2021 ANNUAL REPORT FOR THE MONTANA DEPARTMENT OF TRANSPORTATION RESEARCH PROGRAMS

FHWA/MT-21-009/8010

Annual Report

prepared for
THE STATE OF MONTANA
DEPARTMENT OF TRANSPORTATION

in cooperation with
THE U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL HIGHWAY ADMINISTRATION

December 2021

prepared by
Chad DeAustin
Bobbi deMontigny
Susan C. Sillick

Montana Department
of Transportation
Helena, MT

Vaneza Callejas

CTC & Associates LLC
Madison WI

RESEARCH PROGRAMS

MONTANA
Department of Transportation

2021 ANNUAL REPORT
FOR THE MONTANA DEPARTMENT OF TRANSPORTATION
RESEARCH PROGRAMS

Prepared by

Susan C. Sillick

Chad DeAustin

Bobbi DeMontigny

Vaneza Callejas

Montana Department of Transportation

December 2021

TECHNICAL REPORT DOCUMENTATION PAGE

1. Report No. FHWA/MT-21-009/8010	**2. Government Accession No.**	**3. Recipient's Catalog No.**
4. Title and Subtitle 2021 Annual Report for the Montana Department of Transportation Research Programs	**5. Report Date** December 2021 **6. Performing Organization Code** 5401	
7. Author(s) Susan C. Sillick (ORCID: 0000-0002-8617-417X), Chad DeAustin, Bobbi deMontigny (ORCID: 0000-0001-7140-0982), Vaneza Callejas	**8. Performing Organization Report No.**	
9. Performing Organization Name and Address Research Programs Montana Department of Transportation 2701 Prospect Avenue PO Box 201001 Helena MT 59620-1001	**10. Work Unit No.** **11. Contract or Grant No.** 9529-589	
12. Sponsoring Agency Name and Address Research Programs Montana Department of Transportation 2701 Prospect Avenue PO Box 201001 Helena MT 59620-1001	**13. Type of Report and Period Covered** Annual Report; 10/1/20–9/30/21 **14. Sponsoring Agency Code** 5401	

15. Supplementary Notes Research performed in cooperation with the Montana Department of Transportation and the U.S. Department of Transportation, Federal Highway Administration. This report can be found at http://www.mdt.mt.gov/research/annual_report.shtml.

16. Abstract

Montana Department of Transportation's (MDT's) Research Programs are internally driven applied research, development, and technology transfer (RD&T) programs necessary in connection with the planning, design, construction, management, and maintenance of highway, public transportation, and intermodal transportation systems. Funding is limited and to keep research relevant to MDT staff, implementable results are the goal. Implementation of research results also helps MDT in meeting its mission of providing a transportation system and services that emphasize quality, safety, cost-effectiveness, economic vitality, and sensitivity to the environment. The purpose of this report is to give a comprehensive description of research, development, and technology transfer activities for federal fiscal year (FFY) 2021 within the Research Programs of MDT. Through these activities, the Research Programs enhance MDT's ability to meet its mission and to deliver efficient and effective transportation services. MDT's Research Programs impact each and every part of MDT's mission. Research projects completed in FFY 2021 yielded results that when fully implemented will improve:

- Efficiency and effectiveness of MDT operations and technology transfer, and the quality of what we do and how we do it, including: improving cost estimating, decreasing overruns, and providing for improved construction portfolio of projects; improved bridge, culvert, and pavement design and processes; improved construction materials and methods; improved support for cities and counties; improved research processes; improved rockfall evaluation and mitigation; improved roadside revegetation; and improved air quality.
- Economic vitality.
- Sensitivity to the environment, including: improved roadside reclamation materials and methods; improved roadside revegetation; decreased erosion on construction and maintenance projects; improved environmental processes; decreased vehicle–wildlife collisions; improved habitat connectivity; and improved air quality.
- Safety, including: improved safety on low-volume roads and in rockfall areas and work zones; reduced vehicle–wildlife collisions; and improved safety culture both within MDT and among the travelling public.

17. Key Words Montana, Research Programs, Annual Report, Research Projects, Experimental Projects, Technology Transfer, Experimental Features, Library, Library Services		**18. Distribution Statement** Unrestricted. This document is available through the National Technical Information Service, Springfield, VA 21161.	
19. Security Classif. (of this report) Unclassified	**20. Security Classif. (of this page)** Unclassified	**21. No. of Pages** 192	**22. Price**

DISCLAIMER STATEMENT

This document is disseminated under the sponsorship of the Montana Department of Transportation (MDT) and the United States Department of Transportation (USDOT) in the interest of information exchange. The State of Montana and the United States assume no liability for the use or misuse of its contents.

The contents of this document reflect the views of the authors, who are solely responsible for the facts and accuracy of the data presented herein. The contents do not necessarily reflect the views or official policies of MDT or the USDOT.

The State of Montana and the United States do not endorse products of manufacturers.

This document does not constitute a standard, specification, policy, or regulation.

ALTERNATIVE FORMAT STATEMENT

MDT attempts to provide accommodations for any known disability that may interfere with a person participating in any service, program, or activity of the Department. Alternative accessible formats of this information will be provided upon request. For further information, call 406.444.7693, TTY 800.335.7592, or Montana Relay at 711.

TABLE OF CONTENTS

TECHNICAL REPORT DOCUMENTATION PAGE iv
DISCLAIMER STATEMENT v
ALTERNATIVE FORMAT STATEMENT v
TABLE OF CONTENTS vi
LIST OF TABLES x
LIST OF FIGURES x
1 INTRODUCTION 1
2 ANNUAL PROGRAMS 2
2.1 AASHTO TECHNICAL SERVICES PROGRAMS 2
2.2 ADMINISTRATIVE PROJECTS – ADMINISTRATION AND CONDUCT OF RESEARCH PROGRAMS 4
2.3 MDT CONSULTANT PROJECT MANAGEMENT 13
2.4 MONTANA LOCAL TECHNICAL ASSISTANCE PROGRAM (LTAP) 14
2.5 TRANSPORTATION RESEARCH BOARD SUPPORT 16
3 RESEARCH PROJECTS 20
3.1 OVERVIEW 20
3.2 BRIDGE AND HYDRAULICS RESEARCH PROJECTS 24
3.2.1 Active Projects 24
3.2.1.1 Bridge Deck Cracking Evaluation 24
3.2.1.2 Concrete-Filled Steel Tube to Concrete Pile Cap Connections: Further Evaluation/Improvement of Analysis/Design Methodologies (Phase IV-V) 26
3.2.1.3 Development of Deterioration Curves for Bridge Elements in Montana 28
3.2.1.4 Evaluation of Thin Polymer Overlays for Bridge Decks 30
3.2.1.5 Exploration of UHPC Applications for Montana Bridges 32
3.2.1.6 Feasibility of Non-Proprietary Ultra-High Performance Concrete (UHPC) for Use in Highway Bridges in Montana: Implementation 34
3.2.1.7 A Feasibility Study of Road Culvert Bridge Deck Deicing Using Geothermal Energy 36
3.2.1.8 Monitoring Streamflow Using Video Cameras 38
3.2.2 Completed Projects 40
3.2.2.1 Feasibility of Non-Proprietary Ultra-High Performance Concrete (UHPC) for Use in Highway Bridges in Montana – Phase 2: Field Application 40
3.2.2.2 Regression Equations Based on Channel-Width Characteristics to Estimate Peak-Flow Frequencies at Ungauged Sites Using Data Through Water Year 2011 42
3.3 CONSTRUCTION RESEARCH PROJECTS 44
3.3.1 Active Projects 44
3.3.1.1 Artificial Intelligence (AI) based Tool to Estimate Contract Time 44
3.3.2 Completed Projects 46
3.3.2.1 Effective Production Rate Estimation and Activity Sequencing Logics Using Construction Daily Work Report Data: Phase 2 46

3.3.3 Implementation Projects 48
3.3.3.1 Effective Production Rate Estimation and Activity Sequencing Logics Using Daily Work Report Data: Phases 1 and 2 Implementation 48
3.4 ENVIRONMENTAL RESEARCH PROJECTS 50
3.4.1 Active Projects 50
3.4.1.1 Effective Wildlife Fences through Better Functioning Barriers at Access Roads and Jump-Outs 50
3.4.2 Completed Projects 52
3.4.2.1 Testing Wildlife-Friendly Fencing Modifications to Manage Wildlife and Livestock Movements 52
3.4.3 Implementation Projects 54
3.4.3.1 MDT Wildlife Accommodations Process Implementation 54
3.4.3.2 Testing Wildlife-Friendly Fencing Modifications to Manage Wildlife and Livestock Movements Implementation 56
3.4.4 Proposed Projects 58
3.4.4.1 Evaluate MDT Electrified Wildlife Deterrent Mats 58
3.5 FINANCE/REVENUE RESEARCH PROJECTS 60
3.5.1 Proposed Projects 60
3.5.1.1 Economic Benefits of Improving Montana's Transportation Infrastructure (EBIMTTI) 60
3.6 GEOTECHNICAL RESEARCH PROJECTS 63
3.6.1 Completed Projects 63
3.6.1.1 Large-Scale Laboratory Testing of Geosynthetics in Roadway Applications 63
3.6.2 Implementation Projects 65
3.6.2.1 Guidelines for Chemically Stabilizing Problematic Soils Implementation 65
3.6.3 Proposed Projects 66
3.6.3.1 Development of P-Y Curves for Analysis of Laterally Loaded Piles in Montana 66
3.6.3.2 Organization and Analysis of Measurement While Drilling (MWD) Data 68
3.7 INFORMATION SERVICES RESEARCH PROJECTS 70
3.7.1 Active Projects 70
3.7.1.1 Analyze Business Models for Implementation and Operation of a Statewide GNSS Real-Time Network 70
3.7.1.2 Montana LTAP Learning Management Systems 72
3.8 MATERIALS/DATA COLLECTION AND ANALYSIS RESEARCH PROJECTS 74
3.8.1 Active Projects 74
3.8.1.1 Alkali-Silica Reactivity in the State of Montana 74
3.8.1.2 Numerical Modeling of the Test Pit for Falling Weight Deflectometer Calibration 76
3.8.2 Proposed Projects 78
3.8.2.1 Aging Conditions for Hot Mix Asphalt Cracking Test 78

3.9 SAFETY RESEARCH PROJECTS 80
3.9.1 Active Projects 80
3.9.1.1 Developing a Methodology for Implementing Safety Improvements on Low-Volume Roads in Montana 80
3.9.1.2 Effectiveness of Highway Safety Public Education at Montana Motor Vehicle Registration Stations by Streaming a Variety of Safety Content 82
3.9.1.3 Icy Road Forecast and Alert (IcyRoad): Validation and Refinement Using MDT RWIS Data 84
3.9.1.4 Traffic Safety Culture Transportation Pooled Fund (TSC-TPF) Program – Phase 1 86
3.9.1.5 Traffic Safety Culture Transportation Pooled Fund (TSC-TPF) Program – Phase 2 96
3.9.2 Proposed Projects 100
3.9.2.1 Safety Evaluation of Sinusoidal Centerline Rumble Strips 100
3.9.2.2 Use of Fluorescent Orange Delineators in Temporary Traffic Control Work Zones 102
4 EXPERIMENTAL PROJECTS 103
4.1 Overview 103
4.1.1 Work Plan 103
4.1.2 Construction Report 104
4.1.3 Progress and Final Reports 104
4.2 Active Projects 106
4.2.1 3/8” Asphalt Cement Mix Placement with No Chip Seal Evaluation 106
4.2.2 3D Synthetic Geocomposite for Added Subsurface Drainage Layer in Asphalt Cement Pavement Structure Evaluation 107
4.2.3 Centerline Rumble Strip Evaluation 108
4.2.4 Crafco Mastic One Joint Filler Evaluation 109
4.2.5 CRS-2P and CHFRS-2P Emulsion Comparison on Chip Seal 110
4.2.6 Electric Wildlife Deterrent Mat 111
4.2.7 Fog Seal Chip Retention Evaluation 112
4.2.8 Fog Seal Over Chip Seal Evaluation 113
4.2.9 High Float vs. Polymer Modified Emulsion Seal and Cover With and Without a Fog Seal 114
4.2.10 JOINTBOND Asphalt Joint Stabilizer 115
4.2.11 Longitudinal Centerline Asphalt Cement Joint Membrane 116
4.2.12 Nomaflex Concrete Joint Filler Evaluation 117
4.2.13 Reinforcing Fibers in Plant Mix Asphalt Cement Evaluation 118
4.2.14 Road Smoothing 119
4.2.15 Sinusoidal Centerline Rumble Strip Evaluation 120
4.2.16 SKAPS GT116N Nonwoven Textile Bond Breaker 122
4.2.17 Sprayroq SprayWall Polyurethane Applied Culvert Rehabilitation Evaluation 123

4.2.18 Surfacing In-Slope Treatment Evaluation 125
4.2.19 T15 Base One Soil Stabilization Evaluation 126
4.2.20 TenCate Mirafi MPV400 Polypropylene Nonwoven Geotextile Evaluation 128
4.3 Completed Projects 129
4.3.1 Seal Coat Asphalt Emulsion (or Fog Seal Coating) Over Chip Seal for Improved Chip Retention Evaluation 129
4.4 Pending Projects 131
4.4.1 Polymer Overlay on PCCP 131
4.4.2 TENAX LBO 220 Geogrid 132
4.5 Proposed Projects 133
5 PARTNERING PROJECTS AND POOLED FUND STUDIES 135
6 SUMMARY 136
6.1 GENERAL 136
6.2 FISCAL 137
Appendix A: Research Project Technical Panel Roles and Responsibilities 143
Appendix B: On Developing a Research Project Scope of Work 148
Appendix C: Research Partnering Project Funding Request 153
Appendix D: Research Partnering Project Annual Evaluation 156
Appendix E: Research Partnering Project Close-Out Evaluation 159
Appendix F: Research Project Identification, Prioritization, and Selection 161
Appendix G: Implementation of Research Results 170
Appendix H: Implementation Planning and Documentation 178

LIST OF TABLES

Table 1. Library Collection Analysis by Item Type 10
Table 2. FFY 2021 Partnering and Pooled Fund Contributions 135

LIST OF FIGURES

Figure 1. Library Collection Analysis by Item Type 10
Figure 2: Research Project Process 23
Figure 3. Experimental Process Summary 105
Figure 4. FFY 2021 Percent of Research Programs Expenditures by Project Type 137
Figure 5. FFY 2021 Percent of Research Project Expenditures by Subject 138
Figure 6. FFY 2021 Number of Research Project Expenditures by Subject 138
Figure 7. FFY 2021 Research Programs Overhead and Indirect Expenditures as Compared to Project Expenditures 139
Figure 8. FFY 2021 Research Program Expenditures by Funding Source 139
Figure 9. FFY 2021 Research Project Expenditures by Researcher Location 140
Figure 10. FFY 2021 Number of Research Projects by Researcher Location 140
Figure 11. FFY 2021 Research Project Expenditures by Sector 141
Figure 12. FFY 2021 Number of Research Projects by Sector 141
Figure 13. FFY 2021 Research Project Expenditures by Researcher Type 142
Figure 14. FFY 2021 Number of Research Projects by Researcher Type 142

1 INTRODUCTION

Montana Department of Transportation's (MDT's) Research Programs are internally driven applied research, development, and technology transfer (RD&T) programs necessary in connection with the planning, design, construction, management, and maintenance of highway, public transportation, and intermodal transportation systems. Funding is limited and to keep research relevant to MDT staff, implementable results are the goal.

The purpose of this report is to give a comprehensive description of research, development, and technology transfer activities for federal fiscal year (FFY) 2021 within the Research Programs of MDT. Through these activities the Research Programs enhances MDT's ability to deliver efficient and effective transportation services.

Responsibilities of the MDT Research Programs include:

- Administer the Research portion of the State Planning and Research Program (SPR);
- Lead and participate in cooperative research efforts with other states, universities, industry, and other partners through pooled fund and other cooperative research, development, and technology transfer efforts;
- Assist MDT staff in identifying and finding ways to meet research needs;
- Provide leadership for research, development, technology, and technology transfer initiatives within MDT;
- Conduct the Research and Experimental Projects Programs, and the Technology Transfer Program;
- Assist with the implementation of research results; and
- Conduct project and program evaluation.

In taking a look back at where we have been, we are given a clearer view of where we are heading, continuously improving as we move forward.

Janus, this Roman God symbolizes change and transition, such as the progression from past to future or of one vision to another.

2 ANNUAL PROGRAMS

2.1 AASHTO TECHNICAL SERVICES PROGRAMS

Project Number:	7831
Start Date:	10/1/20
Completion Date:	9/30/21
Total Cost (100% federal)	$112,737
Total SPR Funds:	$112,737
Total MDT Indirect Costs:	$10,252

Objective:

Research funds pay for seven AASHTO Technical Services Programs (TSPs).

AASHTO Innovation Initiative (AII): The purpose of the AII is to identify and champion the implementation or deployment of a select few proven technologies, products or processes that are likely to yield significant economic or qualitative benefits to the users. The AII works with the Special Committee on Research and Innovation (SCRI), Research Advisory Committee (RAC), and the AASHTO Innovation Community of Practice (ICOP) as well as others to identify new technologies.

AASHTO re:source: AASHTO re:source promotes the quality of testing in construction material laboratories of the AASHTO member departments and others through four activities: the routine assessment of laboratories; the distribution of proficiency test materials; technical support to the AASHTO Committee on Materials and Pavements in the operation of the AASHTO Accreditation Program (AAP); and the development of precision estimates for the AASHTO Committee on Materials and Pavements test methods. Also, MDT's 11 district and area labs are evaluated annually.

Development of AASHTO Materials Specifications (DAMS): DAMS supports the development of new materials standards and test methods, as well as revisions and updates to current standards, through assistance from independent technical writers. Funding expedites the development of these important documents and allows the Committee on Materials and Pavements to make better use of its volunteer members.

Equipment Management Technical Service Program (EMTSP): EMTSP assists state DOTs in more efficiently managing their equipment fleets with the goal of yielding significant savings as well as improved performance and reliability.

LRFD Bridges and Structures Maintenance (LRFDSM): This program supports maintenance of the LRFD specifications, as well as other related bridge specifications. Funding is also used for special studies on bridge design issues, AASHTO staff support to the Committee on Bridges and Structures, and updates of LRFD design examples.

National Transportation Product Evaluation Program (NTPEP): NTPEP cooperatively tests manufactured transportation products that are of common interest to all member departments and shares the results from these laboratory and field evaluations.

Transportation System Preservation Technical Services Program (TSP2): Participation in the TSP2 program helps the state DOTs preserve their pavements and bridges by helping them develop and implement their own preservation programs. Program staff field questions and provide technical guidance on preservation issues such as pavement and bridge treatments, materials, strategies, and best practices.

Accomplishments:

Champions attended meetings, reviewed progress reporting, and participated in activities.

MDT Project Manager:

Sue Sillick
406.444.7693
ssillick@mt.gov

2.2 ADMINISTRATIVE PROJECTS – ADMINISTRATION AND CONDUCT OF RESEARCH PROGRAMS

Project Number:	8010
Start Date:	10/1/20
Completion Date:	9/30/21
Total Cost:	$367,170
Total SPR (80%) Funds:	$293,736
Total State (20%) Funds:	$73,434
Total MDT Indirect Costs:	$35,442

Project Number:	8020
Start Date:	10/1/20
Completion Date:	9/30/21
Total Cost:	$29,564
Total SPR (80%) Funds:	$23,651
Total State (20%) Funds:	$5,913
Total MDT Indirect Costs:	$2,662

Project Number:	8021
Start Date:	10/1/20
Completion Date:	9/30/21
Total Cost:	$49,397
Total SPR (80%) Funds:	$39,518
Total State (20%) Funds:	$9,879
Total MDT Indirect Costs:	$4,731

Objective:

The purpose of these three annual projects is fourfold. The first is to plan and administer the Research Programs and related research activities of MDT to find solutions to existing highway and transportation challenges in Montana. The second objective is to manage, coordinate, and conduct a program to test and properly evaluate new highway materials, products, designs, and/or methods for the ultimate purpose of improving highway performance; decreasing various highway costs; or attempting to solve existing highway construction, rehabilitation, or maintenance problems in Montana. The third objective is to provide funding for MDT staff when working on MDT research or experimental projects, where other federal funds are not appropriate or available. This can include, for example, fieldwork, such as traffic control and coring; and meeting time and travel associated with research or experimental projects. The fourth and final objective is to plan and conduct a program of technology transfer and to develop and maintain knowledge and understanding of the latest highway research projects and programs.

Accomplishments – Research Projects:

For funding beginning FFY 2021, one solicitation cycle (March - April 2020) was completed with 18 submitted research topics, resulting in five topics being moved forward to technical panels.

- Artificial Intelligence (AI) based Tool to Estimate Contract Time (9929-819)
- Effective Wildlife Fences through Better Functioning Barriers at Access Roads and Jump-Outs (9923-808)
- Exploration of UHPC Applications for Montana Bridges (10000-844)

- Feasibility of Non-Proprietary Ultra-High Performance Concrete (UHPC) for Use in Highway Bridges in Montana: Implementation (9925-818)
- Safety Evaluation of Sinusoidal Centerline Rumble Strips (9932-820)

During FFY 2021, for funding beginning FFY 2022, one solicitation cycle (March - April 2021) was completed, with 17 submitted research topics, resulting in four topics being moved forward to technical panels.

- Aging Conditions for Hot Mix Asphalt Cracking Test (22-008)
- Development of P-Y Curves for Analysis of Laterally Loaded Piles in Montana (22-012)
- Evaluate MDT Electrified Wildlife Deterrent Mats (22-013)
- Organization and Analysis of Measurement While Drilling (MWD) Data (22-014)

Thirty-six projects were active in FFY 2021.

- Alkali-Silica Reactivity in the State of Montana (9577-607)
- Analyze Business Models for Implementation and Operation of a Statewide GNSS-RTN (9922-807)
- Artificial Intelligence (AI) based Tool to Estimate Contract Time (9929-819)
- Bridge Deck Cracking Evaluation (9696-700)
- Concrete-Filled Steel Tube to Concrete Pile Cap Connections: Further Evaluation/Improvement of Analysis/Design Methodologies (Phase IV-V) (9630-628)
- Developing a Methodology for Safety Improvements on Low-Volume Roads in Montana (9679-699)
- Development of Deterioration Curves for Bridge Elements in Montana (9831-765)
- Effective Production Rate Estimation and Activity Sequencing Logics Construction Daily Work Report Data: Phase 2 (9344-723)
- Effective Production Rate Estimation and Activity Sequencing Logics Using Daily Work Report Data: Phases 1 and 2 Implementation (9344-504 and 723)
- Effective Wildlife Fences through Better Functioning Barriers at Access Roads and Jump-Outs (9923-808)
- Effectiveness of Highway Safety Public Education at Montana Motor Vehicle Registration Stations by Streaming a Variety of Safety Content (9832-766)
- Evaluation of Thin Polymer Overlays for Bridge Decks (9757-705)
- Exploration of UHPC Applications for Montana Bridges (10000-844)
- Feasibility of Non-Proprietary Ultra-High Performance Concrete (UHPC) for Use in Highway Bridges in Montana – Phase 2: Field Application (9578-606)
- Feasibility of Non-Proprietary Ultra-High Performance Concrete (UHPC) for Use in Highway Bridges in Montana: Implementation (9925-818)
- A Feasibility Study of Road Culvert Bridge Deck Deicing Using Geothermal Energy (9890-784)
- FFY 2020 Local Technical Assistance Program (LTAP) (2443-038)
- FFY 2021 LTAP (2443-039)
- Guidelines for Chemically Stabilizing Problematic Soils Implementation (9389-522)
- Icy Road Forecast and Alert (IcyRoad): Validation and Refinement Using MDT RWIS Data (9891-785)
- Large-Scale Laboratory Testing of Geosynthetics in Roadway Applications (9564-602)
- LTAP State Transportation Innovation Council (STIC) Learning Management Systems Grant (9963-827)

- MDT Consultant Project Management (9529-589)
- MDT Wildlife Accommodations Process: Implementation (5896-423)
- Monitoring Streamflow Using Video Cameras (9790-727)
- Numerical Modeling of the Test Pit for Falling Weight Deflectometer Calibration (9921-806)
- Regional Regression Equations Based on Channel-Width Characteristics to Estimate Peak-Flow Frequencies at Ungauged Sites Using Data Through Water Year 2011 (9353-511)
- Testing Wildlife-Friendly Fencing Modifications to Manage Wildlife and Livestock Movements (9596-617)
- Testing Wildlife-Friendly Fencing Modifications to Manage Wildlife and Livestock Movements Implementation (9596-617)
- Traffic Safety Culture Transportation Pooled Fund (TSC-TPF): Phase 1 - 2015 -2019 FFY (8882-309) and Phase 2 – 2020-2024 FFY (8882-444)
    - FFY 2020 Management Support Contract (8882-444-17)
    - FFY 2021 Management Support Contract (8882-444-18)
    - Guidance for Evaluating Traffic Safety Culture Strategies (8882-309-14)
    - Guidance on Messaging to Avoid Reactance and Moral Disengagement (8882-309-15)
    - Guidance to Promote Workplace Policies and Family Rules to Reduce Cell Phone Use While Driving and Promote Engaged Driving (8882-309-16)
    - A Review of Methods to Change Beliefs (8882-444-19)
    - Resources and Tools to Reduce Multi-Risk Driving Behaviors (8882-444-20)

Of the 36 active research projects, 11 were completed in FFY 2021.

- Effective Production Rate Estimation and Activity Sequencing Logics Construction Daily Work Report Data: Phase 2 (9344-723)
- Feasibility of Non-Proprietary Ultra-High Performance Concrete (UHPC) for Use in Highway Bridges in Montana – Phase 2: Field Application (9578-606)
- FFY 2020 Local Technical Assistance Program (LTAP) (2443-038)
- Large-Scale Laboratory Testing of Geosynthetics in Roadway Applications (9564-602)
- Regional Regression Equations Based on Channel-Width Characteristics to Estimate Peak-Flow Frequencies at Ungauged Sites Using Data Through Water Year 2011 (9353-511)
- Testing Wildlife-Friendly Fencing Modifications to Manage Wildlife and Livestock Movements (9596-617)
- Traffic Safety Culture Transportation Pooled Fund (TSC-TPF): Phase 1 - 2015 -2019 FFY (8882-309)
    - FFY 2020 Management Support Contract (8882-444-17)
    - Guidance for Evaluating Traffic Safety Culture Strategies (8882-309-14)
    - Guidance on Messaging to Avoid Reactance and Moral Disengagement (8882-309-15)
    - Guidance to Promote Workplace Policies and Family Rules to Reduce Cell Phone Use While Driving and Promote Engaged Driving (8882-309-16)

A research project close-out questionnaire was sent to all technical panel members and a separate questionnaire was sent to all principal investigators at the completion of each project. Results were compiled and disseminated with the ultimate goal of improving the conduct and management of research projects.

In addition, five projects are pending proposal review, approval by the technical panel and Research Review Committee, and contracting:

- Aging Conditions for Hot Mix Asphalt Cracking Test (22-008)
- Development of P-Y Curves for Analysis of Laterally Loaded Piles in Montana (22-012)
- Evaluate MDT Electrified Wildlife Deterrent Mats (22-013)
- Organization and Analysis of Measurement While Drilling (MWD) Data (22-014)
- Safety Evaluation of Sinusoidal Centerline Rumble Strips (9932-820)

Finally, two projects remain on hold.

- Economic Benefits of Improving Montana's Transportation Infrastructure (EBIMTTI) (20-007)
- Use of Fluorescent Orange Delineators in Temporary Traffic Control Work Zones (19-006)

Funds were contributed for 19 partnering projects:

- AASHTO Equipment Management Technical Services Program (EMTSP) (7831-795)
- AASHTO Innovation Initiative (AII) Technical Services Program (7831-795)
- AASHTO Load and Resistance Factor Design (LRFD) Bridges and Structures Specification Maintenance (LRFDSM) Technical Services Program | PDF (7831-795)
- AASHTO National Transportation Product Evaluation Program (NTPEP) Technical Services Program, includes AASHTO Product Evaluation List (APEL) (7831-795)
- AASHTO re:source (7831-795)
- AASHTO Technical Service Program to Develop AASHTO Materials Standards (DAMS) | PDF (7831-795)
- AASHTO Transportation System Preservation Technical Services Program (TSP2) (7831-795)
- AASHTOWare Project Data Analytics (9811-746)
- Clear Roads Phase II (TPF-5(353))
- Comprehensive Field Load Test and Geotechnical Investigation Program for Development of LRFD Recommendations of Driven Piles on Intermediate GeoMaterials (TPF-5(391))
- Improve Pavement Surface Distress and Transverse Profile Data Collection and Analysis, Phase II (TPF-5(399))
- National Cooperative Highway Research Program (NCHRP) (TPF-5(421))
- Northwest Passage Phase #4 (TPF-5(376))
- Technology Transfer Concrete Consortium (TPF-5(437))
- Traffic Control Device (TCD) Consortium (3) (TPF-5(447))
- Transportation Research Board Core Services Support (TPF-5(473))
- Updating U.S. Precipitation Frequency Estimates for the Northwest (TPF-5(454))
- Western Alliance for Quality Transportation Construction (WAQTC) (TPF-5(349))
- Western Maintenance Partnership – Phase 3 (TPF-5(394))

Accomplishments – Experimental Projects:

During FFY 2021, 21 experimental projects were active.

- 3/8" Asphalt Cement Mix Placement with No Chip Seal Evaluation
- 3D Synthetic Geocomposite for Added Subsurface Drainage Layer in Asphalt Cement Pavement Structure Evaluation
- Centerline Rumble Strip Evaluation
- Crafco Mastic One Joint Sealer Evaluation

- CRS-2P and CHFRS-2P Emulsion Comparison on Chip Seal
- Electric Wildlife Deterrent Mat
- Fog Seal Chip Retention Evaluation
- Fog Seal Over Chip Seal Evaluation
- High Float vs. Polymer Modified Emulsion Seal and Cover with and without a Fog Seal
- JOINTBOND Asphalt Joint Stabilizer
- Longitudinal Centerline Asphalt Cement Joint Membrane
- Nomaflex Concrete Joint Filler Evaluation
- Reinforcing Fibers in Plant Mix Asphalt Cement Evaluation
- Road Smoothing
- Seal Coat Asphalt Emulsion (or Fog Seal Coating) Over Chip Seal for Improved Chip Retention Evaluation
- Sinusoidal Centerline Rumble Strip Evaluation
- SKAPS GT116N Nonwoven Textile Bond Breaker
- Sprayroq Spraywall Polyurethane Applied Culvert Rehabilitation Evaluation
- Surfacing In-Slope Treatment Evaluation
- T15 Base One Soil Stabilization Evaluation
- Tencate Mirafi MPV400 Polypropylene Nonwoven Geotextile Evaluation

During FFY 2021, one active project was completed.

- Seal Coat Asphalt Emulsion (or Fog Seal Coating) Over Chip Seal for Improved Chip Retention Evaluation

During FFY 2021, two projects were pending. Pending experimental projects are assigned to a construction or maintenance project and a plan-in-hand meeting has been held.

- Polymer Overlay on PCCP
- TENAX LBO 220 Geogrid

During FFY 2021, eight projects were proposed. Proposed projects may or may not have been assigned to a construction or maintenance project, but a plan-in-hand meeting has not been held.

- Animal Detection System: Zapcrete Evaluation
- Diamond Road Smoother
- High Friction Surface Treatment
- Prefabricated Steel Truss/Bridge Deck System Evaluation
- Roundabout Striping Durability Trials Evaluation
- Texas Underseal with Added Scrub Seal Evaluation
- Weather-Activated Detection System Evaluation
- Yellow-Dyed Concrete Curbing to Replace Epoxy-Applied Curbing Evaluation

Accomplishments – Technology Transfer and Library Services:

Technology transfer and Library-related accomplishments achieved in FFY 2021 include the following:

- Published two research newsletters.
- Updated and promoted OverDrive digital materials for MDT employee professional development.

- Updated in-depth library training classes on the MDT Moodle, an open source learning management system.
- Provided library marketing through the Interchange.
- Developed and distributed a departmentally targeted weekly library bulletin to keep people in the know of all library resources as they become available.
- Integrated better outreach and remote access options for employees working from home with links to books and webinars sent directly through email and featured on Moodle.
- Converted library appreciation day and National Library Week into a month of remote learning tools and games to help people learn how to better use library services remotely.
- Provided database training for MDT employees.
- Provided catalog training for MDT employees.
- Provided new employee orientation sessions.
- Provided 309 brief reference (less than 5 minutes).
- Provided 87 in-depth reference (requiring research).
- Added 255 new titles to the library collection.
- Registered 254 patrons.
- Purged library patrons to remove former MDT employees from the library catalog.
- Circulated materials.
- Processed incoming and outgoing interlibrary loans, borrowing materials for patrons and lending materials to other libraries.
- Maintained mail-to-home options for MDT staff working from home.
- Requested free materials offered through the transportation librarian network.
- Purchased new materials in response to patrons' requests.
- Served as the Montana Shared Catalog role of Executive Board Representative for special libraries statewide.
- Served as the Special Library Association role of Chair for the Transportation Division.
- Represented and wrote for the National Transportation Library Network.
- Presented at the Transportation Librarians Roundtable.
- Served on the Committee on Information and Knowledge Management for the Transportation Research Board.
- Performed knowledge capture for succession planning in Research.

Library Services Analysis:

The library services analysis is as follows:

- **255 titles cataloged**. This means 255 new publications were added to the MDT Library.
- **309 reference questions (brief).** This means 309 questions were answered that were short in nature and, generally, took five or less minutes to answer (for example, how do I check out a book, how long can I keep materials, where are you located, etc.).
- **87 in-depth references.** This count includes literature searches, where literature was gathered on particular topics and presented to requestors in a report format; surveys to other state departments of transportation; and any in-depth reference, defined as answering customer questions that require more than five minutes to respond.

Library Collection Analysis:

The principal findings of the library collection analysis, as indicated in Table 1 and Figure 1, include the following:

- The MDT Library has a total of 37,678 copies held in the collection.
- The collection holds 34,124 titles. For some of these titles, there is more than one copy in the collection, which is why the total number of copies is greater than the number of titles.
- Of the 34,124 titles, 11,901 titles are held in electronic format only. These include electronic reports and web-only documents. This category is the second largest format type held in the library, after books.

Table 1. Library Collection Analysis by Item Type

Item Type	Number of Items
Book	20,041
CD	352
Digital	11,901
DVD	249
Journal	1,121
Kit	20
Map	5
Media-Equip	10
Microform	2
OverDrive	414
Pamphlet	9
TOTAL	**34,124**

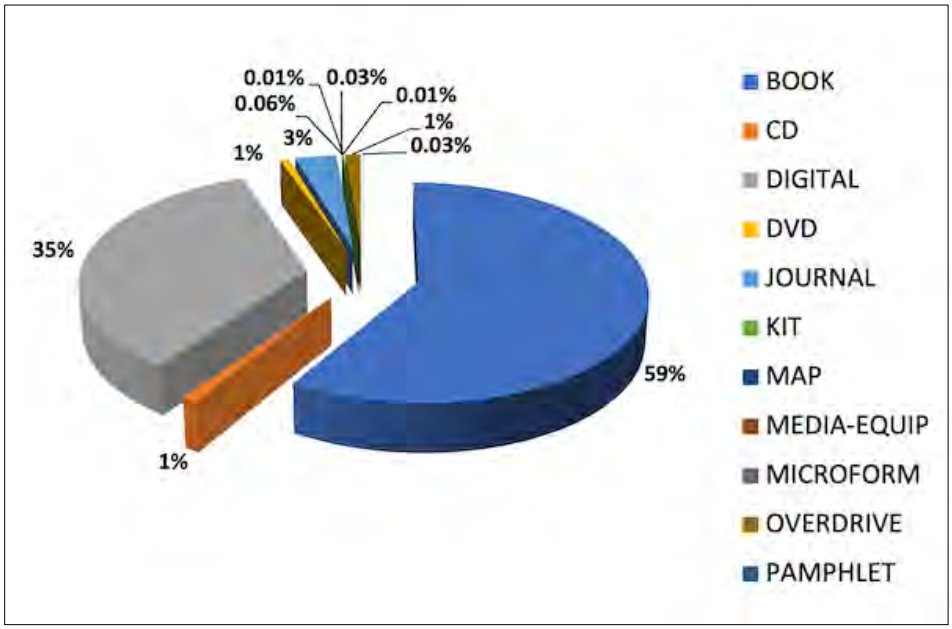


Figure 1. Library Collection Analysis by Item Type

Research and Library Website Analysis:

The principal findings of the research and library website analysis includes the following:

- From October 1, 2020, to September 30, 2021, 21,773 visitors accessed the external MDT Research home page; 16,229 of these visitors were new to the site.
- The most commonly visited link on the MDT Research page was the Montana Transportation and Land Use page (https://www.mdt.mt.gov/research/toolkit/m1/ftools/fd/rlot.shtml) at 8,448 users, followed by the main research landing page at 998 users.
- The MDT Library catalog was visited 1,046 times by 753 unique users. During those visits, 753 unique users performed 1,675 searches; 277 of those users logged into their MDT Library accounts during those searches.
- The MDT Library catalog is the primary access point for electronic resources with access limited to MDT staff. This supports the supposition that electronic resources are the largest circulating portion of MDT Library resources currently.

