies can also be adjusted.

Steps in this process include the following:

1. Create a causal diagram of the situation.
2. Identify Leading and Lagging Indicators for the strategies to be implemented.
3. Create a model of the situation, such as the Project Pipeline Simulator.
4. Implement the recommended strategies.
5. Track all indicators – Leading and Lagging.
6. As the future unfolds, keep the simulation updated with current information.
7. Note the differences between the model outputs and the actual Lagging Indicators.
8. Determine the reasons for discrepancies (inaccurate inputs, incorrect calculation relationships, etc.), and adjust the simulation model accordingly.
9. Adjust the strategies, if applicable, according to the lessons learned.
10. Perform additional research to verify assumptions in the original analysis.

7.2 REVIEW OF RECOMMENDED STRATEGIES

In an effort to distill the causal analysis and the results of the historical project research into a format that would be useful for strategy identification and development, it was decided that it would be helpful to “linearize” the causal diagram as shown in table 10. The objectives for developing a table of cause, effect, results, and strategy included the need to explain the complex subject matter and thus lay it out in a more traditional manner that more people could understand and appreciate. The summary of the strategies that have been derived during this study are in the column on the far right.

MANAGING RISKS IN THE PROJECT PIPELINE

Table 10. Chart. Strategy Development Tool

Causes	Effects	Results	Candidate Strategies
<p>Root Causes of Delays --</p> <p>Low project cost estimates Inaccurate revenue projections Inaccurate inflation projections Uncertain funding</p>	<p>Revenue shortfalls. Over-programming of projects</p>		<p>Pipeline loading Cost estimates (and updates) Projections (Inflation, Rev) Project mix and project size Project volume -- "go leaner" Use of projections (volume and timing of loading)</p>
<p>"Hurry Up" Projects --</p> <p>Volatile funding, Stimulus funds, "One-Time" infusions from the State, etc.</p>	<p>1R2Rs get attention and get delivered. 3R4Rs pile up on the shelf and risk being delayed</p>	<p>Project splits Cost Escalation Downscoping Project Delays Increased crashes Redesign costs Lower performance</p>	<p>Design time reduction Pipeline adaptability "Critical Project" method 3R4Rs held sacred "Pool" of 1R2Rs ready to go</p>
<p>Organizational Responses --</p> <p>Beefing up projects already in the pipeline Tendency to provide low estimates "Early PCS" approach</p>	<p>Continued over-programming and project delays</p>		<p>TAM process improvements Formality, rigor, consistency. STIP information availability. Corridor plans, designs Revenue "smoothing" Fewer losses from volatility Org. response fixes Stop the systemic feedback PCS enhancements PeopleSoft integration</p>

There are two major categories of strategies that are recommended for implementation. These include the Core Strategies identified in chapters 5 and 6, and the System and Organizational Improvement Strategies identified in chapter 2.

7.2.1 Core Strategies

Model

The Core Strategies were developed after modeling the project pipeline dynamics, analyzing the causal diagram, and determining what strategies would be helpful to positively influence the system dynamics in the project pipeline. In table 10, these strategies fall under the categories of Pipeline loading, Design time reduction, "Critical Project" method, TAM process improvements, Revenue smoothing, Organization response fixes, and PCS enhancements.

- Pipeline loading:
 - Improve project cost estimates and updates—analyze recent estimates to determine whether estimates are getting better and what the remaining barriers might be to making estimates that more accurately predict final costs, such as periodic updating of estimates.
 - Revenue and inflation projections—by making and utilizing revenue projections, the Project Pipeline can be loaded according to anticipated revenues. Through

MANAGING RISKS IN THE PROJECT PIPELINE

simulations, this has been shown to be a significant method for reducing pipeline losses.

- Have better projections of inflation and revenue.
- Optimize project mix and project size.
- Project volume—go leaner and keep fewer projects on the shelf.
- Use of projections—try to make revenue projections one or two years out and that will dramatically improve project deliveries and decrease losses.
- Design time reduction—Design cycle time reduction for major rehabilitations (3R4Rs) will increase pipeline adaptability.
- Critical Project Method:
 - There are anticipated benefits of having fewer projects on the shelf and, instead, running “leaner” and keeping the major rehabilitations (3R4Rs) sacred to be delivered on time and as intended.
 - Pool of minor rehabilitation projects (1R2Rs)—Have more minor rehabilitation projects ready to go and avoid the cost of having to accelerate 1R2R projects.
- TAM process improvements:
 - Improve the formality, rigor, and consistency of PSR, Scope Statements, and Scope Amendments.
 - Ensure STIP information availability.
 - Corridor plans help determine project size and timing, and make plan visible and transparent.
- Revenue smoothing:
 - If you have constant funding you have less loss in delayed project deliveries.
 - Work with legislature towards more predictable funding.
- Organization response fixes:
 - Minimize the downward spirals found in the causal diagram (figure 28).
- PCS enhancements:
 - Potential technical improvements can provide further cost savings (See chapter 2, 2.3.4 Project Control System (PCS) Opportunities.

The Case for Measures

In order to implement the strategies, it is necessary to identify measures to manage and track their implementation. This is important not only for the initial rollout of these strategies, but for managing over the long-term as well. Like managing a business, the effectiveness of strategies, especially new ones, needs to be monitored over time, and the strategies need to be updated or adjusted based upon the learning that will inevitably occur.

A useful tool that was developed during the study and described in chapter 5 is shown in figure 28. This causal diagram was instrumental in understanding the complex situation that was central to this study and in deriving strategies for improvement. Not surprisingly, due to the nature of the diagram, it is also very useful in identifying the indicators (measures) that should be employed in managing the implementation of the recommended strategies.

MANAGING RISKS IN THE PROJECT PIPELINE

The convention for the diagram is as follows:

- “S” means that the entity at the end of the arrow moves in the “same” way that the entity at the front end of the arrow does, such as “revenue shortfalls increase as actual future inflation increases”.
- “O” means that the entity at the end of the arrow moves in the “opposite” way that the entity at the front end of the arrow does, such as “projects programmed per year decrease as projected inflation increases”.
- The “R” designation is when there is a “reinforcing loop”. In other words, the causality around a continuous loop works to strengthen the loop, rather than dissipate the influences around the loop. As you can see there are several R (reinforcing) loops at work in this diagram.

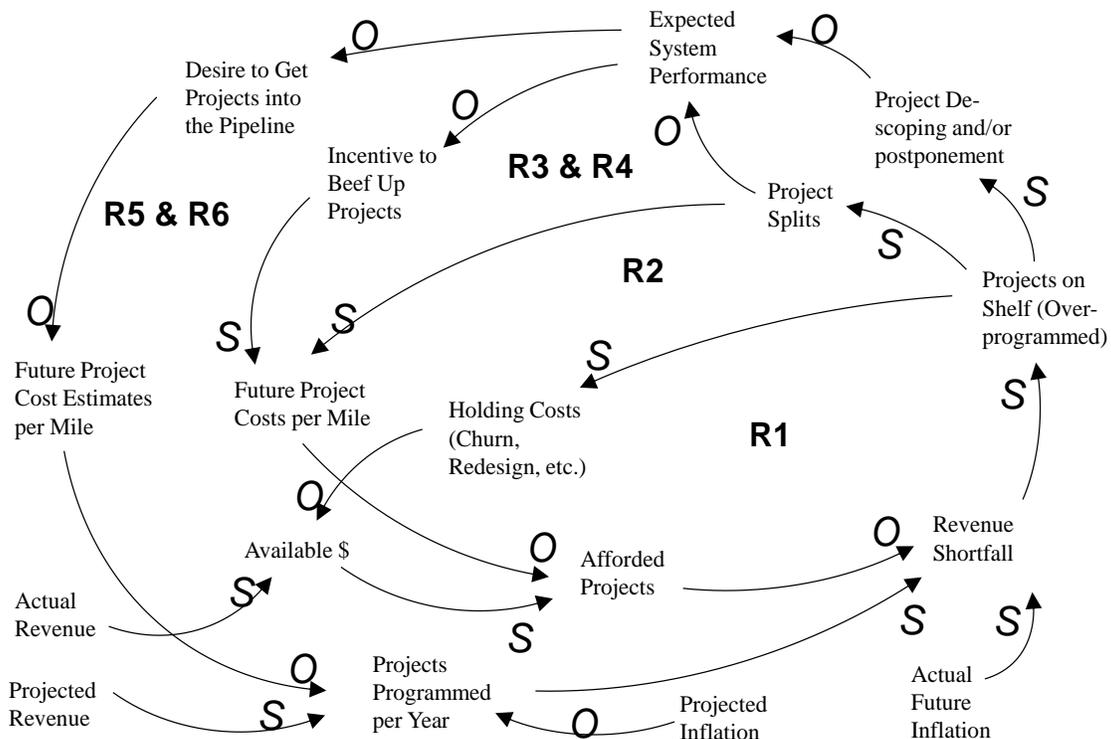


Figure 28. Illustration. Causal Diagram of Project Delivery Dynamics

The central issue of this study was whether there is a mismatch, annually, between available revenue and projects that are ready to go. The system entity of “Revenue Shortfall” is shown on the diagram, and is the measure of this revenue-to-project mismatch. Shown in the diagram are several things that influence Revenue Shortfall, and these are referred to here as “Leading indicators”. In other words, these system entities either cause the amount of Revenue Shortfall to increase or to decrease. Similarly, there are the “effects” that result from either a positive Revenue Shortfall (or a negative one, which would be a revenue surplus). These are referred to here as “Lagging indicators”.

MANAGING RISKS IN THE PROJECT PIPELINE

It is recommended that these two sets of measures, Leading and Lagging indicators, should be monitored during the implementation of the core strategies. The Leading and Lagging indicators identified in the study are listed here.

Leading indicators include:

- Projected inflation versus actual inflation—Inflation affects whether projects will be under-programmed or over-programmed in the pipeline.
- Projected revenue versus actual revenue amounts. If projected revenues are used for loading the pipeline, this is a key factor to monitor and improve upon.
- Programmed amounts versus revenue projection—It is essential to track what is actually programmed each year for the future years, in order to look back and determine whether the pipeline was under-programmed or over-programmed.
- Scope growth over and above inflation rate—It is important to determine, after inflation has been subtracted out, what the scope growth has been for a sample of projects. In the past, this has been a major contributor to over-programming.
- Number of projects purposefully put onto the shelf—Preparing projects and putting them on the shelf has led to financial losses due to the costs of project delays, splits, etc. This quantity is a visible indicator of policies and a contributing cause of over-programming.
- Adherence to the Critical Project Method, if it is adopted, and to what extent it is implemented (e.g. by the number or percentage of 3R4Rs that do not get bumped or delayed).
- Accuracy of project cost estimates—Are they getting better? Chronically low project cost estimates are a leading cause of project delays, etc. This is a major leverage point for improving the project delivery process.

An example of a useful tool for tracking these indicators is the project cost estimate tracking tool developed for this study and shown in figure 29 (this tool is described in chapter 4 in further detail). The tool allows the analysis of cost estimates from the Program Study Report (PSR), through additional estimates found in the Scope Statement and Scope Amendments, until the delivery of a project. This tool can be utilized to track a sample of projects in order to determine whether the cost estimating capabilities of WYDOT are improving.

MANAGING RISKS IN THE PROJECT PIPELINE

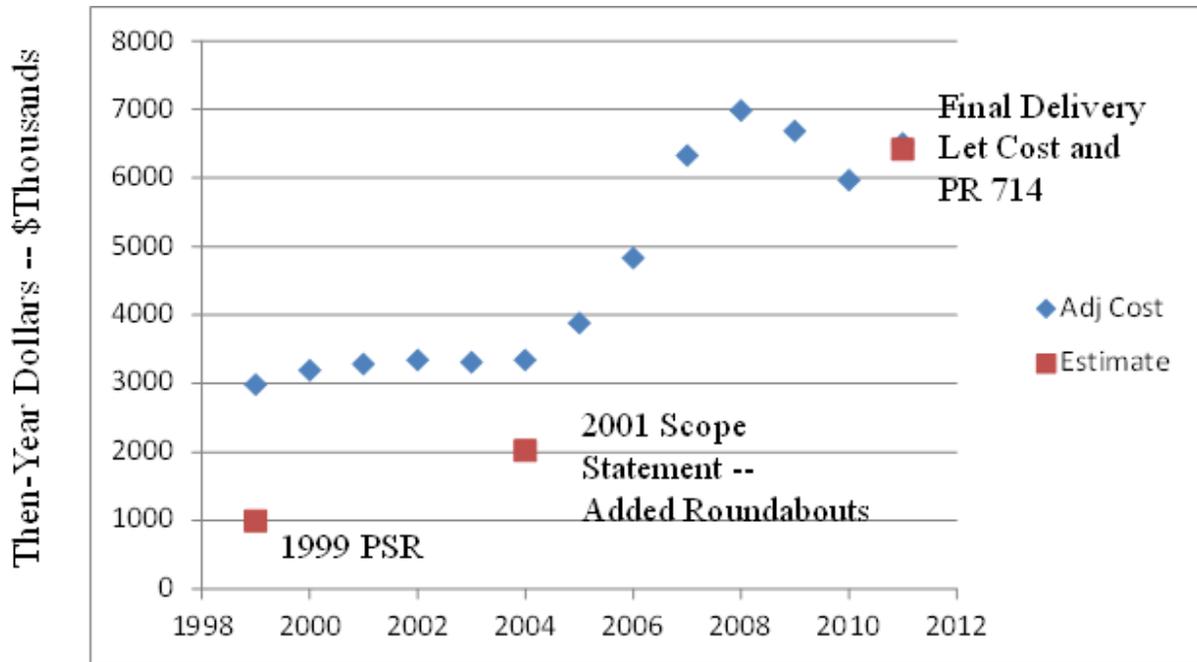


Figure 29. Graph. Project Cost Estimate Tracking Tool

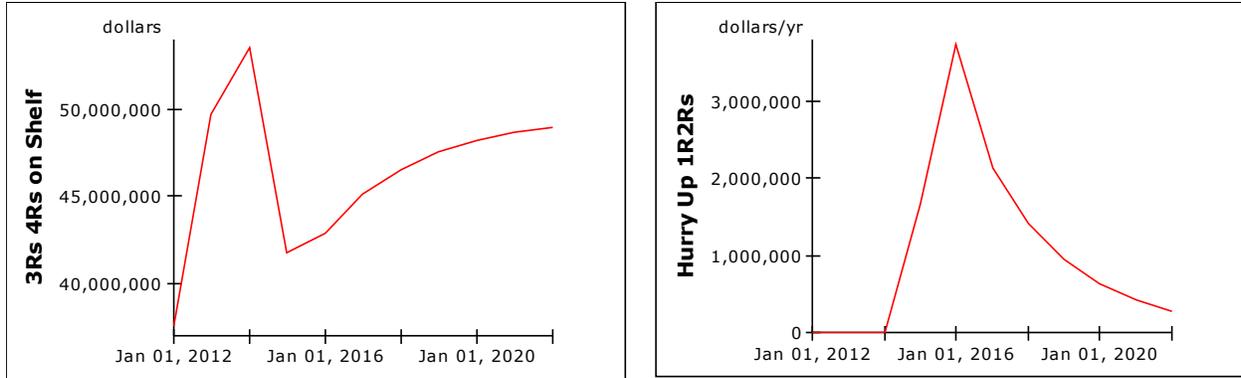
In addition to monitoring the Leading indicators, it will be important to track the Lagging indicators. The Lagging indicators will measure the “effects” of the leading indicators, in terms that are more directly linked to the goals of the department.

Lagging indicators include:

- Excess projects on the shelf—this is basically a measure of on-going amounts of projects that are not getting delivered, and are the source of costs over time.
- Number and cost of projects that have been delayed over 5 years—in the past WYDOT had built up a significant amount of “project baggage”, and this amount is a key proxy for costs to the department in projects not being delivered on time and as intended.
- Number of project splits (dollar amounts of split projects versus original estimates)—project splits are very costly, and a key contributor to losses related to project delays and revenue shortfalls.
- Numbers of projects that are down-scoped or redesigned due to delay—these indicators are also key indicators of project delays and proxies for the losses in performance related to project delays and revenue shortfalls.
- Number of minor rehabilitation projects that have been accelerated—this amount is an indicator of excess revenue. When there is more revenue than what was anticipated in any given year, it has been an organizational practice that minor rehabilitation projects have been accelerated in order to spend all of the funds available. The amount and efficiencies of these project accelerations is a key measure to monitor.

As an example of these indicators, figure 30 shows two of the above-mentioned measures – major rehabilitation projects on the shelf (3R4R projects) and the amount of accelerated projects (1R2R projects) by year.

MANAGING RISKS IN THE PROJECT PIPELINE



3R4R Projects on the Shelf

Accelerated 1R2R Projects

Figure 30. Illustration. Examples of Lagging Indicators

In addition, regarding the number of delayed projects, tables of project delivery information such as Percentage of Large and Medium Projects Delayed 8 years or More as shown in table 11 and table 12 can be used to determine how progress is being made in reducing the number and duration of delayed projects over time. This information should be monitored on an annual basis.

Table 11. Chart. Percentage of Large Projects (10 Million Dollars or More) Delayed 8 years or More*

District	Already LET % Delayed 8yrs+	To Be Let (TBL) % Delayed 8yrs+	Overall Average % Delayed 8yrs+
1	80% (12:15)**	78% (7:9)	79% (19:24)
2	67% (14:21)	78% (7:9)	70% (21:30)
3	67% (12:18)	69% (9:13)	68% (21:31)
4	50% (8:16)	100% (20:20) (average # years delayed = 19)	78% (28:36)
5	87% (13:15)	75% (6:8)	83% (19:23)
Overall WYDOT Averages of Projects Delayed 8 or More Years	70%	80%	76%

* Based on STIP information as of June 2013

** (Projects Delayed : Total Projects) Based on STIP information from 1980-2013

MANAGING RISKS IN THE PROJECT PIPELINE

Table 12. Chart. Percentage of Medium Projects (5 to 10 Million Dollars) Delayed 8 years or More*

District	Already LET % Delayed 8yrs+	To Be Let (TBL) % Delayed 8yrs+	Overall Average % Delayed 8yrs+
1	48% (19:40)**	28% (8:29)	39% (27:69)
2	28% (10:36)	44% (8:18)	33% (18:54)
3	62% (18:29)	17% (1:6)	54% (19:35)
4	59% (31:53)	53% (9:17)	57% (40:70)
5	44% (10:23)	62% (8:13)	50% (18:36)
Overall WYDOT Averages of Projects Delayed 8 or More Years	48%	41%	47%

* Based on STIP information as of June 2013

** (Projects Delayed : Total Projects) Based on STIP information from 1980-2013

Manage

Tracking, monitoring, and analyzing the measures, including both leading and lagging indicators, will allow managers to manage the implementation and adjust strategies according to lessons learned.

7.2.2 System and Organizational Improvement Strategies

The other major category of strategies to be implemented is the System and Organizational Improvement Strategies. These strategies help support the Core Strategies and can be implemented at the same time. They also can be managed using the Model, Measure, Manage process.

Model

Modeling the organization's systems is a key step in understanding how the organization currently operates. Again, causal diagramming is a useful tool to model organizational interactions from how departments interact with each other to how well operations within a department are working. Determining what factors influence each other, what drives positive and negative reinforcing dynamics, and what and where the leverage points are in the system allows management to make changes in policies, procedures, and how the organization operates. This can lead to significant financial savings and greatly improve how the organization functions.

MANAGING RISKS IN THE PROJECT PIPELINE

Potential System and Organizational Improvements

As outlined in chapter 2, there are several areas that were identified for potential system and organizational improvement. Trends and issues were documented as research on historical projects was done and as interviews were conducted within the organization. Table 13 contains some of the areas where process improvements could help the organization operate more efficiently and effectively. In the first column of table 13 the Trends/Issues are identified, in the second column the Potential Problems that may arise from a trend or issue are outlined, and in the last column the Process Improvements are defined.

Table 13. Chart. System and Organizational Trends/Issues, Potential Problems, and Process Improvements

Trend/Issue	Potential Problems	Process Improvement
<p>Organizational Trends</p> <p>Policies and procedures produce unintended consequences that reduce organizational efficiency and effectiveness.</p>	<ul style="list-style-type: none"> • System dynamics create incentives to: <ul style="list-style-type: none"> -Put excess numbers of projects “on the shelf”. -Increase scope of projects. -Split projects. -Underestimate project costs. -Delay projects, etc. 	<ul style="list-style-type: none"> • Model the system dynamics of the organization’s policies and procedures. • Identify leverage points in the system to alter the dynamics and create positive, reinforcing cycles. • Change or adopt new policies and procedures to positively affect the system dynamics.
<p>Pockets of unclear roles and responsibilities across the organization (departments, districts).</p>	<ul style="list-style-type: none"> • Duplication of efforts across the organization. • Questions about who “owns” projects in the pipeline at different times in the life cycle: Planning, Project Design and Development, Contracts and Estimates, ROW, Environmental; District Engineers, Resident Engineers, Design Leads, Consultants, etc. • Questions about how districts can communicate their priorities, needs, and expectations. 	<ul style="list-style-type: none"> • Analyze the critical path for projects by mapping “who provides what to whom”. • Determine how delays in the process affect critical path. • Clarify the roles and responsibilities across the organization to reduce or eliminate duplication of effort, and determine where shared accountability might be useful in the system (ex: shared accountability between the resident engineer and designer to ensure projects stay on a critical path or timeline.

MANAGING RISKS IN THE PROJECT PIPELINE

Trend/Issue	Potential Problems	Process Improvement
<p>Transportation Asset Management (TAM) Trends</p> <p>Allowing or encouraging “Early PCS” for projects</p>	<ul style="list-style-type: none"> • More and more projects are on the shelf waiting for delivery and incurring holding costs. • Encourages gaming the system to get more projects and money for a district. • Encourages adding scope to projects. • Encourages low-ball estimates of project costs. 	<ul style="list-style-type: none"> • Re-think the Early PCS process and determine how to minimize Holding Costs while still having enough projects ready to go. • Look at allowing more 1R2R projects to be “on the shelf” and the possibility of implementing the Critical Project Method for 3R4R projects.
<p>Formality, rigor, and consistency of PSR, Scope Statements, and Scope Amendments can vary widely between projects and between districts.</p>	<ul style="list-style-type: none"> • Inconsistent information and tracking about changes in cost estimates, project scope changes, reasons for splitting projects, etc. 	<ul style="list-style-type: none"> • Determine how loose or tight the paperwork process (PSR, Scope Statements, Scope Amendments, etc.) should be, and develop and implement guidelines.
<p>Use of email to document changes in project scope, estimated cost increases/decreases, project splits, etc. versus using Scope Amendments/Addenda.</p>	<ul style="list-style-type: none"> • Less clarity about why projects change. • Makes project changes easier/less formal which can increase volatility in project planning/design/delivery. • Without Scope Amendment, no rationale is apparent for increase/decrease in cost estimates. • Unexplained project changes can cause system ripples throughout the planning and design organizations. 	<ul style="list-style-type: none"> • Determine optimum amount of rigor versus flexibility desired in the Scope Amendment process and develop and implement clear guidelines for districts and departments to follow.

MANAGING RISKS IN THE PROJECT PIPELINE

Trend/Issue	Potential Problems	Process Improvement
<p>TAM Trends</p> <p>Multiple project scope changes (increase and/or decrease in scope) cause ripples throughout the planning and design organizations and across districts.</p>	<ul style="list-style-type: none"> • Scope changes can create delays in one project in one district, or multiple projects in one district, or for multiple projects in multiple districts (system effects). • Multiple changes in scope can be evident in project management notes but no official Scope Amendment or other documentation may be in the file. 	<ul style="list-style-type: none"> • Research the ripple effects of scope changes throughout the organization. • Determine the best process to use to track scope changes and to analyze and mitigate the system effects in order to reduce potential problems and costs.
<p>Funding Trends</p> <p>Inconsistent, “bumpy” funding from the state and other sources.</p>	<ul style="list-style-type: none"> • Mismatches occur between the number of projects ready to go (too many or too few) versus the funding available each year. • Causes additional Holding or Hurry-Up costs. 	<ul style="list-style-type: none"> • Work with the DOT legislative liaison and finance office to determine options for smoothing funding from year to year. • Develop legislative/agency briefing materials to build the case for multi-year or smoother funding (scenario analyses, cost savings, increased organizational effectiveness, more money going directly to road projects, etc.).
<p>Sudden increase in funding or opportunity to obtain additional highway monies (Stimulus funds, special federal or state highway grants, etc.).</p>	<ul style="list-style-type: none"> • Hurry-up design costs are incurred to ensure there are enough projects ready to go. • Difficulty meeting deadlines to use stimulus or grant money can lead to leaving money on the table. 	<ul style="list-style-type: none"> • Model events and outcomes during the most recent Stimulus timeframe or other times when extra money was available. • Determine what worked, how priorities were handled, and where there were system problems or bottlenecks. • Develop a plan to most effectively and efficiently handle stimulus funds and build this into strategic and long range planning.

MANAGING RISKS IN THE PROJECT PIPELINE

Trend/Issue	Potential Problems	Process Improvement
<p>Economic Trends</p> <p>Accuracy of cost estimates declines during periods of steep inflation.</p>	<ul style="list-style-type: none"> • Inaccurate cost estimates can lead to project delays, splits, scope changes, etc. • The project pipelines can become congested or overloaded with too many projects and cause delays within and across districts. • Costs can increase due to wasted design work, wasted recon, cost per mile escalation in construction costs for a corridor (if projects are split), etc. 	<ul style="list-style-type: none"> • Ensure updated cost estimates are made within 2-3 years of Let date. • Ensure updated cost estimates for projects in the pipeline are done regularly during periods of high inflation and again when inflation stabilizes or declines.
<p>Project Management Software Trends</p> <p>Double entry of data into PeopleSoft and Primavera.</p>	<ul style="list-style-type: none"> • Time delays and duplication of effort. 	<ul style="list-style-type: none"> • Determine how to integrate PeopleSoft and Primavera and reduce duplication of effort.
<p>Lack of consistent knowledge across the organization regarding the capabilities of Primavera.</p>	<ul style="list-style-type: none"> • Not fully utilizing Primavera’s software capabilities. • Reduced efficiency and effectiveness within the organization. 	<ul style="list-style-type: none"> • Identify the organization’s training needs regarding Primavera’s capabilities and how to use Primavera. • Determine who should receive training, what the training would consist of, when, where, how often, etc. • Schedule training sessions.

MANAGING RISKS IN THE PROJECT PIPELINE

Measure and Manage

Once management selects and prioritizes what processes they want to change or improve, decisions can be made about what measures to put in place to track outcomes. By monitoring system changes and outcomes, managers can determine what additional modifications are needed to strategies or processes to maximize positive outcomes. For example, after altering the Scope Amendment process (versus using email to change or amend project scope), the measures could involve sampling files for both large and small project from each district over a period of one to five years and interviewing district staff to determine how the new process is working and making adjustments as needed.