Reports/Training/Technology Transfer:

- Research and experimental project progress and final reports were published on the Research Programs website (https://www.mdt.mt.gov/research/projects/sub_listing.shtml).
- The Research Review Committee (RRC) met three times throughout the year to discuss research and pooled fund projects.
- The Research Programs Manager attended periodic online meetings for the following AASHTO and TRB committees:
  - AASHTO and TRB Knowledge Management Committees
  - AASHTO RAC Coordination and Collaboration Task Force
  - AASHTO RAC Implementation Working Group
  - AASHTO RAC Performance Measures Working Group
  - AASHTO RAC Program Management and Quality Task Force
  - AASHTO RAC Research Program and Project Management Content and Marketing Working Group
  - AASHTO RAC Value of Research Task Force
  - AASHTO RAC Website Working Group
  - AASHTO Region 4 RAC
  - TRB Annual Meeting
  - TRB Committee Research Coordinator's Council
  - TRB Executive Management Issues Section
  - TRB Research Innovation Implementation Management Committee
- The Librarian attended the following periodic online meetings throughout the year:
  - AASHTO RAC Region 4
  - AASHTO RAC Summer Meeting
  - AASHTO RAC Website Working Group
  - Montana Shared Catalog member and Executive Board
  - Montana State librarian's quarterly roundtable
  - National Transportation Knowledge Network (NTKN)
  - Special Library Association
  - Transportation Librarian Roundtable

- TRB Annual Meeting
- TRB Committee on Information and Knowledge Management

★ The Experimental Project Manager attended the following periodic online meetings throughout the year:

- AASHTO RAC Region 4
- AASHTO RAC Summer Meeting

MDT Project Manager:
Sue Sillick
406.444.7693
ssillick@mt.gov

2.3 MDT CONSULTANT PROJECT MANAGEMENT

Project Number:	9529-589
Start Date:	7/1/20
Completion Date:	6/30/21
Total Cost[1]:	$171,791
Total SPR Funds:	$171,791
SPR Funds (80%) Expended:	$137,433
State (20%) Expended:	$34,358
Indirect Costs Expended:	$15,133
Unexpended Funds:	$33,966
Consultant:	CTC & Associates LLC

[1] This contract is run on a state fiscal year. This information summarizes the year completed in federal fiscal 2021.

Objective:

With the 2017 Montana legislative session, MDT lost nearly 70 positions. Guidance has been to contract-out more work. One of the positions lost and being contracted is a Research Project Manager (RPM) position. An RFP was issued in 2018 and CTC & Associates was hired to provide staff for this work. The consultant RPM serves as an extension of staff and manages projects just as internal staff would.

Progress:

The initial contract concluded in 2019. One-year renewals were enacted in June 2019, 2020, and 2021. This contract can be renewed up to a total of seven years, as per Montana State Law. In FFY 2021, the consultant RPM oversaw 25 active research projects, four of which were in the implementation stage, and four of which were in the scope of work and proposal development stage and were approved for contracting in FFY 2022. RPMs follow a research project tasks checklist and guidance by the Research Programs Manager. In addition to the 25 active projects, two projects were on hold. Seventeen of the active projects were in the contract phase in FFY 2021, with 14 remaining active and three projects being completed in FFY 2021. The completed projects have moved into the implementation phase. Finally, this consultant RPM also provided the notes for three Research Review Committee meetings and additional consultant staff prepared the 2020 FFY annual report.

The Research Programs Manager oversaw 18 projects in FFY 2021, seven of which fall under two pooled fund programs and six of which are annual projects. Ten of these projects were completed in FFY 2021, six of which were annual projects and four of which fall under the pooled fund program. Eight projects remain active. The Librarian/Technology Transfer Specialist also managed one project which was contracted in FFY 2021.

Reports:

Monthly progress reports are provided with each billing.

MDT Project Manager:
Sue Sillick
406.444.7693
ssillick@mt.gov

Consultant Project Manager:
Vaneza Callejas
802.546.0217
vcallejas@mt.gov

2.4 MONTANA LOCAL TECHNICAL ASSISTANCE PROGRAM (LTAP)

Project Number:	2443-038
Start Date[1]:	7/1/20
Completion Date:	6/30/21
Total Cost:	$380,000
Total SPR Funds:	$80,000
SPR Funds (80%):	$64,000
State (20% plus Gas Tax):	$166,000
Other Federal Funds:	$150,000
Total MDT Indirect Costs[2]:	$0
Unexpended Funds:	$0
Consultant:	Montana State University

URL: https://www.mdt.mt.gov/research/ltap/ltap.shtml

[1] The LTAP program is run on a state fiscal year. Hence, it is run nine months behind the federal fiscal year. FFY 2021 LTAP is currently active, running from 7/1/21 to 6/30/22 Therefore, the FFY 2020/SFY 2021 LTAP Program is presented here.

[2] MDT Indirect Costs have been waived for LTAP.

Objective:

The mission of the national Local Technical Assistance Program (LTAP) is to foster a safe, efficient, and environmentally sound transportation system by improving skills and knowledge of local transportation providers through training, technical assistance, and technology transfer. LTAP centers enable counties, parishes, townships, cities, and towns to improve their roads and bridges by supplying them with a variety of training programs, an information clearinghouse, new and existing technology updates, personalized technical assistance, and newsletters. Through these core services, LTAP centers provide access to training and information that may not have otherwise been available. Centers are able to provide local road departments with workforce development services; resources to enhance safety and security; solutions to environmental, congestion, capacity, and other issues; technical publications; and training videos and materials.

Montana has more than 70,000 miles of roads in over 185 jurisdictions including towns, cities, counties, and highway districts. Montana LTAP has focused on assisting state and county road offices and city street departments in road and bridge maintenance and repair. By sharing technical information and improving the distribution of this information, the program promotes efficient use of local transportation agencies' scarce resources. Specific LTAP tasks in FFY 2020/SFY 2021 included: compile and maintain a mailing list; maintain class completion and Montana LTAP Road Scholar program database; publish a regular newsletter; provide technical assistance on-site to local roadway agencies; provide technology transfer materials; conduct trainings and arrange seminars/training sessions at annual conferences; conduct on-demand training, and conduct program evaluation/reporting.

Progress:

Three newsletters (Fall 2020, Spring 2021, and Summer 2021) were published and distributed electronically to a large listserv via email, with numerous digital contacts (via email, website contacts, and social media/Facebook) to customers regarding upcoming trainings, classes, and updates on

technical assists. Technical assists included on-site visits, emails, reports, and analyses, as well as information distributed and responded to through phone calls, faxes, personal contact at workshops, conferences, and emails. Local, state of Montana, and Federal Highway Administration (FHWA) initiatives were highlighted in the LTAP newsletters.

Montana LTAP worked with FHWA to promote the Every Day Counts (EDC) initiatives, including the Local Road Safety Plans, Low-Cost Safety Countermeasures, FHWA EDC-5 focus on reducing rural roadway departures (FoRRRwD) initiative including Systemic Safety countermeasures for local roads.

A few examples of LTAP efforts include:

- Director Matt Ulberg was elected President of the National LTAP Association in June 2021 and will serve a term of one year.
- Administered Road Scholar program as an educational incentive and recognition program for training participants statewide.
- Organized numerous safety and operations trainings within the Road Scholar class framework.
- Provided numerous on-site technical assists from sign placement assistance to guardrail evaluations.
- Provided winter maintenance and safety trainings at many locations around the state.
- Renewed the forklift/skid steer certification program and worked with several local agencies to renew their training certifications and internal training programs.
- Provided administration of the Montana Work Zone Flagger Certification program, training and certifying numerous flaggers every year.

Since 2017, LTAP has experienced an over 44% increase in program content delivery, and the 2021 Program Assessment Report shows further growth that includes increased content in local trainings. Technical assists have also improved and expanded. At any given time, LTAP is frequently working on over a dozen technical assists of varying complexity and duration.

Due to COVID-19 restrictions, spring and summer 2021 were challenging for program delivery. In response to this challenge, LTAP staff have adjusted by offering more digital content delivery and virtual options, increasing focus on direct one-on-one technical assistance when appropriate, and keeping class sizes small, venues large and maintaining social distance and mask use requirements.

Reports:

Four quarterly progress reports were submitted, reviewed, and published on the project website at the above URL. Further details of LTAP's activity is included in these reports.

MDT Project Manager:
Sue Sillick
406.444.7693
ssillick@mt.gov

Consultant Project Manager:
Matt Ulberg
406.531.1142
matthew.ulberg@montana.edu

2.5 TRANSPORTATION RESEARCH BOARD SUPPORT

Project Name: TRB Core Services
Project Number: TPF-5(473)
Start Date: 10/1/2020
Completion Date: 9/30/2021
Total Cost: $109,103
SPR Funds – B (100%): $109,103
URL: http://www.trb.org/Main/Home.aspx

Project Name: NCHRP
Project Number: TPF-5(421)
Start Date: 10/1/2020
Completion Date: 9/30/2021
Total Cost: $489,687
SPR Funds – A (100%): $244,848
SPR Funds – B (100%): $244,849
URL: http://www.trb.org/NCHRP/NCHRP.aspx

TRB Core Services Support:

TRB was founded in 1919 to convene experts—from the public, private, and academic sectors, across transportation modes and disciplines—to advance the knowledge and practice of transportation in an open and non-partisan setting. These experts identify research needs, share the latest ideas and innovations, oversee cooperatively funded research, and provide independent advice on policy issues that entail significant and technical aspects.

The partnership of TRB and the state transportation research community has been in place since 1920, with states providing direct financial support beginning in the 1940s. This TRB/state partnership promotes the development and implementation of innovations that save countless lives, improve mobility and access, and vastly increase the cost-effectiveness of materials, designs, construction practices, and operations.

TRB provides an information infrastructure that is designed to serve the nation's highly decentralized transportation system in which no single organization dominates. Indeed, the cooperation that TRB encourages among transportation agencies at all levels is the envy of other sectors that are similarly decentralized but do not have a mechanism like TRB to facilitate interactions among practitioners and researchers in an independent setting.

MDT invests in TRB's Core Program, which provides a forum for state DOT employees to collaborate with transportation professionals from other organizations to share information on research and issues of interest.

MDT's investment leverages a considerable return. As part of the independent institution, the National Academies of Sciences, Engineering, and Medicine (NASEM), TRB has earned a national and international reputation for objective, high-quality products.

With MDT's financial contribution, MDT employees are involved in the following activities:

- Selecting and providing oversight to projects in TRB's National Cooperative Highway Research Program.
- Serving on panels for other TRB cooperative research programs in the areas of transit, airports, behavioral traffic safety, freight, and hazardous materials.
- Providing input to TRB's Technical Activities Division, which functions as a research clearinghouse and facilitates collaboration among the states, transportation organizations, academia, and individual researchers and practitioners.

- Serving on National Research Council-appointed committees that develop, refine, or offer direction on national transportation issues, often based on a request for advice from a public or private agency.

This investment in TRB and the pooled funding it represents is mission-critical, enabling MDT to:

- Have a voice in setting national research priorities and agendas;
- Continue to have access to the user-oriented research;
- Avoid duplication of research efforts;
- Demonstrate a return on investment of taxpayers' dollars;
- Support the uniform, practical, and common-sense application of transportation research results;
- Continue to develop a more enlightened and informed workforce;
- Improve customers' experiences by accelerating the development and implementation of solutions to problems that affect transportation planning, design, construction, operation, and maintenance; and
- Retain employees by offering stimulating and professionally rewarding opportunities to participate in efforts that will help improve the nation as a whole.

Tangible Benefits:

MDT receives the following tangible benefits.

- Complimentary registration to the TRB Annual Meeting. The face-to-face meetings and interactions that take place at the Annual Meeting generate ideas, products, and partnerships from which MDT benefits. The Annual Meeting provides an unparalleled opportunity for MDT staff to share knowledge and perspectives with over 13,000 colleagues and to learn about the latest in transportation research, policy, and practice. This sense of community also offers a significant morale boost during tough economic times.
- To address budget restrictions within states, TRB offers activities that not only save states money, but push traditional conference type-information out to state employees who are not able to travel. Examples include the following:
  - **Complimentary access to Annual Meeting papers, extended abstracts, and speaker visual aids through the TRB Annual Meeting Online portal, or AMOnline for short.** Speaker visual aids are from lectern and poster sessions, workshops, and peer-reviewed papers at committee meetings. Non-TRB sponsors are charged $20 per paper/presentation.
  - **Complimentary, unlimited participation in TRB webinars.** These webinars also provide continuing education credits for MDT employees who attended webinars. This provides MDT with a flexible and extremely economical way to ensure employees' professional licenses and certifications remain current.
- **Complimentary copies of TRB publications.** TRB fulfills all individual "over the counter" publication requests from state employees on a complimentary basis. (Note: Most states are now moving to all-electronic distribution. This refers to printed publications.)
- **Complimentary, electronic access to the TRR Journal Online**, which includes more than 13,900 peer-reviewed papers that have been published as part of the *Transportation Research Record: Journal of the Transportation Research Board* (TRR Journal) series since 1996.
- **Reduced fees to TRB-sponsored specialty conferences**. This discount is about 25% below the general registration fee for the more than 25 specialty conferences TRB conducts each year.

- **Reimbursement for State Representative meeting travel**. TRB reimburses the costs for lodging for TRB State Representatives to attend the State Representatives annual meeting, which is held in conjunction with the AASHTO Research Advisory Committee meeting. The reimbursement and reduction in travel cost savings associated with the dual scheduling of these events amounts to a value of approximately $1,800 per year.

Intangible Benefit – Avoiding Duplication:

- **Access to research collaboration tools** such as the Research Needs Statements (RNS) and Research in Progress (RiP), which were built and are maintained by TRB in part by the Department's contribution to TRB.
- **Access to the Transport Research International Documentation (TRID) database.** TRID is an integrated database that combines the records from TRB's Transportation Research Information Services (TRIS) Database and the Organisation for Economic Co-operation and Development's Joint Transport Research Centre's International Transport Research Documentation (ITRD) Database. TRID provides access to more than one million records of transportation research worldwide. TRID is maintained by TRB in part by the Department's contribution to TRB.
- **Weekly notices on TRB Activities** via TRB E-Newsletter. The weekly electronic service is designed to keep individuals up to date on TRB activities and to highlight selected transportation research-related activities taking place at the federal and state levels, and within the academic and international transportation communities.
- **In-state, periodic access to TRB staff**. Not all of our staff can participate in TRB, so TRB comes to us. TRB's field visit program is designed to keep TRB aware of and responsive to our needs. TRB's last visit to Montana was in 2019 and the next visit, which will be virtual, is scheduled for FFY 2022.

National Cooperative Highway Research Program (NCHRP):

- A portion of MDT's federal State Planning and Research funds is invested in and is the primary source of funding for TRB's National Cooperative Highway Research Program, which conducts and delivers research in acute problem areas that affect state DOT highway planning, design, construction, operation, and maintenance nationwide.
- Our state's contribution to that total was $489,687, which means we leverage approximately $45 in research-related activity for every $1 we invest in TRB's NCHRP activities.
- MDT participates in NCHRP by:
  - Submitting problem statements (A problem statement on Developing a Traffic Safety Culture Research Roadmap was submitted by MDT in FFY 2019. This problem statement was approved and is now contracted. The Research Programs Manager serves on the Technical Advisory committee for this project.)
  - Rating problem statements
  - Participating on and chairing NCHRP panels. TRB reimburses state employees for travel and lodging expenses related to participation in panel meetings.
- MDT benefits by implementing research results developed through NCHRP. In addition to conducting research on specific problems identified by practitioners and selected by the AASHTO Special Committee on Research and innovation, NCHRP through its 20-24 project series addresses issues selected by state CEOs in the areas of resource development, decision support, and financial management; issues selected by AASHTO committees are addressed through its 20-123 series.

- NCHRP's Impact on Practice series, available at http://www.trb.org/NCHRP/NCHRPImpactsonPractice.aspx, highlights how transportation agencies have put NCHRP research results to use.

Other TRB Research Programs:

In addition to TRB's NCHRP, TRB also manages a variety of other programs that are not directly supported by the states, but from which MDT benefits. These programs are authorized by Congress and funded through various administrations within the U.S. Department of Transportation. The programs include the following:

- **Airport Cooperative Research Program (ACRP).** ACRP is an industry-driven, applied research program that develops near-term, practical solutions to problems faced by airport operators.
- **Behavioral Traffic Safety Cooperative Research Program (BTSCRP).** BTSCRP is a forum for coordinated and collaborative research to address issues integral to the Governors Highway Safety Association (GHSA), the National Highway Traffic Safety Administration (NHTSA), and traffic safety professionals at all levels of government and the private sector.
- **Transit Cooperative Research Program (TCRP).** TCRP is an applied, contract research program that develops near-term, practical solutions to problems facing transit agencies.

Leadership within TRB:

Montana's employees help provide direct leadership on TRB activities by participating in TRB committees and panels. Their direct involvement enables Montana to affect national transportation research agendas and activities and provides direct information to Montana on the latest information from other states and countries.

Visit the following address to see a list of Montana's employees who help provide direct leadership for TRB activities: https://www.mytrb.org/CompanyDetails.aspx?CID=6744.

MDT Project Manager:

Sue Sillick
406.444.7693
ssillick@mt.gov

3 RESEARCH PROJECTS

3.1 OVERVIEW

Once a year, the Research Programs Manager solicits research ideas from as wide a variety of individuals as possible. This open solicitation enhances the possibility of receiving a diverse spectrum of research suggestions.

The solicitation process begins with the Stage 1: Research Idea form (https://www.mdt.mt.gov/research/unique/solicit.shtml). This simple form is due each March 31st and contains following four fields:

- Title
- Idea description
- Submitter information
- Champion information

A champion is any MDT staff with a vested interest in the research, and who is willing to chair the technical panel if the research should move forward to that stage. Champions make presentations to the Research Review Committee (RRC) at various stages in the life of the project. In doing this, the champion asserts there is a research need and this need is important to MDT. If an idea is submitted by MDT staff, that person or their designee is the champion. If an idea is submitted by someone other than MDT staff and they do not include a champion, Research staff will attempt to secure a champion. If one is not secured, the idea does not move forward.

For all ideas that have a champion, the MDT librarian conducts a literature search on the topic and shares this information with the champion, who determines, based on the results of this literature search, if the idea should move forward to the Stage 2: Research Topic Statement (https://www.mdt.mt.gov/research/unique/solicit.shtml). The Stage 2 form is due each April 30th and contains the following fields:

- Title
- Topic statement
- Related research summary
- Research proposed
- Research period
- IT component(s)
- Feasibility, probability of success, and risk
- Urgency
- Importance, and expected benefits/payoff; implementability, implementation plan, and responsibility
- MDT priority focus areas
- Total funding requested
- Funding source(s)
- Funding match source and amount (if any)
- Funding partners
- Potential technical panel members
- Submitter information
- Champion information
- Sponsor information

A sponsor is MDT staff at or above the District and Division Administrator level. Sponsors agree each topic is consistent with MDT needs and goals, should be considered by a technical panel, and ensure implementation, as applicable. A sponsor is required for each topic statement before it can be prioritized.

The champions for each topic statement present their topic to the RRC and District Administrators in May of each year. Between May and July, based on available funding, the RRC and District Administrators then select the topics that will move forward to the technical panel stage for funding beginning October 1st of each year. These topics are chosen because they address actual concerns of the Department.

Following the selection of these high-priority topics, Research Programs staff form a technical panel for each topic. Technical panels are formed to follow research projects from inception through implementation and are typically composed of three to 10 people with knowledge or expertise and interest in the specific area of research. See Appendix A for Technical Panel Roles and Responsibilities and for more information on the RRC. Panel members are drawn from MDT's Division and District offices, as well as from outside the Department. FHWA is invited to appoint staff to each technical panel. The technical panel's responsibility begins with a review of the literature to determine the need for research, if any, and continues with the development of a scope of work (SOW), which is developed on the SOW form (Appendix B) and includes the following fields:

- Project Title
- Project Background
- Benefits/Business Case/Impact
- Objectives
- Tasks
- Acceptance Criteria
- Cooperators/Stakeholders/Partners
- Communications Considerations
- Data Requirements
- IT Components
- Intellectual Property Considerations
- MDT Involvement
- Deliverables, especially those that facilitate implementation
- Risks
- Implementation Considerations, including barriers and any attempts to reduce or eliminate the barriers
- Performance Measures Considerations

The SOW is used by consultants to prepare a proposal. The champion presents the proposal recommended by the technical panel to the RRC for funding approval.

During the conduct of research, the Research Programs representative on each technical panel serves as MDT's project manager and liaison between the technical panel and the consultant. The technical panel monitors research progress by reviewing monthly or quarterly, annual, task, final, project summary, implementation, and performance measures reports, and any other reports and deliverables produced. Products to facilitate implementation are included in research contracts.

When a contract is executed for each project, the Research Project Manager completes Part A of the Implementation Planning and Documentation form. The Research Project Manager completes Parts B-D when the research is concluded. Part D is signed by the project champion and sponsor. Also at this time, the champion presents the research results and implementation plan to the RRC. The Implementation Planning and Documentation form provides a living implementation plan to track implementation activities until all are fully implemented or it is clear that no additional implementation will follow.

The research projects process as detailed above is shown in Figure 2 on page 23. In addition to the solicitation process (as described above), there are a number of other methods to initiate research projects that require funding outside of the annual funding process described above; these include the following: Montana Partnership for the Advancement of Research in Transportation (MPART Small Projects); other partnership projects such as pooled funds and AASHTO Technical Services Programs TSP); and Administration High Priority topics (Figure 2). In these cases, a champion identifies a sponsor, and presents the need and why it cannot wait until the next funding cycle to the RRC. Champions and sponsors are required for all projects; these roles may be filled by the same person if that person meets the requirements for a sponsor as described above.

MDT has contracts in place with the Montana University System for small projects (<$50,000 and one year in duration) under the MPART Small Projects agreement. If there is a need for a small project, such as a synthesis project, which includes a review of the literature and a survey of the state of the practice, similar to NCHRP synthesis projects, the steps below are followed:

- Champion notifies Research Programs of need.
- Technical panel is formed.
- Proposal is obtained.
- Technical panel recommends proposal for funding to RRC through the champion.
- RRC approves or denies funding request.

For pooled fund projects and AASHTO TSPs, a technical panel is not required. The champion requests funding from the RRC via the Partnering Project Funding Request form (Appendix C), justifying the need for the expense and why it cannot wait until the next funding cycle. Each partnering project champion must prepare the Partnering Project Annual Evaluation form (Appendix D). When a partnering project is concluded, the champion completes the Partnering Project Close-Out Evaluation form (Appendix E) and presents to the RRC the results and implementation activities stemming from the project.

Finally, if MDT Administration identifies a research need that requires immediate attention, the Research Programs Manager is informed, a technical panel is formed, and a proposal(s) is obtained and approved either by the RRC or Administration.

More details on the research project identification, prioritization, and selection process can be found in Appendix F and more details on the implementation process can be found in Appendix G.

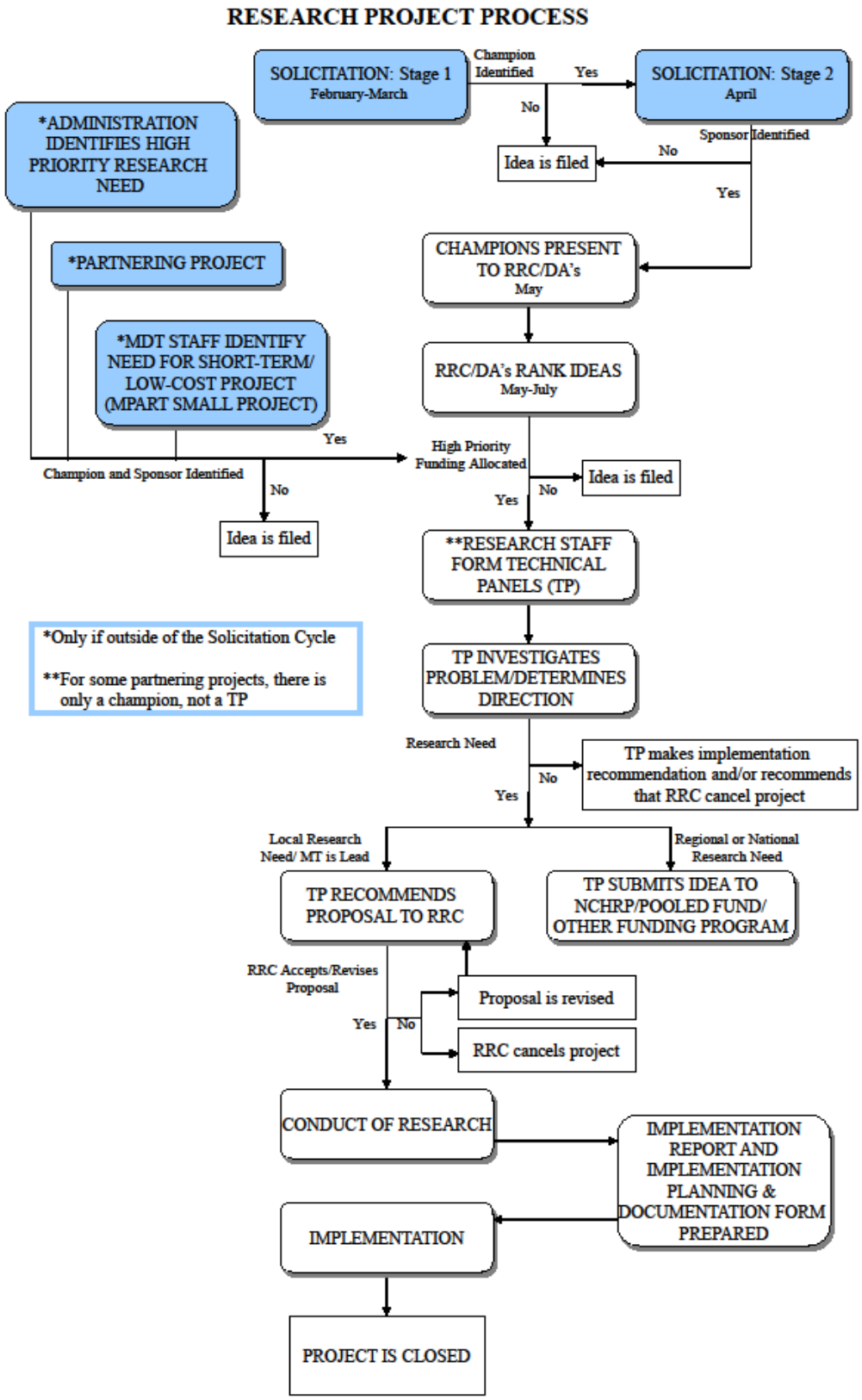


Figure 2: Research Project Process

3.2 BRIDGE AND HYDRAULICS RESEARCH PROJECTS

3.2.1 Active Projects

3.2.1.1 Bridge Deck Cracking Evaluation

Project Number:	9696-700
Start Date:	8/6/19
Completion Date:	12/31/21
Total Cost:	$228,000
Total SPR Funds:	$228,000
Total SPR Funds (80%):	$182,400
Total State Funds (20%):	$45,600
Total MDT Indirect Costs:	$23,339
Total Expended:	$225,868
Total MDT Indirect Costs Expended:	$21,209
2021 FFY Total Expended:	$31,696
2021 FFY Total SPR Expended:	$31,696
2021 FFY SPR Funds (80%) Expended:	$25,357
2021 FFY State Funds (20%) Expended:	$6,339
2021 FFY MDT Indirect Costs:	$2,799
Consultant:	Wiss, Janney, Elstner and Associates

URL: https://www.mdt.mt.gov/research/projects/const/deckcracking.shtml

Objective:

In the spring of 2016, MDT noted severe cracking on two bridge decks in the Missoula District which led to holes in these decks after small sections of concrete fell through. MDT hired Wiss, Janney, Elstner and Associates (WJE) to investigate the cause of these cracks and provide recommendations. The report by WJE was published in April 2017 and some, but not all, of the recommendations were implemented and proved successful in reducing early age cracking in new bridge decks. Although MDT had success with implementation, documentation of actual in-field procedures was not sufficient and there was not a clear understanding of which of the recommendations implemented were causing the success. The purpose of this project is to determine a better way to document in-field procedures and specification enforcement as well as identifying which recommendations are the main cause of the success and which ones may not be proving beneficial.

Progress:

The final report has been submitted and is in review. The project summary and implementation reports will be completed after the implementation meeting in FFY 2022.

Reports:

Six progress reports were received. Project information can be viewed on the project website at the above URL.

MDT Project Manager:
Vaneza Callejas
802.546.0217
vcallejas@mt.gov

Consultant Project Manager:
Todd Nelson
847.753.6583
tnelson@wje.com

3.2.1.2 Concrete-Filled Steel Tube to Concrete Pile Cap Connections: Further Evaluation/Improvement of Analysis/Design Methodologies (Phase IV-V)

Project Number:	9630-628
Start Date:	7/10/18
Completion Date:	9/30/22
Total Cost:	$256,000
Total SPR Funds:	$241,000
Total SPR Funds (80%):	$192,800
Total State Funds (20%):	$48,200
Total Consultant Cost Share:	$15,000
Total MDT Indirect Costs:	$23,595
Total Expended:	$133,615
Total MDT Indirect Costs Expended:	$12,103
2021 FFY Total Expended:	$27,000
2021 FFY Total SPR Expended:	$16,875
2021 FFY SPR Funds (80%) Expended:	$13,500
2021 FFY State Funds (20%) Expended:	$3,375
2021 FFY Total Consultant Cost Share Expended:	$10,125
2021 FFY MDT Indirect Costs:	$1,855
Consultant:	Montana State University

URL: https://www.mdt.mt.gov/research/projects/structures/seismic.shtml

Objective:

MDT has found concrete-filled steel tube (CFST) piles connected at the top by a concrete pile cap to be a very cost-effective support system for short- and medium-span bridges. This type of system offers low initial cost, short construction time, low maintenance requirements, and a long service life. While the gravity load performance of these systems is well understood, their strength and ductility under extreme lateral loads (e.g., seismic events) is more difficult to reliably predict using conventional design procedures. The research aims to further develop newly established design and analysis methodologies, and to ultimately ensure the desired bridge performance.

The primary objective of the research is to further validate/improve MDT's CFST to concrete pile cap connection design/analysis methodologies, and to ensure the efficacy of these methodologies for a wide variety of potential design configurations. Work will begin by identifying potential gaps in the existing

design/modeling strategies, and then designing tests that will help close these gaps. Physical tests will then be conducted and analyzed, with the results being used to develop recommendations as appropriate to improve the analysis and design methodologies.

Progress:

The literature review (Task 1) and experimental design (Task 2) were completed in FFY 2021.

Reports:

Four progress reports were received. Project information and reports can be viewed on the project website at the above URL.

MDT Project Manager:
Vaneza Callejas
802.546.0217
vcallejas@mt.gov

Consultant Project Manager:
Mike Berry
406.994.1566
berry@montana.edu

3.2.1.3 Development of Deterioration Curves for Bridge Elements in Montana

Project Number:	9831-765
Start Date:	8/5/19
Completion Date:	7/15/22
Total Cost:	$83,000
Total SPR Funds:	$83,000
Total SPR Funds (80%):	$66,400
Total State Funds (20%):	$16,600
Total MDT Indirect Costs:	$8,396
Total Expended:	$49,899
Total MDT Indirect Costs Expended:	$4,742
2021 FFY Total Expended:	$34,215
2021 FFY Total SPR Expended:	$34,215
2021 FFY SPR Funds (80%) Expended:	$27,372
2021 FFY State Funds (20%) Expended:	$6,843
2021 FFY MDT Indirect Costs:	$3,257
Consultant:	Montana State University

URL: https://www.mdt.mt.gov/research/projects/structures/deterioration-curves.shtml

Objective:

This research is in response to FHWA's objective of implementing a transportation management plan for the National Highway System (NHS). One of the standards that state departments of transportation must meet is the development and operation of a bridge management system that includes deterioration forecasting for all NHS bridge assets. MDT uses two analysis programs for this purpose: FHWA's National Bridge Investment Analysis System (NBIAS) and the Bridge Data Analytics Tool, which is currently under development. Both of these tools require deterioration curves for different bridge elements (e.g., bridge deck, superstructure, and substructure). The objectives of this research are to 1) develop deterioration models specific to Montana's five transportation districts using inspection data related to time-dependent element deterioration, operation practices, and annual average daily traffic; 2) identify existing or new data that could be used to improve the accuracy of the deterioration curves; and 3) compare the results from Montana-specific data with data from the National Bridge Inventory to identify similarities and differences in the deterioration models.

Progress:

Site selection and the analysis plan (Task 2) were completed. Work also started on the statistical analysis (Task 3) and deterioration curve development (Task 4).

Reports:

Four progress reports were received. Project information and reports can be viewed on the project website at the above URL.

MDT Project Manager:
Vaneza Callejas
802.546.0217
vcallejas@mt.gov

Consultant Project Manager:
Damon R. Fick
406.994.6123
damon.fick@montana.edu

3.2.1.4 Evaluation of Thin Polymer Overlays for Bridge Decks

Project Number:	9757-705
Start Date:	1/22/20
Completion Date:	3/31/23
Total Cost:	$83,000
Total SPR Funds:	$83,000
Total SPR Funds (80%):	$66,400
Total State Funds (20%):	$16,600
Total MDT Indirect Costs:	$8,396
Total Expended:	$60,434
Total MDT Indirect Costs Expended:	$5,834
2021 FFY Total Expended:	$24,718
2021 FFY Total SPR Expended:	$24,718
2021 FFY SPR Funds (80%) Expended:	$19,774
2021 FFY State Funds (20%) Expended:	$4,944
2021 FFY MDT Indirect Costs:	$2,323
Consultant:	Wiss, Janney, Elstner and Associates

URL: https://www.mdt.mt.gov/research/projects/const/evaluation.shtml

Objective:

Thin composite polymer overlays are a cost-effective method for extending the service life and serviceability of concrete bridge decks by filling concrete cracks and increasing skid resistance. The overlay is a thin (1/4 to 1/2 inch) layer of polymer that seals existing cracks and is embedded with aggregate for wear and skid resistance. MDT has recently observed varying performance of two different polymer overlay systems applied to four different bridge decks across the state. This research will assess the performance of thin polymer overlays on concrete bridge decks in Montana.

The project includes a literature review, a review of the polymer systems on MDT's qualified product list and recent skid resistance data for two of these materials. The project also includes the implementation of an expanded and focused field investigation to measure skid resistance and durability of selected polymer systems. The anticipated product of this research will be an updated process for selecting and utilizing thin polymer overlays to increase the service life of bridge decks in Montana.

Progress:

Work continued on the analysis of DOT polymer practice survey results (Task 4.1). Initial site visits and data compilation (Task 4.2) were completed. Work started on core testing (Task 4.3) and findings for the first-year site monitoring were compiled (Task 4.4).

Reports:

Eleven progress reports were received. Project information can be viewed on the project website at the above URL.

MDT Project Manager:
Vaneza Callejas
802.546.0217
vcallejas@mt.gov

Consultant Project Manager:
Paul Krauss
847.753.6517
pkrauss@wje.com

3.2.1.5 Exploration of UHPC Applications for Montana Bridges

Project Number:	10000-844
Start Date:	8/1/21
Completion Date:	10/31/23
Total Cost:	$178,000
Total SPR Funds:	$178,000
Total SPR Funds (80%):	$142,400
Total State Funds (20%):	$35,600
Total MDT Indirect Costs:	$16,985
Total Expended:	$2,345
Total MDT Indirect Costs Expended:	$207
2021 FFY Total Expended:	$2,345
2021 FFY Total SPR Expended:	$2,345
2021 FFY SPR Funds (80%) Expended:	$1,876
2021 FFY State Funds (20%) Expended:	$469
2021 FFY MDT Indirect Costs:	$207
Consultant:	Montana State University

URL: https://www.mdt.mt.gov/research/projects/uhpc.shtml

Objective:

Ultra-high performance concrete (UHPC) has mechanical and durability properties that far exceed those of conventional concrete. However, using UHPC in conventional concrete applications has been cost prohibitive, with commercially available/proprietary mixes costing approximately 30 times more than conventional concrete. Previous research conducted at Montana State University focused on the development and evaluation of non-proprietary UHPC mixes made with materials readily available in Montana. These mixes are significantly less expensive than commercially available UHPC mixes, thus opening the door for their use in construction projects in the state. Building on the success of previous research, the focus of this project is to investigate further uses of this novel material in MDT bridge projects

Progress:

The project kick-off meeting was held in August 2021. The principal investigator began working on the literature review (Task 1).