7.3 CONTINUOUS IMPROVEMENT RESEARCH: VERIFYING ASSUMPTIONS

One of the key continuous improvement steps in the Model, Measure, Manage process is to perform additional research to verify assumptions in the analysis. Some of the key assumptions which still need further research in order to make additional system improvements include:

- **Size of Projects:** Project sizing could be researched in an effort to avoid splits for projects that are too large, yet not have projects sized too small to take advantage of scaling efficiencies. Monitoring the number of splits (and associated project size), and also quantifying the components of the splits – losses in economies of scale, post-split scope growth, and being able to quantify the tradeoffs of smaller projects (with less risk of a split) versus the lower economy of scale due to smaller project size.
- **Two-Year Projections:** Determine the feasibility of using two-year projections and then track whether financial losses are reduced due to better loading of the Pipeline.
- **Maintaining a set of 1R2R “ready to go” projects:** Determine the ease of maintaining a set of 1R2Rs ready to go (candidate list of projects); if implemented, measure reduction of Hurry-Up costs (inefficiencies) when 1R2Rs need to be accelerated, as well as reduction of impacts on 3R4Rs in the Pipeline (through continuous design). This process also supports the Critical Project Method in managing the risks of the project pipeline.
- **Design Time Reduction:** Determine how real reductions in design times for major rehabilitation projects (3R4Rs) result in reduced losses (stemming from the reduced time delays in the project pipeline).
- **Track the components of cost escalation** (inflation estimates, project cost estimates, scope creep, etc.) and determine how these affect overall paving results.

7.4 PRACTICES ALREADY PUT INTO PLACE--MONITOR, MEASURE, MANAGE ON-GOING PERFORMANCE

For system and organizational changes that have already been put into place, monitoring how those are affecting the system and measuring the results are important steps in managing the change process and ensuring it is creating the positive results that were anticipated. It also allows management to make changes in or adjust the processes as needed.

- **Scope Growth Measures:** Compare current, “improved” methods to manage scope growth with historic levels of scope growth to monitor and measure progress.

MANAGING RISKS IN THE PROJECT PIPELINE

- Expanded Program Study Report (PSR) format and improved project cost estimating methods: Monitor and measure over time the effects on the project pipeline such as reducing the number of projects bumped during revenue shortfalls.

7.5 SUMMARY

A major objective of Departments of Transportation is to deliver as much road improvement as possible every year, given the amount of revenue they receive. DOTs encounter myriad risks and uncertainties every day and this study focused on maximizing the delivery of highway projects in the midst of these risks and uncertainties.

Researchers were able to identify effective strategies for process and organizational improvements by using causal diagramming, which allowed them to understand the mechanics of a complex situation. With this understanding of cause-and-effect, they could determine what candidate strategies to test against real-world scenarios and select the most beneficial policies and process improvements to implement.

Core Strategies were identified by mapping out Causes, Effects, and Results from the causal diagram. It was discovered that minimizing the amount of projects held “on the shelf” and employing practices that minimize the risks of incurring Holding Costs can lead to significant savings. In particular, using the Critical Project Method shifts the impact of revenue uncertainties from major rehabilitation projects to minor rehabilitation projects and provides a sound, core strategy for managing the risks in the project pipeline. In addition, through the research on the project pipeline, researchers identified system and organizational trends, potential problems, and process improvements. By following a Model, Measure, Manage approach, both Core Strategies and System and Organizational Improvement Strategies can be implemented and tracked through a process focused on continuous improvement.

In conclusion, significant savings in delivering highway projects can be possible by implementing the recommendations from this research. By analyzing the dynamics of project delivery using causal diagramming and modeling, a DOT can realize significant process improvements, make real progress in organizational performance, and substantially improve results by creating virtuous, positive reinforcing cycles. Optimizing programming and project delivery can save DOTs millions of dollars and assure that projects are delivered on time and as intended. A 3 percent savings is representative, based on the findings of the analysis. This would amount to a total savings of 90 million dollars, for example, for a budget of 3 billion dollars over a ten-year period.

MANAGING RISKS IN THE PROJECT PIPELINE

APPENDIX A PROJECT NARRATIVES – LARGE PROJECTS (10 MILLION DOLLARS OR MORE)

DISTRICT 1

0804197 Rawlins-Walcott/Rawlins E/00 (Sinclair West Section—later called Rawlins East Section)

Project entered into STIP in 1989 as a structure replacement, pavement rehabilitation, widening, and ramp lengthening at an interchange. Scope Statement was done in December 1989 but unable to locate this document (reference number 80-4(177)216). Reference to this document states that it was originally scheduled to be delivered in FY 1995. Per Programming Meeting notes from December 1993, the estimated cost was \$8M and the construction year was changed from FY 1995 to FY 1997. Per a memorandum in November 1994, the construction date was changed from FY1999 to FY2001 in order to sequence three projects differently and try to save approximately \$2M. The project was Let in 2000 for \$10.283M. Although from STIP to Let was 11 years, due to lack of information and lack of PSR or Scope, we were unable to discern what the original estimates were for this project. Further analysis could not be done.

Lack of Data/Information/No Real Delay: Actual inflation was 1 percent per year from 1995 to 2000. The total escalation was 6 percent per year therefore the net escalation was 5 percent per year. This project was only seven years from the first estimate in the file (December 1993) to Let (2000). Since the 1989 PSR or Scope could not be located, original cost estimates for this project were not available. Further analysis could not be done.

0806171 Laramie-Cheyenne/Harriman Section/03

Project entered into STIP in 1990 and PSR done September 7, 1989, however, PSR was unable to be located. Scope Statement done February 1999 and project original intent was listed as widening and resurfacing. Scope changed to add isolated reconstruction, ramp, crossroad, bridge, and “other work” with a construction year of 2002 at a cost of \$10.300M in 1998 dollars. Scope Addendum done Sept 2002 and added additional truck parking, changed the construction year to 2003 and updated the cost to \$12.085M in 2002 dollars. Project was Let in 2003 at a cost of \$12.7M. Although from STIP to Let was 13 years, a Scope Statement was not done until 1999; therefore from Scope to Let was only four years and estimates were accurate given this timeframe.

NOTE: The following is information from Design Department regarding redesign costs:

0806171 Laramie - Cheyenne/Harriman Section

Yes, a lot of the design effort on this project was devoted to investigating various grading alternatives in different areas, at the direction of the District, to minimize earthwork volumes—widen both lanes to the outside, widen both lanes toward the median, etc.

Since the structures were not replaced, transition areas with variable widening widths on both sides of the roadway were required on each end of each bridge to tie the widened-to-the-outside / widened-to-the-median lanes into the bridges.

MANAGING RISKS IN THE PROJECT PIPELINE

This project had "many" typical sections, and there was one plan inspection where WWC developed a color coded plot that extended completely across one wall of the meeting room to define the different sections of the project associated with each of the typical sections.

No Real Delay: STIP entry to Let was 13 years but Scope to Let was only four years. Actual inflation from 1998 to 2002 was 2.5 percent per year, total escalation was 4.5 percent, and the net escalation was 2 percent per year. No additional design cost information.

P231022 Medicine Bow-Bosler Jct/Medicine Bow East

This project was entered into the STIP in 1994 and a PSR was done in December 1994 indicating the project intent was a reconstruction of 11.50 miles of road on US Hwy 30 between Medicine Bow and Laramie to be constructed in FY 2000 at an estimated cost of \$5.5M (2000 dollars). A Scope Statement done in August 2002 indicated a change in intent from reconstruction to widen and overlay with a change in construction year to FY 2007 at an estimated cost of \$8.824M in 2007 dollars. Per a Request for Project Authorization in December 2008, the project intent was changed back to reconstruction and the construction year was moved from FY 2009 to FY 2010 at an estimated cost of \$16.846M. Also in December 2008, a PR714 was issued indicating a Let date of January 2009 and an estimated cost of \$16.087M. Although no formal documentation is in the file, the project scope was evidently changed back again just before letting to widen and overlay (per the STIP) and was Let in FY 2009 at a cost of \$11.454M.

Scope Changes/Escalation-- Reconstruction to Widen/Overlay to Reconstruction to Widen/Overlay: This project was in the STIP for 15 years from 1994 to 2009 and fluctuated between Reconstruction and Widen/Overlay over this time period. Between a low estimate in 2002 and then a high inflation rate in 2005-07 of 30 percent, this project experienced several scope changes due to fluctuating inflation and uncertain funding. It was Let in 2009 as widen/overlay for \$11.454M. Between the 2002 Scope estimate of \$8.824M (2007 dollars) and Let price of \$11.454M in 2009, there was a total escalation of 13 percent per year, an inflation rate of 3 percent, and net escalation of 10 percent per year.

0109021 Bosler Junction-Wheatland/North Sybille Creek Section

Entered into STIP in 1989 as a reconstruction of 7.9 miles of State Hwy 34 between Bosler Junction and Wheatland Road, a PSR was done May 22, 1984, but the document could not be found. In the Scope Statement dated October 1990, the project was described as one of seven projects scheduled to improve the entire 52.3 miles of Wyoming 34 and the scope was shortened to 4.9 miles to adjust the MP to coincide with other projects in the area. The construction year was given as FY 1996 at an estimated cost of \$3.740M in 1989 dollars.

No activity was recorded in the file from 1990 until 2002. Starting in March 2002, PCS notes state that the project design is fairly advanced but has been on hold since being delayed. In July 2002 the PCS notes state that "the Environmental Assessment states explicitly that this project cannot be pursued until the black footed ferrets are moved out of the Game and Fish Research Unit and that it uncertain if/when this will occur." Per the PCS notes, the R/W and Engineering plans were issued in May 1998 and may need to be revised.

Multiple delays occur from 2002 until 2011 including delays in meetings and resolution of black footed ferret issue with Game and Fish. A consultant was also working on this project for

MANAGING RISKS IN THE PROJECT PIPELINE

multiple years on the R/W and Engineering Plans (consultant agreement revised in 2003 and R/W & Engineering plans were not completed until 2009). Other Tiger Grant projects in 2009 appear to have pulled bridge designers off this project causing further delays. Project was finally Let in 2011 for \$11.598M, 22 years after entering the STIP and was Let (according to a PR714) for an extra 1.2 miles of reconstruction for a total of 6.01 miles of reconstruction.

NOTE: Information from Design Department regarding redesign costs:

0109021 North Sybille Creek

- 1) The District wanted the Consultant to keep working on the job, but could never come up with the funds in any given year to build it.
- 2) Well into the design, the horizontal and vertical alignments were revised to tie into the adjacent project where horizontal and vertical alignments were changed during construction.
- 3) At other times throughout the design process, further revisions were made to the horizontal and vertical alignments:
 - a. At the request of Bridge Design to lower the fill heights to accommodate the use of MSE walls
 - b. At the request of Game & Fish, to minimize impacts at their Research Center in areas where various species of test animals were pastured
 - c. To avoid rocky areas, wetlands, etc.
 - d. To incorporate changes in surfacing thicknesses made by Materials
 - e. To balance the earthwork
- 4) Designing the project in metric units, coming up with quantities in metric units, etc. was very time consuming.
- 5) The design of the project was started in V7, and PD had to use some sort of hybrid version of V8 (which did not have the same functionality as "English V8") to complete the metric design.

Project Delay (22 Years) and Game & Fish and Environmental Issues: Given the 22 year delay, the original estimate was fairly accurate. Total escalation including inflation per year was approximately 5 percent therefore there was not much escalation over and above inflation. (No additional design cost or other holding cost information available)

251141 & 251158 Colorado-Cheyenne/State Line North (251141 SBL only) (251158 NBL only)

Project entered into STIP in 1997 as 7.36 miles of reconstruction for NBL and SBL under Project 251141. PSR was done in 1999 with an estimated total cost of \$8.5M in 2000 dollars for reconstruction of both NBL and SBL. Scope done in 2001 and reconstruction reduced to 38 percent of project with remainder as un-bonded concrete overlay at an estimated cost of \$15.708M in 2004 dollars. Project split in 2004 with 251141 as SBL only and 251158 as NBL only. Project 251141 was Let in 2005 for \$13.434M. In 2006, a memo states Project 251158 was up-scoped to include an auxiliary lane to connect the port of entry on-ramp with College Drive Interchange off ramp. Memo in 2007 states "This project has grown" and that project now estimated at \$16.9M for Construction (not including CE). Project 251158 was Let in 2008 for \$15.839M.

MANAGING RISKS IN THE PROJECT PIPELINE

Project Split: Cost of original project was underestimated in 1999 and 2001. By 2004, the project was split into NBL (251158) and SBL (251141). In 2005 dollars, the actual cost of delivering the original project scope was \$20.897M for both pieces. The actual inflation rate during those five years was 4 percent per year. When projecting the \$8.5M estimated cost to 2005, with inflation, the cost is \$10.3M in 2005 dollars. Therefore, the split penalty for this project was a 102 percent increase in the cost for the original project scope, independent of inflation.

N211056 Rawlins-Muddy Gap/Bell Springs Section

Entered into STIP in 1999 as widen and overlay of 10.1 miles on US Hwy 287 between Rawlins and Muddy Gap. This road is part of the Trans-America bicycle route and most of this section of road is less than standard paved width. PSR in 2000 showed cost estimated at \$4.840M in 2000 dollars. Scope done in 2004 with construction year of 2007 and estimated cost of widen/overlay at \$8.529 in 2007 dollars. In January 2010, an Amended Reconnaissance Report indicated an estimated cost of \$19.468M. A Scope Amendment done in April 2010 changed scope from 4R widen and overlay and possible four-lane divided highway to 3R widen and overlay with intermittent passing lanes with four-lane divided highway alternative eliminated and shoulder width increased to eight feet due to project falling within the Transamerica Bicycle Route. Per the 2010 Scope Amendment, the estimated cost of the down-scoped project in 2013 dollars was \$16.704M. According to the STIP, in June 2012 the estimated cost of the project was listed as \$10.669M. However, the PR714 done in October 2012 showed an estimated Let cost of \$16.172M and the final Let price was \$13.358M in December 2012.

Down-Scope: Project cost was underestimated in 2000 and again in 2004. By 2010, an Amended Reconnaissance Report indicated the project cost estimate was \$19.468M and the project was then down-scoped from a 4R to a 3R project and the project was Let for \$13.358M in December 2012.

DISTRICT 2

0254138 Glenrock-Casper/Casper East

Entered into STIP in 1993 and according to the PSR in 1999, the project was to be a widen and overlay for 10.5 miles on I-25 slated for construction in 2004 at a cost of \$8.250M in 1998 dollars. The Scope Statement in 2001 shortened the project by 0.6 mile and still kept it as widen and overlay to be constructed in 2004 with a cost of \$19.101M in 2004 dollars. The Scope Amendment in 2002 maintained the same distance on I-25 but added the reconstruction of Hat Six Road for 1.08 miles to the project, adjusted the construction date to 2006, and had a combined total cost of \$25.272M in 2006 dollars. VE study (due to cost) took eight months (Nov04-July05). The Scope Amendment in 2006 states the project was split in half and now covers 5.88 miles of I-25 as a widen and overlay. Hat Six Road (U253005) was attached to the split-off project 0254146-Glenrock-Casper/Hat Six Section. The construction year for project 0254138 remained as 2006 and the cost was estimated at \$11.817M in 2006 dollars. The project was Let in 2007 for \$15.966M. Project 0254146 was slated as 3.98 miles of widen and overlay to be Let in October 2007 at a cost of \$19.781M (2008 dollars). This project was Let in 2008 for

MANAGING RISKS IN THE PROJECT PIPELINE

\$23.844M. Hat Six Road maintained its own project number and the cost appears to also have been kept separate from project 0254146.

NOTE: Information from Design Department regarding redesign costs:

0254138 Casper East

This project originally included the Hat Six Section also. The original project was split into two separate projects (254138 -Casper East & 0252146 Hat Six Section& Hat Six Road) after final inspection plans and special provisions for the original project were already completed. Needed to prepare an amended recon report and issue new AFE's very late in the process, and had to completely split up the plans and redo all the project summaries for the split. This took an estimated two or three extra months to complete. Project 254138 went to contract first in late 2006 and 0252146 went to contract in early 2008.

Project Split-- Scope Decreased then Scope Increased then Split and Down-scoped (removed Hat Six Road): The initial Scope in 2001 estimated the cost of the whole project (not including Hat Six Road) at \$19.101M (2004 dollars). This estimate, adjusted to 2001 dollars, was \$16.5M. Projected out to 2007, with inflation, the estimated delivery cost of the whole project would be \$31.23M. The actual Let cost of both projects (not including Hat Six Road), adjusted to 2007 dollars, was \$37.566M. Therefore, the split penalty was a 20 percent increase in the cost for the original project scope, independent of inflation.

N212084 Casper/West Belt Loop/Section 1 + N212094 Casper/West Belt Loop/Section 2

Project entered into STIP in 1997 and PSR done in 1998 stating this project would be new construction beginning at a new junction with State Hwy 220 and extend northeast for 5.8 miles ending at US Hwy 20/26. The estimated construction year was 2008 at a cost of \$8.070M for the roadway and \$2.150M for the bridges (1998 dollars). A Scope Statement was done in April 2005 and stated that the length of the roadway was changed to 7.5 miles (scope increase) and the project was split into two contracts, one for structures and grading (084) to be constructed in 2010 and the second for surfacing (094) to be constructed in 2012. The estimated cost was \$10M for (084) and \$11M for (094) for a total cost of the original construction work of \$21M in 2010 dollars. Project N212084 was Let in 2012 for \$21.334M for structures and grading. The second part, N212094 is to be Let in 2015 for an estimated price of \$15.181M in 2015 dollars. Total cost of the original construction work package to date is estimated at: \$35.424M adjusted to 2012 dollars. This project (084) utilized consultants for much of the design work and PE eventually cost \$3.471M according to a PR714 in January 2009.

Consultant started in 2004 or earlier. Letting of this project was moved constantly, changing Let year or month at almost every quarterly meeting from 2002-2011. In 2005, expedited project to use \$22M in high priority funding before new highway bill expired at end of FY 2009. Missed deadline for 2009 Let. R/W and Utility Plans delayed nine months. There was a legal right of way issue with landowner. Court ruled in WYDOT's favor.

Scope Increase Then Split: (Section 1 Let in 2012 and Section 2 to be Let in 2015) The whole package of the original construction work was estimated to be \$21M in 2010 dollars; when this

MANAGING RISKS IN THE PROJECT PIPELINE

cost is projected, with inflation, to 2012 the cost is \$24.360M in 2012 dollars. The cost estimate of the delivery of the split projects (combined) comes to \$35.424M adjusted to 2012 dollars. Therefore, the split penalty amounts to a 45 percent increase in the cost for the original project scope, independent of inflation.

0252140 Dwyer Junction-Glendo Road/El Rancho/NBL

Entered into STIP in 1990, postponed in 1992 and interim improvements done under Project 252123 and then a PSR was done in 1998 stating the project was a 5.4 mile 4R reconstruction to be constructed in 1998 at an estimated cost of \$7.150M (1998 dollars). According to the Scope Statement in 2003, the miles increased to 6.66 miles and is now widen and overlay with isolated reconstruction. Changes noted: estimated costs have increased from \$1.32M per mile to \$2.45M per mile. Estimated cost of construction in 2008 was \$16.331M in 2008 dollars for Construction, CE, and structures. A Scope Amendment was done in 2011 reducing the miles to 3.3 miles, “project length was cut in half and work will only be performed on NBL” (in effect project was cut into fourths: two 3.3 mile stretches in the NBL and two 3.3 miles stretches in the SBL). Estimated construction year was 2013 and the cost for 3.32 miles of NBL was \$10.887M in 2013 dollars. Current estimated construction year is 2013 at an estimated \$11.540M.

NOTE: Information from Design Department regarding redesign costs:

0252140 Dwyer Jct- Glendo (NBL)

The original project was split from one project to two projects, and then from two projects to four projects, and was value engineered which led to some re-design delays, but they were limited.

Split Into 4 Segments: When adjusted for inflation, the 2008 construction cost of \$16.331M for the 6.66 miles including both NBL and SBL becomes \$17.100M in 2013 dollars. The current estimated cost of the whole project to be done in four segments (6.66miles NBL and SBL—split into four segments of 3.33 miles each) is \$46.160 in 2013 dollars. Therefore, the split penalty amounts to a 170 percent increase in the cost for the whole, original project scope, independent of inflation. This project may have experienced a split/delay due to a ripple effect from the stimulus money in 2009. This would need further investigation to verify this hypothesis.

0255095 Casper-Kaycee Road/Tisdale Section

Project entered into STIP in 1998 and PSR done in 1999 stating the project was an 11.5 mile stretch of I-25 between Tisdale Mountain Interchange and Powder River Interchange slated for reconstruction and they recommended it be split and developed as two sections. Construction year estimated to be 2004 at a cost of \$13.750M (1998 dollars). No Scope Statement to date. Current STIP information: Estimated Construction FY 2019 at an Estimated Cost of \$19.505M. Estimated delay from STIP entry to construction is 21 years.

Potential Escalation: It will be critical to update estimates as this project moves forward in time. No updated estimate in the file since the PSR in 1999. Current estimated construction date is 2019.

MANAGING RISKS IN THE PROJECT PIPELINE

0253094 Douglas-Glenrock/Glenrock E Section/05

Entered into STIP in 1997 as widen and overlay of 10.5 miles of I-25 between Douglas and Glenrock Road. The PSR in 1998 indicated a construction year of 2001 with a cost of \$8.943M in 1998 dollars. The Scope statement in 1999 changed the intent from widen and overlay to “increased work to meet 4R standards” including “two 12 foot travel-ways in each direction, with eight foot outside shoulders, four foot inside shoulders, and narrow medians”. Construction year listed as 2002 with a cost of \$12.925M in 1999 dollars. Project not let until 2005 at a cost of \$19.323M. According to PCS notes from March 25, 2003, the “estimate increased due to increased amount of reconstruction, surfacing section changes, interchange increased scope of work, structural items need to haul borrow up to five miles...,etc.”

Escalatiopn/Up-Scope: Project cost underestimated in 1998 PSR and again in the 1999 Scope even with the estimated increase in work to meet 4R standards. Project Let date originally 2002 but delayed until 2005. The total escalation for the six years is 7 percent. The actual inflation was 4.5 percent. The net escalation was 2.5 percent per year over six years. This project was not a truly “delayed” project since it was delivered within seven years from the PSR.

P581013 Douglas Streets-Yellowstone Highway

Entered into STIP in 1996 as widen and overlay for 1.38 miles with bridge replacement. The reported crash rate on the west end of this section was notably high. The PSR in 1998 indicated a construction year of 2000 with a cost of \$3.850M in 1998 dollars. The Scope statement in 2002 changed the intent from widen/overlay and structure replacement to an increase in scope to reconstruction and shortened the project length by 0.14 miles to 1.24 miles. Construction year listed now as 2006 at a cost of \$10.791M in 2006\$. In an email from February 2007, the latest estimate based on R/W and Engineering Plans was \$13.7M for Construction only. In a Federal Project Report in November 2007, Construction and CE were estimated at \$17.718M. The project was Let in 2008 at \$18.010M.

Escalation/Up-Scope: Project cost significantly underestimated in 1998 PSR, especially if the project would have been delivered in 2000. The Scope statement in 2002 gave a more accurate estimate for the project in 2006 dollars, yet still underestimated the cost by 16 percent total (8 percent per year net escalation between 2006 and 2008). The total escalation from 1998 to 2008 delivery was 17 percent per year. The actual inflation rate over that time period was 9 percent therefore the net escalation was 8 percent per year over 10 years.

DISTRICT 3

0803135 Rocksprings-Rawlins/Wamsutter West Section

Entered into STIP in 2001 and PSR done in 2002 stating the project was an 11.4 mile resurfacing on I-80 between Rock Springs and Rawlins west of the Wamsutter Interchange. Estimated construction year was 2007 at a cost of \$5.060M in 2002 dollars. A Scope Statement was done in 2003 indicating the project length increased by 1.3 miles for a total of 12.7 miles, the estimated construction year was changed to 2008 and the estimated cost was \$20.143M in 2008 dollars. A Scope Amendment was done in 2005 stating the project was shortened by 0.68 mile and the construction year and cost stayed the same. The last document in the file was a PR714 estimating

MANAGING RISKS IN THE PROJECT PIPELINE

the construction cost in 2008 to be \$47.293M. Scope of project seemed to increase and included a bridge removal and replacement, fencing, roadway lighting system, and remote camera system. Project was Let in 2008 for \$50.386M.

Scope Creep/Escalation: When adjusted for length from 11.4mi to 12 mi, the 2002 estimated cost of \$5.060M becomes \$5.326M, adjusted for inflation becomes \$11.128M in 2008 dollars. The total escalation from 2002 to 2008 was 45 percent per year and the net escalation was 32 percent per year when adjusted for 13 percent inflation per year during this time period. It also appears that there was significant scope creep in this project. PCS notes indicated scope growth included replacement of 6 bridges with new interchanges and yet in June 2008 PCS notes indicate the estimate went up “dramatically”, possibly indicating cost estimates were not updated in the tracking system.

N104006 Alpine Junction-Hoback Junction/Snake River Section & N104065 Bridge

Entered into the STIP in 1981 and a PSR was done in 2000 stating reconstruction is recommended along a 1.8 mile stretch from Fall Creek Bridge extending north past Hoback Junction and ending 0.3 miles south of the Snake River Bridge at an estimated cost of \$3.4M for the roadway and \$5M for bridge replacement in 2000 dollars with a estimated construction year of 2005. A Scope Statement was done in 2009 recommending 4R reconstruction but shortening the length by 1.1 miles to 0.7 miles with an estimated construction year of 2010 at a cost of \$5.033M for the road and \$18.539M for the bridge in 2010 dollars. Both projects (006) and (065) were Let in 2010 at a cost of \$13.173M for the road and \$13.790M for the bridge. PCS notes indicate this project was combined but the STIP lists the projects separately even though construction may have been done simultaneously/sequentially.

Escalation: Adjusted for inflation, the \$8.4M in 2000 dollars inflates to \$15.700M in 2010 dollars. Over 10 years, from 2000 to 2010, the net escalation for the project was 6 percent per year above the normal inflation rate of 6.5 percent per year.

P132064 Daniel Junction-Hoback Junction/Dell Creek Section

Entered into the STIP in 1992 and PSR done in 1992 indicating the project would be 11.2 miles of reconstruction on US Hwy 189/191 between Daniel and Hoback Junctions to be constructed in 1998 and 1999 for an estimated cost of \$8.418M (1990 dollars). A Scope Statement was done in Sept 1998 shortening the project to 4.85 miles (decreasing length 54 percent) starting at Bondurant and running northwest east of Cliff Creek Crossing. Estimated construction year was 2004 at a cost of \$5.8M in 1998 dollars. Emails from June and August 2007 indicate another project was combined with 064 and lengthened the reconstruction to 5.11 miles but no Scope Amendment was found in the file. The project was Let in 2010 for \$10.390M.

Delayed 12 Years From Scope To Let: The estimate from the 1998 Scope Statement of \$5.8M when adjusted for inflation to 2010 dollars was quite accurate. The original 1998 estimate, when adjusted for inflation, was about 10 percent high when compared to the actual Let price of \$10.390M in 2010. Average annual inflation between 1998 and 2010 was 6.2 percent per year. The total escalation from Scope to Let was 5 percent per year. Therefore, the net escalation was negative 1.2 percent per year.

MANAGING RISKS IN THE PROJECT PIPELINE

N104066/79 & N104083 (Roadways) Hoback Junction-Jackson/Snake River Section + Spin Offs: N104087 & N104088 (Slide Mitigations)

Project N104066 was entered into the STIP in 1995 and a PSR was done in 1999 stating the project intent was a 4R full reconstruction of a 6.1 mile section of the road beginning 1.2 miles north of Hoback Junction and ending 2.2 miles north of Flat Creek Bridge to be constructed in 2006 for \$6.662M in 1999 dollars. A Scope Statement was done in November 2011 stating the project was split into two separate projects after the beginning location was moved south by 0.8 mile. The scope for N104066 was changed from 6.1 miles to 3.8 miles. Construction year was moved out 11 years to 2017 for an estimated cost of \$31.460M (2017 dollars). In addition, two slide mitigation projects were spun off in this stretch of road in 2011 (Hoback North (N104087) and Munger Mountain (N104088) at an estimated cost of \$6M each in 2015 dollars. The slide mitigation work is currently scheduled for 2015 and 2016 respectively.