Reports:

Project information can be viewed on the project website at the above URL.

MDT Project Manager:
Vaneza Callejas
802.546.0217
vcallejas@mt.gov

Consultant Project Manager:
Kirsten Matteson
406.994.6125
kirsten.matteson@montana.edu

3.2.1.6 Feasibility of Non-Proprietary Ultra-High Performance Concrete (UHPC) for Use in Highway Bridges in Montana: Implementation

Project Number:	9925-818
Start Date:	12/10/20
Completion Date:	4/30/23
Total Cost:	$114,000
Total SPR Funds:	$114,000
Total SPR Funds (80%):	$91,200
Total State Funds (20%):	$22,800
Total MDT Indirect Costs:	$11,737
Total Expended:	$64,807
Total MDT Indirect Costs Expended:	$6,109
2021 FFY Total Expended:	$64,807
2021 FFY Total SPR Expended:	$64,807
2021 FFY SPR Funds (80%) Expended:	$51,846
2021 FFY State Funds (20%) Expended:	$12,961
2021 FFY MDT Indirect Costs:	$6,109
Consultant:	Montana State University

URL: https://www.mdt.mt.gov/research/projects/mat/high_performance_concrete.shtml

Objective:

Ultra-high performance concrete (UHPC) has mechanical and durability properties that far exceed those of conventional concrete. However, using UHPC in conventional concrete applications has been cost prohibitive, with commercially available/proprietary mixes costing approximately 30 times more than conventional concrete. Previous research conducted at Montana State University has focused on the development and evaluation of non-proprietary UHPC mixes made with materials readily available in Montana. These mixes are significantly less expensive than commercially available UHPC mixes, thus opening the door for their use in construction projects in the state. The focus of this project is to use this material beyond the laboratory, and successfully use it on a bridge project in Montana, specifically for field-cast joints. This project is a required step to fully understand and capitalize on the benefits of using UHPC for this application and increase the performance, durability, and efficiency of Montana bridges.

Progress:

The project kick-off meeting was held in January 2021. The principal investigator began working on the literature review (Task 1), as well as closing minor research gaps (Task 2) and activities related to bridge construction (Task 3).

Reports:

Two progress reports were received. Project information can be viewed on the project website at the above URL.

MDT Project Manager:
Vaneza Callejas
802.546.0217
vcallejas@mt.gov

Consultant Project Manager:
Mike Berry
406.994.1566
berry@montana.edu

3.2.1.7 A Feasibility Study of Road Culvert Bridge Deck Deicing Using Geothermal Energy

Project Number:	9890-784
Start Date:	7/13/20
Completion Date:	12/31/23
Total Cost:	$235,000
Total SPR Funds:	$235,000
Total SPR Funds (80%):	$188,000
Total State Funds (20%):	$47,000
Total MDT Indirect Costs:	$24,299
Total Expended:	$55,343
Total MDT Indirect Costs Expended:	$5,452
2021 FFY Total Expended:	$53,033
2021 FFY Total SPR Expended:	$53,033
2021 FFY SPR Funds (80%) Expended:	$42,426
2021 FFY State Funds (20%) Expended:	$10,607
2021 FFY MDT Indirect Costs:	$5,223
Consultant:	Montana State University

URL: https://www.mdt.mt.gov/research/projects/deicing-geothermal.shtml

Objective:

Adverse winter weather conditions have a significant impact on the safety, operation, and maintenance of transportation infrastructure. Snow accumulation on roads and bridges reduces their capacity, decreases safety, and increases travel delays. Ice accumulation in and around culverts may adversely affect fish movement and causes flooding and extensive economic losses. Ice accumulation can also lead to propagation of the freezing front into the soil around the culvert and increase the risk of frost heave in the frost-susceptible subsoil in road sections adjacent to the culvert. Therefore, deicing bridge decks and culverts is a major maintenance concern in areas with extreme cold weather. Reduction of ice and snow on bridges also leads to safer roadways and enhanced winter traffic mobility. The research project will investigate the feasibility of using a ground-coupled system that utilizes heat energy harvested from the ground as an alternative for deicing bridges and culverts. The ground-coupled system relies on the circulation of water through pipes placed underground (either vertically or horizontally) to utilize the natural heat retained by the earth.

Progress:

The literature review (Task 1) and geotechnical and geochemical testing (Task 2) were completed. The model-scale instrumented experiments (Task 3) and numerical modeling (Task 4) were initiated.

Reports:

Four progress reports were received. Project information and reports can be viewed on the project website at the above URL.

MDT Project Manager:
Vaneza Callejas
802.546.0217
vcallejas@mt.gov

Consultant Project Manager:
Mohammad Khosravi
406.994.6122
mkhosravi@montana.edu

3.2.1.8 Monitoring Streamflow Using Video Cameras

Project Number:	9790-727
Start Date:	8/5/19
Completion Date:	3/31/22
Total Cost:	$153,600
Total SPR Funds:	$96,000
Total SPR Funds (80%):	$76,800
Total Other Federal Funds:	$57,600
Total State Funds (20%):	$19,200
Total MDT Indirect Costs:	$9,600
Total Expended:	$125,395
Total MDT Indirect Costs Expended:	$7,590
2021 FFY Total Expended:	$57,427
2021 FFY Total SPR Expended:	$32,658
2021 FFY SPR Funds (80%) Expended:	$26,126
2021 FFY Other Federal Funds Expended:	$21,535
2021 FFY State Funds (20%) Expended:	$6,532
2021 FFY MDT Indirect Costs:	$3,234
Consultant:	United States Geological Survey

URL: https://www.mdt.mt.gov/research/projects/hyd/streamflow.shtml

Objective:

Stream velocity information is critical for triggering site visits or other action by MDT personnel for scour-critical bridges in response to floods. Large-scale particle image velocimetry (LSPIV) installations might provide valuable data for MDT's plans of action (POAs) for such sites. LSPIV installations also could provide data on ice jam formation and breakup, and on debris buildup at bridges. LSPIV installations include a video camera, surveyed reference marks, and small computer. LSPIV installations can provide stream velocity information and, when used along with channel cross sections and other field data, stream discharge data.

But LSPIV is relatively new, and the U.S. Geological Survey (USGS) is just beginning to test the technology in select locations across the United States.

The objectives of this project are threefold: 1) investigate the effectiveness and limitations of LSPIV for measuring velocity magnitude and direction related to bridge scour, for detecting changes in a channel

thalweg, for POAs for scour-critical bridges and for bridge scour modeling and assessment; 2) investigate the potential for providing real-time information from LSPIV installations using live-stream video, or periodic photographs or data delivery; and 3) investigate best practices for data processing and distribution, especially for transferring data from the sites to both USGS and MDT personnel.

Progress:

Work on site selection (Task 1) and LSPIV equipment installation and operation (Task 2) was completed; processing of the LSPIV data (Task 3) continued. Data distribution, publishing, and evaluation (Tasks 4 and 5) were initiated.

Reports:

Four progress reports were received. Project information can be viewed on the project website at the above URL.

MDT Project Manager:
Vaneza Callejas
802.546.0217
vcallejas@mt.gov

Consultant Project Manager:
Stephen R. Holnbeck
406.457.5929
holnbeck@usgs.gov

3.2.2 Completed Projects

3.2.2.1 Feasibility of Non-Proprietary Ultra-High Performance Concrete (UHPC) for Use in Highway Bridges in Montana – Phase 2: Field Application

Project Number:	9578-606
Start Date:	3/20/18
Completion Date:	7/31/21
Total Cost:	$162,000
Total SPR Funds:	$156,206
Total SPR Funds (80%):	$124,965
Total State Funds (20%):	$31,241
Total Other State Funds:	$5,794
Total MDT Indirect Costs:	$16,332
Total Expended:	$160,501
Total MDT Indirect Costs Expended:	$14,833
2021 FFY Total Expended:	$19,727
2021 FFY Total SPR Expended:	$19,727
2021 FFY SPR Funds (80%) Expended:	$15,782
2021 FFY State Funds (20%) Expended:	$3,945
2021 FFY MDT Indirect Costs:	$1,952
Unexpended Funds:	$1,499
Consultant:	Montana State University

URL: https://www.mdt.mt.gov/research/projects/mat/high_performance_concrete.shtml

Objective:

Ultra-high performance concrete (UHPC) has mechanical and durability properties that far exceed those of conventional concrete. However, using UHPC in conventional concrete applications has been cost prohibitive, with commercially available/proprietary mixes costing approximately 30 times more than conventional concrete. Previous research conducted at Montana State University resulted in non-proprietary UHPC mixes made with materials readily available in Montana. These mixes are significantly less expensive than commercially available UHPC mixes, thus opening the door for their use in construction projects in the state. The MDT Bridge Bureau is interested in using UHPC in field-cast joints between precast concrete deck panels. The use of UHPC in this application will reduce development lengths, and subsequently reduce the requisite spacing between the decks and improve the overall performance of the bridge. This research built on the non-proprietary UHPC research completed in Phase 1 of this project and focused on ensuring the successful application of this material in these field-cast joints. Specifically, this research investigated several items related to the field batching of these mixes, and the potential variability in performance related to differences in constituent materials. Further, rebar bond strength and the subsequent effect this has on development length was investigated.

Progress:

All research is complete.

Reports:

All final deliverables can be viewed on the project website at the above URL.

Implementation:

Implementation of this project is occurring through Feasibility of Non-Proprietary Ultra-High Performance Concrete (UHPC) for Use in Highway Bridges in Montana: Implementation (page 34).

MDT Project Manager:
Vaneza Callejas
802.546.0217
vcallejas@mt.gov

Consultant Project Manager:
Mike Berry
406.994.1566
berry@montana.edu

3.2.2.2 Regression Equations Based on Channel-Width Characteristics to Estimate Peak-Flow Frequencies at Ungauged Sites Using Data Through Water Year 2011

Project Number:	9353-511
Start Date:	2/1/17
Completion Date:	5/28/21
Total Cost:	$240,000
Total SPR Funds:	$150,000
Total SPR Funds (80%):	$120,000
Total Other Federal Funds:	$90,000
Total State Funds (20%):	$30,000
Total MDT Indirect Costs:	$15,000
Total Expended:	$239,555
Total MDT Indirect Costs Expended:	$14,722
2021 FFY Total Expended:	$27,000
2021 FFY Total SPR Expended:	$16,875
2021 FFY SPR Funds (80%) Expended:	$13,500
2021 FFY Other Federal Funds Expended:	$10,125
2021 FFY State Funds (20%) Expended:	$3,375
2021 FFY MDT Indirect Costs:	$1,855
Unexpended Funds:	$445
Consultant:	United States Geological Survey

URL: https://www.mdt.mt.gov/research/projects/hyd/peak_flow.shtml

Objective:

MDT uses peak-flow frequency data (i.e., 100-year flood) to design highway infrastructure, secure floodplain permits, and perform stream restoration activities. The United States Geological Survey (USGS), in cooperation with MDT, developed regression equations which use channel width as a predictor to provide peak-flow frequency estimates to MDT. The research developed channel width-based regression equations that could increase accuracy and reduce uncertainty when determining flood magnitudes and frequencies. Channel width measurements are commonly obtained through on-site surveys. However, this project evaluated the use of aerial photography and other remote measurement methods to quickly estimate channel widths to reduce the need for on-site surveys.

Progress:

All work was completed and all final products, which include two USGS Scientific Investigations Reports, were delivered and published in FFY 2021.

Implementation:

The USGS developed regression equations to estimate peak-flow frequencies at ungaged sites in Montana, using channel-width characteristics. The equations are based on peak-flow data at streamgages through September 2011 (end of water year 2011) and channel widths measured in the field and from aerial photographs. In 2017, channel widths (active-channel width and bankfull width) were measured in the field at 64 sites across Montana. In addition to field measurements, channel widths were measured near 515 streamgages from National Agricultural Imagery Program photography. These new channel-width data, along with more than 438 historical channel-width measurements, are published in a separate data release.

The channel-width regression equations can be used to estimate peak-flow frequencies (peak-flow magnitudes associated with annual exceedance probabilities of 66.7, 50, 42.9, 20, 10, 4, 2, 1, 0.5, and 0.2 percent) at ungaged sites in each of the eight hydrologic regions in Montana. The equations for channel widths measured from aerial photographs are associated with larger mean standard error of prediction (SEP) values than equations from field-measured channel widths (both from this study and from earlier work). Methods for weighting estimates from the channel-width equations with estimates from equations using basin characteristics also are presented.

In addition to the regression equations, USGS also evaluated the crest-stage gage network in Montana, to allow for better decision making in the management of the network. The evaluation of the CSG network is intended to assist in prioritization for discontinuation of CSGs and other activities involving changes to the CSG network.

An implementation plan and implementation activities will be identified in FFY 2022.

Reports:

Final project information and reports can be viewed on the project website at the above URL.

MDT Project Manager:
Vaneza Callejas
802.546.0217
vcallejas@mt.gov

Consultant Project Manager:
Kathy Chase
406.457.5957
kchase@usgs.gov

3.3 CONSTRUCTION RESEARCH PROJECTS

3.3.1 Active Projects

3.3.1.1 Artificial Intelligence (AI) based Tool to Estimate Contract Time

Project Number:	9929-819
Start Date:	4/8/21
Completion Date:	5/31/23
Total Cost:	$162,897
Total SPR Funds:	$145,000
Total SPR Funds (80%):	$116,000
Total State Funds (20%):	$29,000
Total Consultant Cost Share:	$17,897
Total MDT Indirect Costs:	$15,000
Total Expended:	$0
Total MDT Indirect Costs Expended:	$0
2021 FFY Total Expended:	$0
2021 FFY Total SPR Expended:	$0
2021 FFY SPR Funds (80%) Expended:	$0
2021 FFY State Funds (20%) Expended:	$0
2021 FFY Total Consultant Cost Share Expended:	$0
2021 FFY MDT Indirect Costs:	$0
Consultant:	Texas Transportation Institute

URL: https://www.mdt.mt.gov/research/projects/const/ai_based_contracting_tool.shtml

Objective:

MDT is required by federal regulations to have a procedure and tools for contract time determination. The contract time drives much of the contractor's approach to bidding a specific project. If MDT sets a period that is shorter than the construction industry's estimate, bids will increase across the board as competing contractors bid the cost to accelerate the project. If the period is longer than the industry's estimate of time, the bids also increase as contractors bid the additional costs to remain mobilized. Either way, the public loses due to inaccurate and sometimes arbitrary contract completion times. Emerging artificial intelligence (AI) algorithms have the power to process various types of data and learn the hidden patterns to make reasonable predictions with reliable accuracy. This research project will use one of the promising AI algorithms, namely, the neural network algorithm to quickly estimate the most likely contract time for a highway project. The principal idea is to use key project characteristics that may include work type, project location, major controlling work items and their quantities of work as input variables. The neural network algorithm will then estimate the most likely project duration or contract time of a new project by analyzing the historical data of previous MDT highway projects. One of the major challenges that MDT schedulers face is the short period of time allowed for contract time determination. Thus, a quick and effective contract time determination tool that produces high-quality results in a more reliable and defensible manner will serve as a great support tool for improving work efficiency.

Progress:

The project kick-off meeting was held in April 2021. The principal investigator completed the literature review (Task 1). Work started on data collection and preliminary analysis (Task 2).

Reports:

One progress report was received. Project information and report can be viewed on the project website at the above URL.

MDT Project Manager:
Vaneza Callejas
802.546.0217
vcallejas@mt.gov

Consultant Project Manager:
David Jeong
979.458.9380
djeong@tamu.edu

3.3.2 Completed Projects

3.3.2.1 Effective Production Rate Estimation and Activity Sequencing Logics Using Construction Daily Work Report Data: Phase 2

Project Number:	9344-723
Start Date:	6/7/19
Completion Date:	12/31/20
Total Cost:	$50,000
Total SPR Funds:	$50,000
Total SPR Funds (80%):	$40,000
Total State Funds (20%):	$10,000
Total MDT Indirect Costs:	$5,000
Total Expended:	$49,528
Total MDT Indirect Costs Expended:	$4,715
2021 FFY Total Expended:	$8,693
2021 FFY Total SPR Expended:	$8,693
2021 FFY SPR Funds (80%) Expended:	$6,954
2021 FFY State Funds (20%) Expended:	$1,739
2021 FFY MDT Indirect Costs:	$955
Unexpended Funds:	$472
Consultant:	Texas Transportation Institute

URL: https://www.mdt.mt.gov/research/projects/const/production_rates.shtml

Objective:

A production rate is a quantity of production accomplished over a specific period of time. Realistic production rates are the key in determining reasonable contract times for construction projects. The production rates of major construction activities are important for planning resources and tracking project progress as these activities typically fall in the critical path of the project schedule. Therefore, the accuracy and reliability of the estimated production rates is an effective contract administration tool. The goal of Phase 1 (9344-504) was to enhance MDT's current contract time determination procedures by developing a historical data driven production rate estimation system using data available in construction daily work reports. This second phase addressed activity sequence logics for different types of projects based on historical data. These new tools will significantly improve the accuracy and reliability of MDT's contract time determination.

Progress:

All work was completed and all final deliverables were published in FFY 2021.

Reports:

The project summary and implementation reports were completed after the implementation meeting and posted to the project website in FFY 2021.

Implementation:

An implementation report was completed, and an implementation plan was developed. Refer to the implementation project below for more information.

MDT Project Manager:
Sue Sillick
406.444.7693
ssillick@mt.gov

Consultant Project Manager:
David Jeong
979.458.9380
djeong@tamu.edu

3.3.3 Implementation Projects

3.3.3.1 Effective Production Rate Estimation and Activity Sequencing Logics Using Daily Work Report Data: Phases 1 and 2 Implementation

Project Numbers: 9344-504 and 9344-723
Start Date: 1/1/21
Completion Date: TBD
URL: https://www.mdt.mt.gov/research/projects/const/production_rates.shtml

Objective:

A production rate is a quantity of production accomplished over a specific period of time. Realistic production rates are the key in determining reasonable contract times for construction projects. The production rates of major construction activities are important for planning resources and tracking project progress as these activities typically fall in the critical path of the project schedule. Therefore, the accuracy and reliability of the estimated production rates is an effective contract administration tool. The goal of Phase 1 was to enhance MDT's current contract time determination procedures by developing a historical data driven production rate estimation system using data available in daily work reports. The purpose of Phase 2 was to develop construction activity sequencing logics for different types of projects based on historical data, which can help MDT quickly identify the most common work sequence of the given project and determine the project schedule. Both phases were successfully completed.

Implementation:

All work was completed and all draft deliverables were provided in FFY 2021. The final report, construction activity sequence logics, and the project poster were all completed in FFY 2021 and posted to the project page. The project summary and implementation reports will be completed after the implementation meeting and posted to the project website in FFY 2022.

An implementation report was completed, and an implementation plan with six activities was developed.

1. Implementation Activity 1 – Update MDT Tools and Documentation based on the results of this research. This implementation activity was completed in early FFY 2022.
2. Implementation Activity 2 – Incorporate the visual sequence diagrams into the Excel spreadsheets as templates for the benefit of schedulers while developing and reviewing schedules. This implementation activity was completed in FFY 2021.
3. Implementation Activity 3 – Update the Contract Time Determination Manual to reflect the tools and information provided through this research: The Contract Time Determination

Procedures Manual was updated to include these new tools. This implementation activity was completed in early FFY 2022.

4. Implementation Activity 4 – Post the tools developed through this research to the MDT intranet and internet. The tools were posted to MDT's Contract Time Calculation internet (https://www.mdt.mt.gov/business/consulting/contracttime.shtml) and intranet websites. Also, an article was published in the MDT Interchange, the biweekly employee newsletter. This implementation activity was completed in early FFY 2022.
5. Implementation Activities 5 and 6 – Develop and conduct training on the tools developed through this research. This activity is pending replacement of the champion who left employment at MDT.

MDT Project Manager:
Sue Sillick
406.444.7693
ssillick@mt.gov

MDT Champion:
Bill Squires
406.444.6228
bsquires@mt.gov

3.4 ENVIRONMENTAL RESEARCH PROJECTS

3.4.1 Active Projects

3.4.1.1 Effective Wildlife Fences through Better Functioning Barriers at Access Roads and Jump-Outs

Project Number:	9923-808
Start Date:	12/20/20
Completion Date:	8/31/23
Total Cost:	$81,000
Total SPR Funds:	$70,000
Total SPR Funds (80%):	$56,000
Total State Funds (20%):	$14,000
Total Consultant Cost Share:	$11,000
Total MDT Indirect Costs:	$6,140
Total Expended:	$32,288
Total MDT Indirect Costs Expended:	$2,669
2021 FFY Total Expended:	$32,288
2021 FFY Total SPR Expended:	$27,903
2021 FFY SPR Funds (80%) Expended:	$22,322
2021 FFY State Funds (20%) Expended:	$5,581
2021 FFY Total Consultant Cost Share Expended:	$4,385
2021 FFY MDT Indirect Costs:	$2,669
Consultant:	Montana State University

URL: https://www.mdt.mt.gov/research/projects/admin/wildlife-jumpouts.shtml

Objective:

Wildlife fences in combination with wildlife crossing structures are the most effective and robust measure to improve human safety through reducing collisions with large mammals, and to provide safe crossing opportunities for wildlife. However, in multifunctional landscapes, access roads for agriculture, dispersed housing, and other roads result in openings in the fence. Along US Hwy 93 North on the Flathead Indian Reservation, wildlife guards (similar to cattle guards) at access roads have proven to be a substantial barrier to deer species (about 80% to nearly 100% barrier), but unfortunately, they are quite permeable to species with paws, including bear species (about 50% to nearly 100% permeable). In addition, animals that do end up in the fenced road corridor must be able to escape quickly. Earthen mounds built up against the fence

allow animals to jump down to the safe side of the fence. However, deer use of these wildlife jump-outs has been low (only about 32% use by mule deer, only about 7% use by white-tailed deer). This means that these animals spend more time inside the fenced road corridor before they exit, either at one of the jump-outs or at a fence-end. To further improve human safety, and to reduce direct road mortality of wildlife, including grizzly bears, additional measures are needed at access roads, and deer species need to use the jump-outs more readily.

Progress:

Work on select study sites (Task 1) and selecting measures or modifications (Task 2) was completed. Researchers initiated contacts to stakeholders and agreeing on measures and modifications (Task 3), purchasing and installing mitigation equipment (Task 4), purchasing and installing research equipment (Task 4), and evaluating effectiveness of modified mitigation measures (Task 5).

Reports:

Two progress reports were received. Project information can be viewed on the project website at the above URL.

MDT Project Manager:
Vaneza Callejas
802.546.0217
vcallejas@mt.gov

Consultant Project Manager:
Marcel Huijser
406.543.2377
mhuijser@montana.edu

3.4.2 Completed Projects

3.4.2.1 Testing Wildlife-Friendly Fencing Modifications to Manage Wildlife and Livestock Movements

Project Number:	9596-617
Start Date:	6/19/18
Completion Date:	2/28/21
Total Cost:	$247,456
Total SPR Funds:	$64,000
Total SPR Funds (80%):	$51,200
Total State Funds (20%):	$12,800
Total Consultant/Other Cost Share:	$183,456
Total MDT Indirect Costs:	$7,112
Total Expended:	$246,325
Total MDT Indirect Costs Expended:	$5,981
2021 FFY Total Expended:	$0
2021 FFY Total SPR Expended:	$0
2021 FFY SPR Funds (80%) Expended:	$0
2021 FFY State Funds (20%) Expended:	$0
2021 FFY Consultant/Other Cost Share Expended:	$0
2021 FFY MDT Indirect Costs:	$0
Unexpended Funds:	$1,131
Consultant:	University of Montana

URL: https://www.mdt.mt.gov/research/projects/env/wildlife_fence_mods.shtml

Objective:

Fences along roadways serve as safety measures to protect humans from vehicular collisions with wildlife and livestock by containing animals in appropriate pastures and keeping them off roadways. Fences can act as semi-permeable or complete barriers to wildlife movement. As a consequence, through landscape fragmentation, fences reduce landscape connectivity, impede resource selection, and are a direct cause of mortality in ungulates (e.g., pronghorn, elk, deer) and other species (e.g., greater sage-grouse). To combat these effects on wildlife, multiple fence modifications have been recommended by management agencies using the best available science to either facilitate or deter wildlife and/or livestock from crossing fences.

Progress:

All work was completed and all final products delivered in FFY 2021.

Reports:

Project information and reports can be viewed on the project website at the above URL.

Implementation:

An implementation report was completed and an implementation plan was developed. Refer to the implementation project on page 56 for more information.

MDT Project Manager:
Vaneza Callejas
802.546.0217
vcallejas@mt.gov

Consultant Project Manager:
Erin Landguth
406.243.5221
erin.landguth@mso.mtu.edu

3.4.3 Implementation Projects

3.4.3.1 MDT Wildlife Accommodations Process Implementation

Project Number: 5896-423
Start Date: 2/14/19
Completion Date: 10/31/24
URL: https://www.mdt.mt.gov/research/projects/env/wap.shtml

Objective:

MDT has accommodated a variety of wildlife species in the last two decades in a number of different ways. However, the processes, justification, and criteria used for recommending and implementing accommodations have varied just as the technology and practices in the field have rapidly evolved. This project investigated how to establish a process to incorporate these features into construction projects by a documented justification process to determine the appropriateness of including wildlife accommodations in project development and design. The overall objective is to implement a wildlife accommodations process specifically tailored to meet MDT's project development processes, Montana wildlife, and evaluate needs as well as feasibility.

Implementation:

In FFY 2021, the implementation plan was regularly reviewed. Completed implementation tasks include the following:

1. Populate the Wildlife Accommodations Process (WAP) tracking spreadsheet with all projects using the process (i.e., every project that has a Wildlife Accommodations Recommendations Memo (WARM)). This task in ongoing.
2. Develop a survey to determine performance measures. The survey was developed in MDTClassrooms.

Tasks pending implementation include the following:

1. Implement survey. This survey was originally intended for FFY 2021. However, it was postponed until FFY 2022 to increase the number of projects using this process.
2. Annual process review: Download survey and format survey results, schedule technical panel meeting, and send results of survey and tracking spreadsheet to technical panel.
3. Technical panel meeting to discuss survey results and tracking spreadsheet. The Environmental Services Bureau will develop the process review summary report with specific action items to include possible process changes, etc. The Environmental Services Bureau will send this document to the technical panel for review and revision. Finally, the Environmental Services Bureau will revise and finalize document for distribution.
4. Implement tasks from #3 immediately above.

Previously completed tasks include the following:

1. Update construction project milestone report templates.
2. Discuss implementation plan at an Engineering Bureau Chiefs meeting.
3. Discuss implementation plan at Preconstruction meeting with headquarters and district staff.

4. Modify MDT WARM and Wildlife Accommodations Decision Report (WADR) so that they can be used by consultants as well. Post on website. Archive files.
5. Prepare scope of work activity descriptions (128, 214, 415, and 566) to include the WADR language, and precursors and successors.
6. Determine activity durations and man-hours (214, 415, 566, 706, and 707): 60 days for 706 (BRR/PBA - MDT).
7. Update flowcharts and add activity description for activities 109 and 707 (WARM).
8. Discuss implementation at seven regional Fish, Wildlife and Parks (FWP) meetings.
9. Make all activities (109, 128, 182, 214, 415, 566, 706, and 707) and flowcharts, WARM, and WADR live.
10. Determine and announce go live date.
11. Develop and implement tracking spreadsheet; implementation will occur beginning on the go live date.
12. Develop training (Moodle). Develop a Q&A forum; test and distribute training.

MDT Project Manager:
Sue Sillick
406.444.7693
ssillick@mt.gov

MDT Champion:
Tom Martin
406.444.0879
tomartin@mt.gov

3.4.3.2 Testing Wildlife-Friendly Fencing Modifications to Manage Wildlife and Livestock Movements Implementation

Project Number: 9596-617
Start Date: 7/19/21
Completion Date: 7/19/22
URL: https://www.mdt.mt.gov/research/projects/env/wildlife_fence_mods.shtml

Objective:

Fences along roadways serve as safety measures to protect humans from vehicular collisions with wildlife and livestock by containing animals in appropriate pastures and keeping them off roadways. Fences can act as semi-permeable or complete barriers to wildlife movement. As a consequence, through landscape fragmentation, fences reduce landscape connectivity, impede resource selection, and are a direct cause of mortality in ungulates (e.g., pronghorn, elk, deer) and other species (e.g., greater sage-grouse). To combat these effects on wildlife. To this end,this research investigated various fence modifications to facilitate wildlife and to deter livestock from crossing fences.

Implementation:

An implementation report was completed, and an implementation plan with eight activities was developed.

1. Implementation Activity 1 – Generate additional data from the four targeted mitigation areas. This implementation activity was completed in FFY 2021.
2. Implementation Activity 2 – Present the findings of this research to internal stakeholders (the Director of Transportation, FHWA, District Administrators, and Right of Way (ROW) and Maintenance leadership) at a future RRC meeting. This implementation activity is planned for FFY 2022.
3. Implementation Activity 3 – Present the findings of this research to internal stakeholders at the next Preconstruction meeting. This meeting will be held in late November and early December 2021, resulting in this implementation activity being completed in FFY 2022.
4. Implementation Activity 4 – Present the findings of this research to internal stakeholders at the next Construction meeting. This meeting will be held in February 2022, resulting in this implementation activity being completed in FFY 2022.
5. Implementation Activity 5 – Investigate re-branding “wildlife-friendly fence” to a less polarizing title that could be used/presented during ROW negotiations, with a goal of wider acceptance of this fencing design and its purpose. This implementation activity is planned for FFY 2022.
6. Implementation Activity 6 – Depending on Task 4 above, ROW manual rewrite.
7. Implementation Activity 7 – Depending on Task 4 above, fencing brochure rewrite.

8. Implementation Activity 8 – Conduct public outreach to the community at large (i.e., farmers, ranchers, landowners, county commissioners, etc.) to encourage acceptance and buy-in. This has already begun and is an ongoing task.

MDT Project Manager:
Vaneza Callejas
802.546.0217
vcallejas@mt.gov

MDT Champion:
Larry Sickerson
406.444.0462
lsickerson@mt.gov

3.4.4 Proposed Projects

3.4.4.1 Evaluate MDT Electrified Wildlife Deterrent Mats

URL: https://www.mdt.mt.gov/research/projects/deterrent-mats.shtml

Topic Statement:

Wildlife-vehicle collisions (WVC) can cause motorist fatalities, injuries, and property damage to vehicles. One way to reduce the risk of these collisions is through the use of wildlife exclusion fence in conjunction with wildlife crossing structures. To ensure that wildlife utilize crossing structures rather than crossing at grade, wildlife fence is used to guide animals to the structures or to safer crossing locations. Wildlife fence in combination with crossing structures has been determined to be the most effective and robust strategy to improve human safety through reducing collisions with large mammals and providing safe crossing opportunities for wildlife. Deterring wildlife from entering the "highway side" of the fence and addressing wildlife end-runs of the fence are important considerations in the proper implementation of this strategy. Although wildlife fence is effective in reducing WVC, limited research is available on the effectiveness of state-of-the-art technology fence end treatments such as electrified wildlife deterrent mat systems installed at the fence ends to prevent wildlife from entering the "highway side" of the fencing.

Related Research:

While there are several studies that have investigated the effectiveness of wildlife deterrent measures, none of them have investigated the effectiveness of this newest wildlife deterrent mat technology used on MT 200 and MT 287 to prevent wildlife from entering the "highway side" of the fencing at the fence ends. To date, there are no studies that investigate this research topic statement specifically related to this application and technology.

Research Proposed:

This proposed research will study the effectiveness of embedded electrified concrete mats in deterring wildlife from entering the fenced road corridor; wildlife behavior at the mats and the end of the fencing; and the performance of the wildlife deterrent mats under various environmental conditions. The research will use analytic software and thermal imaging to recognize wildlife and trigger video recording. This is an important component of the research as the research focuses on the roadway and screening the traffic vehicles from animal movement is critical to efficient and accurate analysis. Video clips will allow researchers to conduct qualitative and quantitative data analysis of the interaction between wildlife, roads, and electrified mats. Imaging would observe wildlife behavior at a) the right of way (approach to the road), b) the roadway, and c) the electrified mat.

Urgency and Expected Benefits:

Given MDT's commitment to wildlife accommodations and public engagement, a better understanding of the performance and effectiveness of electrified wildlife deterrent mats to prevent wildlife from entering the "highway side" of the fencing at the fence ends is essential to reduce WVC and inform the public. Evaluating this innovative technology in a timely manner is needed to inform cost-effective and efficient wildlife accommodation recommendations in the future.

Documenting the effectiveness of the wildlife deterrent mats is expected to translate into reduced risk for wildlife-vehicle conflict in treated areas and increased motorist safety—the benefits of investment in innovative technology. This research will be useful to MDT and other departments of transportation and stakeholders planning for wildlife accommodation projects.

MDT Project Manager:

Vaneza Callejas
802.546.0217
vcallejas@mt.gov

3.5 FINANCE/REVENUE RESEARCH PROJECTS

3.5.1 Proposed Projects

3.5.1.1 Economic Benefits of Improving Montana's Transportation Infrastructure (EBIMTTI)

URL: https://www.mdt.mt.gov/research/projects/admin/eco-benefits.shtml

Topic Statement:

Promoting economic vitality is one mission of MDT. There are several avenues to quantify this mission. First is the primary impact of MDT activities on Montana's economy as measured by income, employment, and other indicators. Second are the impacts on state revenues, including the General Fund and other taxes and fees. And third is the impact of an efficient transportation system on increasing overall productivity which enhances returns to households and private and public firms. The overall research will quantify all three avenues with the goal of estimating the economic gains to Montana of improving infrastructure to raise the state's grade from the American Society of Civil Engineers (ASCE) from a C- to a B. These findings may be used by MDT to inform policymakers and stakeholders about the economic impacts associated with MDT infrastructure improvement.

Related Research:

What are the economic and general fund impacts of current projected transportation infrastructure funding? And what would the impacts look like if funding increased to improve the state of Montana's road and bridge infrastructure? Montana's bridges and road system received grades of C and C- respectively according to ASCE's "Infrastructure Report Card" published in 2017. What would be the net economic impact to the state if there were additional infrastructure expenditures sufficient to raise the grades to a B? Just maintaining the status quo would require about $15 billion over the next 10 years, according to MDT. The Bureau of Business and Economic Research (BBER) would work with MDT to derive the cost estimates to raise the grade to B and then estimate the economic impacts and contributions to the state's general fund under three different scenarios over a 10- to 20-year time horizon: 1) with current projected funding (33% of the $15 billion required to maintain); 2) maintaining the status quo; and 3) additional impacts of raising the ASCE grade to a B. This research would provide insights into the economic impacts of improving the state's transportation network and fit within the "Mobility and Economic Vitality" component of the 20-year TranPlan MT program. The economic impacts will be estimated using a dynamic mathematical/empirical model of the Montana economy and MDT regions. This approach is "state of the art" in that it includes contemporaneous direct and indirect impacts. It also includes social returns to public investment, such as lower transportation, congestion, and health costs of an efficient transportation system.

Research Proposed:

Two different methods will be used to identify and calculate the economic benefits of additional Montana highway infrastructure investments:

- The first method will utilize the economic models prepared by Regional Economic Models Incorporated (REMI) and IMPLAN (Impact Analysis for Planning). The REMI model will be used to identify and estimate the total economic impact on statewide income and employment of the additional out-of-state revenues and associated additional infrastructure expenditures. The IMPLAN model will be used to corroborate the REMI estimates and provide additional details for certain items. The statewide totals will be disaggregated into estimates for each MDT region.
- The second method estimates the total rate of return and the productivity gains of additional roadway investment and maintenance over a 10-year period. Previous research has identified the significant returns to national and state incomes from infrastructure investment. For example, one research report stated, "Over the period 1950 to 1989, U.S. industries realized production cost savings averaging 18 cents annually for each dollar invested in the road system."

There are several approaches to estimate the rate of return and productivity gains. A variety of publications describing the methods used to derive these estimates and results at the state and national level are available. For example, Florida estimated the rate of return on investment. FHWA/USDOT and others use production and cost regressions to estimate the returns on investment. Whichever approach is chosen, estimates will be presented for different types of roadways to identify differences between them.

In summary, this portion of the research will provide "observable" economic impacts for increased income and employment as well as less quantifiable returns to increased infrastructure due to gains in productivity and returns on investment. Both the "observable" and less quantifiable estimates are part of MDT's mission to provide services that emphasize "economic vitality" and "cost-effectiveness."

Several factors will be observed throughout the research:

1. The analysis will clearly distinguish between all roads and bridges (73,000) and those under MDT management. Estimates for MDT-managed roads and bridges will be presented separately.
2. The researchers will closely coordinate with MDT and ASCE to determine the methodology ASCE used to identify roads that fall into the "poor" or "fair" categories and reconcile the differences when conducting economic analyses.

Lastly, the proposed study will update the impact of MDT on Montana state revenues last analyzed in the 2002 MDT research project "The Revenue Contribution of Montana Department of Transportation Expenditures to the Montana General Fund" (FHWA/MT-02-012/8170).

Urgency and Expected Benefits:

This research will assist MDT in meeting its mission to serve the public by providing a transportation system and services that emphasize quality, safety, cost-effectiveness, economic vitality, and/or sensitivity to the environment. Specifically, the findings will aid MDT in presenting the economic impacts of transportation system expenditures to elected officials, decision-makers, the media, the federal government, and the public. The economic impacts will be calculated on a regional basis so that the users will be able to identify the specific local impacts that are important to them. The users may have confidence in their accuracy because the impacts will be calculated using a sophisticated modern

methodology. The more information users have on the direct and indirect features of a project, the more likely they will approve and support the projects.

The practical and concrete economic focus of this research will assist in raising the public's knowledge and interest in MDT's role of providing infrastructure. The Tranplan21 survey of Montanans (also conducted by the BBER) reported a roughly 40% item nonresponse rate for questions regarding infrastructure. This hesitancy to respond suggests a very low level of knowledge among respondents. The findings of this research will be reported in terms of jobs and income, concepts that are readily understandable to the layperson.

MDT Project Manager:
Vaneza Callejas
802.546.0217
vcallejas@mt.gov

3.6 GEOTECHNICAL RESEARCH PROJECTS

3.6.1 Completed Projects

3.6.1.1 Large-Scale Laboratory Testing of Geosynthetics in Roadway Applications

Project Number:	9564-602
Start Date:	2/21/18
Completion Date:	06/30/21
Total Cost:	$450,073
Total SPR Funds:	$450,073
Total SPR Funds (80%):	$360,058
Total State Funds (20%):	$90,015
Total MDT Indirect Costs:	$43,330
Total Expended:	$450,073
Total MDT Indirect Costs Expended:	$43,330
2021 FFY Total Expended:	$0
2021 FFY Total SPR Expended:	$0
2021 FFY SPR Funds (80%) Expended:	$0
2021 FFY State Funds (20%) Expended:	$0
2021 FFY MDT Indirect Costs:	$0
Unexpended Funds:	$0
Consultant:	Montana State University

URL: http://www.mdt.mt.gov/research/projects/geotech/lab_testing.shtml

Objective:

This project characterized the performance of geosynthetic-reinforced test sections when compared to an unreinforced case to assess benefit in terms of a reduction in the base course thickness, an extension of the life of the pavement, or the strengthening of the individual pavement layers. This objective was achieved through the construction of a single test track containing three test sections, a detailed analysis and synthesis of the results, and the evaluation of an analytical design tool to be used by pavement engineers to design geosynthetic-reinforced pavements.

Given the common use of geotextiles in the state for stabilization and separation, MDT was interested in studying whether geotextiles commonly used in the state for stabilization and separation also provide a reinforcement function for typical Montana rural low-volume highway conditions. Documentation of reinforcement benefit for geotextiles commonly used by MDT for typical low-volume highway conditions was not available in the literature. The majority

of studies available focus on the use of geogrids for reinforcement. Many studies also use subgrades that are weaker than typical design values applicable to Montana roadways.

MDT initiated this project to experimentally document reinforcement benefit for conditions commonly encountered in Montana roadways. A spreadsheet design model for geosynthetic reinforcement was previously developed for MDT. MDT was interested in further validation of this model and updating this model to a current version of Excel.

Progress:

All work was completed and all final deliverables were published in FFY 2021.

Implementation:

The geosynthetic reinforcement spreadsheet model on average compared well to previously published results from studies where test sections were constructed. This model predicted little reinforcement benefit for the conditions present in this study. This model, however, showed moderate reinforcement benefit for weaker subgrade conditions (i.e., subgrade CBR of 2.5) that might be present in typical Montana roadways during seasonally wetter periods.

During the course of the project, the results were implemented. MDT is maintaining standard operating procedure; thus, no additional implementation activities are required.

Reports:

Final project information and reports can be viewed on the project website at the above URL.

MDT Project Manager:
Vaneza Callejas
802.546.0217
vcallejas@mt.gov

Consultant Project Manager:
Steve Perkins
406.994.6119
stevep@montana.edu

3.6.2 Implementation Projects

3.6.2.1 Guidelines for Chemically Stabilizing Problematic Soils Implementation

Project Number: 9389-522
Start Date: 5/21/20
Completion Date: 4/1/22
URL: https://www.mdt.mt.gov/research/projects/geotech/chemical_stablize.shtml

Objective:

This project established protocols to help evaluate the utilization of chemical stabilization methods to potentially improve the engineering behavior of problematic soils with and without soluble sulfates within the state of Montana. In addition, construction life cycle cost analyses were used to compare existing approaches used by MDT versus chemical stabilization alternatives for problematic soils. The additional resources and time required to incorporate chemical stabilization were not included in the life cycle cost analysis.

Progress:

In FFY 2021, the implementation plan was regularly reviewed, and a spreadsheet was developed to track projects that have been evaluated to utilize the research results. In addition, an ongoing task is to evaluate appropriate projects where chemical stabilization may be utilized.

Tasks pending implementation include the following:

1. Develop training materials (PowerPoint and Word).
2. Provide training to construction personnel.

MDT Project Manager:
Vaneza Callejas
802.546.0217
vcallejas@mt.gov

MDT Champion:
Jeff Jackson
406.444.3371
jejackson@mt.gov

3.6.3 Proposed Projects

3.6.3.1 Development of P-Y Curves for Analysis of Laterally Loaded Piles in Montana

URL: https://www.mdt.mt.gov/research/projects/pycurves.shtml

Topic Statement:

The response of a laterally loaded pile depends on the lateral stiffness of the soil, the pile stiffness, and the interaction between the pile and the surrounding soil. A laterally loaded pile can be analyzed using different methods; among which, the P-Y method, a method of intermediate complexity and reasonable accuracy, has been widely accepted by the geotechnical engineering community. In the P-Y method, the soil reaction is replaced with a series of independent nonlinear springs, and the nonlinear behavior of the soil is represented by the P-Y curves and relating the oil reaction and pile deflection at points along the pile length. The P-Y curves are developed based on a relatively small amount of data in specific soil conditions. Their accuracy depends on the data from which the curve was developed which may or may not correlate well with soils in Montana. Consequently, the applicability of these procedures to different soil conditions is uncertain and may lead to overly conservative designs.

Related Research:

Pile foundations supporting highway bridges are subjected to lateral loads as well as vertical, gravity loads. Thus, in the design of pile foundations, both lateral and vertical loads must be considered. Several methods have been developed for evaluating pile response to lateral loading among which P-Y curve analysis has been accepted as an accurate and reliable method. Previous experimental and numerical studies found by MDT staff demonstrate that the accuracy of P-Y methods depends directly on the accuracy with which the P-Y curves represent the ability of soil to resist lateral pile deflections. While there are several studies pertaining to P-Y curve analysis of laterally loaded piles that will be beneficial in the development of this study, there is a lack of information on the applicability of existing P-Y curve criteria to Montana soil conditions.

Research Proposed:

The research proposed will be accomplished with the following steps: 1) review the current methods for analysis of laterally loaded piles, from the most common methods (e.g., P-Y method) to the most complex, and evaluate the applicability of P-Y curves to Montana soil conditions; 2) review and prioritize soil conditions in Montana for which laterally loaded pile behavior is not well known; 3) perform a series of model-scale, instrumented centrifuge experiments on piles embedded in prioritized soils collected from different regions of Montana in the centrifuge facility at the University of New Hampshire to develop a data set capable of gaining insight into the characteristics of P-Y resistance in Montana soil conditions; 4) couple the experimental results with numerical simulations to understand the behavior of a single pile laterally loaded in different prioritized soil conditions and develop P-Y curves for analysis of

laterally loaded piles in Montana; and 5) use the findings from previous tasks in this research to re-evaluate the performance of a laterally loaded pile from a project site located on Interstate 15 in Lewis and Clark County, MT, and validate the findings of the new research.

Urgency and Expected Benefits:

The benefits of the proposed research are to identify available methods for the development of P-Y curves and to determine which is the most appropriate for the soil conditions encountered in Montana. The results of this proposed research will lead to a more accurate prediction of pile response and less conservative design of pile foundations and improve the safety and economy of pile foundations.

MDT Project Manager:

Vaneza Callejas
802.546.0217
vcallejas@mt.gov

3.6.3.2 Organization and Analysis of Measurement While Drilling (MWD) Data

URL: https://www.mdt.mt.gov/research/projects/mwd.shtml

Topic Statement:

Obtaining sufficient and reliable in-situ geologic substrate data and characterizing the subsurface conditions for engineering design purposes has always been a challenge to the natural resources and civil engineering industries. Availability and accuracy of such information is key, however, for successful planning, design, construction, and operation of many engineering projects including transportation infrastructure.

Measurement While Drilling (MWD) technology has shown a lot of potential for improving the subsurface characterization process in some industries. Since the 1980s, for example, MWD has been critical to the development of directional drilling within the petroleum industry. In the geotechnical engineering industry, however, MWD technology is in its early research stages.

Research Proposed:

Utilizing a $50,000 contract funded in early 2020 through FHWA's Every Day Counts (EDC) 5 Initiative, MDT is currently evaluating the MWD technology on their Central Mine Equipment (CME) 1050 ATM drill rig. For the past several months, MDT has been collecting continuous and consistent measurements of MWD data at several of their projects. The collected data include drilling depth, drilling rate, rotation speed, own pressure, hold-back pressure, mast vibration, flow rate, and fluid pressure. Beginning this spring, MDT will continue to collect more MWD data with an attempt to also collect accurate mechanical torque data. It is worth mentioning that other data including the standard penetration test (SPT), vane shear test (VST), cone penetration test (CPT), as well as geophysical survey data, will also be collected. This data will be collected at MDT project sites that have proposed ruts, embankment fills, culverts, and bridge foundations. The projects from which MDT chooses to collect MWD data will be located throughout Montana. The challenges with MWD technology include a combination of organizing large amounts of collected data and correlating this data to the desired subsurface characteristics such as the subsurface soil and rock strength parameters. Finding meaningful and reliable correlations is especially challenging as the multivariable nature of such correlations will not allow the simple regression analyses to be used. These challenges could be addressed by creating a database and using Machine Learning (ML) methods such as Artificial Neural Networks (ANNs), and Deep Learning (DL) algorithms.

Urgency and Expected Benefits:

Organizing, analyzing, and interpreting the MWD data is of huge importance and urgency to MDT as it can benefit the organization in several ways.

First, a lack of information about the substrata in a project may result in construction change orders requested by contractors. These change orders are not only costly but also time-consuming and usually end up altering the completion dates. The FHWA has hypothesized that collecting and interpreting MWD data could help to reduce the number of such requests significantly.

Second, the information obtained through MWD process could increase the drilling efficiency by guiding the drillers on choosing the optimum drilling rate, flow rate, injection pressure, etc. This will help to ensure efficient drilling techniques and proper tooling are used.

Third, based on MDT's conversation with their drillers, the MWD process will not only provide education but also increase the excitement and engagement of drillers.

Finally, the interpreted data can be used in determining the index and engineering properties of the subsurface layers in a more consistent and continuous manner. MWD has the potential to provide a continuous detailed and accurate record of geotechnical subsurface characteristics (strength versus depth, CPT-like index graphs, presence of subsurface voids, fissures, and other anomalies). This could improve the project's design recommendations and potentially even reduce the number of subsurface exploration locations required for a project. A reduction of subsurface exploration locations and an increase of subsurface data will likely result in significant cost savings.

MDT Project Manager:
Vaneza Callejas
802.546.0217
vcallejas@mt.gov

3.7 INFORMATION SERVICES RESEARCH PROJECTS

3.7.1 Active Projects

3.7.1.1 Analyze Business Models for Implementation and Operation of a Statewide GNSS Real-Time Network

Project Number:	9922-807
Start Date:	12/2/20
Completion Date:	1/31/23
Total Cost:	$153,510
Total SPR Funds:	$84,000
Total SPR Funds (80%):	$67,200
Total Other Federal Funds:	$69,510
Total State Funds (20%):	$16,800
Total MDT Indirect Costs:	$9,009
Total Expended:	$54,538
Total MDT Indirect Costs Expended:	$2,930
2021 FFY Total Expended:	$54,538
2021 FFY Total SPR Expended:	$29,843
2021 FFY SPR Funds (80%) Expended:	$23,874
2021 FFY Other Federal Funds Expended:	$24,695
2021 FFY State Funds (20%) Expended:	$5,969
2021 FFY MDT Indirect Costs:	$2,930
Consultant:	Montana State University

URL: https://www.mdt.mt.gov/research/projects/planning/gnss.shtml

Objective:

MDT and the State Library are leading an effort to develop a Statewide GNSS (Global Navigation Satellite System) Real-Time Network (RTN). A statewide RTN benefits multiple public and private entities that utilize Global Positioning System (GPS) survey and geographic information system mapping services. Users can realize reduced equipment and time performing field surveys. Infrastructure and assets can be efficiently inventoried and mapped. GPS automated machine control is supported. Data across all users of a network can be connected.

The goal is to provide a statewide RTN covering most of the Montana geographical area that 1) provides survey grade RTN survey and mapping services minimally to public and private network partners and

preferably offered as a public service to subscribers as well; and 2) is a fiscally sustainable business operation. MDT and the State Library are collaborating in a planning effort to identify and resolve technical planning and design issues for implementation and operation. MDT completed a gap analysis identifying multiple RTN operation and maintenance business models for further investigation including multiple system access variations of the business models. This research project will investigate the feasibility of different business models for sustainable operation and maintenance of a statewide RTN accessible minimally to network partners is necessary to make sound decisions regarding access to network services and ownership, operation, maintenance, and repair of RTN components including CORS (continuously operating reference stations), CPC (central processing center) and network communications.

Progress:

The project kick-off meeting was held in December 2020. Work on the literature review (Task 2) was completed. Work began on the state of the practice assessment (Task 3), as well as characterizing the Montana GNSS-RTN infrastructure (Task 4).

Reports:

Three progress reports were received. Project information and reports can be viewed on the project website at the above URL.

MDT Project Manager:
Vaneza Callejas
802.546.0217
vcallejas@mt.gov

Consultant Project Manager:
Ahmed Al-Kaisy
406.994.6116
alkaisy@montana.edu

3.7.1.2 Montana LTAP Learning Management Systems

Project Number:	9963-827
Start Date:	7/1/21
Completion Date:	6/30/23
Total Cost:	$30,000
Total SPR Funds:	$0
Total SPR Funds (80%):	$0
Total Other Federal Funds:	$24,000
Total State Funds (20%):	$0
Total Other State Funds:	$6,000
Total MDT Indirect Costs:	$0
Total Expended:	$7,088
Total MDT Indirect Costs Expended:	$0
2021 FFY Total Expended:	$7,088
2021 FFY Total SPR Expended:	$0
2021 FFY SPR Funds (80%) Expended:	$0
2021 FFY Other Federal Funds Expended:	$1,088
2021 FFY State Funds (20%) Expended:	$0
2021 FFY Other State Funds Expended:	$6,000
2021 FFY MDT Indirect Costs:	$0
Consultant:	Montana State University

Objective:

Montana LTAP is a Statewide training program that delivers workforce development, safety, and infrastructure management training to all 56 Montana counties, 129 cities and towns, federal, state, and private customers on a programmed and on-demand basis. Two primary areas of emphasis and anticipated focus areas for all LTAPs in the new Strategic Plan are innovation and workforce development.

As part of the LTAP program, educational records are kept for all participants which integrates into the LTAP workforce development platform—the Road Scholar program and associated record-keeping system.

LTAP also administers the Flagger Certification program statewide.

The Montana LTAP Road Scholar program is robust and thriving with an average class of 20 graduates each year. There are two levels of recognition for participant achievement: Level 1, Road Scholar, and Level 2, Road Master. Level 1, Road Scholar, includes a minimum completion of 10 courses, including a base curriculum requirement and six optional classes. Level 2 requires at least 10 more class completions.

In addition, LTAP is in the process of adding the Montana component of the National Road Safety Scholar program records to its database. This addition is pushing the current system far beyond its capabilities and LTAP staff capabilities to manage the database with in-house expertise.

Updating this dated and failing system will improve efficiency, reliability, and customer service. Other benefits would be increased confidence in LTAP's ability to serve its customers; increased credibility of the LTAP program due to improved accuracy; sufficient and timely record keeping; and increased efficiency in records management, class administration, program review, and individual transcript generation.

The objective of this project is to complete selection and delivery of an adequate learning management system (LMS) to serve the Montana LTAP center for the next 10 years (minimum).

Scope of Work:

There are several LMS platforms in use by other centers with similar Road Scholar and record-keeping programs. The tasks for this project include the following:

- Review available LMS platforms
- Select and implement a comprehensive LMS that will support LTAP's needs
- Software acquisition
- Database transfer
- Configuration of user interface features and implementation

Progress:

The review of LMS platforms task was initiated.

Reports:

The first semiannual progress report is due in FFY 2022.

MDT Project Manager:
Sue Sillick
406.444.7693
ssillick@mt.gov

Consultant Project Manager:
Matt Ulberg
406.531.1142
matthew.ulberg@montana.edu

3.8 MATERIALS/DATA COLLECTION AND ANALYSIS RESEARCH PROJECTS

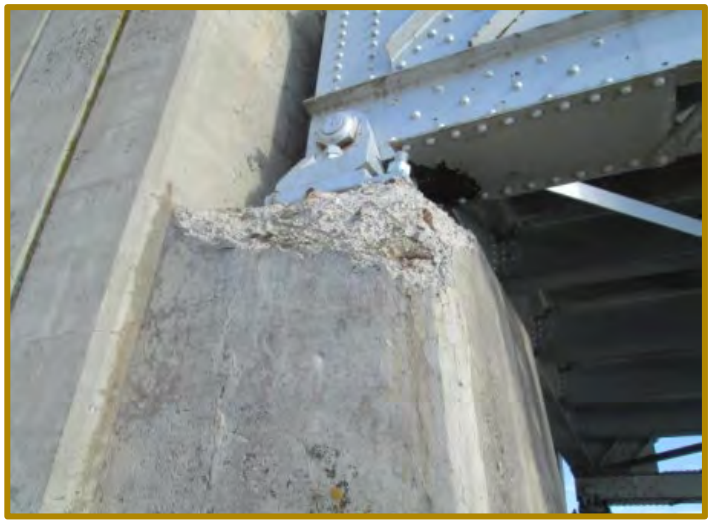
3.8.1 Active Projects

3.8.1.1 Alkali-Silica Reactivity in the State of Montana

Project Number:	9577-607
Start Date:	4/6/18
Completion Date:	11/30/21
Total Cost:	$109,000
Total SPR Funds:	$74,000
Total SPR Funds (80%):	$59,200
Total State Funds (20%):	$14,800
Total Cost Share:	$35,000
Total MDT Indirect Costs:	$7,572
Total Expended:	$89,460
Total MDT Indirect Costs Expended:	$5,844
2021 FFY Total Expended:	$15,566
2021 FFY Total SPR Expended:	$10,568
2021 FFY SPR Funds (80%) Expended:	$8,454
2021 FFY State Funds (20%) Expended:	$2,114
2021 FFY Cost Share Expended:	$4,998
2021 FFY MDT Indirect Costs:	$931
Consultant:	Montana State University

URL: https://www.mdt.mt.gov/research/projects/mat/alkali_silica.shtml

Objective:



Concrete can be susceptible to expansive reactions between alkalis in the Portland cement and reactive forms of silica in the aggregates, which can ultimately reduce the lifespan of the concrete resulting in costly repairs or even replacement. While alkali-silica reactivity (ASR) has been documented as an issue in many states, little work has been conducted to determine the presence/potential of ASR in Montana.

The primary objectives of the proposed research are to evaluate the potential for deleterious ASR in the state of Montana, and to develop a testing protocol for identifying potential reactive aggregates. This research will also identify/document existing ASR damage in the state and investigate the potential underlying geological features that may contribute to the presence of

reactive aggregates. Finally, this research will explore the efficacy of potential mitigation techniques employed to limit the effect of ASR.

Progress:
All work was completed and the final report was provided in FFY 2021. Work on remaining draft deliverables continued.

Reports:

Three progress reports were received. Project information can be viewed on the project website at the above URL.

MDT Project Manager:
Vaneza Callejas
802.546.0217
vcallejas@mt.gov

Consultant Project Manager:
Mike Berry
406.994.1566
berry@montana.edu

3.8.1.2 Numerical Modeling of the Test Pit for Falling Weight Deflectometer Calibration

Project Number:	9921-806
Start Date:	11/19/20
Completion Date:	2/28/22
Total Cost:	$36,641
Total SPR Funds:	$30,000
Total SPR Funds (80%):	$24,000
Total State Funds (20%):	$6,000
Total Cost Share:	$6,641
Total MDT Indirect Costs:	$3,431
Total Expended:	$21,542
Total MDT Indirect Costs Expended:	$1,678
2021 FFY Total Expended:	$21,542
2021 FFY Total SPR Expended:	$18,237
2021 FFY SPR Funds (80%) Expended:	$14,590
2021 FFY State Funds (20%) Expended:	$3,647
2021 FFY Cost Share Expended:	$3,305
2021 FFY MDT Indirect Costs:	$1,678
Consultant:	Montana State University

URL: https://www.mdt.mt.gov/research/projects/tpfwdc.shtml

Objective:

Evaluation of pavements is commonly conducted using the deflection data from Falling Weight Deflectometers (FWDs) tests. The reliability of these evaluations is highly dependent on the accuracy of the measured deflections. Therefore, to ensure the desired accuracy of measured deflections, FWDs undergo annual calibration and monthly relative calibrations. These calibrations are conducted according to AASHTO R32-11. The calibration tests are conducted on an indoor test pit made of a concrete slab underlaid by a base and a soft subgrade.

The calibration facility operated by MDT has used a 12 ft. wide, 15 ft. long, and 5-inch-thick slab overlying a 6-inch sandy base and a 4-ft.-thick clay subgrade (R32 design). The measured deflections during calibration tests conducted by MDT on this test pit met the deflection requirements laid out by AASHTO R32-11 for a few years, after which the test area needed to be replaced. Because rebuilding the test area is both costly and time-consuming, MDT was interested in a new setup design that could operate over longer periods. MDT designed an alternative to the R32 design, using geofoam instead of the clay layer as the soft subgrade.

The purpose of this study is to use dynamic response analyses to investigate the possibility of using geofoam instead of the clay layer in the test pit. If the results of the investigation revealed that geofoam can in fact be used, the next goal of this study will be to modify the preliminary alternative design and provide recommendations to improve the performance of the test area to where it meets the AASHTO R32-11 deflection requirements.

Progress:

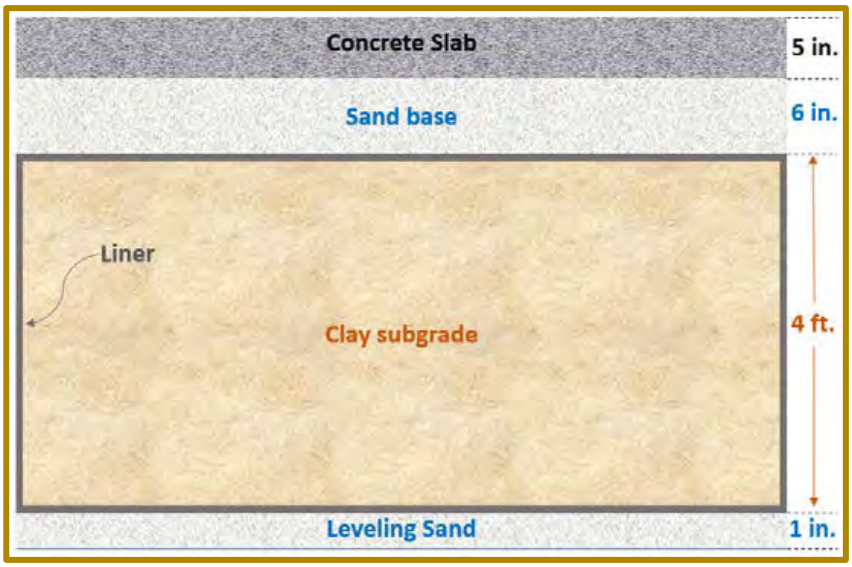
In FFY 2021, all tasks were completed, and the final report was in the drafting stage.

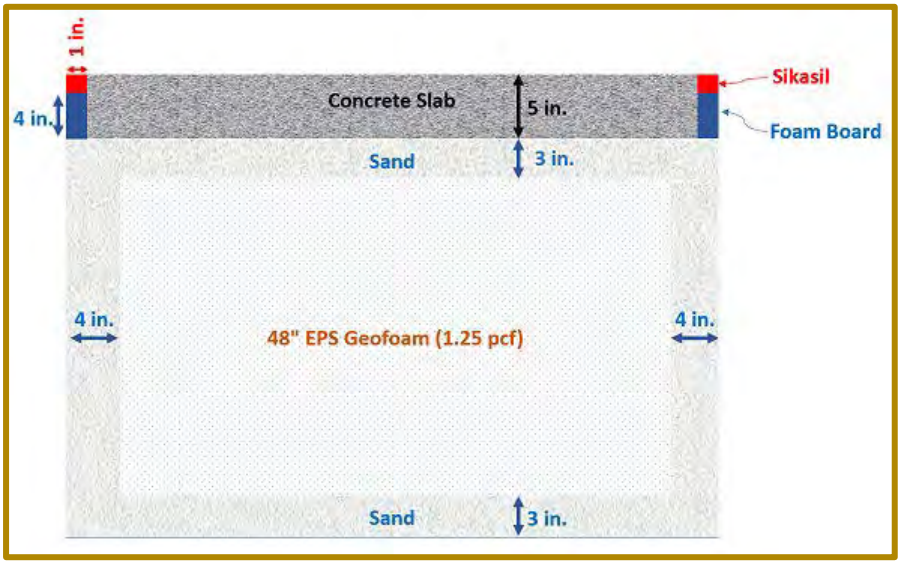
Reports:

Three task reports were received. Project information can be viewed on the project website at the above URL.

MDT Project Manager:
Sue Sillick
406.444.7693
ssillick@mt.gov

Consultant Project Manager:
Mohammadhossein Sadeghiamirshahidi
406.496.4353
msadeghi@mtech.edu





3.8.2 Proposed Projects

3.8.2.1 Aging Conditions for Hot Mix Asphalt Cracking Test

URL: https://www.mdt.mt.gov/research/projects/aging-hot-mix.shtml

Topic Statement:

Cracking, either due to reflection, fatigue, and/or low temperature, is one of the major distresses of asphalt pavements. Like many other agencies, MDT is considering implementing laboratory cracking performance test(s) into the hot mix asphalt design process to ensure that the asphalt mix to be used for construction is cracking resistant. One of the key components of the cracking test(s) is the aging condition of the asphalt mix prior to the tests. The aging level greatly affects the cracking test results and, therefore, needs to be determined before an acceptance threshold of the cracking index is established as a specification. The aging level of asphalt mix in the laboratory needs to match that of asphalt materials in the field at the time of occurrence of pavement cracking. The 5-day aging at 95 °C (or 12 hours at 135°C) simulates field aging of approximately 7 to 10 years of asphalt surface layer. However, MDT often places chip seals within one year after the asphalt paving. The presence of chip seals significantly reduces the aging of underlying asphalt mix, based on previous studies. Therefore, determination of the appropriate aging condition of asphalt mix that is suitable for MDT paving practices and for climatic conditions in Montana is greatly needed before a specification of cracking test(s) can be developed.

Related Research:

Cracking typically starts occurring a few years after the pavement or its overlay has been in service. During this time, asphalt materials age as a result of oxidation and/or ultraviolet light. In the laboratory, asphalt mixes are often aged at an elevated temperature to accelerate the aging to a level that mimics the aging in the field. AASHTO R30, "Standard Practice for Mixture Conditioning of Hot Mix Asphalt (HMA)," is the current standard on long-term laboratory aging which specifies 5-day aging at 85°C. However, studies have reported that 5-day, 85°C aging does not represent long-term field aging. Recently completed NCHRP Project 09-54 has found that on average, 5-day at 95°C represents the long-term aging nationwide. Other researchers have also studied the effects of aging on cracking performance. However, the recommendations on aging conditions are inconclusive, ranging from 1-day at 95°C, to 8 hours at 135°C, to 12 days at 95°C.

Research Proposed:

The proposed study includes the collection of hot mix asphalt samples from pavements in Montana at the initial stage of cracking. The asphalt binders will be extracted and recovered, and performance grades of recovered asphalt binders will be determined and compared to original performance grades at the time of paving to determine the aging over the years. Laboratory-produced asphalt mixes will be aged in the laboratory to determine appropriate aging time and temperature that would render

equivalent aging in the laboratory to that of asphalt mixes in the field. The aging conditions can then be included in the protocols of cracking test(s).

Urgency and Expected Benefits:

Most paved roadways in the state of Montana are surfaced with asphalt materials. Each year, MDT spends hundreds of millions on asphalt roadways. Like many other highway agencies, MDT is considering implementing the IDEAL-CT test as the HMA cracking test to prevent the use of cracking-prone hot mix asphalt from highway construction. The determination of laboratory aging conditions is the first step needed to implement the cracking test. The selection and use of cracking-resistant hot mix asphalt would increase the pavement service life, reduce the life cycle costs, and reduce user costs associated with traffic disruptions during roadway repairs.

MDT Project Manager:

Vaneza Callejas
802.546.0217
vcallejas@mt.gov

3.9 SAFETY RESEARCH PROJECTS

3.9.1 Active Projects

3.9.1.1 Developing a Methodology for Implementing Safety Improvements on Low-Volume Roads in Montana

Project Number:	9679-699
Start Date:	2/15/19
Completion Date:	11/30/21
Total Cost:	$134,887
Total SPR Funds:	$71,000
Total SPR Funds (80%):	$56,800
Total Other Federal Funds:	$63,887
Total State Funds (20%):	$14,200
Total MDT Indirect Costs:	$7,499
Total Expended:	$131,691
Total MDT Indirect Costs Expended:	$6,454
2021 FFY Total Expended:	$291
2021 FFY Total SPR Expended:	$153
2021 FFY SPR Funds (80%) Expended:	$122
2021 FFY Total Other Federal Funds Expended:	$138
2021 FFY State Funds (20%) Expended:	$31
2021 FFY MDT Indirect Costs:	$14
Consultant:	Montana State University

URL: https://www.mdt.mt.gov/research/projects/planning/lvr-safety.shtml

Objective:

Maintaining safety on the highway system has been a top priority for most highway agencies in the U.S. given the heavy toll in deaths and casualties associated with traffic crashes. The limited funds available to highway agencies for safety improvements require a careful consideration of sites that are more promising in improving safety at the network level. Therefore, highway agencies systemically screen the network to identify those sites that are expected to yield greater safety benefits, thus deserving more consideration for safety improvement funds. While this process has been successfully implemented by many agencies for urban and well-traveled major rural highways, it may prove difficult on rural low-volume

roads including local county roads. The low traffic exposure on these roads and consequently the low number of crashes occurring may preclude the possibility of using crash data alone in identifying and ranking candidate sites for safety improvement projects. The proposed research will attempt to address this issue by providing much-needed guidance on how to systemically screen the network and rank sites on low-volume roads that are most deserving of safety improvements funds.

Progress:

Research on assessing benefits of the proposed methodology (Task 7) was completed, and all draft deliverables were provided in FFY 2021.

Reports:

Two progress reports and all draft deliverables were received. Project information and reports can be viewed on the project website at the above URL.

MDT Project Manager:
Vaneza Callejas
802.546.0217
vcallejas@mt.gov

Consultant Project Manager:
Ahmed Al-Kaisy
406.994.6116
alkaisy@montana.edu

3.9.1.2 Effectiveness of Highway Safety Public Education at Montana Motor Vehicle Registration Stations by Streaming a Variety of Safety Content

Project Number:	9832-766
Start Date:	3/15/20
Completion Date:	10/31/22
Total Cost:	$240,656
Total SPR Funds:	$166,000
Total SPR Funds (80%):	$132,800
Total State Funds (20%):	$33,200
Total Consultant Cost Share:	$74,656
Total MDT Indirect Costs:	$16,000
Total Expended:	$129,105
Total MDT Indirect Costs Expended:	$7,632
2021 FFY Total Expended:	$92,083
2021 FFY Total SPR Expended:	$63,517
2021 FFY SPR Funds (80%) Expended:	$50,814
2021 FFY State Funds (20%) Expended:	$12,703
2021 FFY Total Consultant Cost Share Expended:	$28,566
2021 FFY MDT Indirect Costs:	$5,958
Consultant:	Montana State University

URL: https://www.mdt.mt.gov/research/projects/safety/safetyvideos.shtml

Objective:

There is a need to educate Montanans about highway safety, the consequences of exhibiting risky behaviors while driving such as texting while driving, driving while impaired or distracted, driving unbuckled, and the benefits of proven innovative road safety countermeasures such as roundabouts and rumble strips installed by public transportation agencies. There is an opportunity to install video equipment at select Motor Vehicle Division licensing and vehicle registration stations around the state to continuously play highway safety video clips. At many of these locations, the public has waiting times of five minutes or longer. This is enough time for people to give their attention to a video screen playing safety messages.

Progress:

Work on predeployment planning (Task 2) was completed. Work started on deployment (Task 3) and evaluation and support (Task 4).

Reports:

Four progress reports were received. Project information and reports can be viewed on the project website at the above URL.

MDT Project Manager:
Vaneza Callejas
802.546.0217
vcallejas@mt.gov

Consultant Project Manager:
Jaime Sullivan
774.571.3503
jaime.sullivan2@montana.edu

3.9.1.3 Icy Road Forecast and Alert (IcyRoad): Validation and Refinement Using MDT RWIS Data

Project Number:	9891-785
Start Date:	7/13/20
Completion Date:	3/31/22
Total Cost:	$84,000
Total SPR Funds:	$84,000
Total SPR Funds (80%):	$67,200
Total State Funds (20%):	$16,800
Total MDT Indirect Costs:	$9,631
Total Expended:	$71,119
Total MDT ICAP Expended:	$6,859
2021 FFY Total Expended:	$57,355
2021 FFY Total SPR Expended:	$57,355
2021 FFY SPR Funds (80%) Expended:	$45,884
2021 FFY State Funds (20%) Expended:	$11,471
2021 FFY MDT Indirect Costs:	$5,497
Consultant:	University of Montana

URL: https://www.mdt.mt.gov/research/projects/safety/icy-road-rwis.shtml

Objective:

Drivers need reliable forecasts and alerts for icy road conditions, particularly the presence of black ice, to reduce winter driving risks. MDT currently has 73 road weather information system (RWIS) stations throughout the state, which are used to measure road surface temperature, subsurface temperature, air temperature, humidity, dew point, pressure, wind speed, and precipitation type and occurrence. Select sites (six or fewer) have advanced precipitation sensors, visibility sensors or infrared illuminators for nighttime camera images. This data makes it possible to study geospatial distribution of black ice formation and identify different mechanisms of black ice for various orographic and surrounding environmental conditions. Consequently, it advances the capability to forecast black ice. Icy Road Forecast and Alert (IcyRoad) is a technology based on weather forecasts, remote sensing observations, cloud computing, and data mining. The purpose of this research project is to validate and refine the IcyRoad scientific algorithm, particularly the black ice algorithm, using MDT RWIS ground observations to develop a black-ice forecast scheme.

Progress:

Work on the evaluation for refinement and validation (Tasks 1 and 2) was completed. Drafts of the Tasks 1 and 2 reports were submitted to the technical panel for review.

Reports:

Four progress reports were received. Project information can be viewed on the project website at the above URL.