The roadway project split (N104083) was entered into the STIP in March 2006 and a Scope Statement was done in November 2011 stating this project starts where N104066 leaves off and extends 3.1 miles north. The intent is a 4R reconstruction and was created by splitting the original project (N104066) into two pieces. Construction year is 2018 with an estimated cost of \$27.390M in 2018 dollars.

Split: Project cost was significantly underestimated in 1999 and the project was split into two roadway projects by 2011. This roadway has many complex issues including landslides and multiple environmental concerns (crucial winter ranges for big game, multiple threatened and endangered species located within the range, possible impacts to the river including fish passage and water quality, an archeological site that bisects the highway and several wetlands).

Currently the project is designated to occur in four phases with the two slide mitigations occurring first in 2015 and 2016 and the road projects N104066 in 2017 and N104083 in 2018. Currently, the total estimated cost associated with this stretch of road with the slide mitigations is approximately \$73.778M in 2017 dollars.

Split and Escalation Analysis: The split analysis looked at the original estimated cost in 1999 dollars for the two road projects (without the slide mitigations) which was \$6.662M (1999 dollars) and when inflated to 2017 dollars, the cost estimate is \$19M. The split penalty between the \$19M and the current estimate of \$57.687M for this same stretch of road is approximately 200 percent. This is a 200 percent increase in the cost for the original project scope, independent of inflation.

Updating cost estimates for these projects will be critical to understanding the impact on the District's budget and how to best manage this corridor.

MANAGING RISKS IN THE PROJECT PIPELINE

DISTRICT 4

0433022 Gillette-Montana State Line/Corral Creek Section

Project entered into the STIP in 1989 and PSR done in Aug 1988 stated the project intent was widen and overlay for 9.8 miles on State Hwy 59 with an estimated construction year of 1993 and 1994 for an estimated cost of \$6.447M in 1986 dollars. A Scope Statement was done in Sept 1989 for same mileage (9.8mi) and intent was changed to reconstruction with two bridge replacements with an estimated construction year of 1993 and estimated cost of \$5.177M in 1989 dollars. A Scope Amendment was done in Aug 2001 and the project was lengthened 0.8 miles to 10.6 miles and intent was down-scoped to widen and resurface with isolated reconstruction with an estimated construction year of 2003 and a total cost of \$8.326M in 2001 dollars. The project was Let in 2005 for \$10.823M as a 3R Reconstruction. Total delay from Scope to Let was 16 years.

Down-Scope/Delay/Escalation/Lack of Information: The PSR in 1988 stated the project intent was widen and overlay. The Scope Statement in 1989 indicated project scope was increased to reconstruction. A Scope Amendment in 2001 down-scoped the project to widen and resurface with isolated reconstruction, changing the scope from 4R to 3R. Due to the length of time involved (16 years), the fluctuating scope, and the down-scoping of the project, escalation analysis was not performed.

P432032 Gillette-Douglas/I 90-US 14

Project entered into STIP in 1993 and Scope Statement done in Sept 1999 describing project as Gillette Streets: Douglas Highway on State Hwy 59 pavement rehab and isolated reconstruction, sidewalk and miscellaneous for 1.1 miles with a construction year of 2002 at an estimated cost of \$3.045M in 1999 dollars. A Scope Amendment was done in October 2001 changing the intent to Reconstruction at an estimated cost of \$3.458M (2001 dollars). Another Scope Amendment was done in Aug 2003 stating length of project decreased to 0.84 mile (a reduction of 24 percent). Estimated construction year was 2006 at a cost of \$4.571M in 2006 dollars. The project was Let in 2008 at a cost of \$12.074M and intent was listed as reconstruction. Overall the project had multiple changes in scope including intersection modifications and multiple revised reconnaissance reports

Escalation-- Urban Project, Scope Increase to Reconstruction and nine year delay from Scope to Let (15yrs from Entering STIP to Let): The estimated cost of \$3.458M (2001 dollars) for 1.1 miles of roadwork becomes \$2.456M (2001 dollars) for the 0.81 miles which was finally Let. The final Let cost of \$12.074M (2008 dollars) divided by the estimated cost of \$2.456M (2001 dollars) is a total escalation of 25 percent per year over 7 years. The actual inflation over this time period was 12 percent per year. Therefore, the net escalation was 13 percent per year.

P601023 Sheridan/Main Street North Section/Pav

Project entered into the STIP in 1991 and PSR done in Jan 2005 with intent to resurface 1.3 miles in Sheridan on Main Street with an estimated construction year of 2009 at an estimated price of \$7.737M in 2005 dollars. A Scope Statement was done in Sept 2005 and project was

MANAGING RISKS IN THE PROJECT PIPELINE

shortened to 1.2 miles and intent was changed from resurface to full reconstruction with an estimated construction year of 2009 and estimated cost of \$9.951M in 2009 dollars. A Scope Amendment from January 2007 states project length was reset to 1.3 miles with added minor work and an estimated construction year of 2011 at a cost of \$11.957M. Scope creep is evident from cost breakdown on Scope Amendment which shows a bridge, storm drain, and two additional projects added on including a city project for utilities and enhancements and another Enhancement project bringing the grand total up to \$22.138M. There were 226 days of negative float in 2007. Multiple delays including design changes, scope changes by the City, ROW issues. In 2009, the Water Development Committee stipulated that the project needed to be let no later than December 2009 or they would take the money and give it to another town. The final Let date for just the 023 project was FY 2010 (November 2009) at a cost of \$12.150M.

Not Delayed-- Delay from STIP to Let was 19 years but from Scope to Let was only five years/Scope Creep: Both the 2005 PSR estimate of \$7.737M (2005 dollars) and the 2007 Scope Addendum estimate of \$11.957M (2011 dollars) were quite accurate compared to the final cost of \$12.150M when adjusted to 2010 dollars. However, the Scope done in 2005 which estimated the cost at \$9.591M (2009 dollars) was quite low compared to the final Let cost. Therefore, it was good to have the updated 2007 Scope Addendum estimate in 2011 dollars as another data point since this was a much more accurate estimate. This demonstrates the need to update estimates frequently during times of high inflation.

1708010 Sheridan-Banner/Widen & Resurface

Project entered into STIP in 1996 and PSR done in May 1999 stating the intent as widening and resurfacing of a 9.6 mile section of US Hwy 87 beginning south of Sheridan and extending to the junction with State Hwy 193 in Banner with an estimated construction year of 2005 for an estimated \$4M in 1999 dollars. The June 2012 STIP printout showed an estimated construction year in the STIP of 2030 at an estimated cost of \$25.594M. In an October 2012 printout of the STIP, the estimated cost of the project was \$15.826 in 2018 dollars.

Major Delay/Escalation-- Project to Watch-- Not Let Yet: Delay from entry into the STIP to estimated Let year is currently at 34 years. By extrapolating inflation from 2018 to 2030 by 4 percent per year, the project goes from \$15.826M (2018 dollars) to \$25.500M (2030 dollars). If inflation increases beyond 4 percent per year or if there is any scope growth or splitting of this project, all cost estimates should be recalculated to avoid over-programming projects in the district.

N362013 (later combined with N362015) Tensleep-Buffalo West Section

Project N362013 was entered into the STIP in 1989 and a Final Reconnaissance Report done in January 1989 showed the project as 8.3 miles of reconstruction on US Hwy 16 from 3.4 miles west of the Big Horn National Forest to 3.2 miles west of the city limits of Buffalo. Construction year was estimated as 1993-94 at a cost of \$9.515M in 1989 dollars (per the Recon Report).

The Recon Report recommended that the project be split into two projects and Scope Statements were done in March 1989 for N362013 (MP 80.1-83.5 [3.4mi]) and N362015 (MP 83.5-88.4 [4.9mi]). Project N362013 was estimated to be \$3.025M in 1987 dollars with a construction year of 1990. Project N362015 was estimated to be \$6.490M in 1987 dollars with a

MANAGING RISKS IN THE PROJECT PIPELINE

construction year of 1991. (Note: the estimates in the Scope Statements match the dollar amounts in the Recon Report, however, the Recon Report states the estimates are in 1989 dollars versus Scope Statements state the estimates are in 1987 dollars—one of the set of estimates is inaccurate regarding then year dollars). The only other information in the file is an E-79 for project N362013 in April 2009 stating the MP for the project N362013 was 79.58-88.40 which encompasses the total length of N362013 and N362015 combined.

At some point these two projects were evidently combined and the total Let price listed in the STIP for N362013 was \$19.966M and it was Let in 2003, thirteen years after the estimated construction year of 1990 in the 1989 Scope statement.

Two Projects Combined Into One/Underestimated: Project cost underestimated in the 1989 Scope Statements for the two separate projects. File lacks any additional information but was evidently combined into one project between 1987 and 2003 and delivered for \$19.966M. For the two projects combined, the total escalation over 15 years from 1987 to 2003 was 5.5 percent per year. The inflation over this time period was 3 percent per year therefore the net escalation was 2.5 percent per year. For 16 years from initial cost estimate to Let, the estimate was fairly accurate.

N362025 Buffalo-UCRS/Buffalo East Section

This project was entered into the STIP in 1996 and a PSR was done in Aug 1999 describing it as a reconstruction on US Hwy 16 at the junction with I-25 extending 1.5 miles to the junction with I-90. The estimated construction year was 2005 with a cost of \$1.617M in 1999 dollars. The Scope Statement in May 2003 shows that the project was lengthened by 0.85 mile (64 percent) for a total of 2.17 miles, the construction year was changed to 2007 and the cost was estimated at \$4.119M in 2006 dollars.

While no additional Scope Amendments are found in the file, PCS notes indicate that in 2007 the lab recommended asphalt for the majority of the project but the District was considering using concrete throughout. It is unclear whether the final project was primarily asphalt with concrete in isolated locations or concrete throughout. It is also unclear whether the three-lane design was changed to a five-lane design which was also being considered in 2007. The PR 714 from May 2009 showed an estimated Construction and CE cost of \$13.904M and the project was Let for \$11.749M two months later.

Project delays from STIP to Let appear to be due to project complexity including delays in mapping, need for storm drain layout, engineer requisitions, hydraulic report, preliminary traffic requisitions, structure selection report, final thickness requisitions, COE permit, geology investigation, coordination with city on storm sewer work, and wetland impact report regarding a new bridge.

Underestimated/Possible Scope Creep: The original estimated construction cost of \$1.617M (1999 dollars) for 1.5 miles was adjusted to \$2.37M (1999 dollars) for the actual delivery length of 2.17 miles. Then, the Let cost of \$11.749M in 2009 was divided by the \$2.37M which gives a total escalation over the 10 years of 17 percent per year. The actual inflation rate over this time period was 8 percent per year, resulting in a net escalation of 9 percent per year.

MANAGING RISKS IN THE PROJECT PIPELINE

DISTRICT 5

0311064 Yellowstone Park-Cody/Hanging Rock/98

Project entered into STIP in 1979 and a memo from 1996 “guesstimated” the cost at \$9.6M with an additional \$4.3M for the Hanging Rock structure. No other records in the file and no PCS notes. Project was Let in 1998 for \$11.984M and intent was stated as Reconstruction.

Delay/Lack Of Information: Project took 19 years from entry into STIP to project Let. Not enough data for further analysis.

0301018 Moran Junction-Dubois/Togwotee Pass

PSR done in August 1988 describing the project as 5.45 miles of reconstruction of the Togwotee Pass Section of US Hwy 26/287 between Moran Junction and Dubois with a construction year of 1996 at an estimated cost of \$3.986M in 1986 dollars. This is one section of a 37.70 mile corridor slated for reconstruction between 1993 and 2000. This project was entered into the STIP in 1998. A Scope Statement was done in March 1998 with the same mileposts, the intent was described as reconstruction with isolated widening and overlay, and the construction year was changed to 2003 at an estimated cost of \$5.060M in 1998 dollars. A Scope Amendment was done in June 1999 changing the length to 9.8 miles, combining the Togwotee Pass Section and the Pilot Knob Section, with the intent described as full reconstruction, estimated construction year of 2005, and estimated cost of \$28.529M in 1999 dollars. Another Scope Amendment done in February 2002, splitting the project back into 2 projects with the Togwotee Pass Section returning to 5.45 miles of reconstruction and changing the construction year to 2007 at an estimated cost of \$11.157M in 2007 dollars. In March 2002, according to an E-79 AFE, mileposts were changed again to 21.28-30.90 and total miles were back to 9.6 with most of the Pilot Knob Section added back. No additional Scope Amendments are in the file. A PR 714 from March 2008 indicates the mileposts were changed again and included part or all of the following sections: Fourmile Meadows, Black Rock Meadows, Togwotee pass, and Pilot Knob, for a total of 16.28 miles at an estimated Let date of May 2008 and an estimated cost of \$46.968M. The project was Let in 2008 for \$49.460M. However, see project N301016, Fourmile Meadows, for additional construction costs. Total cost of the 16.28 miles, which includes the Fourmile Meadows project (Let in 2008 for \$22.118M), appear to be: \$71.578M (2008 dollars)

Scope Creep/Splits/Combined: Scope Increase/Combine (combined two projects and changed to full reconstruction) —**Split** (split back into two projects)—**Scope Increase** (combined Togwotee Pass with part of Pilot Knob)—**Scope Increase/Combine** (combined Togwotee Pass with parts of three other projects)—total length listed as 16.28 mile. See N301016 which has the same mileposts listed on the Let information for that project—there is overlap between these two projects. For analysis purposes, the results from **0301018 are combined with project N301016** since the final mileposts/lengths of these two projects were exactly the same, indicating these projects were combined yet they maintained separate project numbers. See N301016 for results.

Future Research Note: May want to check to see how many crashes and how much maintenance had to be done to keep this road passable during the delay years (1988-2008).