MDT Project Manager:
Vaneza Callejas
802.546.0217
vcallejas@mt.gov

Consultant Project Manager:
Bart Bauer
406.243.4828
AASO@mso.umt.edu

3.9.1.4 Traffic Safety Culture Transportation Pooled Fund (TSC-TPF) Program – Phase 1

Project Number:	8882-309
Start Date:	10/1/14
Completion Date:	9/30/22
Total Cost:	$1,194,000
Total SPR Funds (100%):	$80,000
Total Other Federal Funds:	$954,000
Total State Funds (100%):	$160,000
Total MDT Indirect Costs:	$114,345
Total Expended:	$1,193,943
Total MDT Indirect Costs Expended:	$112,735
2021 FFY Total Expended:	$162,992
2021 FFY MDT SPR Funds (100%) Expended:	$10,921
2021 FFY Other Federal Funds (100%) Expended:	$131,595
2021 FFY Other State Funds (100%) Expended:	$20,476
2021 FFY MDT Indirect Costs:	$17,197
Consultant:	Montana State University

MDT URL: https://www.mdt.mt.gov/research/projects/trafficsafety.shtml

Phase 1 Pooled Fund URL: https://www.pooledfund.org/Details/Study/558

Phase 2 Pooled Fund URL: https://www.pooledfund.org/Details/Study/668

Objective:

In FFY 2015, the Montana Department of Transportation initiated a five-year pooled fund program in partnership with the Center for Health and Safety Culture (CHSC) within the Western Transportation Institute (WTI) at Montana State University. This program is a cooperative effort of participating state DOTs and other organizations vested in traffic safety. The purpose of this effort is to accelerate the development and delivery of tools and services to transform traffic safety culture. The goal of this transformation is to support the Toward Zero Deaths (TZD) vision with sustainable traffic safety solutions.

The Toward Zero Deaths (TZD): National Strategy on Highway Safety is a cooperative and coordinated effort amongst state highway safety agencies and other stakeholders. The transformation of the traffic safety culture is a primary element of the TZD strategy. Only through the growth of a positive safety culture can significant and sustainable reductions in crash fatalities and serious injuries be achieved. Such transformation would not only support traffic safety goals by reducing risky behaviors and increasing protective behaviors, but it would also increase public acceptance of other forms of effective safety programs.

Progress and Reports:

There are a total of 16 projects (including annual management support renewals) under this Phase 1 pooled fund program umbrella. A follow-on pooled fund program for an additional five years (Phase 2) was initiated.

Management Support:

This project provides project management assistance, including meeting support (web conference set-up, in-person meeting logistics and travel reimbursement, agenda input, post-meeting follow-up, and meeting notes), quarterly progress reporting, support for outreach and awareness activities, and support for work plan and project development.

This is an annual contract renewed each year of the pooled fund, for a total of five years. For FFY 2021, all tasks were completed, and four quarterly progress reports were received; they can be viewed at https://www.pooledfund.org/Details/Study/558.

Driving After Cannabis Use:

The purpose of this project was to develop a better understanding of the traffic safety culture (i.e., shared values, beliefs, and attitudes) of driving under the influence of cannabis (DUIC). A survey was developed based on an augmented integrated model of behavior and was implemented using mailed and internet-based methods. Adults age 18 and older from the U.S. responded. Two states with legalized recreational use of cannabis (Colorado and Washington) were oversampled. The survey measured DUIC behavior, intention, willingness, attitudes, behavioral beliefs, perceived norms, and perceived control. About half of the individuals who had used cannabis in the past 12 months reported driving within four hours of use. Partial correlation coefficients showed that many components of the model correlated with willingness to DUIC. Significant differences in attitudes and beliefs were found between non-users of cannabis, users of cannabis, and those who DUIC. No differences in beliefs or attitudes were found between states with and without legalized recreational use laws nor between states with legalized medical use laws. Recommendations for strategies to reduce DUIC are provided.

This project was completed in FFY 2017. The final deliverables, which include final and project summary reports, and a webinar recording, can be viewed at https://www.mdt.mt.gov/research/projects/cannabis-use.shtml.

Exploring Traffic Safety Citizenship:

The purpose of this project was to develop a better understanding of the values, beliefs, and attitudes regarding engagement in behaviors that impact the traffic safety of others, informing agencies and others how to grow these beliefs in communities—thereby creating a culture that achieves greater improvements in traffic safety. A survey was developed based on an augmented integrated model of behavior and was implemented with adults age 18 and older from the U.S. using mailed and internet-based methods. About half of the people who responded to the survey indicated they had been in a situation in the past 12 months when someone was not wearing a seat belt or was reading or texting while driving. Of those who indicated they were in a situation to intervene, more than half did. They were more likely to intervene with others who were socially closer to them (e.g., family and friends) than with those more socially distant (e.g., acquaintances or strangers). Most people had favorable attitudes and beliefs about intervening. The analysis revealed that the perception of whether most people do intervene (e.g., the perceived descriptive norm) was strongly correlated with intervening behavior. Similarly, most people who responded to the survey had favorable attitudes about strategies involving policy or rules to increase seat belt use or decrease reading or typing on a cell phone while driving. Recommendations for growing intervening behaviors are provided.

This project was completed in FFY 2017.The final deliverables, which include final and project summary reports, and a webinar recording, can be viewed at https://www.mdt.mt.gov/research/projects/trafficsafety-citizenship.shtml.

Traffic Safety Cultures and the Safe Systems Approach:

This project brought together expertise in engineering (vehicle safety, road building, and traffic system planning) as well as in the sciences of human action (psychology, sociology, and anthropology) in order to develop a comprehensive framework of traffic safety culture that is useful for practical work in road safety as well as for academic research. Knowledge exchange was a core element of the project, not only via the researchers that are seconded between partner organizations but also through a knowledge platform created for the partners as well as for the public. The project also included data from naturalistic driving studies that has not been used in the context of cultural analysis before. A major focus was on factors that can be changed comparatively easy under given cultural conditions in order to contribute to road safety work in practice.

This project was completed in FFY 2019. More information can be found at https://www.mdt.mt.gov/research/projects/trafficsafety-ss-approach.shtml.

Understanding Law Enforcement Attitudes and Beliefs About Traffic Safety:

Law enforcement plays a critical role in traffic safety. However, traffic safety is one of many issues that law enforcement agencies must address. A variety of factors including budget limitations, political support, and agency culture can influence engagement in traffic safety. A decrease in law enforcement's engagement in traffic safety could make a reduction in fatalities and serious injuries less likely.

Recently, some traffic safety professionals have noted a change in the prioritization of traffic safety among law enforcement. It is difficult to determine whether this perception is accurate or not and the reasons and nature of this possible change. Therefore, understanding the attitudes and beliefs of law enforcement leaders and officers regarding traffic safety is critical to growing a positive traffic safety culture and ultimately achieving a goal of zero deaths on the nation's roadways.

The objectives of this case study were to understand:

- How law enforcement leaders and officers within the agencies selected prioritize traffic safety relative to other public safety issues;
- Self-reported attitudes, beliefs, and enforcement behaviors;
- Law enforcement's perceptions of how traffic safety enforcement behaviors have changed in recent years; and
- How prioritization of traffic safety; attitudes, beliefs, and enforcement; and perceptions of change vary between leaders and officers, agency types, and urban and rural settings.

Furthermore, the project proposed methods of increasing engagement in traffic safety efforts based on the beliefs identified in this study.

To support these objectives, this project included the development and implementation of interviews and a survey to measure the beliefs and attitudes among law enforcement that influence traffic safety enforcement.

This project was completed in FFY 2019. Products include a final report, project summary report, dialogue guide and speaking points, and a webinar recording and presentations. These reports and additional information can be found at https://www.mdt.mt.gov/research/projects/trafficsafety-attitudes.shtml.

Key Information for DUIC Policy:

There is growing concern about driving under the influence of cannabis (DUIC), especially as more states change laws around cannabis possession and use. This concern is often exacerbated by the inaccessibility of key information regarding the role of cannabis in crash risk. To rectify this situation, this synthesis project captured the key information for the critical issues that affect policy decisions with DUIC. The synthesis focused on the usability of information to garner stakeholder support and inform rational policy making.

This project provided a set of tools to educate and engage stakeholders (e.g., enforcement agencies, traffic safety agencies, public health departments, etc.) to inform decision-making about effective DUIC policy and counter measures. These tools included several products:

- **Concise information summary** that integrates current research on the key issues involved in the debate surrounding DUIC crash risk (e.g., methodological limitations of measuring DUIC crash risk, evidence of THC impairment on driver behavior, relationship of THC per se limits with crash risk, interactions with alcohol).
- **Two infographics** that summarize the key points, including one on the Effects of Cannabis on Traffic Safety and the other on Cultural Factors that Predict the Frequency of Driving within 4 Hours of Using Cannabis in the Past 12 Months Infographic.
- **Talking points** (based on the information summary and referencing the infographic) which can be used by practitioners to discuss DUIC with stakeholders to garner support for effective DUIC strategies.
- **Poster and PowerPoint presentation** were created for traffic safety professionals to use to disseminate information, including The Effect of Legalization of Recreational Cannabis on Crash Risk poster and Key Information for DUIC Policy webinar.
- **Webinar presentation** and **recording**: Driving Under the Influence of Cannabis (DUIC): Key Information for DUIC Policy presentation.

This project was completed in FFY 2020. In addition to the final report, the above final products were posted to the project website at https://www.mdt.mt.gov/research/projects/trafficsafety-duic.shtml.

Proactive Traffic Safety: Empowering Behaviors to Reach Our Shared Vision of Zero Deaths and Serious Injuries:

Growing traffic safety citizenship is a novel approach that strategically shifts our focus to the engagement of the larger majority of safe road users to influence the behaviors of the smaller group engaging in risky behaviors. Previous research sponsored by the Traffic Safety Culture Pooled Fund to understand traffic safety citizenship revealed a variety of opportunities to bolster traffic safety citizenship behaviors to reduce traffic crashes and fatalities. However, in order for state highway safety agencies and stakeholders to embrace this strategic approach, information learned from research must be translated to practice. Communication tools that make traffic safety citizenship easier to understand and integrate into existing traffic safety efforts are needed.

The objective of this project was to create meaningful communication tools for state and local traffic safety professionals that can be implemented immediately to build the capacity of critical stakeholders about traffic safety citizenship as a strategy to improve traffic safety.

To support this objective, this project resulted in the development of communication tools:

- **Traffic Safety Citizenship Primer** – This tool introduced traffic safety professionals and stakeholders to the concept of traffic safety citizenship. Sections within the Traffic Safety Citizenship Primer includes a) what traffic safety citizenship is; b) the origin and background; c) the state of the science; d) examples of safety citizenship; e) talking points to introduce the concept to other professionals, stakeholders, and the community; and f) examples of traffic safety citizenship activities that can be readily implemented.
- **Traffic Safety Citizenship PowerPoint Presentation** – This tool was created for traffic safety professionals and stakeholders to introduce traffic safety citizenship to other professionals, stakeholders, and the community.
- **Conversation Guide** – This tool was created to support traffic safety professionals' efforts to engage their staff or coworkers about Traffic Safety Citizenship as a strategy to improve traffic safety. This document is a stand-alone document that can be printed and shared with others.
- **Poster** – This tool was created for traffic safety professionals to use to disseminate information in a traffic safety poster session.

This was completed in FFY 2020. In addition to the final report, the above products are posted to the project website (https://www.mdt.mt.gov/research/projects/trafficsafety-cc-tools.shtml).

Traffic Safety Culture Primer:

There is growing interest in traffic safety culture as a key factor to manage and sustain safe roadway transportation systems, especially as more jurisdictions adopt targets of zero traffic fatalities and serious injuries. However, the theory, terminology, and methods involved in addressing traffic safety culture come from human and social science disciplines that are not typically included in traditional traffic safety, engineering, or other behavioral change agencies (e.g., departments of transportation, driver's licensing, and motor vehicles records). The lack of shared language and understanding about traffic safety culture limits the ability of agencies to explore this topic and engage new stakeholders.

Additionally, the variation in the interpretation and implementation of strategies to improve traffic safety has resulted in no consensus about best practices. Communication tools that develop shared language and understanding about traffic safety culture and its relationship to vision zero goals are needed.

The objective of this project was to provide a multimedia primer about traffic safety culture and how a cultural perspective can support vision zero goals. The purpose of this primer is to foster shared language and understanding about traffic safety culture—thus "priming" stakeholders for new and constructive dialogue and thinking about this complex topic. The materials include readily accessible definitions, insights, and examples of how traffic safety culture influences behaviors and questions to guide dialogue among stakeholders to make meaning of these ideas and expand their thinking.

To support this objective, in addition to a final report, the following products were developed:

- **A Traffic Safety Culture Primer** – A brief document was created that can be readily printed by stakeholders. The primer includes sections addressing:
  - what is traffic safety culture;
  - how does traffic safety culture influence behavior;
  - issues about measuring traffic safety culture; and
  - how a cultural perspective expands approaches to improve traffic safety.

  The format of the primer is concise text intended for traffic safety practitioners and other stakeholders. The text is augmented with infographics. The materials are professionally laid out as an "electronic book" suitable for viewing and printing.
- **Series of PowerPoint Slides** – Each of the primer sections have a set of accompanying PowerPoint slides with talking points that practitioners can use to communicate to other stakeholders. There is also a brief overview suitable for a 20-minute presentation.
- **Animated Video** – A short, animated video was developed to introduce the key topics. The video can be easily shared and used to increase awareness and use of the primer.
- **Webinar** – A webinar was created and presented to introduce the primer to the traffic safety community. The webinar highlights key features of the tools and promotes their use.
- **Poster** – A high-resolution graphic was created that is suitable for printing on a large poster for use in a conference poster session for traffic safety professionals to use to disseminate a summary of the primer and the tools.

This project was completed in FFY 2020. In addition to the final report, all deliverables listed above are posted to the project website (https://www.mdt.mt.gov/research/projects/trafficsafety-primer.shtml).

Guidance for Evaluating Traffic Safety Culture Strategies:

In an effort to reduce the number of traffic crashes and resulting injuries and fatalities, traffic safety agencies are developing and implementing new intervention strategies aimed at changing road user culture. However, systematic evaluations of the implementation and impacts of these new programs are not advancing as rapidly as the programs themselves. At this point, there are neither well-developed summative/outcome evaluations nor formative/process evaluations of most existing programs. Compounding this lack of systematic evaluation is an underlying lack of consensus about or development of the sorts of evaluation designs capable of yielding results that researchers and program managers can be confident in to support future programming and resource allocation decisions.

The purpose of this project was to conduct a literature review of the current state of the science in evaluating traffic safety culture strategies. To begin, staff reviewed the literature for examples of evaluation methods applied to traffic safety culture strategies. Due to a lack of examples, this review was extended to other public health domains to learn from evaluations performed by other disciplines. The results of this review were then used to produce three project deliverables: journal article; summary of evaluation guidance (toolkit); and a poster summarizing the key steps for evaluation.

To support this objective, in addition to a final report, the following projects were developed.

- **Summary Guidance on Best Practices to Evaluate Traffic Safety Culture Strategies** – A brief document that can be readily used by traffic safety professionals and stakeholders.
- **Webinar** – A webinar was held to summarize guidance for the traffic safety community. The webinar highlighted how program managers can use this guidance to select intervention strategies.
- **Poster** – A high-resolution graphic was created that is suitable for printing on a large poster for use in a conference poster session for traffic safety professionals to use to disseminate a summary of guidance on the evaluation of traffic safety culture strategies. A handout with talking points was also created.

This project was completed in FFY 2021. All final deliverables and more information can be found at https://www.mdt.mt.gov/research/projects/trafficsafety-strategies.shtml.

Guidance on Messaging to Avoid Reactance and Moral Disengagement:

Not wearing a seat belt and speeding are two significant contributing factors to motor vehicle-related fatalities. Significant efforts, including messaging, have sought to increase seat belt use and decrease speeding. These efforts have been largely successful as the majority of adults wear a seat belt and do not speed. However, traditional messaging may not be as effective with the small minority of individuals still engaging in these risky behaviors because of two psychological phenomena: psychological reactance and moral disengagement. This project sought to better understand if these two phenomena are more prevalent among individuals still engaging in these risky behaviors and how messaging might be adjusted to mitigate these phenomena.

The objectives of this research project were to:

- Determine if the prevalence of psychological reactance and moral disengagement are higher among adult drivers who never or rarely wear their seat belts or who drive aggressively (i.e., speed, follow too closely, and pass excessively) compared to adults who do not engage in these risky behaviors; and
- Identify potential messaging to minimize reactance and overcome moral disengagement regarding seat belt use and aggressive driving.

To support this objective and, in addition, to the final report, the following products were developed:

- **Summary Guidance on Best Practices to Evaluate Traffic Safety Culture Strategies** – A brief document that can be readily used by traffic safety professionals and stakeholders.
- **Webinar** – A webinar was created to summarize guidance for the traffic safety community. The webinar highlighted how program managers can use this guidance to select intervention strategies.
- **Poster** – A high-resolution graphic was created that is suitable for printing on a large poster for use in a conference poster session for traffic safety professionals to use to disseminate a summary of guidance on the evaluation of traffic safety culture strategies. A handout with talking points was also created.

This project was completed in FFY 2021. All final deliverables and more information can be found at https://www.mdt.mt.gov/research/projects/trafficsafety-reactance.shtml.

Guidance to Promote Workplace Policies and Family Rules to Reduce Cell Phone Use While Driving and Promote Engaged Driving:

Distraction while driving is a significant cause of crashes resulting in fatalities and serious injuries. Distracted driving may be more prevalent among young drivers who are already at greater risk for crashes due to novice driving skills. One source of distraction is using a cell phone. Communication (both spoken and typed) is a primary function of cell phones, and such communication is distracting because it takes the driver's eyes off the road and pulls their attention from the driving task. Safe driving requires the driver to be engaged in the driving task. The family and workplace contexts offer two important opportunities to address cell phone use while driving and promote engaged driving. Families can establish rules about never using a cell phone while driving and never communicating using a phone with a family member who is driving. Workplaces can establish similar policies. Guidance to reach families and workplaces is needed for traffic safety practitioners to promote engaged driving – driving free of distractions like cell phones.

The objectives of this project were to identify strategies for families and workplaces that foster engaged driving (i.e., practices that promote engagement by the driver in the driving task). Specifically, the project sought to answer the following questions:

- How do expectations within families and workplaces influence cell phone use while driving?
- What beliefs and attitudes need to shift to change these expectations and increase engaged driving?
- What are potentially effective strategies (and associated messages) to promote engaged driving within families and workplaces to reduce cell phone use?

In addition to the final report, additional products were developed, including the following:

- Family Conversations to Support Engaged Driving
- Resources to Promote Family Conversations about Engaged Driving
- Workplace Conversations about Engaged Driving
- Resources to Promote Workplace Conversations about Engaged Driving
- PowerPoint Presentation
- Project Webinar

This project was completed in FFY 2021. All final deliverables and more information can be found at https://www.mdt.mt.gov/research/projects/trafficsafety-engaged.shtml.

MDT Project Manager:
Sue Sillick
406.444.7693
ssillick@mt.gov

Consultant Project Manager:
Nic Ward
406.994.5942
nward@ie.montana.edu

3.9.1.5 Traffic Safety Culture Transportation Pooled Fund (TSC-TPF) Program – Phase 2

Project Number:	8882-444
Start Date:	10/1/19
Completion Date:	9/30/24
Total Cost:	$1,440,000
Total SPR Funds (100%):	$125,000
Total Other Federal Funds:	$1,190,000
Total Other State Funds (100%):	$125,000
Total MDT Indirect Costs:	$153,010
Total Expended:	$93,373
Total MDT Indirect Costs Expended:	$9,072
2021 FFY Total Expended:	$77,530
2021 FFY SPR Funds (100%) Expended:	$6,730
2021 FFY Other Federal Funds (100%) Expended:	$64,070
2021 FFY Other State Funds (100%) Expended:	$6,730
2021 FFY MDT Indirect Costs:	$7,527
Consultant:	Montana State University

MDT URL: https://www.mdt.mt.gov/research/projects/trafficsafety.shtml

Phase 1 Pooled Fund URL: https://www.pooledfund.org/Details/Study/558

Phase 2 Pooled Fund URL: https://www.pooledfund.org/Details/Study/668

Objective:

The Montana Department of Transportation initiated a multiyear pooled fund program in partnership with the Center for Health and Safety Culture (CHSC) within the Western Transportation Institute (WTI) at Montana State University. This program is a cooperative effort of participating state DOTs and other organizations vested in traffic safety. The purpose of this effort is to accelerate the development and delivery of tools and services to transform traffic safety culture. The goal of this transformation is to support the Toward Zero Deaths (TZD) vision with sustainable traffic safety solutions.

The Toward Zero Deaths (TZD): National Strategy on Highway Safety is a cooperative and coordinated effort among state highway safety agencies and stakeholders. The transformation of the traffic safety culture is a primary element of the TZD strategy. Only through the growth of a positive safety culture can significant and sustainable reductions in crash fatalities and serious injuries be achieved. Such transformation would not only support traffic safety goals by reducing risky behaviors and increasing protective behaviors, but it would also increase public acceptance of other forms of effective safety programs.

Progress and Reports:

Through 2021 FFY, there were four projects under the Phase 2 pooled fund program umbrella, two of which were the 2020 and 2021 Management Support contracts, as described below. Two additional research projects were contracted in FFY 2021: A Review of Methods to Change Beliefs, and Resources and Tools to Reduce Multi-Risk Driving Behaviors.

Management Support:

This project provides project management assistance, including meeting support (web conference set-up, in-person meeting logistics and travel reimbursement, agenda input, post-meeting follow-up, and meeting notes), quarterly progress reporting, support for outreach and awareness activities, and support for work plan and project development.

This is an annual contract renewed each year of the pooled fund, for a total of five annual projects. For FFY 2021, all tasks were completed and four quarterly progress reports were received; they can be viewed at https://www.pooledfund.org/Details/Study/668.

A Review of Methods to Change Beliefs:

Many of us—as traffic safety stakeholders—have the goal to reduce traffic fatalities and serious injuries to zero. Because road user behavior is a common factor in traffic crashes, we must explore ways to encourage safer behaviors. Traffic safety culture recognizes that intentional behavior is influenced by the values, beliefs, and attitudes shared among a group of people. Therefore, to change behavior within a group, it is necessary to change the beliefs. However, changing beliefs is difficult, and we require a better understanding of how beliefs are formed and changed so that we can develop more effective traffic safety culture strategies.

The aims of this project are to:

1. Understand the processes and conditions that influence belief formation and change.
2. Guide traffic safety stakeholders in the design of effective strategies to change traffic safety culture.

Final products will include: final report, tool for stakeholders to assess potential effectiveness, project summary poster, and a project summary webinar and presentation.

This project was initiated in FFY 2021. Also in FFY 2021, quarterly progress reports and the literature review (Task 1) were delivered. View more information on this project and the Task 1 report at https://www.mdt.mt.gov/research/projects/trafficsafety-cb.shtml.

Resources and Tools to Reduce Multi-Risk Driving Behaviors:
There is growing recognition that drivers involved in fatal crashes are often engaged in multiple risky behaviors—not wearing a seat belt, speeding, and driving impaired. Also, research has established associations between impulsivity and multiple risky driving behaviors. While the association between impulsivity and various risky driving behaviors is established in the literature, there is limited understanding about how to address impulsivity and the underlying beliefs and behaviors of individuals engaging in multiple risky driving behaviors. The proposed research seeks to address this gap by creating and testing an intervention designed to address traffic impulsivity to improve driver behaviors.

Research findings suggest that brief interventions focused on impulsive behavior may be an important strategy to address multiple risky driving behaviors. Characteristics such as psychological reactance and moral disengagement may also influence the decisions of drivers engaging in multiple risky driving behaviors. An intervention will likely need to address these characteristics. This project can build on previous research that has been done by the Traffic Safety Culture Pooled Fund to understand these two characteristics and mechanisms to decrease reactance and overcome moral disengagement. Designing an intervention with these factors and characteristics in mind will be important to address multiple risky driving behaviors.

This project proposes to develop and test a brief intervention designed to address multiple risky driving behaviors that can augment existing infrastructures. This project will provide a set of tools to inform decision making about strategies that focus on individuals who engage in multiple risky driving behaviors.

Objectives of this project include:

1. Conduct a review of literature to understand the multifaceted nature of impulsivity (what it is, types of impulsivity, etc.), how impulsivity is measured, and the relationship between impulsivity and high-risk driving behaviors. Researchers will also explore in the review of literature other factors like sensation seeking, affinity for risk, risk awareness and substance use disorders as these factors are also shown to influence multiple risky driving behaviors. Further, the literature review will explore ways to reduce impulsivity and other factors associated with multiple risky driving behaviors and inform the development of an effective virtual intervention to influence high-risk driving behaviors. The review will use a keyword search within relevant literature databases.
2. Synthesize what is learned from the literature to develop a brief intervention to reach drivers who engage in multiple risky behaviors.
3. Test the brief intervention that was created to reach drivers who are engaging in multiple risky behaviors.
4. Create recommendations and guidance that traffic safety professionals can use to address multiple risky driving behaviors and seek to leverage existing infrastructures.

The final products will include the following:

- **Develop Recommendations and Provide Guidance** – Based on what is learned from testing the brief intervention, researchers will provide recommendations about how traffic safety professionals can address multiple risky driving behaviors and could seek to leverage existing infrastructures.
- **Poster** – A poster will be created for traffic safety professionals to use to disseminate information in a traffic safety poster session.
- **PowerPoint Presentation** – A PowerPoint presentation will be created for traffic safety professionals to use to disseminate information.

- **A Recorded Webinar** – A webinar will be completed to disseminate findings from this project.
- **Final Report** – A final report will be completed summarizing each task in the project.

This project was initiated in FFY 2021. Also, in FFY 2021, quarterly progress reports were delivered. View more information on this project at https://www.mdt.mt.gov/research/projects/trafficsafety-rrb.shtml.

MDT Project Manager:
Sue Sillick
406.444.7693
ssillick@mt.gov

Consultant Project Manager:
Nic Ward
406.994.5942
nward@ie.montana.edu

3.9.2 Proposed Projects

3.9.2.1 Safety Evaluation of Sinusoidal Centerline Rumble Strips

URL: https://www.mdt.mt.gov/research/projects/sclrs-safety-eval.shtml

Topic Statement:

Centerline rumble strips (CLRS) are a proven safety feature to reduce high severity cross-over type crashes on rural and suburban roadways. Although the primary crash types reduced are head-on and sideswipe opposite direction crashes, studies have shown a reduction for all crash types. When traversed, conventional CLRS create significant additional traffic noise which can travel several hundred feet and create a nuisance to nearby residents. Previous studies show a quieter CLRS option is the sinusoidal centerline rumble strip (SCLRS). Currently there are no studies to quantify the crash reduction effects of the SCLRS. This proposed project will investigate the effectiveness of sinusoidal centerline rumble strips in lowering the number of observed crashes.

Related Research:

CLRS are nationally recognized as a cost-effective tool for reducing lane departure crashes. While conventional CLRS are effective, they can produce what is perceived as excessive exterior noise, particularly in areas with frequently used passing zones adjacent to residences. Many states have explored the use of modified rumble strips, also known as sinusoidal rumble strips, to lessen exterior noise impacts. A number of studies have shown sinusoidal rumble strips provide for significantly reduced exterior noise levels. Studies have also quantified changes to interior noise and vibration levels of sinusoidal rumble strips with the assumption that these would correlate with changes to driver response. Real-world performance testing using actual crash data has not yet been conducted for sinusoidal rumble strips. MDT proposes to use two planned CLRS projects to conduct a before-and-after crash comparison for approximately 600 miles of SCLRS on highways in western Montana.

Research Proposed:

The proposed research will analyze two SCLRS projects using safety performance function (SPF) modeling with empirical Bayes methodology. This will aid in determining the effectiveness of SCLRS on a variety of roadways for multiple crash types. The type of roadways to be studied are rural flat and rolling two-lane undivided highways, and rural mountainous two-lane undivided highways. Crash types to be analyzed include total crashes, injury crashes, single vehicle run-off-road total and injury crashes, and head-on and sideswipe opposite direction total and injury crashes. Achieving the objective of the research will be a three-part process. First, SPFs will be created and calibrated for the specific roadway and crash types. Five years of pre-installation crash data along with three to five years of post-installation data will then be collected at the identified sites. Finally, utilizing the specific SPFs, the before-installation crash rate will be compared to the after-installation crash rate. The research plan will include having the research team on board during construction so they can note any issues or anomalies

that could skew the data. The plan will also include documenting any issues during or after construction such as issues with centerline pavement joints.

Urgency and Expected Benefits:

Improved safety of the traveling public is a high priority for MDT and critical to achieving the goals of Vision Zero. This proposed research project will provide MDT and other states important information on the use of an alternative rumble strip option. Favorable crash reduction may allow the installation of centerline rumble strips in noise-sensitive areas deemed infeasible for conventional rumble strips which would further reduce crashes and save lives.

Progress:

In FFY 2021, an RFP was issued, and a consultant was chosen to conduct this research. The project is in contract negotiations.

MDT Project Manager:

Vaneza Callejas
802.546.0217
vcallejas@mt.gov

3.9.2.2 Use of Fluorescent Orange Delineators in Temporary Traffic Control Work Zones

Consultant: Montana State University

URL: https://www.mdt.mt.gov/research/projects/safety/delineators.shtml

Objective:

Road maintenance and reconstruction often present serious safety challenges to highway agencies due to the dynamic and variable work environment which may well be inconsistent with drivers' expectations. As such, proper delineation of travel path through work zones is critical for safe and efficient work zone operations. Currently the Manual on Uniform Traffic Control Devices (MUTCD) only allows white and yellow delineators within temporary traffic control work zones (Section 6F.80, MUTCD 2009). Field observations suggest that using the conventional white and yellow delineation may not be adequate to effectively delineate traffic through work zones.

This research project will consist of six primary tasks: 1) State-of-the-art review on work zone delineation devices and the different approaches for assessing their effectiveness; 2) Selection of study sites to include a limited number of work zones with different work activity and site conditions; 3) Data collection: traffic surveillance cameras and traffic recorders (on mobile trailers) will be used to collect data from study sites using the regular and the proposed delineation devices; 4) Data processing and compilation which involves extraction of information from video records and traffic sensors in a format appropriate for analysis; 5) Data analysis where major study variables (e.g., lateral clearance between vehicle and delineation devices, roadside encroachments, speeds, etc.) will be analyzed to examine the effectiveness of the proposed delineation devices, and; 6) Final report to include a description of the investigations performed along with a summary of major findings and recommendations.

Progress:

As a result of COVID-19 and traffic volumes having dropped by 30% to 50% of normal on the selected projects for this research, it was decided to postpone the research until November 2021.

MDT Project Manager:
Vaneza Callejas
802.546.0217
vcallejas@mt.gov

Consultant Project Manager:
Ahmed Al-Kaisy
406.994.6116
alkaisy@montana.edu

4 EXPERIMENTAL PROJECTS

4.1 Overview

The experimental features program is a FHWA-sponsored program that allows incorporation of experimental features into a project (e.g., construction, maintenance, and safety projects) and provides a vital field evaluation of new materials and methods. This evaluation, if performed well and scientifically based, allows MDT to evaluate specifications and to determine the implementation value in terms of performance and cost-effectiveness of these innovative practices.

FHWA defines an experimental feature as *a material, process, method, equipment item, or other feature that has not been sufficiently tested under actual service conditions or has been accepted but requires comparison with alternative acceptable features to determine their relative merits* (https://www.fhwa.dot.gov/programadmin/contracts/expermnt.cfm). This means that a material, process, method, equipment item, or other feature has not been sufficiently tested or requires comparison with alternative acceptable features in Montana.

Experimental features are identified by MDT staff (not Research staff) through the standard project process. The champion notifies the Experimental Projects Manager (ExPM) of the proposed experimental feature. The ExPM then attends all project meetings. Also, prior to developing a work plan, the ExPM may conduct a survey of other states and search TRB's TRID database to determine previous documented performance of an experimental feature, which may result in cancelling the proposed experimental feature.

4.1.1 Work Plan

Prior to construction, the ExPM writes a formal work plan. FHWA has delegated authority to MDT to proceed with experimental features without FHWA approval; however, every work plan is sent to FHWA for their information. This work plan includes the following information:

- Project location
- Project name
- Construction project number
- Experimental project number
- Project type/experimental feature
- Principal investigator
- Technical contact/champion
- Expected construction year
- Statement of objectives
- Experimental design
- Estimated quantities and costs (if applicable)
- Evaluation plan and schedule
- Reporting requirements

This work plan is important as it yields two additional benefits:

- FHWA will participate in the original construction, as appropriate, and repair, if the project should fail prematurely, at the percent funded during construction.

- Proprietary features may be specified without a public interest finding as otherwise required by FHWA. Also, in terms of state procurement laws and regulations, proprietary features can be sole sourced, as approved.

The ExPM may visit the project site prior to construction to document site conditions and delineate test and control sections.

4.1.2 Construction Report

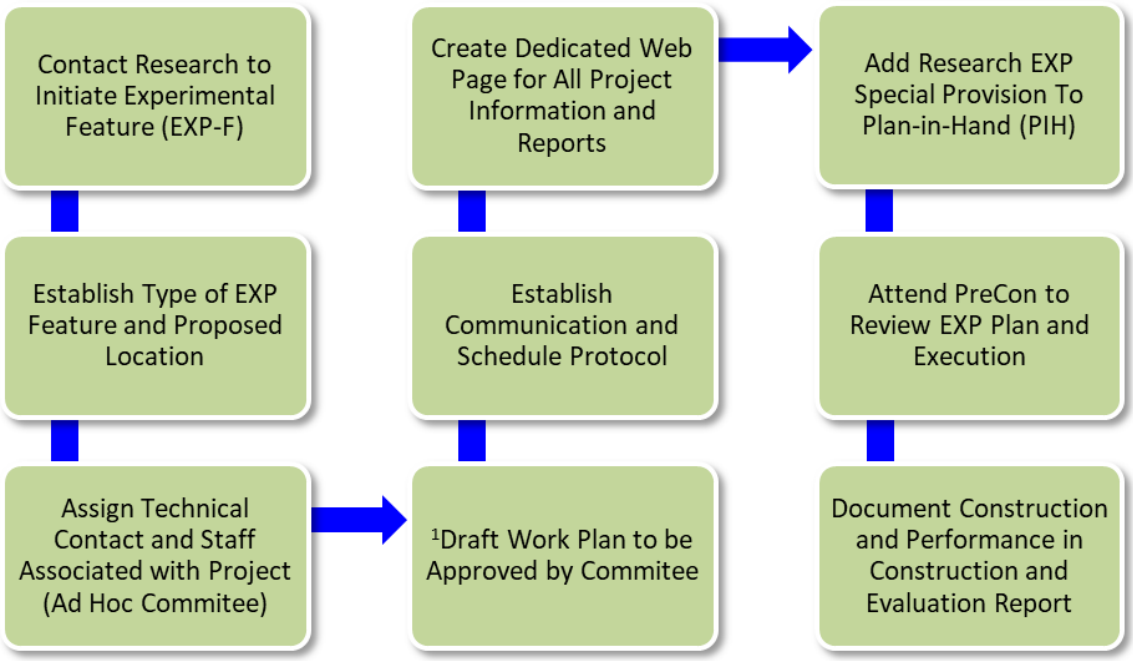
The ExPM will be present during construction of each experimental feature to observe construction practices, especially those that may influence performance. Following the construction of an experimental feature, the ExPM prepares a construction report to document construction practices and baseline conditions. All reports are distributed to MDT statewide, via Listserv, and posted on the experimental projects website (https://www.mdt.mt.gov/research/projects/exp_sub_listing.shtml). This report includes the following information:

- Project location
- Project name
- Construction project number
- Experimental project number
- Project type/experimental feature
- Principal investigator
- Technical contact/champion
- Construction year
- Statement of objectives
- Experimental design
- Evaluation plan and schedule
- Reporting requirements
- Summary of materials and methods
- Quantity and cost of experimental feature
- Construction details
- Construction problems and a statement of how these problems might have been alleviated

4.1.3 Progress and Final Reports

Performance is evaluated as per the work plan, usually annually for a minimum of five years, unless otherwise indicated by the type of feature. Sometimes, evaluations continue beyond the initial five-year evaluation, if needed, to allow enough data to be collected to distinguish performance among the various test and control sections. Progress and final performance evaluations are documented and appended to the construction report. This process is documented in Figure 3. Annually, progress and final project results are presented to FHWA and MDT staff from Maintenance; Design; Construction; Materials; and District Offices, including the Field Research Coordinators and the District Construction Services Supervisors. This helps to ensure all parties are kept in the loop with performance of the experimental features and creates a feedback loop from design to construction to maintenance and then back to design.

Finally, experimental projects are conducted in association with the Department's Product Acceptance Program. A related AASHTO Technical Services Program is the National Transportation Product Evaluation Program (NTPEP).



[1] The work plan contains project location, description, and extent of the experimental feature, how the EXP-F will be evaluated, schedule of installation, on-site evaluations, and reporting requirements. As a rule, all EXP projects should have a work plan.

Figure 3. Experimental Process Summary

Visit the MDT Research Programs website for additional information and current project reports available at http://www.mdt.mt.gov/research/.

4.2 Active Projects

4.2.1 3/8” Asphalt Cement Mix Placement with No Chip Seal Evaluation

Location:	Great Falls District, Cascade County, Interstate 15 (C000015), Approximate RP 282-283 (NB Lane Only)
Project Name:	Emerson Junction - Manchester
Project Number:	IM 15-5(124)282
Experimental Project Number:	MT-17-05
Project Type:	Asphalt Concrete Pavement Evaluation
Principal Investigator:	Chad DeAustin, Experimental Project Manager
Construction Year:	2017
Inspection Dates:	Nov. 2017, May 2018, Jan. 2019, Oct. 2019, May 2020, and Sep. 2021
Project End Date:	2022

URL: https://www.mdt.mt.gov/research/projects/asphalt-cement.shtml

Description:

The purpose of this project is to determine how a 3/8" asphalt cement (AC) mix design performs without a chip seal compared to a 3/4" AC with conventional chip seal.

The two main measures of effectiveness of this project are 1) visual distress of the pavement over time, and 2) the texture characteristics of the pavement. The Department’s Pavement Management section will conduct skid testing on both the 3/8" non-chipped and 3/4" chipped sections of the interstate for comparison annually. That data will be added to the report when available.

Analysis to Date:

No visual distress to report.

The Great Falls District has reported the results of Hamburg rut tests were peripheral with several of the samples marginally passing and several with signs of rutting. Although test results did not initiate any rework on the project (possible pavement replacement), there may be potential for reduced service life of the AC pavement structure.

The next evaluation will be in 2022.

MDT Project Manager:
Chad DeAustin
406.444.6269
cdeaustin@mt.gov

4.2.2 3D Synthetic Geocomposite for Added Subsurface Drainage Layer in Asphalt Cement Pavement Structure Evaluation

Location:	Butte District, Gallatin County, State Highway 287 (P-87), R.P. 6.81-6.95
Project Name:	Jct. Raynolds Pass - Quake Lake
Project Number:	STPP 87-1(11)0
Experimental Project Number:	MT-15-02
Project Type:	Geocomposite Application
Principal Investigator:	Chad DeAustin, Experimental Project Manager
Construction Year:	2016
Inspection Dates:	Apr. 2017, Aug. 2017, Apr. 2018, Oct. 2018, Apr. 2019, Apr. 2020, and Aug. 2021
Project End Date:	2022

URL: https://www.mdt.mt.gov/research/projects/roadrain.shtml

Description:

This project is located on US 287 (P-87) in Gallatin County, from the junction with Montana Highway 87 (P-13) approximately 7.0 miles southbound, toward West Yellowstone. Work to be performed includes cold milling, plant mix surfacing, seal and cover, guardrail installation, dig-outs, and signing and pavement marking.

As of four years ago, prior to the new construction, the section of Highway 287 in question (R.P. 6.81-6.95) had deteriorated to the point a dig-out was performed and treated using usual methods of rehabilitation (geotextile, special borrow, crushed aggregate course, PMS). The section has since failed, and the Department has installed a synthetic subsurface drainage layer (SSDL) under the assumption that water retention within the pavement layers deteriorated the structural base course, contributing to the premature failure of the pavement.

The Department elected to install Tensar RoaDrain 5 (RD-5) as an experimental feature in this project.

Analysis to Date:

A small section of frost heave was detected in 2019, and field marked for future reference. As of 2021, the frost heave has caused a transverse crack but overall, the section is holding up well. The next evaluation will be in 2022.

MDT Project Manager:
Chad DeAustin
406.444.6269
cdeaustin@mt.gov

4.2.3 Centerline Rumble Strip Evaluation

Location: Missoula District, Lincoln County, US 2; RP 0.0-13.75
Project Name: 508 E/W
Project Number: N/A
Experimental Project Number: MT-17-04
Project Type: Centerline Rumble Strip
Principal Investigator: Chad DeAustin, Experimental Project Manager
Technical Contact: Justun Juelfs, Kalispell Maintenance Chief
Construction Year: 2017
Inspection Dates: Apr. 2018, Sep. 2018, Apr. 2019, Apr. 2020, and Oct. 2021
Project End Date: 2023
URL: https://www.mdt.mt.gov/research/projects/rumblestrip.shtml

Description:

This project is a centerline rumble strip (CLRS) longitudinal joint performance evaluation located in Lincoln County on US Highway 2 (C000001/N1), Missoula District, reference point 0.0 to 13.75. The 2016 annual average daily traffic through this corridor was 1,539 and as of 2020 was 1,667.

A CLRS is a longitudinal safety feature installed at or near the centerline of a paved roadway. On this project, the strip is a series of rectangular milled indents intended to alert distracted drivers (through vibration and sound) that their vehicles have left the travel lane.

Asphalt pavements are typically constructed with a longitudinal joint (or meet line) along the center of the road. Degradation over time may allow the entry of water, leading to early pavement deterioration. Rumble strips provide another potential reservoir to hold water and could accelerate this joint deterioration. Traffic and environmental characteristics may also affect joint performance.

This project has a test section of CLRS (TS1) adjacent to a control section on non-CLRS (CS2) to compare performance. TS1 begins at reference point (RP) 0.0 on the Idaho/Montana border and runs east to the section transition CS2 at RP 8.2, which continues to RP 13.75 just east on the entrance to the township of Troy. TS1 pavement treatment was a mill and fill with CS2, a standard overlay.

Analysis to Date:

No performance issues to date. The next site inspection will be in 2022.

MDT Project Manager:
Chad DeAustin
406.444.6269
cdeaustin@mt.gov

4.2.4 Crafco Mastic One Joint Filler Evaluation

Location:	Great Falls District, Pondera County, Interstate-15 and Secondary 218
Project Name:	Brady N and S (NB) and Conrad-East
Project Number:	IM 15-6(43)323 and STPS 218-1(11)0
Experimental Project Number:	MT-20-04
Project Type:	Crack Seal and Pavement Repair
Principal Investigator:	Chad DeAustin, Experimental Project Manager
Construction Year:	2020
Inspection Dates:	Sep. 2021
Project End Date:	2025

URL: https://www.mdt.mt.gov/research/projects/crafco.shtml

Description:

Crafco Mastic One is a hot-applied, single component, pourable, aggregate-filled, polymer-modified asphalt mastic used for maintenance, repair, and preservation of pavement and bridge surfaces.

Mastic One is used for sealing, filling, and repairing many distresses in both asphalt concrete and Portland cement concrete pavements that are larger than those typically repaired by crack or joint sealing, but smaller than repairs requiring remove-and-replace patching procedures.

This application of the Mastic One will primarily be used for transverse cracks on the Conrad-East project and the ramps on the Brady N&S project. Both applications will be sealed with a standard chip seal.

Analysis to Date:

No performance issues to date. The next site inspection will be in 2022.

MDT Project Manager:
Chad DeAustin
406.444.6269
cdeaustin@mt.gov

4.2.5 CRS-2P and CHFRS-2P Emulsion Comparison on Chip Seal

Location:	Missoula District, Sanders County, Montana Highway 200 (P-6), RP 98.7-116.1
Project Name:	Dixon-West – Dixon-Ravalli
Project Number:	STPP 6-1(156)99/STPP 6-1(154)109
Experimental Project Number:	MT-19-02
Project Type:	Chip Seal (CS) Performance
Principal Investigator:	Chad DeAustin, Experimental Project Manager
Technical Contact:	Joshua Dold, Missoula District Design Supervisor
Construction Year:	2019
Inspection Dates:	Apr. 2020 and Aug. 2021
Project End Date:	2024

URL: https://www.mdt.mt.gov/research/projects/chip_seal_emulsion.shtml

Description:

The project was initiated to compare the performance of two asphalt cement (AC) emulsions in an application of a conventional chip seal using Type I chips; no added fog seal was applied.

The chosen emulsions are cationic high-float rapid set (CHFRS-2P) and cationic rapid set (CRS-2P). The Dixon-Ravalli project will utilize CHFRS-2P (for the project length, full roadway width); the Dixon-West project will utilize CRS-2P (for the project length, full roadway width).

Annual average daily traffic for both project sections was approximately 1,921 in 2018 and was recorded at 2,212 in 2020.

Analysis to Date:

No construction issues were reported that may affect future performance of the chip seals. No visible distress to report. The next scheduled inspection will be in the spring of 2022.

MDT Project Manager:
Chad DeAustin
406.444.6269
cdeaustin@mt.gov

4.2.6 Electric Wildlife Deterrent Mat

Location:	Butte District, Broadwater County, MT Route 287/12 (N-8) Missoula District, Sanders County, MT Route 200 (P-6)
Project Name:	Toston Structure East of Thompson River – East
Project Number:	NHIP-NHPBIP 8-4(66)86 STPP 6-1(126)57
Experimental Project Number:	MT-20-01
Project Type:	Wildlife Crossing Structure
Principal Investigator:	Chad DeAustin, Experimental Project Manager
Construction Year:	2020-2021
Project End Date:	Pending

URL: https://www.mdt.mt.gov/research/projects/electmat.shtml

Research Project URL: https://www.mdt.mt.gov/research/projects/deterrent-mats.shtml

Description:

Generically known as electric mats, these structures are crossing deterrents to discourage animals from entering an area deemed necessary to be "animal free" to mitigate conflicts with travelling motorists. These mats incorporate a mild electric shock when a hooved animal attempts to enter the crossing.

The electric wildlife deterrent mat (EWDM) units are embedded directly in the pavement (concrete and metal fiber or rubberized composite material) in a full-width roadway application. Electric mats serve as an alternative to cattle guards and other nonelectric crossing structures to manage ungulate movements.

The information gathered and analyzed from this project may result in a better understanding of how existing roadways may be utilized as wildlife barrier structures. In addition to gaining a better understanding of how "funnel" fencing can be used on existing and future projects, the goal is a roadway system that is safer for motorists and wildlife. Both areas use a bridge end as one end of the wildlife free area and the other is controlled by a fencing pinch. The Thompson Falls location was chosen specifically because of the high number of incidents with bighorn sheep.

Analysis to Date:

This Thompson Falls EWDM was completed in 2020 and has begun showing signs of distress in the concrete. The Toston EWDM was completed in 2021 and is described in the construction report now in process. The next evaluation will be in 2022. There is also a research project included with this evaluation.

MDT Project Manager:
Chad DeAustin
406.444.6269
cdeaustin@mt.gov

4.2.7 Fog Seal Chip Retention Evaluation

Location:	Butte District, Gallatin County, Targhee Pass-West Yellowstone, State Highway 20 (N-12) – Reference Point 0.0-9.4
Project Name:	Targhee Pass-West Yellowstone
Project Number:	NH 12-1(20)0, UPN 8762000
Experimental Project Number:	MT-15-01
Project Type:	Fog Seal on Chip Seal
Principal Investigator:	Chad DeAustin, Experimental Project Manager
Construction Year:	2017
Inspection Dates:	Apr. 2018, Oct. 2018, May 2019, May 2020, and Aug. 2021
Project End Date:	2022

URL: https://www.mdt.mt.gov/research/projects/seal_coat.shtml

Description:

The project was nominated to determine if the performance of a fog seal over the top of a chip seal (FSCS) will extend the service life (chip retention) of the pavement treatment compared to that of a conventional chip seal (seal and cover).

The area selected is a mountainous (average project elevation of 6,800 ft.) section of state (secondary) highway with extreme weather conditions that maximize maintenance activities and has severely limited the effectiveness of past pavement preservation treatments.

The FSCS test section encompasses the westbound lane for the length of the project, with the eastbound lane serving as the conventional chip seal (CS) control section.

The level of objective relief (the visual appearance of the ratio of binder to the exposed vertical area of the aggregate) of the chip seal as compared to the level of an additional binder layer for an enhanced embedment of chip may show the FSCS creates a tighter bond with the aggregate. The level of texture is not an indicator of friction coefficient. The second objective is to ascertain the level of chip loss between the sections over time.

Analysis to Date:

Both lane treatments displayed good visual condition during the 2021 inspection. The next site inspection will be in the spring of 2022.

MDT Project Manager:
Chad DeAustin
406.444.6269
cdeaustin@mt.gov

4.2.8 Fog Seal Over Chip Seal Evaluation

Location:	Missoula District, Mineral County, Interstate Highway 90 (C-000090), RP 5.7-23.3
Project Name:	Exit 5 – East – CN 8954000
Project Number:	IM 90-1(220)6
Experimental Project Number:	MT-18-01
Project Type:	Fog Seal on Chip Seal
Principal Investigator:	Chad DeAustin, Experimental Project Manager
Construction Year:	2017
Inspection Dates:	Oct. 2017, Apr. 2018, Oct. 2018, May 2019, May 2020, and Sep. 2021
Project End Date:	2022

URL: https://www.mdt.mt.gov/research/projects/seal_coat.shtml

Description:

This project was implemented to determine the performance of an applied fog seal to chip seal (FSCS), which may extend the service life of the pavement treatment (chip retention) compared to the conventional practice of a chip seal (seal and cover).

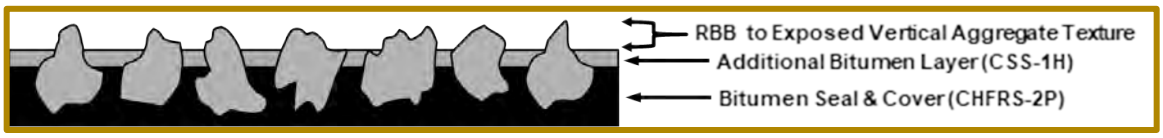
The area selected is a high mountain (average project elevation of 6,800 ft.) section of state (secondary) highway with extreme weather conditions that maximize maintenance activities and has severely limited the effectiveness of past pavement preservation treatments.

The FSCS section encompasses both the westbound and eastbound lanes of the interstate.

The objective of the project is to determine if the selected emulsion (CSS-1H) will add additional reinforcement of the embedded Type III chip (within the conventional seal using CHFRS-2P) to enhance the residual bitumen binder (RBB) on the FSCS section. The visual appearance of the ratio of binder to the exposed vertical area of the aggregate (as seen in the diagram below) may offer a tighter bond with the RBB, however the level of texture is not an indicator of friction coefficient.

Analysis to Date:

No performance issues to date. The next and final site inspection will be spring of 2022.



MDT Project Manager:
Chad DeAustin
406.444.6269
cdeaustin@mt.gov

4.2.9 High Float vs. Polymer Modified Emulsion Seal and Cover With and Without a Fog Seal

Location: Great Falls District, Hill County, US 2 (N-1)
Project Name: Gilford-East
Project Number: NH 1-6(123)355
Experimental Project Number: MT-20-02
Project Type: Fog Seal/Chip Seal Emulsion Comparison
Principal Investigator: Chad DeAustin, Experimental Project Manager
Construction Year: 2020
Inspection Dates: Sep. 2021
Project End Date: 2025
URL: https://www.mdt.mt.gov/research/projects/seal_coat.shtml

Description:

The purpose of this project is to compare two emulsions with and without a fog seal, determining the short- and long-term performance benefits of each application including cost-effectiveness, long-term durability, and/or potential chip retention benefits. The two emulsions are Cationic High Float Rapid-Set High Viscosity Polymer (CHFRS-2P) and Cationic Rapid Set High-Viscosity Polymer (CRS-2P). The former will be placed with a chip seal only. The latter will be placed with a chip seal and with a Cationic Slow-Set Low Viscosity Hard-Base (CSS-1H/diluted 50 percent) fog seal treatment. Maintenance is routinely using the CHRFS-2P chip seal oil.

This project contains three test sections, one for each treatment, and will be monitored to attempt to formally document benefits of fog seal on a new chip seal.

Analysis to Date:

No performance issues to date. The next site inspection will be in 2022.

MDT Project Manager:
Chad DeAustin
406.444.6269
cdeaustin@mt.gov

4.2.10 JOINTBOND Asphalt Joint Stabilizer

Location:	Butte District, Gallatin County, Bridger Canyon Rd.; Montana Highway 86 (P-86), RP 11-13.8
Project Name:	Bridger Canyon
Project Number:	STPP86-1(55)10
Experimental Project Number:	MT-19-05
Project Type:	Centerline Joint Stabilizer Treatment
Principal Investigator:	Chad DeAustin, Experimental Project Manager
Technical Contact:	Tyrell Murfitt, Helena Road Design
Construction Year:	2019
Inspection Dates:	Apr. 2020 and Oct. 2021
Project End Date:	2025

URL: https://www.mdt.mt.gov/research/projects/jointbond.shtml

Description:

JOINTBOND longitudinal joint stabilizer was developed to inhibit the premature deterioration of construction joints by penetrating the asphalt pavement and combining with the existing asphalt binder.

As a polymerized maltene-based emulsion, JOINTBOND stabilizer may extend the service life of longitudinal joints and adjacent areas in two ways:

- Improving the chemistry of the in-place asphalt binder
- Adding a physical in-depth seal to the construction joint, thereby sealing the joint and surrounding area against intrusion by air, water, and salt brine

Annual average daily traffic for the project was approximately 1,980 when construction was completed and is up to 2,386 daily as of 2020.

Analysis to Date:

No construction issues were reported during the application of the joint sealer. No performance issues to date. The next scheduled inspection will be in the spring of 2022.

MDT Project Manager:
Chad DeAustin
406.444.6269
cdeaustin@mt.gov

4.2.11 Longitudinal Centerline Asphalt Cement Joint Membrane

Location:	Missoula County, MT 83 (P-83), RP 31.5-47.8
Project Name:	Condon – North & South
Project Number:	STPP 83-1(40)32
Experimental Project Number:	MT-20-06
Project Type:	Void Reducing Asphalt Membrane (VRAM)
Principal Investigator:	Chad DeAustin, Experimental Project Manager
Construction Year:	2020
Inspection Dates:	Sep. 2021
Project End Date:	2025
URL:	Pending

Description:

Condon – North & South is an approximately 16-mile-long mill and fill project in the Seeley/Swan Valley in western Montana. This area receives heavy snowfall in the winter and the existing roadway was experiencing significant centerline joint failure. JBAND is a void reducing asphalt membrane used to fill air voids in plant mix and paving joints. They idea is that the JBAND product will help reduce the amount of freeze/thaw damage along the centerline to preserve the joint.

The contractor decided to mill and fill each lane individually to create a solid edge to pave the centerline joint against. The JBAND was sprayed in a 9-inch pass in each lane on the milled surface prior to paving. The product needed approximately 15 to 30 minutes to cure and was followed by a standard tack coat over the entire milled surface. Next was paving and the same process was followed in the other lane.

Analysis to Date:

No performance issues to date. However, during the first site inspection in 2021, it appeared that the JBAND had bled through the plant mix and chip seal and was visible on the road surface. The next site inspection will be in 2022.

MDT Project Manager:
Chad DeAustin
406.444.6269
cdeaustin@mt.gov

4.2.12 Nomaflex Concrete Joint Filler Evaluation

Location:	Butte District, Gallatin County, Rouse Ave-Bozeman
Project Name:	Rouse Ave – Main to Oak
Project Number:	STPP 86-1(27)0
Experimental Project Number:	MT-21-06
Project Type:	Concrete Expansion Joint
Principal Investigator:	Chad DeAustin, Experimental Project Manager
Construction Year:	2021
Project End Date:	Pending
URL:	Pending

Description:

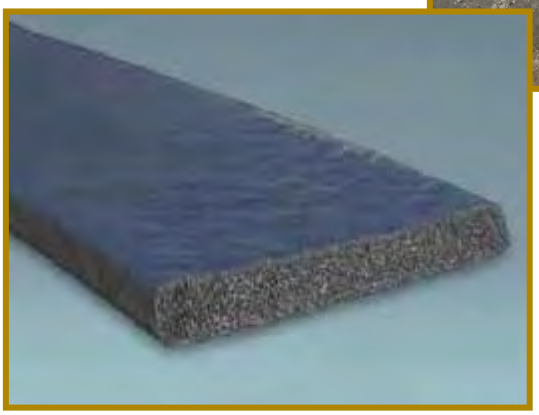
Nomaco Nomaflex is a closed-cell polypropylene foam used as a preformed expansion joint in concrete sidewalk applications. This product does not require the use of a bond breaker commonly used with other conventional expansion joints (i.e., asphalt saturated fiber). This product is also recyclable.

The manufacturer's information states that it extends the service life of concrete by reducing the number of incompressible materials that may enter the joint over time and accelerate cracking or spalling.

Crews installed 3000 linear feet of Nomaflex from reference point (RP) 0.0 (Main Street) to RP 0.85 (Oak Street).

Analysis to Date:

Project was completed in 2021 and a construction report is in progress.



MDT Project Manager:
Chad DeAustin
406.444.6269
cdeaustin@mt.gov

4.2.13 Reinforcing Fibers in Plant Mix Asphalt Cement Evaluation

Location: Billings District, Yellowstone County-Billings, Division St. and 6th Ave N (27th to 32nd)
Project Name: Division St.-Billings and 6th Ave. N-27th to 32nd
Project Number: UPPIP 1017(2)7/UPPIP 1029(4)
Experimental Project Number: MT-18-03
Project Type: Sasobit-Aramid Fiber Reinforced Asphalt Cement
Principal Investigator: Chad DeAustin, Experimental Project Manager
Construction Year: 2018
Inspection Dates: Apr. 2019 and Apr. 2020
Project End Date: 2023
URL: https://www.mdt.mt.gov/research/projects/fiber-rac.shtml

Description:

The Billings District incorporated synthetic fibers as an additive to improve asphalt cement (AC) properties. This is the first trial in the state that has used AC fiber reinforcement in a pavement preservation application. The intent of this chosen admixture is to improve resistance to cracking and rutting, increase dynamic modulus, and increase service life.

Surface Tech is the chosen vendor to supply Ace Fiber (pretreated aramid fibers coated with Sasobit wax) used in the production of fiber-reinforced asphalt cement (FRAC). Surface Tech was on site to monitor the inclusion of the Ace Fiber during AC production. Surface Tech also furnished the Ace Fiber Line-Vac delivery system, which is the device that introduces the fibers into the drum mixer. Over 18 million Aramid fibers are dispersed for each ton of mix to provide three-dimensional reinforcement.

Because untreated aramid fiber is a very lightweight material and difficult to work with, the fibers are soaked in a wax binder. This pretreatment adds weight to the fiber clips and prevents them from blowing away or clumping during the delivery and feeding process.

Analysis to Date:

No issues were reported in connection with the Ace Fiber addition at the AC production plant. The FRAC paving went well and to date no visible pavement distress is reported. The AC fiber production phase was conducted in July 2018. The next evaluation will be in 2022.

MDT Project Manager:
Chad DeAustin
406.444.6269
cdeaustin@mt.gov

4.2.14 Road Smoothing

Location:	Butte District, Broadwater County, US HWY 12/287
Project Name:	Townsend – North
Project Number:	NH 8-4(79)68
Experimental Project Number:	MT-21-02
Project Type:	Road Smoothing
Principal Investigator:	Chad DeAustin, Experimental Project Manager
Construction Year:	2021
Project End Date:	2026
URL:	Pending

Description:

Road smoothing is the practice of grinding the surface of a roadway to eliminate bumps and rutting while maintaining a proper profile by means of a diamond grinding mill. MDT chose the Townsend-North job to test this equipment as the road was structurally in good condition but was experiencing rutting and bump issues. Preconstruction ride test data for the driving lanes in the northbound was an International Roughness Index (IRI) of 64.90 and southbound at 62.92. The Diamond Road Smoother is a semi and trailer combo that moves down the roadway intaking information with averaging level arms and outputting a smooth road via the diamond grinding teeth on a revolving drum. This operation allows an improved surface to be created without the expensive costs of an overlay or mill and fill.

Analysis to Date:

Construction was completed in the summer of 2021. The ride data in the driving lanes resulted in an improvement of an average of 26% in IRI. The Butte District was unsure of the new surface as it produced more noise heard within the vehicle and although the ride data improved, the surface texture was rougher than expected. The new surface had a chip seal applied and in the spring of 2022 the surface will be re-evaluated.

MDT Project Manager:
Chad DeAustin
406.444.6269
cdeaustin@mt.gov

4.2.15 Sinusoidal Centerline Rumble Strip Evaluation

Location: Glendive District, Rosebud County, MT-39; RP 31-32.4
Project Name: Sinusoidal CLRS-Colstrip
Project Number: UPN 9370
Experimental Project Number: MT-18-02
Project Type: Centerline Sinusoidal Rumble Strip
Principal Investigator: Chad DeAustin, Experimental Project Manager
Construction Year: 2018
Inspection Dates: Apr. 2019, Feb. 2020, May 2020, and May 2021
Project End Date: 2023
URL: https://www.mdt.mt.gov/research/projects/sclrs.shtml
Research Project URL: https://www.mdt.mt.gov/research/projects/sclrs-safety-eval.shtml

Description:

The purpose of this project is to demonstrate the application of a sinusoidal centerline rumble strip (SCLRS) and evaluate performance, not including safety. There is a research project to evaluate the safety of SCLRS as compared to conventional centerline rumble strips (CLRS). The 2017 annual average daily traffic through this corridor was 1,235 and new data as of 2020 reported that number has increased to 1,337.

CLRS are extremely effective in reducing severe roadway departure crashes at a low cost. Rumble strips use both noise and vibration to alert a driver that their vehicle is leaving the travel path. To be effective, the noise generated inside the vehicle must rouse a drowsy driver or grab the attention of a distracted driver. Since there is a wide range of "drowsiness" and "distraction" inside the vehicle compartment, more noise is typically better.

Conversely, the noise generated outside the vehicle can be disruptive to residents or businesses in the area, and the goal is to produce as little sound as possible broadcast outside the vehicle and still maintain the needed noise level for safety. The focus of this project is to document the method of installation and equipment used to apply this feature and to compare the performance and current noise level of the conventional strips the Department now deploys to the sinusoidal rumble strips on this project.

The following indicates the SCLRS design parameters:

- Design S1: 14” longitudinal frequency, 12” wide, 1/8” to 1/2” depth frequency
- Design S2: 24” longitudinal frequency, 12” wide, 1/8” to 1/2” depth frequency
- Design S3: 14” longitudinal frequency, 14” wide tapered, 1/8” to 1/2” depth frequency
- Design S3A: 24” longitudinal frequency, 14” wide tapered, 1/8” to 1/2” depth frequency

Analysis to Date:

No visible distress to the strip sections to date. On-site decibel testing was conducted in September 2019. The report stated that Design S3A provided the best results and was the consultant’s recommendation. However, there were still a few issues to be considered, as none of the SCLRS had much impact on commercial-sized vehicles, and the standards for SCLRS are still being updated at a federal specification level. The full report is available on the project’s webpage. The next site inspection will be in 2022.

MDT Project Manager:

Chad DeAustin
406.444.6269
cdeaustin@mt.gov

4.2.16 SKAPS GT116N Nonwoven Textile Bond Breaker

Location:	Glendive District, Richland County, Township of Fairview-Montana 200/P-20MT 200-Fairview
Project Name:	MT 200-Fairview
Project Number:	STPP 20-2(31)62
Experimental Project Number:	MT-20-05
Project Type:	Nonwoven Textile Bond Breaker CTB/PCCP
Principal Investigator:	Chad DeAustin, Experimental Project Manager
Construction Year:	2020
Inspection Dates:	May 2021
Project End Date:	2025
URL:	Pending

Description:

The purpose of this project is to rehabilitate the existing surfacing and to provide a smoother and safer roadway to meet the demand of increased traffic the pavement will be milled to the level of cement-treated base (CTB) with a nonwoven fabric interlayer to minimize potential reflective cracking to the Portland cement concrete pavement (PCCP) overlay. The project is on Montana Highway 200 through the town of Fairview.

Analysis to Date:

No performance issues to date. The next site inspection will be in 2022.

MDT Project Manager:
Chad DeAustin
406.444.6269
cdeaustin@mt.gov

4.2.17 Sprayroq SprayWall Polyurethane Applied Culvert Rehabilitation Evaluation

Location:	Missoula District, Mineral County, Interstate 90, Reference Point (RP) 59, Nemote Creek Crossing
Project Name:	I-90 Nemote Creek Culvert
Project Number:	IM 90-1(205)59 – Work Type 312: Structure Safety
Experimental Project Number:	MT-13-14
Project Type:	Culvert Rehabilitation
Principal Investigator:	Chad DeAustin, Experimental Project Manager
Construction Year:	2017
Inspection Dates:	Apr. 2017, Apr. 2018, Jan. 2019, Jan. 2020, and Sep. 2021
Project End Date:	2022

URL: https://www.mdt.mt.gov/research/projects/spraywall.shtml

Description:

This project is located at the crossing of Nemote Creek on Interstate 90, at RP 59.0 ±; approximately two miles west/north of the Tarkio Loop Road interchange, and 1.3 miles east/south of the Quartz Flats westbound rest area. The eight (8) gauge steel plate pipe culvert (SPPC) is 242 linear feet, and has an interior radius of 12 ft.

Bulging and sagging of the steel-plated panels located near the east end of the culvert were noted in 2006 and remedial action was recommended in May 2013. Maximum deflection within areas of deformation was roughly estimated to be 6 inches located in the upper plates of the pipe. The purpose of the rehabilitation effort is to improve the structural capacity of the pipe to reduce the chance of a culvert failure that would impact the I-90 roadway.

Due to site constraints and apparent minimal change in the areas of deformation over the past seven years, the Department used a cure-in-place-pipe (CIPP) process to provide structural enhancement and corrosion resistance.

The selected product is Sprayroq's catalyzed, two-component coatings, SprayWall. SprayWall is a procedure using self-priming, spray-applied structural polyurethane coating as the lining medium. The manufacturer states the lining allows return to active service within an hour of application.

The extent of the treatment encompassed the culvert inlet to approximately 30 ft. down flow into the culvert with a 360° SprayWall application. Areas of the apparent deformation received a thicker application of SprayWall.

Analysis to Date:

During the April 2017 inspection, it was noted that areas of the steel plate seam and bolt connections received an additional (apparently hand-applied) application of SprayWall most likely applied soon after installation.

Information from District staff states the issue of moisture seepage (a condition evident in the culvert preparation phase) was observed after the initial SprayWall application was completed and required

spot patching to eliminate the migration of moisture. Although the contractor attempted to check the leaks using expanding sealants, 100 percent containment was not possible. On the January 2020 inspection plate connections had icicles forming.

In February of 2021, the issues highlighted above were worked on and during the 2021 site inspection no issues were noted. The next and final site inspection is in 2022.

MDT Project Manager:
Chad DeAustin
406.444.6269
cdeaustin@mt.gov

4.2.18 Surfacing In-Slope Treatment Evaluation

Project Name:	Glendive District, Dawson County, I-94
Project Name:	Bad Route Interchange – NE
Project Number:	IM 94-6(59)193
Experimental Project Number:	MT-21-04
Project Type:	Topsoil Surfacing Comparison
Principal Investigator:	Chad DeAustin, Experimental Project Manager
Construction Year:	2021
Project End Date:	2026
URL:	Pending

Description:

A section of Interstate 94 near the township of Glendive has deteriorated to the point a reconstruct is necessary. The primary cause of the subgrade failure exhibited on this project is heave action on the frost susceptible subgrade soils.

When drainage of the surfacing section is hindered, the susceptibility to freeze/thaw action increases significantly. By not top-soiling the new crushed aggregate course surfacing in-slope there may be a better chance of the surfacing section being able to drain during the fall, spring, and winter seasons when the presence of moisture, combined with freeze/thaw action, is most prevalent. Two separate design changes to the roadway in-slope will be constructed to compare efficacy of the treatments as compared to the current practice of topsoil placement.

Analysis to Date:

The project was completed in 2021 and the construction report is in progress.

MDT Project Manager:
Chad DeAustin
406.444.6269
cdeaustin@mt.gov

4.2.19 T15 Base One Soil Stabilization Evaluation

Location:	Glendive District, Valley County-City of Nashua, Montana Route 117 (P-17)
Project Name:	Milk River – North
Project Number:	STPP 17-1(10)11
Experimental Project Number:	MT-18-05
Project Type:	Full-Reclamation Chemical Soil Stabilization
Principal Investigator:	Chad DeAustin, Experimental Project Manager
Construction Year:	2018
Inspection Dates:	May 2019, May 2020, and Jun. 2021
Project End Date:	2025

URL: https://www.mdt.mt.gov/research/projects/t5baseone.shtml

Description:

The project is located on Montana Route 117 (P-17) in Valley County from the north end of the Milk River bridge extending north approximately 1.91 miles to the new alignment and intersection of MT 117 and (NHS/NI) US2. Test sections also include the old stretch of MT 117 through the town of Nashua (Front and Sargent streets).

The pavement sections located on this project were in variable condition with significant cracking, large partial and full-width patched sections, and isolated repaired potholes. The pavement was generally considered to be in poor to fair condition. It was decided that full-depth reclamation was needed to restore the efficacy of the pavement and to employ a soil stabilizer to enforce the integrity of the pavement structure.

The chosen soil stabilizer (SS) is Team Labs T15 Base One, a proprietary blend of silicic acid and sodium salt. Six (6) test sections were installed on the project. A road reclaimer was used for pavement reclamation and for the homogeneous mixing/injection of the SS. The SS application rate was set at 0.005 (0.5 percent) gallons per square yard per inch of reclamation depth.

A Tetra Tech representative, one of the subcontractors on the project, was on hand to assist with and monitor the reclamation and application phases of the Base One soil stabilizer.

Analysis to Date:

The 2021 site inspection revealed no pavement distress to date. The next inspection will be in the spring of 2022.

MDT Project Manager:
Chad DeAustin
406.444.6269
cdeaustin@mt.gov

4.2.20 TenCate Mirafi MPV400 Polypropylene Nonwoven Geotextile Evaluation

Location: Great Falls District, Cascade County, U-5201; Smelter Ave. NW – 5th St. NW to 1st St. NW
Project Name: Smelter-1st to 5th St NW
Project Number: 8978000 UPP 5201(24)
Experimental Project Number: MT-17-03
Project Type: Milled Overlay with Paving Fabric
Principal Investigator: Chad DeAustin, Experimental Project Manager
Construction Year: 2017
Inspection Date: Apr. 2018, Apr. 2019, Apr. 2020, and Sep. 2021
Project End Date: 2022
URL: https://www.mdt.mt.gov/research/projects/tencate-mirifi-mpv400.shtml

Description:

The project is in Cascade County within the township of Great Falls on Route U-5201 (C005201), Smelter Ave. NW, beginning at RP 2.5, at 5th St NW and extending approximately 0.4 miles east ending at RP 3.0, 1st St NW. This is a pavement preservation project involving a cold mill, overlay, and added paving fabric.

The purpose of adding the designated paving fabric on the prepared milled surface is to aid in extending the service life of the pavement. As claimed by the manufacturer, TenCate Mirafi MPV400 nonwoven asphalt overlay fabric forms a membrane that minimizes surface water from penetrating pavement systems and provides a stress relief interlayer that inhibits the growth of reflective cracks. Produced from polypropylene staple fibers, TenCate Mirafi is heat-set to provide a waterproofing barrier.

Analysis to Date:

Significantly more distress appeared during the 2021 site inspection but not enough to raise concern. The next and final site inspection will be spring of 2022.

MDT Project Manager:
Chad DeAustin
406.444.6269
cdeaustin@mt.gov

4.3 Completed Projects

4.3.1 Seal Coat Asphalt Emulsion (or Fog Seal Coating) Over Chip Seal for Improved Chip Retention Evaluation

Location:	Mineral County, Interstate 90 (C000090)
Project Name:	Taft-West
Project Number:	IM 90-1(215)0
Project Type:	Work Type: 183 – Resurfacing – Seal and Cover
Principal Investigator:	Chad DeAustin, Experimental Project Manager
Construction Year:	2015
Inspection Dates:	Jun. 2016, Apr. 2017, Apr. 2018, Jul. 2019*, Jul. 2020*, and Sep. 2021*
Project End Date:	2021

URL: https://www.mdt.mt.gov/research/projects/seal_coat.shtml

* Informal site inspections. District personnel asked Research to conduct informal site inspections since it is in the vicinity of other experimental projects. The final inspection of the site was in 2021 to close out the project.

Description:

The purpose of this project is to determine the effectiveness and added durability of applying a fog seal (SS1 asphalt emulsion) to a chip seal (CS). The goal is to reduce aggregate loss and maximize surface friction in an environment of extreme fluctuations in temperature and numerous snow removal activities.

The project will compare a conventional chip seal procedure to a fog seal over chip seal (FSCS) application on a section of Interstate 90 beginning at reference point 0.0 (Idaho border) east to approximate reference point 5.7 (Taft Area interchange). The project will use Type 2 cover material (1/2" chip). 2015 traffic data estimated an annual average daily traffic at approximately 7,600 with a 30 percent calculated commercial load and that number decreased to 7,000 as of 2020.