MANAGING RISKS IN THE PROJECT PIPELINE

N301016 Moran Junction-Dubois/4 Mile Meadows

Note: This project is linked with the 301018 Togwotee Pass project and there appears to be a complete overlap in mileposts between the two projects, therefore the final analysis was done by combining the information from these two projects.

PSR done in August 1988 describing the project as 9.30 miles of reconstruction with isolated widening and overlay of the Fourmile Meadows and Black Rock sections of US Hwy 26/287 between Moran Junction and Dubois with construction years of 1997/1998 at an estimated cost of \$6.802M in 1986 dollars. These are two sections combined as one project of a 37.70 mile corridor slated for reconstruction between 1993 and 2000. This project was entered into the STIP in 1998. A Scope Statement was done in June 1999 and defined the combined projects as the “Fourmile Meadows Section” with the intent defined as full reconstruction, construction slated for 2006, at an estimated cost of \$18.414M in 1999 dollars. A Scope Amendment was done in February 2002, splitting the project and reducing the length to 4.4 miles encompassing most of the original Fourmile Meadows Section as described in the 1988 PSR. The reduced scope is still described as the Fourmile Meadows Section, to be delivered in 2005, at an estimated cost of \$9.207M in 2002 dollars. An AFE in July 2003 changed the reference markers to MP 14.47-21.28 which lengthened the project to 6.8 miles (adding 2.4 miles which now covers about half of the original Fourmile Meadows section and all of the Black Rock Meadows Section). No change in construction date or costs were noted and no Scope Amendment was found in the file. According to PCS Notes in June 2006, R/W and Engineering Plans would be combined for Fourmile Meadows/Togwotee Pass and were finally issued in late 2007. The PR 714 from March 2008 indicated a change in MP to 14.47-30.75, a total length of 16.28 miles, however, these are the same MP for project 0301018 (Moran-Dubois/Togwotee Pass). These two projects were Let in the same year, 2008, and this project was Let at a cost of \$22.118M. The cost of the two projects (018 and 016) combined was \$71.578M.

Escalation: Combined/Split/Scope increase/Combined with 0301018: Combined Projects (9.3 mi)—Split Projects (4.4 mi)—Scope Increase/Lengthened Project (6.8 mi)—Two Projects Let Simultaneously (Quasi Combined—16.28 mi): The initial combined Scope Statements for project 0301018 (Moran Junction-Dubois/Togwotee Pass) and N301016 (Moran Junction-Dubois/Fourmile Meadows) came to a cost of \$23.470M (1999 dollars). The Let cost of the two projects combined was \$71.578M (2008 dollars). Total escalation per year was 11.8 percent for 10 years. There was annual inflation of 9 percent per year over this time period, therefore the net annual escalation above inflation was 2.8 percent. By combining these two projects and essentially letting them in the same year, it appears that costs were contained fairly well.

N291036 Cody-Powell/Cody NE/Phase 1

Project entered into STIP in October 1996 and a PSR was done in November 1996 describing the project as reconstruction of US Hwy 14-A north of Cody extending 5.89 miles (MP 7.16-13.05) north-northeast with possible increase in traffic capacity. Construction year was estimated to be 2000 at an estimated cost of \$4.860M in 1996 dollars. PSR (Corridor Study) done in April 1998 but no information in file. A Scope Statement was done in August 2000 and the length of project was increased to 6.4 miles (MP 7.48-13.90), intent was reconstruction, with a construction year of 2004 and an estimated cost of \$9.067M in 2000 dollars. An Addendum Scope Statement was

MANAGING RISKS IN THE PROJECT PIPELINE

done in July 2002 and while the mileposts remained the same, the intent was changed to reconstruction to a five lane width, construction year was changed to 2006, and estimated cost was \$11.731M in 2006 dollars. According to the PR 714 done in April 2009 and indicating a May 2009 letting, the RM was changed to MP10.05-13.90, reducing the length of the project to 3.85 miles which was a 40 percent decrease with an estimated cost of \$14.792M. The project was Let in 2009 for \$11.425M. Project N291059 Cody-Powel/Cody NE/PHS 2, was the other portion of the split project and covered MP 7.48-10.28 as a five-lane reconstruction. This project was Let in 2010 at a cost of \$6.608M.

Up-Scope Length—Up-Scope to Five Lane—Split/Length Reduced 40 percent: Based on the Scope Addendum from 2002, the whole project (6.4 miles) was estimated to be \$11.731M (2006 dollars). The actual Let cost for the 6.4 miles (Projects N291036 (Phase 1) plus Project N291059 (Phase 2/Medium Project List), was \$18.825M in 2009 dollars. When the estimated cost of \$11.731M (2006 dollars) is converted to 2009 dollars, the estimate is \$16.22M. Therefore, the split penalty was 16 percent increase in the cost for the original project scope, independent of inflation. Since the projects were completed just one year apart (036 in 2009 and 059 in 2010) and appears to have been coordinated as a Phase 1/Phase 2 project, the split penalty is relatively low.

N301013 Moran Jct-Dubois/Buffalo Fork Section + N301014 Bridge N301015 Moran Jct-Dubois Black Rock Creek (later changed to Rosie's Ridge)

Project N301013 was entered into the STIP in 1992 and a Final Reconnaissance Report was issued in October 1995 with an original intent to widen and overlay a 4.5 mile stretch of US Highway 26/287 starting at MP3.0-7.5 with an estimated construction year of 2008.

Project N301015 was entered into the STIP in 1998 based on a Final Reconnaissance Report issued in Oct 1995 with an original intent of reconstruction with isolated widening and overlay of a 4.5 miles stretch of US Hwy 26/287 starting at MP 7.5-12 with an estimated construction year of 2007. The cost estimate from 1996 for these two separate projects plus the bridge was \$8.213M in 1999 (or 1996) dollars.

A Scope Statement issued June 1999 for Project N301013 combined these two projects plus the bridge and added 0.8 mile to stretch from MP 2.20-12.00 for a total of 9.8miles. In addition, scope increased to full reconstruction, the construction year changed to 2004, and the cost was estimated at \$15.005M (1999 dollars).

Scope Amendments were issued on Feb 11, 2002, for both projects indicating they were split apart. Project N301013 was changed to 5.3 miles of reconstruction from MP 2.20-7.50 (an increase of 0.8 mile from the 1995 intent) and the bridge project was separated out. The new cost estimate was \$8.742M (2006 dollars) and the construction year was changed to 2006. Project N301015 was changed to 5.6 miles of reconstruction from MP 7.50-13.10 (an increase of 1.10 miles from the 1995 intent). The new cost estimate was \$8.000M (2002 dollars) and the construction year stayed at 2004.

The length of Project N301013 was decreased and MP changed again in July 2003 to 4.83 miles and the MP changed to 3.00-7.83. This project was Let in 2006 for \$18.480M and no additional documentation is in the file.

MANAGING RISKS IN THE PROJECT PIPELINE

The length of Project N301015 was increased and MP changed again in March 2002 to 6.64 miles and the MP changed to 7.83-14.47. This project was Let in FY2011 for \$25.618M. No additional documentation in file as far as Scope Amendments, however, in PCS notes and emails, it looks like a Rosie Ridge Slide Mitigation may have been included in this project which would indicate scope growth. A Value Engineering study was done on this project in 2008. Project is complex and in June 2009, the PCS notes indicate there is still information and decisions needed on wildlife crossing structures and locations, hydraulic report, supplemental engineer's recommendations, geology recommendations, slide repair work with associated wetland impacts and earthwork, storm water control recommendations, and wetland mitigation design. PCS notes from June 2009 indicated the project is on an accelerated schedule to try for a letting in less than one year but it missed this target and was Let in October 2010.

Projects Combined/Projects Split (But Some Scope Increase For Each Project)/Scope Decreased (013) and Scope Increased Again (015): The original estimate in 1999 dollars of \$15.005M was for the combined project N301013 + N301015 and when the actual inflation rate of 7 percent per year from 1999 to 2006 is calculated, the value of the combined projects would be \$24.300M in 2006 dollars. Comparing the total Let cost of \$37.5M (2006 dollars) for both projects to the original estimated cost of \$24.300M (2006 dollars), this results in a split penalty of 54 percent. This means that after splitting the projects, there was a 54 percent increase in the cost for the original project scope, independent of inflation.

MANAGING RISKS IN THE PROJECT PIPELINE

APPENDIX B PROJECT NARRATIVES – MEDIUM PROJECTS (5 TO 10 MILLION DOLLARS)

DISTRICT 1

0804228 Rocksprings-Rawlins/Rawlins West/WBL

This project number (0804228) was entered into STIP in 2003 and half of the original project scope was delivered nine years later in 2012 for \$9.580M. This project started out as a three mile reconstruction and dynamic compaction and was changed in 2005 to a 12 mile mill & overlay for \$7.219M (2008 dollars) for 2008 delivery. No additional Scope Amendments were found in the file however, emails from January 2008 indicate the cost of the project had escalated to \$18.885M (2008 dollars) with no indication regarding change of scope or intent. Then, in PCS Notes from October 2008, it states that in the Highway Development Meeting in March 2008 the project was split directionally with project 0804228 as the Westbound Lane (WBL) and project I804243 being the Eastbound Lane (EBL). Project 0804228 was delivered in 2012 for \$9.580M and project I804243 was delivered in 2012 for \$9.383M; the total cost of the original mill and overlay of 12 miles of highway (both EBL and WBL) was \$18.963M.

Scope Change/Split: After changing the intent of the project from three miles of reconstruction to 12 miles of mill and overlay, the construction cost estimate then escalated significantly over a three-year time span to over double the original cost estimate for the 12 mile project (estimate in 2005: \$7.219M (2008 dollars) to estimate in 2008: \$18.885 (2008 dollars)). Rampant inflation was occurring during this time period. The project was then split in half directionally yet still delivered in the same year (2012). The split penalty is calculated as follows: the \$7.2M (2008 dollars) adjusted to 2012 is \$7.157 million (2012 dollars); the 2012 cost of the total delivered project (both pieces) is \$18.963 M, therefore, the split penalty is $(18.963 - 7.157) \div 7.157$ which is 165 percent. This split penalty is extremely high; this may be due to several factors including not updating the 2005 project cost estimate during times of rampant inflation, price volatility of materials (especially asphalt) during this time period, and possible underestimate of the original cost of the project in 2005.

0251147 Cheyenne Marg/Vandehei Interchange

Entered into the STIP in 1999, this 4R interchange upgrade project was delivered in 2011 at a cost of \$6.502M. This project, the Vandehei Interchange, was split off from project 2511913 Cheyenne-Chugwater Road/Cheyenne North Section in 1997 where the original intent was interstate reconstruction. According to the PSR done in 2000, the intent was an upgrade to the interchange scheduled for 2002 at an estimated cost of \$990,000 (1999 dollars). Per a Scope Addendum from 2001, scope increased and modern roundabouts were being placed at each end of the interchange at a revised estimated cost of \$2.014M (2004 dollars). No additional Scope Addendums in the file, however in PCS notes it indicates that Bridge was analyzing whether to widen the bridge by about two feet. It is unclear if this additional scope was delivered. In addition, due to project delays the environmental document needed to be rewritten because of the elapsed time and changes in development around the project site. Cost for this is unknown. An update on the project cost estimate was found in an email from 2009 and indicated the cost was

MANAGING RISKS IN THE PROJECT PIPELINE

estimated to be \$6.413M (2011 dollars). This estimate was very close to the final Let price of \$6.502M in 2011.

Escalation: Using the let price of \$6,502,000 and the 2004 scope statement estimate of \$2,014,000, the total escalation is 18.5 percent per year. The actual inflation is 10 percent per year over the seven years. Thus, the net escalation is 9 percent per year.

805129 Walcott-Laramie/ Quealy Dome /WBL

Entered into the STIP in 1993 and later split so that half of the project was delivered 16 years later in 2009. This project started out as 4.3 miles resurfacing then, according to the Scope Statement in 1999, the intent changed to 8.9 miles of 4R at an estimated cost of \$10.950M (1998 dollars). A Scope Amendment from 2000 stated the intent changed back to 3R in order to reduce costs and also downgraded work to provide 8 foot outside shoulders rather than 10 foot. The cost was estimated at \$8.800M (2000 dollars). A Scope Amendment in 2008 indicated the project would be split into two projects (EBL and WBL) due to increased project costs and would remain a 3R reconstruction project for 8.9 miles of road. Project 805129 would be the WBL and Project I805161 would be the EBL. According to the Scope Amendment in 2008, the estimated cost for 805129 was \$8.220M (2009 dollars). The total delivered cost for the original 2000 project scope of 8.9 miles of 3R reconstruction was: \$7.659 (805129 delivered in 2009) and \$6.201 (I805161 delivered in 2010) for a total of \$13.860M. Adjusted to 2009 dollars, the total Let cost came to \$14.6 M (2009 dollars).

Down-Scope and Split: Project scope in 1993 was resurfacing then changed to 4R according to a 1999 Scope Statement and then changed back to 3R in 2000 per a Scope Amendment. Another Scope Amendment in 2008 indicated the project would be split. The final delivered scope of the project, after splitting the project, was unclear. Calculating the split penalty was not performed due to unclear final scope, unclear road treatment, and how original estimated cost related to the final, delivered, down-scoped project. Sunk design costs and re-design costs may have been another cost factor for this stretch of road.

I251156 Cheyenne-Chugwater/Whitaker Section

This project was entered into the STIP in 2003 and delivered nine years later in 2012 as a 2R resurfacing project. According to the 2007 PSR, the original intent for the project was 6.6 miles of resurfacing; however, it states that although the road appears to be in good condition, it is masking “serious underlying problems.” The purpose is stated as resurface at an estimated cost of \$10.897M (2007 dollars). A Scope Statement in 2008 states the original intent was resurface and current intent is 2R resurface but the estimated cost drops to \$5.200M (2011 dollars). It is unclear why the initial estimate was twice as high; whether the scope was changed from 3R to 2R or if the initial estimate was just too high. The project was delivered in 2012 for a cost of \$5.280M.