Analysis to Date:

The main measure of effectiveness is the average texture of embedded chip within the residual bitumen binder on each of the test sections as compared to the control in an area which, historically, is difficult to maintain an effective chip seal. The project area will be reviewed semiannually with reporting once per year.

District staff reported a high level of plow passes during the 2015/16 and 2016/17 winter seasons. Even with the additional application of emulsion to the chip seal, aggregate loss was almost identical to the conventional CS sections.

Conversely, there are intact sections of CS and FSCS on the project as well. Most of the distress observed is at the higher elevation portions of the project and where roadway curves are present. With almost 23 lane miles on the project, it is difficult to ascertain the percentage of distress areas of pavement to those still intact.

Overall, the addition of the fog seal appeared to perform comparably to the control. Most of the distress observed was in the travel lane, which indicates traffic factors as an indicator of performance. That effect, combined with the severe environment and substantial snowplow miles this corridor receives, may result in the additional benefit of the FSCS being only marginal.

MDT Project Manager:
Chad DeAustin
406.444.6269
cdeaustin@mt.gov

4.4 Pending Projects

4.4.1 Polymer Overlay on PCCP

Location: Missoula District, Flathead County, US HWY 2
Project Name: SF 139 – Dern/Spring Reconstruct
Project Number: HSIP-NH 1-2(193)118
Experimental Project Number: MT-21-05
Project Type: Polymer Overlay on PCCP
Principal Investigator: Chad DeAustin, Experimental Project Manager
Construction Year: 2021/2022
URL: Pending

Objective:

A polymer overlay is a treatment that uses a combination of polymer and aggregate to coat a concrete surface. This treatment has many benefits including: protecting the concrete surface, improving safety by increasing skid resistance, and extending the life of the concrete by filling cracks. This treatment has been used by MDT on many bridge decks throughout the state for the stated reasons. For this project, MDT is reconstructing a four-way intersection with a Portland cement concrete pavement (PCCP) roundabout. The PCCP will then be sealed with a polymer overlay.

Status:

Construction started in 2021. The polymer overlay will not be placed until 2022.

MDT Project Manager:
Chad DeAustin
406.444.6269
cdeaustin@mt.gov

4.4.2 TENAX LBO 220 Geogrid

Location:	Billings District, Big Horn County, MT HWY 313
Project Name:	Hardin – South
Project Number:	STPS 313-1(17)1
Experimental Project Number:	MT-21-03
Project Type:	Geogrid Fabric for Geotech Stabilization
Principal Investigator:	Chad DeAustin, Experimental Project Manager
Construction Year:	2021/2022
URL:	Pending

Objective:

TENAX LBO 220 is a manufactured biaxial geogrid made with a high-quality polypropylene resin. The geogrid stabilizes and reinforces weak soils or aggregate base surfaces and is applied to prevent lateral shearing. The objective for this project is to use the geogrid as a stabilization technique between the subgrade and the surfacing layers to enhance pavement performance. This project will have the biaxial grid throughout the entirety of the project. The subgrade will be covered by the geogrid which will then be covered by a standard MDT specification calcium aluminum cement (CAC) followed by plant mix surfacing.

Status:

Construction began in 2021 with a small portion of the project receiving the geogrid treatment while the remaining work will be done in 2022.

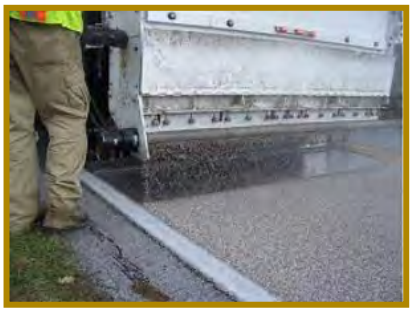
MDT Project Manager:
Chad DeAustin
406.444.6269
cdeaustin@mt.gov

4.5 Proposed Projects

Animal Detection System: Zapcrete System
Cougar Cr., Montana – 7 miles west of West Yellowstone

Diamond Road Smoother

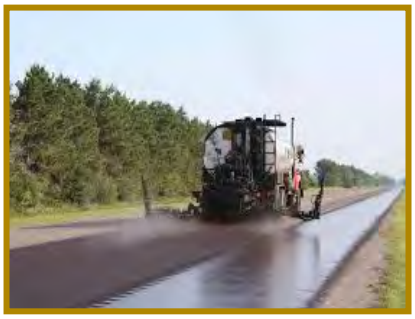
High Friction Surface Treatment
Stephens Orange Safety Improvements



Prefabricated Steel Truss/Bridge Deck System Evaluation
Conly Ave. Bridge-Deer Lodge/STPB 9039(43)

Roundabout Striping Durability Trials Evaluation
Project Review in Billings and Poplar, Montana

Texas Underseal with Added Scrub Seal Evaluation
Lewistown, Montana/UPP 7105(4)
Scobey, Montana – South



Weather-Activated Detection System Evaluation
Granite Powell Safety Improvements
Curve S of Ravalli Safety Improvements

Yellow-Dyed Concrete Curbing to Replace Epoxy-Applied Curbing Evaluation
Project Currently Under Consideration in Billings, Montana

5 PARTNERING PROJECTS AND POOLED FUND STUDIES

MDT contributed funds to the following partnering and pooled fund studies in FFY 2021 (Table 2). Click on the project links to view project information.

Table 2. FFY 2021 Partnering and Pooled Fund Contributions

Number	Name	Funding Level
N/A	AASHTO Equipment Management Technical Services Program (EMTSP)	$5,483
N/A	AASHTO Innovation Initiative (AII) Technical Services Program	$6,580
N/A	AASHTO Load and Resistance Factor Design (LRFD) Bridges and Structures Specification Maintenance (LRFDSM) Technical Services Program	$16,449
N/A	AASHTO National Transportation Product Evaluation Program (NTPEP) Technical Services Program, includes AASHTO Product Evaluation List (APEL)	$21,932
N/A	AASHTO re:source (formerly AASHTO Materials Reference Laboratory (AMRL) Technical Services Program)	$29,395
N/A	AASHTO Technical Service Program to Develop AASHTO Materials Standards (DAMS)	$10,966
N/A	AASHTO Transportation System Preservation Technical Services Program (TSP2)	$21,932
9811-746	AASHTOWare Project Data Analytics	$276,750
TPF-5(349)	Western Alliance for Quality Transportation Construction (WAQTC)	$12,000
TPF-5(353)	Clear Roads Phase II	$25,000
TPF-5(376)	Northwest Passage Phase #4	$25,000
TPF-5(391)	Comprehensive Field Load Test and Geotechnical Investigation Program for Development of LRFD Recommendations of Driven Piles on Intermediate GeoMaterials	$15,000
TPF-5(394)	Western Maintenance Partnership – Phase 3	$5,000
TPF-5(399)	Improve Pavement Surface Distress and Transverse Profile Data Collection and Analysis, Phase II	$15,000
TPF-5(421)	National Cooperative Highway Research Program (NCHRP)	$244,849
TPF-5(437)	Technology Transfer Concrete Consortium (FY20-FY24)	$12,000
TPF-5(447)	Traffic Control Device (TCD) Consortium (3)	$10,000
TPF-5(454)	Updating U.S. Precipitation Frequency Estimates for the Northwest	$133,520

* The AASHTO Technical Services Programs and the AASHTOWare Project Data Analytics projects include MDT's indirect costs at 10.99% for state fiscal year 2021 and 9.66% for state fiscal year 2022.

6 SUMMARY

6.1 GENERAL

MDT's mission is to serve the public by providing a transportation system and services that emphasize quality, safety, cost effectiveness, economic vitality, and sensitivity to the environment. MDT's Research Programs impact each and every part of MDT's mission.

Research projects completed in FFY 2021 yielded results that when fully implemented will improve:

- Efficiency and effectiveness of MDT operations, quality of what we do and how we do it, and technology transfer, including:
  - Improved cost estimating, decreasing overruns and providing for improved construction portfolio of projects
  - Improved construction contracting
  - Improved production rates estimation and construction sequencing
  - Improved bridge, culvert, pavement, and geotechnical design and processes
  - Increased bridge, culvert and roadway design life
  - Improved construction materials and methods
  - Improved construction practices
  - Improved support for cities and counties
  - Improved maintenance
  - Improved equipment management
- Economic vitality
- Sensitivity to the environment, including:
  - Improved environmental processes
  - Decreased vehicle-wildlife collisions
  - Improved habitat connectivity
- Safety, including:
  - Improved bridge, culvert, and pavement design and processes
  - Improved safety on roads and bridges
  - Reduced animal-vehicle collisions
  - Improved safety culture both within MDT and among the travelling public

6.2 FISCAL

Research Programs expenditures occurred through research projects, AASHTO Technical Services Programs (TSP), Local Transportation Assistance Program (LTAP), pooled fund studies, NCHRP and TRB Core Services support, and program administration (Figure 4).

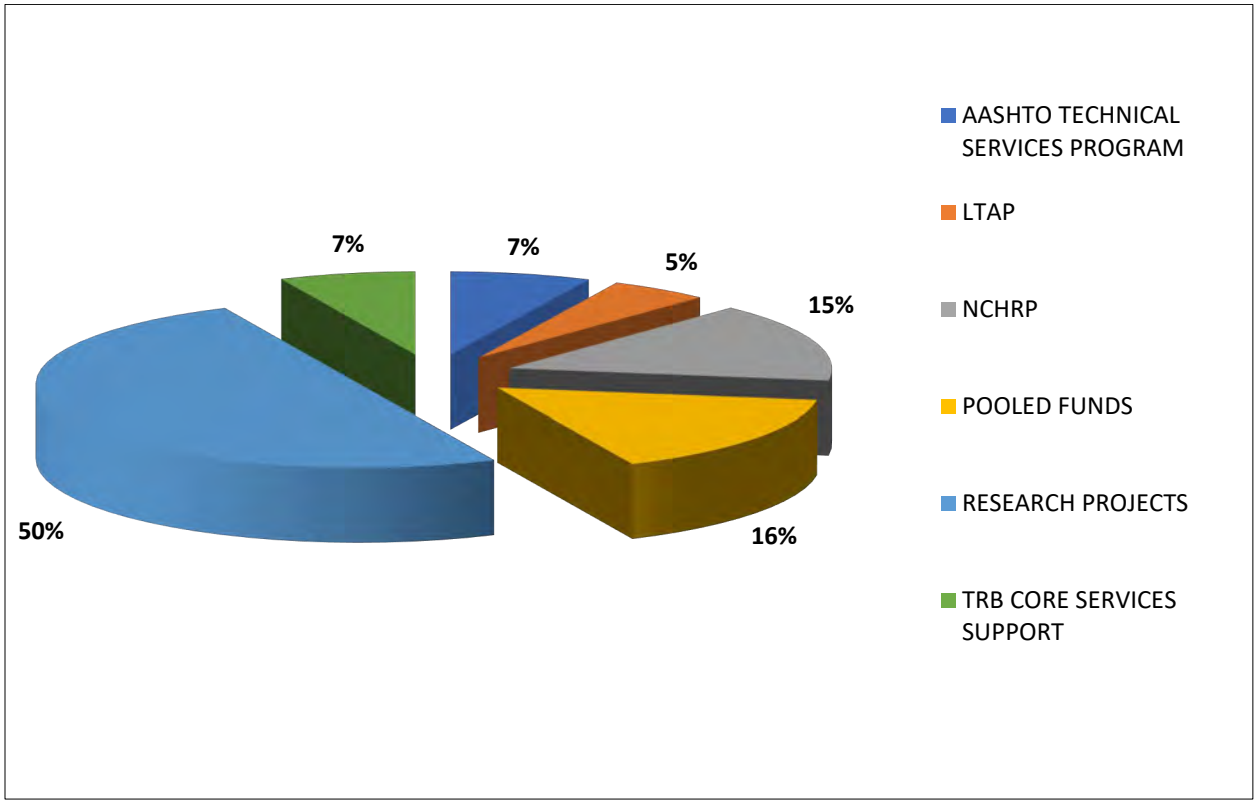


Figure 4. FFY 2021 Percent of Research Programs Expenditures by Project Type

The program administration category not only includes MDT staff support, including travel, but also includes a contract for research project management services. Figures 5 and 6 show these expenditures categorized by subject.

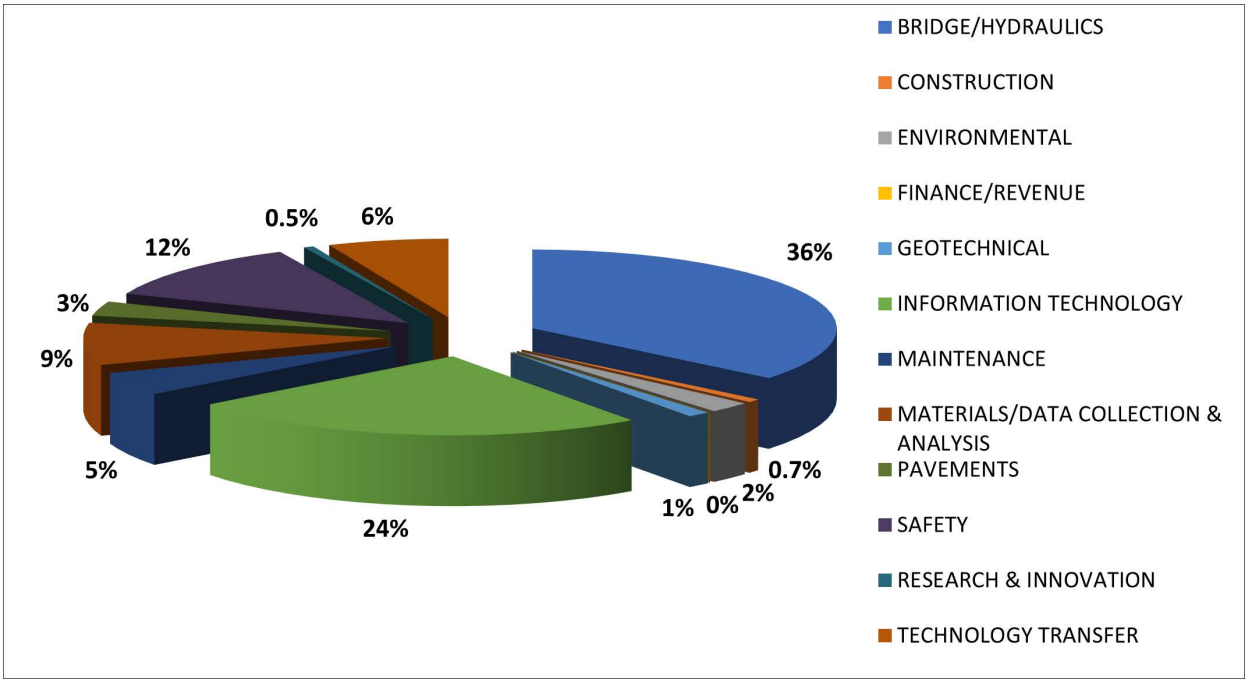


Figure 5. FFY 2021 Percent of Research Project Expenditures by Subject

Note: The data presented in Figure 5 includes pooled fund studies.

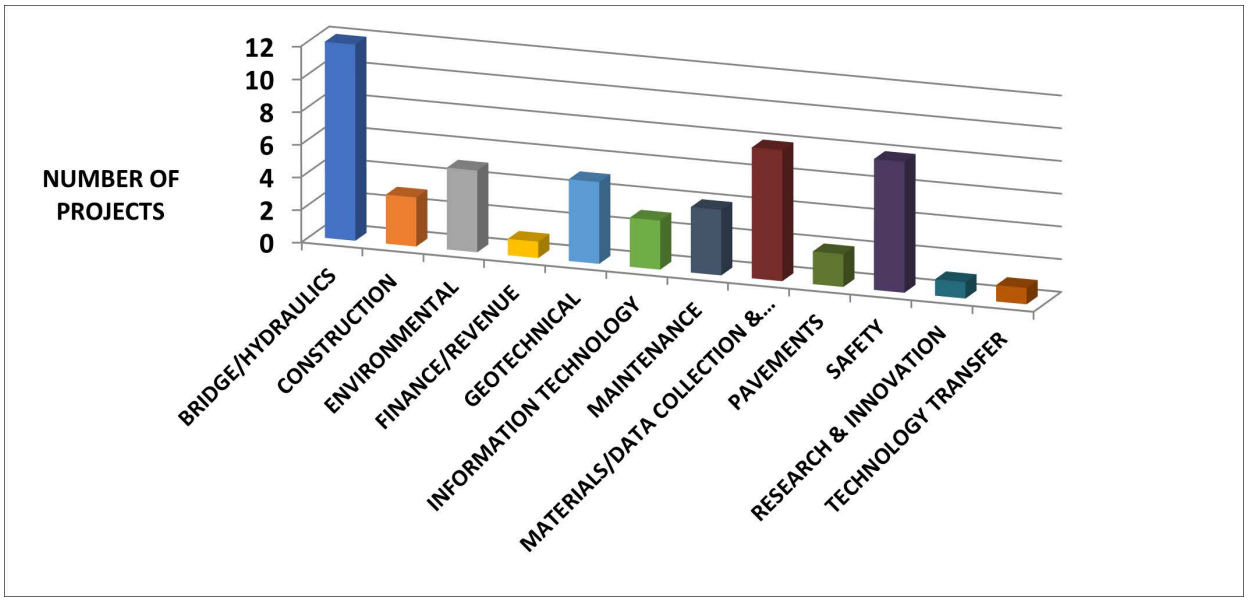


Figure 6. FFY 2021 Number of Research Project Expenditures by Subject

Note: The data presented in Figure 6 includes pooled fund studies.

MDT, as of July 2007, is required to charge indirect costs. The indirect costs rates are revised each state fiscal year (SFY). From July 2020 to June 2021 (SFY 2022), the indirect cost rate charged to each expenditure is 10.99% and from July 2021 through June 2022 (SFY 2022) the indirect cost rate is 9.66%. Figure 7 shows these indirect costs, as well as overhead costs, as compared to total project expenditures, including projects such as pooled fund studies that are not charged indirect costs by MDT.

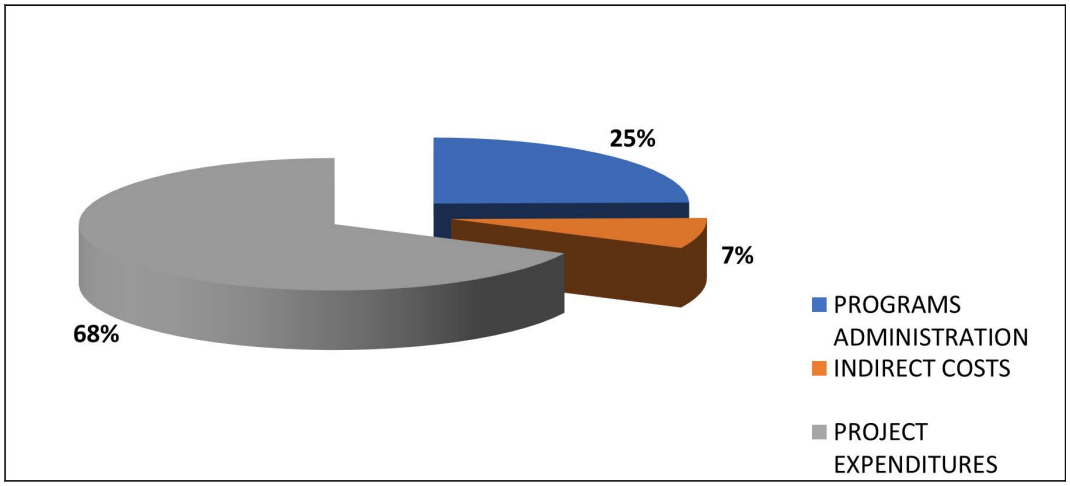


Figure 7. FFY 2021 Research Programs Overhead and Indirect Expenditures as Compared to Project Expenditures

Note: The data presented in Figure 7 includes pooled fund studies.

Figure 8 shows total funding for all active research projects by funding source.

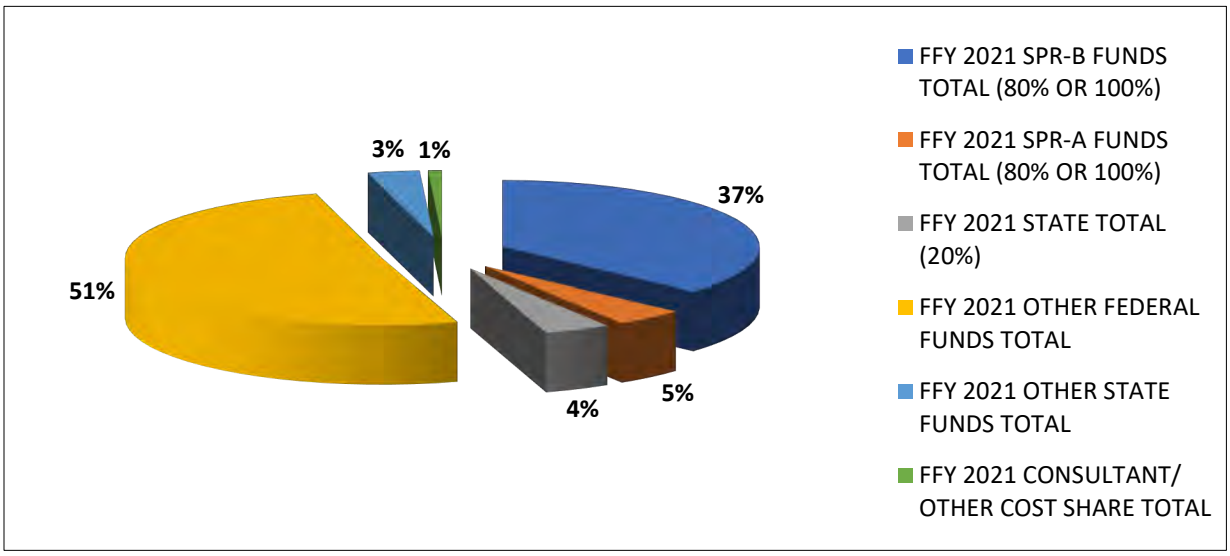


Figure 8. FFY 2021 Research Program Expenditures by Funding Source

Note: SPR-B = Federal Research Funds, SPR-A = Federal Planning Funds, State = Federal Planning and Research Funds Match, Other Federal Funds = Non-MDT Matching Funds, and Other State Funds = Non-MDT Matching Funds. The data presented in Figure 8 includes pooled fund studies.

Figures 9 and 10 show funding for in-state and out-of-state researchers.

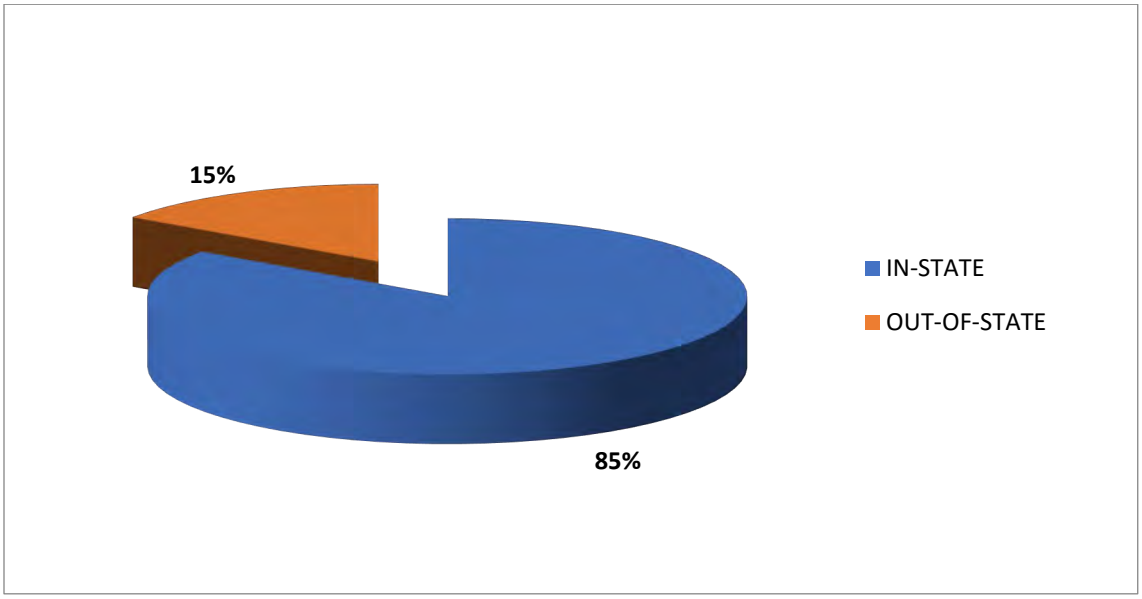


Figure 9. FFY 2021 Research Project Expenditures by Researcher Location

Note: The data presented in Figure 9 does not include non-MDT led pooled fund studies.

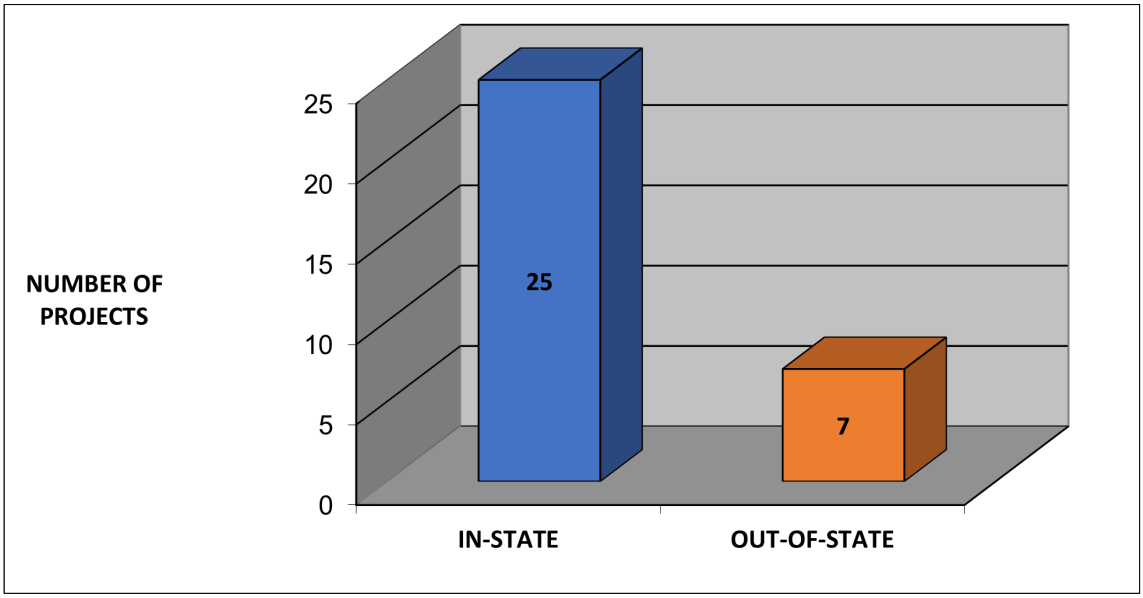


Figure 10. FFY 2021 Number of Research Projects by Researcher Location

Note: The data presented in Figure 10 does not include non-MDT led pooled fund studies.

Figures 11 and 12 show funding by public and private consultants.

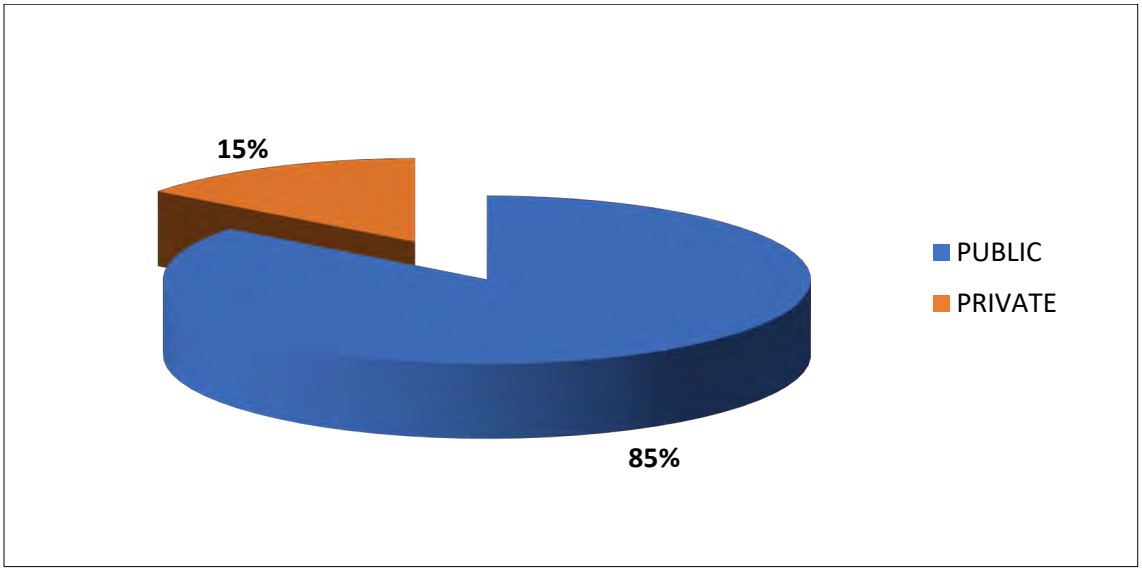


Figure 11. FFY 2021 Research Project Expenditures by Sector

Note: The data presented in Figure 11 does not include non-MDT led pooled fund studies.

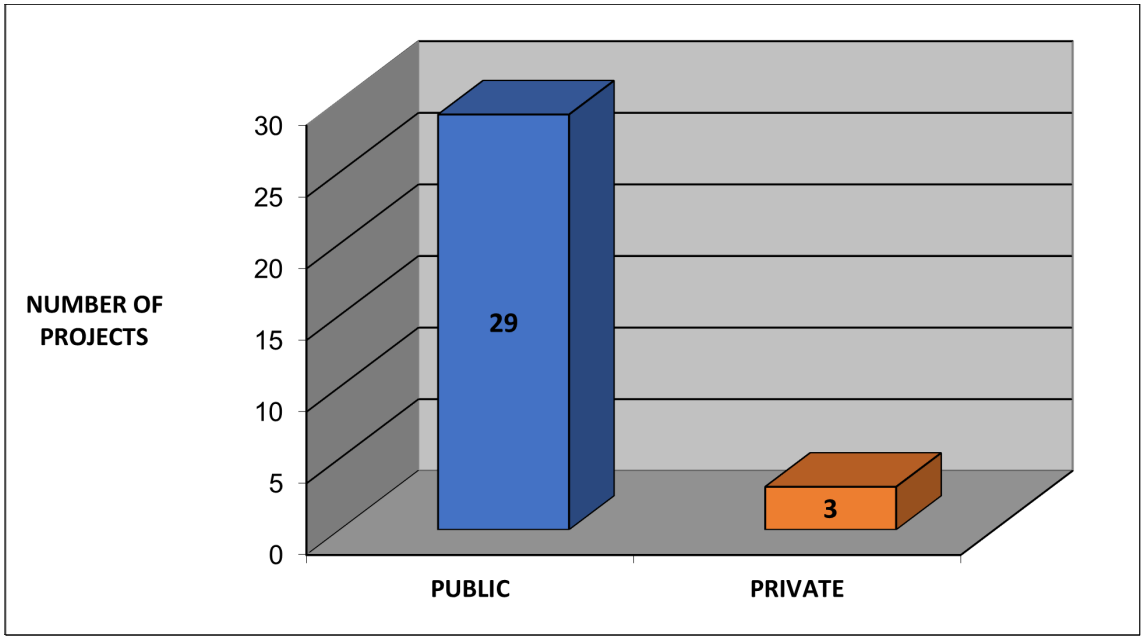


Figure 12. FFY 2021 Number of Research Projects by Sector

Note: The data presented in Figure 12 does not include non-MDT led pooled fund studies.

Figures 13 and 14 show funding by university and non-university researchers.

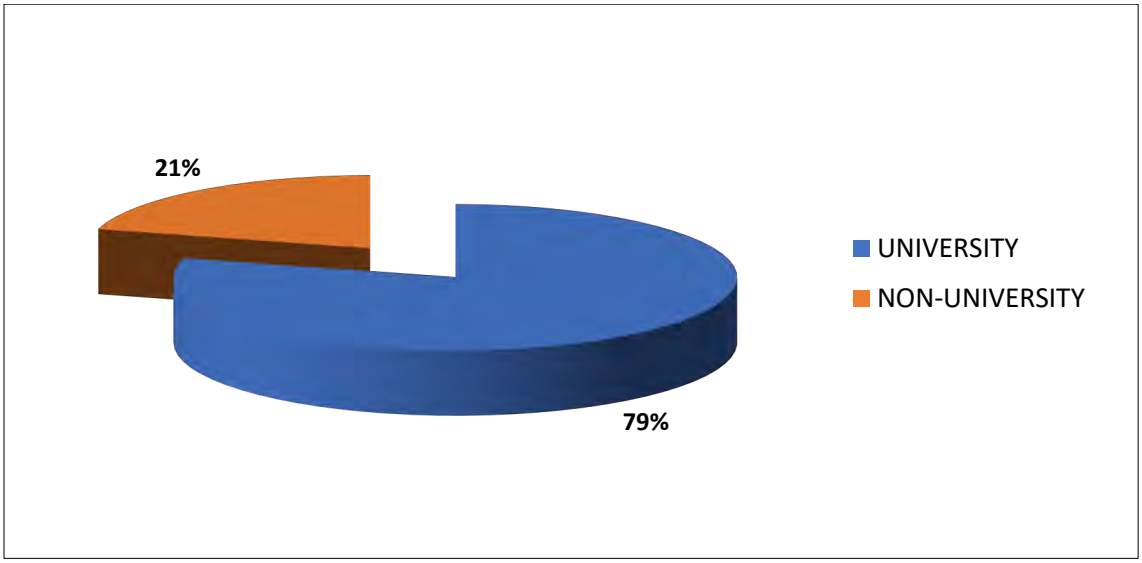


Figure 13. FFY 2021 Research Project Expenditures by Researcher Type

Note: The data presented in Figure 13 does not include non-MDT led pooled fund studies.

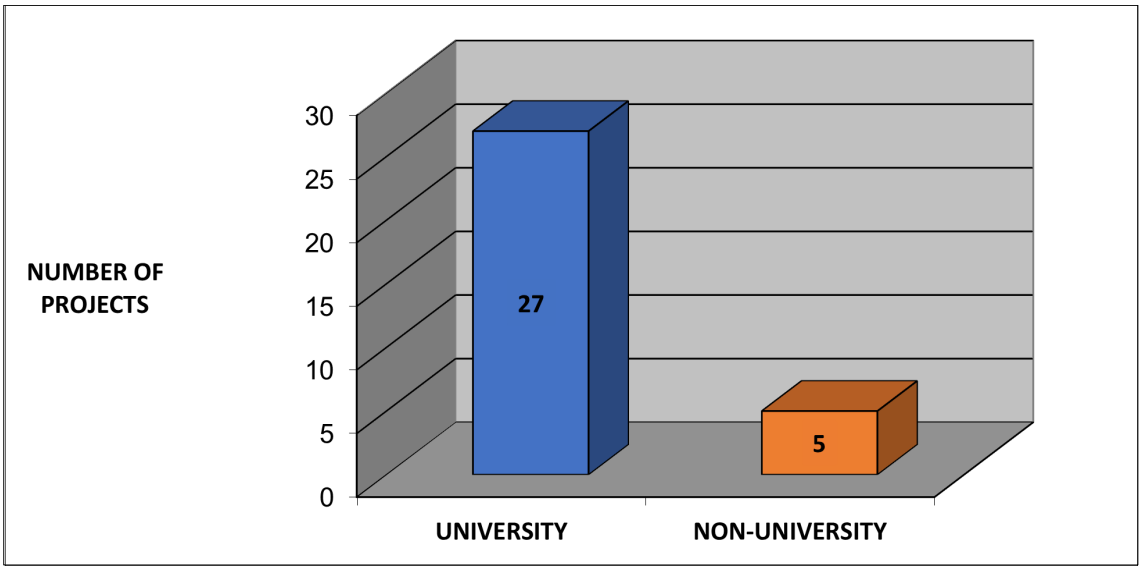


Figure 14. FFY 2021 Number of Research Projects by Researcher Type

Note: The data presented in Figure 14 does not include non-MDT led pooled fund studies.

Finally, for research projects completed in FFY 2021, $37,513 was unexpended.