Down-Scope: Project was put into the STIP in 2003 and delivered in 2012 (nine years later). PSR was not done until 2007 and went from 3R in 2007 to 2R in 2008, after recon in 2007. By changing the scope of the project from a 3R to a 2R, the cost estimate was cut more than half from \$10.9M to \$5.2M. The project was delivered in 2012 for \$5.280M. It is unclear if there were sunk design costs, redesign costs or other down-scoping costs not reflected in the final Let

MANAGING RISKS IN THE PROJECT PIPELINE

price. Tracking this stretch of road in the future to see if there truly are “serious underlying problems” (as mentioned in the 2007 PSR) that still need to be addressed could be important in determining long-term costs of down-scoping road treatments.

212001 Cheyenne/College/BNRR-AVE C/01

Project entered into the STIP in 1991 and delivered 10 years later in 2001. A Scope Statement was done in 1993 and states the intent as three miles of road reconstruction at an estimated cost of \$3.602M (1996 dollars). A Scope Addendum in 1996 stated the length of the project increased to 3.4 miles and intent stayed the same with an adjusted estimated cost of \$4.042M (1996 dollars). The project was delivered in 2001 at a cost of \$6.541M and the intent was stated as widening and resurfacing. .

Escalation: Over the five years from the 1996 Scope Addendum estimate of \$4.042M (1996 dollars) to the Let cost of \$ 6.541M (2001), the actual inflation was 3 percent per year and the overall escalation was 10 percent. Therefore the net escalation per year is 7 percent.

DISTRICT 2

1002014 Kaycee-Sussex/15 Mile Draw SectionW/00

Project entered into STIP in 1989 and delivered 11 years later in 2000 for \$5.114M. Original intent was reconstruction of 15.9 miles of road. Per the Scope Statement in 1990, the original project length was divided into three projects with this project being reconstruction of 4.8 miles of road to Secondary design standards at an estimated cost of \$2.970M (1995 dollars). An Addendum to the Scope was done in 1992 and changed the intent to 3R design standards for low volume, rural secondary roads. No revised cost estimate was provided on the Addendum. The project was Let in 2000 and the final description of the project in the STIP was a resurface, minor widening, and chip seal at a Let cost of \$5.114M. The final scope of the project appears to be similar to the 1990 scope.

Escalation: The total escalation over five years, from 1995 to 2000, using the Scope Statement cost estimate of \$2.97M (1995 dollars) and the Let cost of \$5.114M in 2000 is 11.5 percent per year. The inflation rate during those years was about 2 percent per year. This yields a net escalation rate of 9.5 percent per year.

253085 Douglas-Glenrock/DougW/East Sec SBL

Project entered into STIP in 1993 and let 18 years later in 2011. The original PSR from 1993 indicated this was a surface course rehabilitation on both lanes of 8.6 miles of road at an estimated cost of \$4.072M (1990 dollars). The next PSR from 1998 showed the intent as widen and overlay of 8.6 miles of road at an estimated cost of \$7.110M (2002 dollars). The Scope Statement from 2002 showed a change in intent to widen, mill, overlay with isolated reconstruction noting that full width milling is required at an estimated cost of

\$14.718M (2007 dollars). No additional Scope Statements or Amendments are in the file, however, there are multiple emails beginning in 2008 indicating that initially the project was split into SBL and NBL with project 253085 being the SBL and project I253109 being the NBL.

MANAGING RISKS IN THE PROJECT PIPELINE

According to an email from 2008, the updated estimated cost of the two projects combined was \$38.932M (2010 dollars). Per an email from December 2009, the original project has now been split into four projects both directionally (NBL/SBL) and in length with each portion being approximately 4.2 miles long. The intent listed in the STIP for these projects was widen, overlay, with isolated reconstruction. Project 0253085 was Let in 2011 for \$7.106M, Project I253109 was Let in 2012 for \$5.000M and Project I253113 is scheduled to be Let in 2015 for an estimated cost of \$7.489M (uncertain if these are 2012 or 2015 dollars). Project I253114 would be the fourth segment of the original project and is no longer in the STIP as of June 2012.

Split: The original project was split into four pieces. The “effective” Let Cost (for full length of road section with both NBL and SBL) would be \$26.455M (2011 dollars) based on the actual Let cost of \$7.106M (2011) for one portion of the project. This calculation is based on the split between the West and East sections (4.2 and 4.4 mi), and based on the 45/55 split between SBL and NBL work. This Effective Let Cost divided by the 2002 Scope Statement estimate of \$14.718M (2007 dollars) for the full project gives an escalation rate from 2007 to 2011 of 15 percent per year. There is only about 1 percent inflation per year between 2007 and 2011, so the effective net escalation is 14 percent per year. To calculate the split penalty, the estimate of \$14.718M (2007 dollars) for the whole project is adjusted to 2011\$ and comes to \$15.135M. Therefore, the split calculation $((26.455-15.135) \div 15.135)$ shows a split penalty of 75 percent.

S805006 Sugar Factory Road/E Sec

Project entered into STIP in 1998 and delivered in 2011 as 6.75 miles of reconstruction at a cost of \$9.607M. The PSR was done in 1999 as seven miles of reconstruction at an estimated cost of \$5.500M (1999 dollars). If adjusted to 6.75 miles, the estimated cost would have been \$5.304M (1999 dollars). The Scope Statement from 2004 for seven miles of road was estimated to be \$9.040M (2008 dollars). If adjusted to 6.75 miles, the estimated cost would have been \$8.717M (2008 dollars). An email in January 2008 gave a new estimate of \$13.781M (2009 dollars) and was based on an inflation rate of 16 percent from 2008-2009. No additional cost estimates in file other than PR714 just before letting. The difference in cost between the 2009 dollars estimate and the actual cost in 2011 was over \$4M too high. If planning was done based on the 2009 dollars estimate, the project pipeline would have been under-programmed by \$4M just from the over-estimate of costs for this project. This project is an example of the need for updating cost estimates annually during times of widely fluctuating inflation rates.

Escalation: By using the Let cost of \$9.607M (2011) and the adjusted 2004 estimate of \$8.717M (2008 dollars) (downscaling the scoping estimate of \$9.040M (2008 dollars) for the length change from 7.00 mi to 6.75 mi), the annual total escalation is 3.5 percent per year from 2008 to 2011. Adding this to a NEGATIVE inflation rate between 2008 and 2011 of negative 2.5 percent gives a net escalation rate of 6 percent per year.

1401007 Manville-Lance Creek/Wyatte Creek Section

Project entered into STIP in 1996 and delivered in 2012 as 3.44 miles of reconstruction at a cost of \$6.097M. The PSR was done in 1997 as 2.3 miles of reconstruction at an estimated cost of \$1.760M (1997 dollars). The Scope Statement in 1998 listed the work as 2.9 miles (although in another place within the Scope Statement it said 3.6 miles) of reconstruction at an estimated cost

MANAGING RISKS IN THE PROJECT PIPELINE

of \$2.660M (1998 dollars). No other Scope Amendment documents are in the file. There is one email from July 2011 that provides a new estimate for the cost of the project as \$6.097M (2011 dollars). The project was estimated to be let in 2016 but was let approximately one year later in August 2012 for \$6.097M.

Good Estimate: Project entered into STIP in 1996 and delivered in 2012, a 16 year time span. There was an average 6 percent annual inflation from 1998 to 2012. Adjusting the \$1.760M (1997 dollars) estimate for the increased miles delivered (2.3 miles to 2.9 miles), the estimate becomes \$2.724M (1997 dollars). By calculating 6 percent inflation per year from 1997 to 2012 for the \$2.724M, the estimated delivery cost in 2012 would be \$6M and this was the cost of the actual Let price. Given the long timeframe from entry into the STIP to delivery and the lack of updated estimates, this project appeared to stay on track and was delivered at an expected cost based on the 1997 estimate after calculating inflation.

1600006 Wheatland/Hightower Rd & Wyo 311 Spur

Project entered into STIP in 1996 and delivered in 2012 as three miles of WYO 310 plus two miles of WYO 311 spur as widen and overlay with isolated reconstruction at a cost of \$5.106M. The PSR in 1998 was based on widening and overlaying 6.5 miles of WYO 310 at an estimated cost of \$2.660M (1998 dollars). The Scope Statement in 2008 indicated a change from widen and overlay to 4R widen and resurface and scope increase to 8.5 miles (6.5 miles plus two mile spur) at an estimated cost of \$11.200M (2012 dollars). A Scope Amendment in 2010 indicated a change in length to three miles of WYO 310 and two miles of WYO 311 (five miles total) and change in intent to 3R widen and overlay at a cost of \$5.255M (2012 dollars). This estimate was quite accurate compared to the 2012 final Let cost of \$5.106M.

Escalation: Project entered into STIP in 1996 and delivered in 2012, a 16 year time span. The sections of road changed two times, and went from 3R to 4R and back to 3R and was delivered as widen and overlay with isolated reconstruction.

Using the 2007 recon report which showed the cost for 8.5 miles of widen and overlay, the cost was adjusted down to five miles since this was what was finally delivered. The cost was ratioed down from the full cost of \$4.240M for 8.5 miles to \$2.494M for five miles. Dividing the final Let cost by the estimated cost ($\$5.106\text{M} \div \2.494M) over five yrs gave a total escalation of 15 percent. Taking total escalation of 15 percent minus the 2 percent inflation rate annually between 2007 and 2012, the net escalation was 13 percent annually.

DISTRICT 3

2100020 Evan-Utah/Evan SO/04

Project was entered into the STIP in 1991 and delivered in 2004 as a 4R widen and overlay of 10.4 miles at a cost of \$8.384M. The PSR done in 1991 indicated the intent as widen and overlay at an estimated cost of \$3.640M (1986 dollars). The original PSR was “marked up” in 1998 and cost was re-estimated at \$4.246M (1998 dollars). A Scope Statement was done in 1999 and intent was changed to widen and overlay with isolated reconstructions at an estimated cost of \$6.200M (1998 dollars). The last document in the file was an Engineer’s Estimate in 2003 with a cost estimate of \$8.292M.

MANAGING RISKS IN THE PROJECT PIPELINE

Escalation: Over the six years from 1998 to 2004, there was 5 percent total escalation; subtracting a 2 percent inflation rate this means a 3 percent net escalation rate per year.

N132076 Daniel Jct-Hoback Jct/Pfister Creek Section/05

Project entered into STIP in 1992 and delivered in 2005 as 6.35 miles of reconstruction at a cost of \$6.781M. The Scope Statement in 1998 stated cost was estimated at \$7.070M (1998 dollars) for 6.35 miles of reconstruction; there were only seven years from estimate to delivery.

High Initial Estimate: The 1998 initial estimate appears to be very high. The project was delivered seven years later at a lower cost than the initial estimate. If the initial scope of the project was the same as what was delivered, then the initial estimate was high. Inflation between 1998 and 2005 was about 4 percent, and the overall escalation was negative 1 percent per year (to get to the Let price), so the net escalation is negative 5 percent.

1906018 Green River-Fontenelle Road/Fontenelle East Section

Project entered into STIP in 1998 and delivered in 2008 as a 3R reconstruction of 6.6 miles of road at a cost of \$6.115M. Scope Statement done in 2001 and estimated the cost at \$4.467M (2006 dollars). Delay from Scope to Let was only seven years.

Escalation: According to the PSR in 1999, the estimated cost of the project for 7.23 miles of reconstruction was \$2.000M (1999 dollars). To calculate escalation costs, this cost estimate was adjusted to 6.6 miles of reconstruction to match what was delivered. The adjusted cost was \$1.823M (1999 dollars). Over the nine years from 1999 to 2008, there was a total escalation of 14.3 percent, an inflation rate of 10 percent, and thus a net escalation of 4.3 percent per year.

1903022 Rock Springs-Hiawatha/Salt Wells Creek Section

Project entered into STIP in 1998 and delivered in 2010 as a 3R widen and overlay of 10.5 miles of road at a cost of \$5.742M. Scope Statement in 2002 estimated the cost at \$9.570 (2008 dollars). While this Scope Statement states the intent as widen and overlay, the Recon Report from 2008 states that the original intent was a 4R full reconstruction. In 2008, the intent was changed back to 3R. The Scope Statement in 2002 most likely reflects the project cost as a full reconstruction project rather than widen and overlay and would explain why the estimate was quite high compared to the actual Let cost. No additional Scope Amendments found in the file to reflect the change to 3R or any adjustment in the cost estimate.

Change in Scope/Down-Scope/Missing Documentation: When change in scope to 3R occurred in 2008, no official Scope Amendment was found in the file. There was also high inflation during this time, therefore, the high cost estimate in the Recon Report in 2008 (\$9.886M (2011 dollars)) reflected the inflation rate estimates at that time. Emails were found in the file with different cost estimates but no official documentation of cost estimate changes could be found. This case reflects the need to review all projects in the STIP during times of high and low inflation to adjust cost estimates so STIP accurately reflects new project costs to prevent over and under-programming problems.

MANAGING RISKS IN THE PROJECT PIPELINE

DISTRICT 4

2302011 Upton South/Jct 450 No Section (Stimulus Funded Project)

Project entered into STIP in 1998 and delivered in 2009 as a 3R widen and overlay of 7.3 miles of road at a cost of \$7.703M. Scope Statement done in 1999 listed the project length as 5.7 miles of 3R construction at an estimated cost of \$1.760M (1998 dollars). No additional Scope Amendments are in the file to reflect the change in length or scope. This project was scheduled for delivery in 2011 but moved up for delivery in 2009 when Federal Stimulus Funds became available. A Project Authorization form in the file from January 2009 states that the improvement type is now “Minor Widening”.

NOTE: This project may be good to do further research on regarding the effects of Stimulus Funds and whether the scope of the project was changed/de-scoped in order to quickly deliver the project. Long term effects of any change in the original scope of the project would be good to track (i.e. if the road really needed a more extensive treatment and a minor treatment was applied in order to “use or lose” Stimulus monies). The question is whether, in the near future, the road may deteriorate more quickly and have to be redone sooner than expected.

Escalation: According to the Scope Statement in 1999, the cost estimate for 3R widen and overlay of 5.7 miles of road was \$1.760M (1998 dollars) and since the final length was 7.3 miles, this cost estimate had to be adjusted to \$2.254M (1998 dollars) to account for the mileage increase. The final Let price for 7.3 miles of widen and overlay was \$7.703M in 2009. Total cost escalation from 1999 to 2009 was 13 percent per year, the annual inflation rate was 8 percent per year, and therefore the net escalation was 5 percent per year.

901094 Sheridan-Buffalo Road/Marshall Hill Section

Project entered into STIP in 1994 and delivered in 2010 as a 2R resurface of 5.3 miles of road at a cost of \$7.577M. The Scope Statement from 1998 stated the intent was to widen and resurface the road (3R project) at an estimated cost of \$6.700M (1998 dollars). No additional Scope Amendments were found in the file. An email from December 2009 indicates that engineer reconnaissance lists the project as a simple mill and overlay and hand-written notes on copy of the email indicate the new cost estimate at \$5.876M (2010 dollars).

Change in Scope with Little or No Documentation in File: This project is an example of potential problems that can develop if no Scope Amendments or official documentation is done when there is significant scope change. With a change in scope from 3R to 2R, an official Scope Amendment and cost adjustments are needed to ensure accuracy in forecasting the cost at delivery. The 2010 estimated cost of \$5.876M (done in late 2009) differed from the actual 2010 Let cost of \$7.577M by almost \$2M.

255098 Kaycee-Buffalo/Middle Fork Interchange Section (Stimulus Funded Project)

This project was entered into the STIP in 1998 and delivered in 2011 as a 3R widen and resurface of approximately 10 miles of road at a cost of \$9.822M. The Scope Statement from 2002 listed the project as 9.8 miles of widen and resurface at an estimated cost of \$7.794M (2008 dollars). This project appears to have used Stimulus money to fund the project.

MANAGING RISKS IN THE PROJECT PIPELINE

Escalation: Using the 2002 Scope Statement, there was an 8 percent overall increase per year from 2008 to 2011 for the \$7.794M, with no scope change. Actual inflation between 2008 and 2011 was a negative 2 percent. Therefore the net escalation was 10 percent per year.

P433035 Gillette-Montana State Line/Weston Section

Project entered into STIP in 1990 and delivered 22 years later in 2012 as a 3R widen and overlay of 6.55 miles of road at a cost of \$9.600M. The Scope Statement in 2004 stated the intent of the project was 6.0 miles of 4R reconstruction at an estimated cost of \$7.500M (2008 dollars). In September 2010, an amended Reconnaissance Report was done and the project length was revised to 6.55 miles, and stated that based on the original intent of 4R reconstruction, the cost is now estimated at \$13.367M (2012 dollars). The Reconnaissance Report went on to recommend a change in intent from 4R to 3R widen and overlay with an estimated cost of \$9.365M (2012 dollars). A Scope Amendment was done in November 2010 reflecting the change from 4R to 3R and the project lengthened by 0.55 miles and the cost estimated at \$9.365M (2012 dollars). The final Let cost was very close to the estimate at \$9.600M in 2012.

Down-Scope Due to Cost Escalation: This project started out as a 4R reconstruction project for 6.0 miles of road at a cost of \$7.5M (2008 dollars). By 2010, the cost estimate almost doubled to \$13.367M (2012 dollars) and was then down-scoped to a 3R widen and overlay possibly to just reduce the cost so it could be delivered. Tracking the condition of the road over time to determine if this was the optimum treatment would be beneficial in understanding the impact of down-scoping projects. If the treatment should have been reconstruction to lengthen the life of the road, this needs to be considered when making short term decisions to down-scope a project for delivery purposes.

600016 Sundance-Upton Road/County Line South Section

Project entered into STIP in 1998 and delivered in 2011 as a 3R widen and overlay of 5.91 miles of road at a cost of \$6.148M. The 1999 PSR stated the project was 11.8 miles of widen and overlay at an estimated cost of \$3.080M (1999 dollars). The Scope Statement from 2005 stated the project length was broken into two projects due to funding considerations and that this project was now 6.1 miles of widen and overlay at an estimated cost of \$4.520M (2005 dollars). A Scope Amendment from July 2010 stated that the project was still widen and overlay with isolated reconstruction, length was the same, and the cost was re-estimated as \$5.014M (2011 dollars).

Split and Escalation: Originally, the project was 11.8 miles long, and then was split into two projects and this project's length was changed to 6.0 miles. Adjusting the 1999 PSR from 11.8 miles to 6.0 miles, the cost would be \$1.572M for 6 miles. The total escalation from 1999 to 2011 is 12 percent per year. The inflation during this time is an average of 6.5 percent per year. Therefore the net escalation is 5.5 percent per year. A split penalty was not calculated due to lack of information about the other half of the split project.

MANAGING RISKS IN THE PROJECT PIPELINE

One other note: The Scope Amendment from July 2010 estimated the cost at \$5.014M (2011 dollars) and the final Let cost in 2011 was over \$1M higher at \$6.148M. If cost estimates have been improving in the past few years, this project should be reviewed to determine why the cost was underestimated by more than 22 percent in July 2010. If scope was added to the project, that information does not appear in the file.

DISTRICT 5

0333012 Cody-Montana State Line/Clark's Fork River Section

Project entered into STIP in 1997 and was delivered in 2007 as widening and resurfacing of 5.05 miles of road at a cost of \$7.605M. The Scope Statement in 1998 indicated the original intent was widen and resurface of 5.05 miles of road and the intent was changed to widen, resurface, and isolated reconstruction at an estimated cost of \$3.228M (1998 dollars). Per an E113 from March 2007, an updated cost estimate was given as \$5.884M (2007 dollars).

Escalation: This is a 3R project that was Let 10 years after being entered into the STIP. Total escalation from 1998 to 2007 was 10 percent per year. Average annual inflation during this time period was 9 percent per year. Therefore, the net escalation was 1 percent per year.

One other note: The E113 from March 2007 estimated the cost at \$5.884M (2007 dollars) and the final Let cost in 2007 was over \$1.7M higher at \$7.605M. This project is another example where the cost of the project was underestimated by almost 30 percent just months before the project was Let. The PCS notes do indicate that there were a "number of late changes requested" to the project. It appears that these "late changes" may have driven up the cost significantly.

N331021 Thermopolis-Meeteetse/Thermopolis North

Project entered into STIP in 2001 and delivered in 2012 as 3.28 miles of widen and overlay with isolated reconstruction at a cost of \$6.772M. PSR done in 2002 describing project as reconstruction of 3.1 miles of road at an estimated cost of \$2.750M (2002 dollars); this was the last of a series of projects on this road. Scope Statement done in 2004 and changed the intent from reconstruction to widen and overlay with isolated reconstruction and increased length slightly to 3.3 miles at an estimated cost of \$4.191M (2008 dollars). Emails from 2007 indicate estimated cost if delivered in 2010 would be \$8.012M. Another email in February 2010 indicates the project is listed in the STIP for delivery in 2014 for \$8.250M or if delayed to 2017 the estimated cost would be \$9.831M. At the time of the Feb 2010 email, the 2010 STIP showed a cost of \$13.781M if delivered in 2017. No Scope Amendments found in file. Changes and adjustments of cost estimates appear to be documented only through hard copies of emails. Project was delivered in 2012 as a 3R widen and overlay with isolated reconstruction.

Escalation: Utilizing the 2002 PSR estimate of \$2.750M (2002 dollars) and the 2012 Let price of \$6.772M, this gives an overall escalation of 9.5 percent per year. With an average inflation rate of 7 percent per year during this time period, this gives a net escalation of 2.5 percent per year.

MANAGING RISKS IN THE PROJECT PIPELINE

However, if net escalation is calculated utilizing the Scope Statement from 2004 which estimated the cost at \$4.191M (2008 dollars) and the Let price of \$6.772M (2012), this gives an overall escalation of 13 percent, with basically no inflation during this time period which means a net escalation of 13 percent per year from 2008 to 2012. This points out the importance of having accurate, updated estimates during times of widely fluctuating inflation (high or low inflation) and when material prices are volatile (asphalt/oil price spikes) in order to manage the project pipeline and project deliveries more effectively.

N361053 Worland-Tensleep/Worland East

Project entered into STIP in 1998 and delivered in 2012 as a 4R reconstruction of 3.32 miles of road at a cost of \$7.662M. A PSR was done around 2000 as a reconstruction of 3.77 miles of road (different mileposts (4.23-8.06) but some overlap) at an estimated cost at \$3.974M (2000 dollars). According to the Scope Statement from April 2002, two projects were being combined (053 and 054) with an intent to widen and overlay with isolated reconstruction of 6.48 miles of road at a cost of \$2.586M (2005 dollars) for 053 (MP 4.23-8.06 = 3.83 miles) and \$3.728M (2005 dollars) for 054 (MP 1.58-4.23 = 2.65 miles) for a total estimated cost of \$6.324M (2005 dollars). February 2007 PCS notes indicated the project was split again into two separate projects (“in order to balance the STIP”); no Scope Amendment found in file and no record of 054 listed on the STIP, however, the mileposts of what was eventually delivered are actually the original mileposts of project 054; therefore, it appears that project 054 became project 053 and the original mileposts for 053 (4.03-8.06) were never delivered. Thus, it appears that the original intent of 053 was eliminated/removed from the STIP altogether. According to the PR714 just before letting, the mileposts are now MP 1.52-4.87 (3.35miles) and the description of work sounded like widen and overlay, although the STIP indicates it was a 4R reconstruction of 3.32 miles that was delivered.

Projects Combined/Scope Change/Project Split/Project Numbers Switched/Unclear

Documentation: There seemed to be much confusion over mileposts and project numbers (which project numbers related to which mileposts), combining projects, splitting projects, and moving from 3R to 4R on this section of road. Although the description of what road treatment was finally delivered sounded like widen and overlay, the STIP indicates it was 4R reconstruction. Using the Scope Statement from April 2002, the estimated cost of \$3.728M (2005 dollars) for 2.65 miles of construction was increased to 3.32 miles (the length finally delivered) at a cost of \$4.670M (2005 dollars). Inflation during this time period from 2002 to 2012 was 8.5 percent per year. The escalation of the project from 2002-2012 was 7.5 percent per year, thus the net escalation was negative 1 percent. Given the changes in scope, length, and intent, the original estimate seems to be fairly accurate. However, with the lack of documentation in the files (no Scope Amendment and switching of project numbers 053 and 054) and lack of information about what happened to the other portion (MP 4.03-8.06), the calculations regarding net cost escalation may not tell the whole story.

N361055 Ten Sleep-Buffalo/County Line West Section

Project entered into STIP in 2001 and delivered in 2012 as 2.3 miles 4R road reconstruction/rock fall mitigation at a cost of \$9.072M. The PSR done in 2001 estimated the cost at

MANAGING RISKS IN THE PROJECT PIPELINE

\$3.850M (2002 dollars). The Scope Statement from 2002 indicated a change in intent to reconstruction with minor realignment and a desire to do the project in two phases; phase one would involve flattening a rock cut slope at MP 42 and phase two would involve reconstructing the remainder of the project. The estimate listed on the 2002 Scope was \$4.083M (2005 dollars) and was a handwritten correction to the original estimate. A series of emails from April 2008 indicated a revised cost estimate of \$11.884M (2012 dollars). This estimate was done during a period of high inflation and thus was higher than the actual, delivered cost in 2012. Revising estimates frequently during periods of high inflation will help prevent under-programming and over-programming of the pipeline.

Escalation: This project was delivered 11 years after entering the STIP as 2.3 miles of 4R reconstruction/rock fall mitigation. Using the estimate from the 2002 Scope Statement of \$4.083M (2005 dollars) and the Let price of \$9.072M (2012), there was approximately 12 percent escalation per year from 2005 to 2012. The average annual inflation from 2005-2012 was 8.5 percent. Thus, the net escalation was 3.5 percent per year.

One other note: In the hard copy folder for this project, a series of emails around April 2008 indicated there was a new estimate of the cost of the project and it was listed as \$11.884M (2012 dollars). This estimate was almost \$3 million higher than the Let price in 2012. This “new” estimate occurred during a period of high inflation and underscores the need to revise estimates frequently during periods of high inflation to help prevent under-programming and over-programming of the project pipeline/STIP. In addition, the only place the “new” estimate appeared was in hard copies of emails; thus no Scope Amendments or formal process was apparent. The lack of a formal process could lead to confusion regarding when, why, and how cost estimates are made/updated on projects.

MANAGING RISKS IN THE PROJECT PIPELINE

MANAGING RISKS IN THE PROJECT PIPELINE

REFERENCES

1. NCHRP Report 706, *Uses of Risk Management and Data Management to Support Target-Setting for Performance-Based Resource Allocation by Transportation Agencies*, Transportation Research Board, 2011.
2. NCHRP 08-88, *Effective Project Scoping Practices to Improve On-Time and On-Budget Delivery of Highway Projects Handbook*, RFP, Transportation Research Board, September, 2010.
3. Redd, Larry & McDowell, Tim, *Managing Risks in the Project Pipeline – Minimizing the Impacts of Highway Funding Uncertainties*, presentation to the TRB Annual Meeting, January 2011.
4. Redd, Larry, *Comprehensive Approach to Asset Management: Project Selection and Programming*. Presentation to the WASHTO Annual Meeting, Bismarck, ND, July 2010.
5. Womack, James, *The Machine That Changed the World: The Story of Lean Production*, Simon and Schuster, November 1991.
6. Womack, James, *Lean Thinking: Banish Waste and Create Wealth in Your Corporation*, Simon and Schuster, June 2003.