Appendix A: Research Project Technical Panel Roles and Responsibilities

MONTANA MDT DEPARTMENT OF TRANSPORTATION

RESEARCH PROGRAMS

RESEARCH REVIEW COMMITTEE AND RESEARCH PROJECT TECHNICAL PANEL ROLES AND RESPONSIBILITIES

GENERAL

Research Review Committee

The Research Review Committee (RRC) oversees the Research Projects Program. This committee:

- Along with the District Administrators, determines which research topics submitted during the annual research solicitation move forward to the technical panel stage based on champion presentation, ranking (criteria listed below), and funding availability.
  - Priority research focus areas (e.g., TranPlanMT focus areas that lend themselves to research);
  - Scope, budget, and timeline are appropriate for available resources (limited funds need to be allocated to highest priorities) and timeliness/urgency of topic;
  - Importance (e.g., federal or state initiative or compliance);
  - Benefits and pay-off (including as they relate to MDT's mission and "strategic plan"; e.g., return on investment, cost/lives savings, etc.);
  - Implementability; and
  - Feasibility/probability of success/risk (What is success?)

- Identifies need for and approves administration high priority research topics, partnership projects, and small projects;
- Identifies additional technical panel members;
- Reviews technical panel recommendations (e.g., cancel, fund, implement) for each research project;
- Reviews and approves scopes of work for those research projects where an RFP is to be issued, the cost of the project has increased by the percentage shown in the below table or more, or if there was any contention within the RRC when the project was approved to move forward to the technical panel stage;

Project Cost	Percent Increase in Project Cost
$50,000 or less	N/A
$50,001 to $100,000	30%
$100,001 to $500,000	25%
Greater than $500,000	15%

- Approves funding for all MDT research projects based on the project proposal and technical panel recommendation;
- Approves funding for pooled-fund studies, based on the scope of work and staff recommendation;
- Reviews project progress, as desired; and
- Reviews and makes implementation recommendations.

The RRC consists of a FHWA and WTI representative, and the following MDT positions:

- Director,
- Deputy Director,
- Administrators (except HR), and
- Research Manager.

The RRC meets at most monthly (typically last Wednesday of the month from 9 am to 12 pm). Agenda items must be prepared and final approximately 2 weeks prior to each RRC meeting.

Technical Panels

Technical Panels (TP) oversee all MDT research projects. They are formed at the beginning of each project and members are chosen with careful consideration since the success of a project hinges on the Technical Panel and its oversight. **This is your project, not Research's; the project can only deliver the products the technical panel wants if there is appropriate technical panel oversight.** There is a different technical panel for each project, usually consisting of three to ten individuals from both inside and outside of MDT, with knowledge and a vested interest in the research topic, results, and implementation. FHWA and MDT Research Staff are on all technical panels. Individuals on panels should adequately represent the breadth of the issue at hand and be balanced with respect to viewpoint and representation. Each panel member is chosen to represent the needs of their respective division, department, organization, and/or constituencies.

Benefits

The benefits of serving on a technical panel are many and varied. Some are listed below.

1. Obtain answers to questions and solve problems.
2. Help MDT to meet its mission by improving quality, safety, cost effectiveness, economic vitality, and sensitivity to the environment.
3. Help to guide the future direction of MDT.

4. Help to improve operations within your area.
5. Communicate, coordinate, and collaborate within a team environment.
6. Contribute to your professional development.

Roles

1. Technical Panel Member
2. MDT Research Project Manager
3. Technical Panel Chair

Responsibilities

Note: All tasks must be performed in a timely manner.

1. Technical Panel Members, including Research staff (MDT Research Project Manager) and panel chair, who is usually the project champion
    a. Determine if others need to participate on the technical panel.
    b. Oversee project from inception through implementation. Implementation (i.e., products necessary, identification of barriers, mitigation of barriers) should be considered from the very first panel meeting.
    c. Determine if research need exists by a literature search and completing the research project statement form and, then, the best method to proceed (cancel project; implement available results; or secure funding from local/MDT, regional, or national research programs).
    d. If it is determined a project is necessary and should be funded at the local/MDT level, develop a scope of work (SOW), based on the research project statement. Otherwise, work within the appropriate venue to submit research topic. It is critical that a clear, complete, and concise SOW is developed, as the proposal, which is a part of the project contract, is developed from this SOW.
        i. *Items e. through i. pertain to projects funded at by MDT*.
    e. Determine if RFP should be issued or a governmental agency would be the best entity to conduct research. Review proposal(s) and recommend to the RRC a proposal for funding. Proposals are based on the SOW.
    f. Meet with consultant in project kick-off meeting and other meetings, as determined by the project proposal and/or technical panel.
    g. Carefully review all project products for completeness and accuracy. It is especially critical for technical panel members to review the Task Reports (TR). The TR will provide detailed information on each task, including what was done, how it was done, and the results. The TRs can be combined to form much of the final report.
    h. Ensure the project stays on scope and delivers desired products by reviewing project deliverables (i.e., progress reports, task reports, other interim products, final report and other final products) and communicating issues with contractor through the MDT Research Project Manager. This is critical for project success.
    i. Keep supervisor(s), organizations, and/or constituencies informed of all progress and products of the project.
    j. Make implementation recommendations for MDT.
2. MDT Research Project Manager

a. Identifies technical panel members and forms technical panels.
b. The Research staff on each technical panel serves as the project manager.
c. The project manager is the direct liaison between the technical panel and contractor, communicating panel decisions to the contractor.
d. Serves as a conduit for all information flowing between the technical panel as a whole or individual technical panel members, and the contractor.
e. Ensures project stays within scope and budget, and issues are addressed in a timely fashion.
f. Takes meeting notes prior to contracting and for those meetings not attended by the contractor. Contractor takes meeting notes after contract is in place for those meetings contractor attends.
g. Manages contractual compliance.

3. Technical Panel Chair
    a. Identifies technical panel members and makes sure they have the time and are willing and able to serve on the technical panel.
    b. Presents scope of work and business case information to RRC for approval-in-concept as described in the Research Review Committee Section on page 1.
    c. Presents business case for project and proposal technical panel recommends for funding to RRC for funding approval.
    d. Chairs, schedules, and moderates all technical panel meetings.
    e. Encourages active participation by all panel members.
    f. Helps the panel reach consensus.

Time Commitment

1. Scope and business case development – 2-8 hours.
2. Proposal review – 1-5 days if an RFP is issued; 2-4 hours if not.
3. Meetings and review of progress and interim products. – varies depending on length of project, about 1-2 hours per month.
4. Final Product Review – 1-2 days

Time commitment varies with each project.

Appendix B: On Developing a Research Project Scope of Work

RESEARCH PROGRAMS

On Developing a Research Project Scope of Work

June 2018

Updated: January 2020

Scope of Work Background and Description

MDT's Research Programs are internally driven applied research, development, and technology transfer (RD&T) programs necessary in connection with the planning, design, construction, management, and maintenance of highway, public transportation, and intermodal transportation systems. Funding is limited and to keep research relevant to MDT staff, implementable results are the goal. Implementation of research results also helps MDT in meeting its mission of providing a transportation system and services that emphasize quality, safety, cost effectiveness, economic vitality, and sensitivity to the environment. As defined by MDT, implementation means the widespread use of research results and innovations.

A well-written scope of work (SOW) is critical for the success of a project and successful implementation of research results. Researchers use the scope of work to develop a proposal, which becomes a part of the contract and describes the details of performance, providing the yardstick to which performance is measured. A good SOW is clear, complete, concise, and logical enough to be understood by researchers, technical panels, and research project managers. A SOW describes the work to be performed or the services to be provided; the goal of the research and the application of the results; the benefits and impact, including who may be impacted by the use of research results. However, it does not describe every detail of the work to be conducted, rather it specifies the required elements. This leaves the methods and details of the research approach to the expertise of the researchers and provides a mechanism to select the best research approach.

Scope of Work Content

- **Maximum Project Cost:** This is the cost identified in the Stage 2: Research Topic Statement form. This is just what it is stated to be – the maximum project cost. If a proposal comes in higher than this amount, the project may be delayed until the next year's cycle or cancelled. If a proposal comes in higher than this amount through the RFP process, it will be deemed to not meet the RFP requirements and will not be considered for funding, as meeting or beating this cost in the proposal is a pass/fail condition of the RFP.
- **Title:** The title should briefly and immediately convey to the reader what the proposed study is about. It does not have to capture every element, nuance, and expected task of the research problem. It is like the title of a book—it should attract your attention, quickly convey the subject, draw you in, and make you want to read what's inside. A good title is like a good sound bite—people will remember it.

Hint: Look at every word in your title and ask yourself if it's necessary.

- **Background:** This section sets the stage for the research. It describes the issue and indicates why we care and why we are seeking to fund the research in the first place.

- **Benefits/Business Case/ Impact:** Address urgency, timeliness, and importance of the research. Identify if the research is required for any federal or state initiative or compliance. This section must include a description of how this research will help to meet MDT's mission (i.e., serve the public by providing a transportation system and services that emphasize quality, safety, cost effectiveness, economic vitality and/or sensitivity to the environment). It should also indicate the expected outcomes, such as cost savings, improvements in safety, user benefits, and process improvements.

- **Objectives:** Describe in very brief terms the expected product(s) of the research. The objective should be short, concise, and accurate. Don't put details in the objective related to how the study will be done unless some new or innovative research methodology is the key element of the research. The details will be in the research plan and reflected in the final product. If your objective is "to produce a new fuel-efficient vehicle," say so. Don't say that the objective is "to produce a new fuel-efficient vehicle, including the design, construction, testing, and installation of all necessary components including body, frame, power train, tires, wheels, seats, mirrors, and other appurtenances to be determined through a survey of user needs, performance measures, and financial constraints." If those things need to be done to accomplish the objective, put them in task statements.

  Hint: Go back and read the advice above on titling your research statement. A very reasonable objective statement is "…to develop (insert your title).

- **Tasks:** If you have identified specific tasks that absolutely have to be part of the project work plan, include them in the SOW. However, don't let your own biases determine the research plan. Focus your attention on providing a full and accurate description of the final product(s). To the extent possible, give the proposing research team the flexibility to describe a research plan that they feel will accomplish the project objectives.

  Hint: The more detail you include in the task statements, the less opportunity a researcher has to show initiative and innovation, and the more every proposal will come in looking the same. Don't be prescriptive.

- **Acceptance:** As appropriate and only as required, establish milestones or management control points in the sequence of events where actions for review, approval, acceptance, or rejection are required.

- **Collaborators, Partners, and Stakeholders:** Identify individuals and/or organizations that need to be brought into the fold to create buy-in and acceptance of the results; review results; and/or participate in communications, decisions, and/or deployment. Specify the relationship and roles.

- **Communications:** Identify any communication needs, including technology/knowledge transfer, marketing, and training. Consider such factors as the target audience, end users, communication methods, events, responsible person/area, required approvals, and efforts needed for full implementation. Timing for communications should also be considered.

- **Data Requirements:** Identify available data that may be helpful in conducting the research. Include the limits of the data, such as fields and date ranges. Identify the format, such as Excel spreadsheet or hardcopy documents. Indicate what MDT can provide to the consultant and how.

- **IT:** Identify if the project involves software, hardware, data management, or technology devices, including maintenance, that may require coordination with ISD and/or SITSD.

- **Intellectual Property:** Describe any potential intellectual property issues.

- **MDT and Technical Panel Involvement:** As much as is known at this point, identify all MDT and consultant participation needed for the project, as well as the nature and extent of this participation. For example, MDT will provide gravel samples, traffic control, core samples to the consultant. The consultant may need to provide the time frame and required quantities. Another example may be that the consultant is required to visit MDT to review project hardcopy files or the consultant is required to provide specific equipment for use during the project.

- **Deliverables:** It is critical to identify deliverables needed to implement the results of the research. Final reports, while required, cannot typically be implemented. Determine the products that will facilitate implementation. To achieve a significant impact, products must be well specified, well matched to the needs of the users, implemented in a deliberate and adaptive manner, and supported by a hospitable environment and learning processes.

- **Risks:** Identify risks to budget, resources, schedule, and scope. Identify potential mitigation measures, forewarning indicators, and contingencies. Determine impact and probability. Rate risks as high, medium, and low. Develop a plan to mitigate risks.

- **Implementation:** As much as is possible at this point, describe how the results will be implemented, who will implement the results, and any barriers to implementation and how these barriers might be reduce or eliminated. Define/describe successful implementation and activities necessary for successful implementation. Describe the criteria for judging the progress and consequences of implementation.

- **Performance Measures:** The research to be conducted should include both qualitative and quantitative performance measures if at all possible. Performance measures include such improvements as cost and time savings; improved process, safety, environmental considerations, efficiency, quality, and service; and user benefits. As much as possible, these benefits need to be quantified. This is an indication of the value of the research. Consideration needs to be given to the data that will need to be collected to report performance measures. The proposal must describe how performance measures will be quantified.

- **Timeliness:** Add a timeliness statement to all SOWs, “Time is of the essence. The proposal must be submitted (original and revised), research conducted, and deliverables submitted as detailed in the proposal and the resulting contract.”

MONTANA MDT DEPARTMENT OF TRANSPORTATION

RESEARCH PROGRAMS

Scope of Work

Date: Click to enter a date.	**Champion:** Click to enter name.	**Technical Panel Members:** Click to enter names & areas.
Solicitation Number: Click to enter # (e.g., 19-020)	**Sponsor:** Click to enter name.	
Project Number: Click to enter #.	**Research Project Manager:** Click to enter name.	
Maximum Project Cost: Click to enter $.		
Project Title: Click to enter project title.		
Project URL: Click to enter project URL.		
Project Background: Click to enter text.		
Benefits/Business Case/Impact: Click to enter text.		
Objectives: Click to enter text.		
Tasks: Click to enter text.		
Acceptance: Click to enter text.		
Cooperators, Stakeholders, Partners: Click to enter name, org and role.		
Communications: Click to enter text.		
Data Requirements: Click to enter text.		
IT: Click to enter text.		
Intellectual Property: Click to enter text.		
MDT and /technical Panel Involvement: Click to enter text.		
Deliverables: Click to enter text.		
Risks: Click to enter text.		
Implementation: Click to enter text.		
Performance Measures: Click to enter text.		

Appendix C: Research Partnering Project Funding Request

Montana Department of Transportation
Research Partnering Project Funding Request

2701 Prospect Avenue
PO Box 201001
Helena, MT 59620-1001
www.mdt.mt.gov

Print Form

RESEARCH PROGRAMS

INSTRUCTIONS:

Complete this form to request funding for research projects and programs where MDT will not be the lead and will not contribute all funds for the project/program, such as AASHTO pooled fund programs/projects (TPF) and Technical Service Programs (TSP). Send completed form to the Research Programs Manager.

Part A: General Project/Program Information			
Date:	**Solicitation or Project Number:**		**Lead Entity:**
Title:			
Project/Program URL:			
Project/Program Duration:	**years**	**months**	**Project/Program Begin Date:**
Total Cost:	**Total Cost to MDT:**		**Annual Cost to MDT:**

Part B: For Bureau Chief	
	will be the Technical Representative for this project/program.
☐ **Yes** ☐ **No**	**This employee will be encouraged to request travel approval to attend panel meetings in-person, as funded by the project/program.**
☐ **Yes** ☐ **No**	**If the employee is not granted travel approval, employee will be allowed to attend via conference call or web meeting, as provided through the project/program.**
☐ **Yes** ☐ **No**	**I will annually review MDT's participation in this project/program to determine value to MDT.**
☐ **Yes** ☐ **No**	**If this project/program is funded, but becomes no longer of significant value to MDT, I will alert the Research Programs Manager.**

Part C: For Technical Representative	
☐ **Yes** ☐ **No**	**I will attend project/program meetings, as funded by the project/program.**
☐ **Yes** ☐ **No**	**If I cannot attend in-person, I will attend via conference call or web meeting, as provided**
☐ **Yes** ☐ **No**	**I will review documents and deliverables, determining their value to MDT.**
☐ **Yes** ☐ **No**	**I will complete an annual evaluation form, for this project/program, and provide comprehensive feedback on its value to MDT.**
☐ **Yes** ☐ **No**	**If this project/program is no longer of value to MDT, I will alert my Bureau Chief and the Research Programs Manager.**

Montana Department of Transportation
Research Partnering Project Funding Request

2701 Prospect Avenue
PO Box 201001
Helena, MT 59620-1001
www.mdt.mt.gov

Print Form

Part D: MDT Benefits

Please explain the benefits MDT is expected to achieve through participation in this project/program.

Part E: Approval (Technical Representative and Bureau Chief Sections are to be completed prior to submitting form)

	☐ Yes ☐ No	
Technical Representative Name	**Technical Representative Approval**	**Date**
	☐ Yes ☐ No	
Bureau Chief Name	**Bureau Chief Approval**	**Date**
RRC Approval	☐ Yes ☐ No	**Date**

Appendix D: Research Partnering Project Annual Evaluation

Montana Department of Transportation
Research Partnering Project Annual Evaluation

2701 Prospect Avenue
PO Box 201001
Helena, MT 59620-1001
www.mdt.mt.gov

Print Form

RESEARCH PROGRAMS

INSTRUCTIONS:

Complete this form by April 30th of each year to provide an annual evaluation of your partnering project. Send completed form to the Research Programs Manager.

Part A: General Project/Program Information			
Date:	**Solicitation or Project Number:**	**Lead Entity:**	
Technical Representative:			
Title:			
Project/Program URL:			
Project/Program Begin Date:		**Project/Program End Date:**	
Annual MDT Contribution:	**Number of Years for Annual Contribution:**	**Total Contributed:**	**Total Yet to Contribute:**

Part B: Evaluation–Technical Representative		
Evaluation		
Is this project/program making progress toward stated goals?	☐ **Yes**	☐ **No**
If yes, please describe.		
If no, please explain why.		
What knowledge and/or deliverables has MDT received to date from participation in this project/program?		
Do you anticipate that any results of this project/program will be implemented/used at MDT?	☐ **Yes**	☐ **No**
If yes, please describe.		
If no, please explain why.		
Communications		
How often are meetings held?		
Are you able to attend?	☐ **Yes**	☐ **No**
Do you at least receive quarterly progress reports?	☐ **Yes**	☐ **No**
If no, please explain.		
Should MDT continue to contribute?	☐ **Yes**	☐ **No**
If yes, please explain.		
If no, please explain why.		

Montana Department of Transportation
Research Partnering Project Annual Evaluation

2701 Prospect Avenue
PO Box 201001
Helena, MT 59620-1001
www.mdt.mt.gov

Print Form

Part C: Evaluation –Bureau Chief

What benefits has participation had on your bureau, staff, and/or on MDT?		
Should MDT continue to contribute?	☐ **Yes**	☐ **No**
If yes, please explain.		
If no, please explain why.		

Part D: Approval

	☐ **Yes** ☐ **No**	
Technical Representative Name	**Technical Representative Approval**	**Date**
	☐ **Yes** ☐ **No**	
Bureau Chief Name	**Bureau Chief Approval**	**Date**

Appendix E: Research Partnering Project Close-Out Evaluation

Montana Department of Transportation
Research Partnering Project Close-Out Evaluation

2701 Prospect Avenue
PO Box 201001
Helena, MT 59620-1001
www.mdt.mt.gov

Print Form

RESEARCH PROGRAMS

INSTRUCTIONS:

Complete this form when your partnering project is complete. Send completed form to Research Programs Manager.

Part A: General Project/Program Information		
Date:	**Solicitation or Project Number:**	**Lead Entity:**
Technical Representative:		
Title:		
Project/Program Begin Date:	**Project/Program End Date:**	**Total Cost to MDT:**

Part B: Close-Out Evaluation–Technical Representative		
What Knowledge and/or deliverables did MDT receive from this project/program?		
Do you anticipate that any results of this study will be implemented at MDT?	☐ **Yes**	☐ **No**
If yes, please describe implementation activities..		
If no, please explain why.		
What value did MDT receive from participation in this project/program?		
What value did you receive from participating in this project//program?		

What benefits did participation have on your Bureau and/or MDT?

	☐ **Yes** ☐ **No**	
Technical Representative Name	**Technical Representative Approval**	**Date**
	☐ **Yes** ☐ **No**	
Bureau Chief Name	**Bureau Chief Approval**	**Date**

Appendix F: Research Project Identification, Prioritization, and Selection

MONTANA MDT DEPARTMENT OF TRANSPORTATION

RESEARCH PROGRAMS

Research Project Identification, Prioritization, & Selection

July 2019

The Research Review Committee (RRC) is the governing committee for all research conducted for MDT, regardless of funding source.

MDT's Research Programs are internally-driven applied research, development, and technology transfer (RD&T) programs necessary in connection with the planning, design, construction, management, and maintenance of highway, public transportation, and intermodal transportation systems. Funding is limited and to keep research relevant to MDT staff, implementable results are required.

Definitions of Research

- **Research** means a systematic study directed toward fuller scientific knowledge or understanding of the subject studied. It can be formally defined as a systematic controlled inquiry involving analytical and experimental activities that primarily seek to increase the understanding of underlying phenomena. Research can be basic or applied.
- **Applied Research** means the study of phenomena to gain knowledge or understanding necessary for determining the means by which a recognized need may be met. Applied research serves to answer questions or solve problems. This research tends to respond to specific problems, providing realistic solutions, with lower risk and a short-term focus. **Applied Research is a focus of MDT's Research Programs.**
- **Basic Research** means the study of phenomena, and of observable facts, without specific applications towards processes or products in mind. Basic research serves to increase knowledge and lays the foundation for advancements in knowledge that may lead to applied gains in the future. This research seeks comprehensive understanding and tends to be higher risk, with a long-term focus. In the transportation field, for the most part, basic research is conducted by the federal government, universities, and the private sector. **MDT does not conduct basic research; however, basic research can be a component of a research project if there are matching funds to conduct this research.**
- **Experimental Feature** is any material, method, and/or process that is deployed in the field through an MDT project (e.g., construction, maintenance, or safety) for the purpose of evaluating the material, method, and/or process. **Experimental Feature deployment is a focus of MDT's Research Programs.**
- **Development** means the systematic use of the knowledge or understanding gained from research and innovations, directed toward the production of useful materials, devices, systems or methods, including design and development of prototypes and processes. It includes the delivery, application,

demonstration, or assessment of products, such as through the Experimental Features Program, that have the potential to be implemented by research customers. Development tends to turn research results and innovations into useable materials, devices, systems, and methods. **Development is a focus of MDT's Research Programs.**

- **Technology or Knowledge Transfer** means the communication of knowledge with users and involves the dissemination, demonstration, training, and other activities that can lead to the adoption of a new technique or product by users and eventual implementation and innovation. It can occur at any time in the research cycle. **Technology Transfer is a focus of MDT's Research Programs.**
- **Implementation** means the widespread use of research results and innovations. Implementation activities can occur throughout the research process. While implementation itself is not an SPR-eligible activity, efforts to facilitate implementation are for the most part SPR-eligible. **Facilitating the implementation of research results and innovations is a focus on MDT's Research Programs, translating research results and innovations into practice and making MDT Research relevant to MDT staff.**

What Research is not: While research may involve some of the below activities, they are not the main component of research.

- Data collection
- Implementation of operational changes (e.g. computerizing existing processes)
- Routine testing
- Training
- IT development
- Routine and/or periodic updates of plans, data, surveys, etc.

Applicable federal regulation & law, and other resources:

- 23 CFR 420.203
- 23 USC 505
- NCHRP Synthesis Report 355: Transportation Technology Transfer: Successes, Challenges, and Needs (pages 7-8)
- NCHRP Synthesis Report 461: Accelerating Implementation of Transportation Research Results (pages 6-7)
- NCHRP Synthesis Report 768: Guide to Accelerating New Technology Adoption through Directed Technology Transfer (page 6)

Project Types

All projects, regardless of type, require a champion and sponsor; these roles may be filled by the same person if that person meets requirements for a sponsor as defined in the following text. The champion must be an MDT employee with a vested interest in the results and implementation of those results. This person typically chairs the project technical panel (TP), if one is formed (Note: Not all partnering projects will have a technical panel overseeing each project), and makes requests of and presentations

to the MDT Research Review Committee (RRC). See MDT's Research Project Technical Panel Roles and Responsibilities document in Appendix A. The sponsor is a high-level MDT manager, division or district administrator, or higher. This person agrees the topic is consistent with Department needs and goals, should be considered by a technical panel, if one is formed, and commits to ensuring implementation occurs, as appropriate. The project types are described below.

- **Administration High Priority:** Any project which the Administrative Staff deems necessary and funding is needed prior to the next annual research project funding cycle.
- **Partnering Projects/Pooled Fund Projects:** Any project where MDT will not be the sole contributor of funds, is not the lead for the project, and, funding is needed prior to the next annual research project funding cycle. Pooled fund projects (TPF) and AASHTO Technical Services Programs (TSP) are examples of partnering projects.
- **Quick Response/Small Projects:** Any project low in cost and short in duration, as defined by the latest Montana Partnership for the Advancement of Research in Transportation (MPART) agreement, and funding is needed prior to the next annual research project funding cycle. Contracts with MSU-Bozeman, Montana Tech, and UM-Missoula are executed every seven years to facilitate rapid initiation of these projects. In addition to these contracted small projects, research staff conducts quick response activities, such as literature searches and surveys of other entities.
- **Standard Research Projects:** Any project that does not qualify as any of the above.

Research Topic Solicitation

Research ideas can be submitted by anyone at any time on any research topic, as defined above; however, they may only be considered annually, unless they fall outside of the standard research project as described in the previous section. Also, as previously mentioned, all research topics require an internal champion and sponsor.

The RRC may want to identify priority research focus areas annually or on some other basis. If so, these areas are advertised when research ideas are requested. Research ideas will still be accepted on any topic; however, those addressing a priority research focus area may be ranked higher.

Submittal of research ideas and topic statements is a two-stage process. Stage 1: Anyone submits a Research Idea form (http://www.mdt.mt.gov/research/unique/solicit.shtml) by March 31st of each year. A Champion is identified in the Research Idea Form or Research staff attempt to secure a Champion for the idea. If a Champion is not identified, the idea does not move forward. If a Champion is identified, the Champion works with the MDT librarian to conduct a literature search on the topic to identify related ongoing and completed research. If research is ongoing on the topic, the Champion may wish to wait until the research is complete to identify any additional related research topics or to initiate an implementation process and/or project (Stage 2). If research on the topic is complete, the Champion will evaluate the research to determine if it meets the specific need. If so, the Champion may want to initiate an implementation process and/or project (Stage 2). If completed research does not meet the specific need, the Champion can initiate Stage 2. Implementation of research results can be a research project in and of itself; in this case, the implementation project will move forward to Stage 2. Stage 2: A Research Topic Statement form (http://www.mdt.mt.gov/research/unique/solicit.shtml) will be submitted by April 30th of each year to be considered in May to August of that same year for funding in the next federal fiscal year. Champions present their research topics to the RRC in May of each year.

It must be realized that the cost and research period estimates are only that, as the final cost and research period will be based on the chosen research methods as described in the final proposal and approved by the RRC. However, if the cost is higher than originally estimated, the project may be delayed.

MDT staff is encouraged to reach out to research staff, university staff, and others to discuss problems, rather than research needs. Once these problems are identified, potential for research solution(s) can be identified. Likewise, individuals interested in conducting research for MDT should make connections with MDT staff in their area of expertise to discuss MDT issues and the potential for research solution(s), matching researcher areas of expertise to MDT research needs. However, Research Topic Statements become the property of MDT and no entity is guaranteed to receive research contracts for their topic statements. Technical panels choose to contract directly with a public entity, issue an RFP, or to submit to another research program, such as the National Cooperative Highway Research Program (NCHRP). If a topic statement is submitted by a public entity, the panel will consider recommending the funding for the public entity first.

Topic statement champions will present their topic to the RRC and District Administrators annually at the May RRC meeting.

Research Topic Prioritization and Selection for Standard Research Projects

Who: RRC and District Administrators

When: Annually in June, July, or August, after champions present at the May RRC meeting

How: The process is described below.

The RRC and District Administrators will rank the topic statements after the champion presentations in May, but by the deadline set for receipt of June, July, or August RRC meeting agenda items. Items to be considered in the ranking include:

- Priority research focus areas (e.g., TranPlanMT focus areas that lend themselves to research);
- Scope, budget, and timeline are appropriate for available resources (limited funds need to be allocated to highest priorities) and timeliness/urgency of topic;
- Importance (e.g., federal or state initiative or compliance);
- Benefits and pay-off (including as they relate to MDT's mission and "strategic plan"; e.g., return on investment, cost/lives savings, etc.);
- Implementability; and
- Feasibility/probability of success/risk (What is success?)

Also, the RRC and District Administrators should identify additional technical panel members by naming individuals and/or stakeholder groups/entities. In addition, they should identify topic statements where they feel the requested funding is insufficient and identify an amount they feel is sufficient. Finally, rankers should identify any topic statements which they feel should not move forward.

Research staff will compile the rankings, projects identified for potentially not moving forward, proposed technical panel members, and funding level changes, along with changes to estimated ICAP. This information will be discussed at the June, July, or August RRC meeting. The results of which will be a

final ranking, identification of panel members, funding level, and identification of topic statements that will not be moved forward.

At the June, July, or August RRC meeting, funding will be assigned to research topics based on their ranking, final estimated cost, and funding source(s), until all estimated available funds for research projects have been committed. Partial funding for projects will not be considered, unless, it makes sense to phase the project or it is a partnering project and the project is entirely funding by all of the partners. While funding is allocated to projects at this point, funding is not approved. Final funding approval occurs when each project proposal is presented to the RRC.

A 15%, of total available funds, contingency should be held back to cover potential project costs higher than the original estimate and other needs that arise, such as Administration High Priority Projects, as described below.

Research Topic Development and Proposal Solicitation for Standard Research Projects

Technical panels will be formed for the projects approved in June, July, or August.

Technical panels will continue to fulfill their role, as identified in Appendix A, and as amended. Champions will review ongoing and completed research identified in Stage 1 with panel members. Technical panels will determine the specific research need (i.e., fine-tuning the Stage 2 Research Topic Statement into a scope of work (SOW); see Appendix B). Panels will determine the most appropriate venue for research (e.g., MDT funded research, pooled fund study, or NCHRP project). Panels may determine the need for research does not exist or the research should be submitted to another research program, in these cases, the panel will recommend the RRC cancel the project. If the technical panel recommends a project be cancelled and the RRC approves cancellation, the estimated cost is returned as available funds.

This will all be documented in the Research Project Scope of Work form (Appendix B).

Sometimes, after discussion amongst technical panel members, the scope of the project changes from the original research topic statement. When the scope changes substantially (i.e., the SOW changes from the original intent; e.g., a different champion is required), the SOW will be presented to the RRC prior to requesting proposals. Also, if the estimated cost increases by the percentage shown in the below table or more (projects estimated to cost $50,000 or less do not need additional approval), or there was any contention when the research topic statement was moved forward to a technical panel, the SOW will be presented to the RRC. Finally, the SOW for which an RFP will be issued will be presented to the RRC. Technical panels have the authority to fine-tune the SOW without RRC approval if the original intent does not substantially change, the estimated cost does not increase by the percentage shown in the below table or more, and if an RFP will not be issued.

Project Cost	Percent Increase in Project Cost
$50,000 or less	N/A
$50,001 to $100,000	30%
$100,001 to $500,000	25%
Greater than $500,000	15%

The SOW will be used to solicit a proposal(s) in one of two ways: one or more public entities may be asked to submit a proposal, or an RFP will be issued. The time for proposal development can be quite varied depending on the topic, the method for obtaining each proposal, panel availability, and other factors.

Research Project Funding

Unless stated otherwise, funding is from federal appropriations or other sources and does not refer to state budget authority. State Planning and Research (SPR) funds are legislated as a 2% set aside of the apportionments MDT receives from the Interstate Maintenance, National Highway System, Surface Transportation, Highway Bridge, Congestion Mitigation and air Quality Improvement, and Equity Bonus programs. Legislation also mandates a minimum 25% of SPR funds be allocated to RD&T activities.

The champion will present the proposal selected by the technical panel to the RRC for funding approval. The RRC may approve or reject the proposal, request clarification, or cancel the project.

If the proposed funding for a project is not more than the percentage shown in the below table greater than identified in the Stage 2: Research Topic Statement (excluding ICAP) and the proposal is approved by the RRC, the project will be contracted.

Amount of Final Proposal	Percent Over Estimate
$50,000 or less	N/A
$50,001 to $100,000	30%
$100,001 to $500,000	25%
Greater than $500,000	15%

If the proposed funding for a project is more than that identified in the above table greater than identified in the Stage 2: Research Topic Statement (excluding ICAP) and the proposal is approved by the RRC, the RRC will evaluate the availability of funds and determine if the project can be contracted at the current time. Note: Contracting for projects resulting through an RFP must occur within a specified timeframe (currently, within 6 months of the original RFP posting date), or the RFP needs to be readvertised.

Projects that don't rank high enough to receive funding in the initial cut can be disposed of in a couple of ways, as determined by the RRC: 1) Any funding assigned to projects that are later cancelled can be reassigned to the next highest ranked project(s) and technical panels can be formed for these projects or 2) Champions can resubmit these Research Topic Statements to request funding in a future federal fiscal year.

The estimated ICAP will be updated as soon as the ICAP rate is known for each successive state fiscal year (SFY), during which each project is active. If the ICAP rate increases, it will result in less funds available for non-standard research projects and/or funds available for the next cycle.

Funds will be set aside for the following projects:

- Administration of research activities by Research staff (8010 and 8020);
- MDT staff participation in research activities (8021);
- LTAP SPR (2443) (Note: LTAP is exempt from ICAP);
- NCHRP (Note: This expense is treated as a pooled fund and is exempt from ICAP);
- TRB Core Services Support (Note: This expense is treated as a pooled fund and is exempt from ICAP);
- AASHTO Technical Services Programs (TSP);
- Activities mandated ad/or to support Research, such as peer exchanges.
- WAQTC Pooled Fund (Note: This expense is exempt from ICAP)

Non-Standard Research Projects

Administration High Priority Projects

These projects are deemed high priority by Administrative Staff and funding is needed prior to the next annual solicitation for research topics. These projects are assigned technical panel oversight. As soon as projects are identified, funds are diverted to these projects.

Partnering Projects/Pooled Fund Projects

These projects are any project where MDT will not be the sole contributor of funds, MDT is not the lead, and funding is needed prior to the next annual research project funding cycle. Pooled fund projects (TPF) and AASHTO Technical Services Programs (TSP) are examples of partnering projects. Most partnering projects are assigned only a champion, as opposed to a full technical panel. TPFs are typically approved by FHWA for use of 100% SPR funds and they are not charged ICAP. However, some pooled funds are more planning in nature and do not fit the definition of research as documented above. The RRC will discuss funding these as the situations arise. Many AASHTO TSPs are approved by FHWA for use of 100% SPR funds; however, they are charged ICAP.

Funding request, annual evaluation, and close-out forms for these projects are found in Appendices C, D and E, respectively.

For multi-year partnering projects, funding may be approved for a maximum of three years and funding commitments will be made. However, it will be noted, participation in future years for which commitments have been made is dependent on the results of the annual evaluation and presentation as described above. Champions will be required to present annual progress to confirm the next year's commitment, if applicable, at the May RRC meeting. Funding decisions will be made at the June, July, or August RRC meeting.

Annual limits should be developed by the June, July, or August RRC meeting to allow contribution for current commitments and to additional partnering projects as they arise. Funding for partnering projects, will be approved on a first come, first serve basis, until the funding set aside is exhausted.

Quick Response/Small Projects

Quick Response/Small projects are any project low in cost and short in duration, as defined by the latest Montana Partnership for the Advancement of Research in Transportation (MPART) agreement, and funding is needed prior to the next annual research project funding cycle. Contracts with MSU-Bozeman, Montana Tech, and UM-Missoula are executed every seven years to facilitate rapid initiation of these projects. In addition to these contracted small projects, research staff conducts quick response activities, such as literature searches and surveys of other entities.

Annual limits should be developed by the June, July, or August RRC meeting to allow contribution for current commitments and to additional quick response/small projects as they arise. Funding for quick response/small projects, will be approved on a first come, first serve basis, until the funding set aside is exhausted.

Work Plan Development

The Research portion of the SPR work plan will be developed and approved by FHWA annually in August and September for the FFY that begins in October. All RD&T activities planned for a particular year will be included in that annual work plan. If actual costs are unknown, estimates will be included.

Appendix G: Implementation of Research Results

RESEARCH PROGRAMS

Implementation of Research Results and Innovations – Begin with the End in Mind

July 2019

Introduction

MDT's Research Programs are internally-driven applied research, development, and technology transfer (RD&T) programs necessary in connection with the planning, design, construction, management, and maintenance of highway, public transportation, and intermodal transportation systems. Funding is limited and to keep research relevant to MDT staff, implementable results are the goal. Implementation of research results also helps MDT in meeting its mission of providing a transportation system and services that emphasize quality, safety, cost effectiveness, economic vitality, and sensitivity to the environment. As defined by MDT, implementation means the widespread use of research results and innovations. While implementation itself is the responsibility of research customers and is not an SPR-B-eligible activity, Research provides support to facilitate implementation and tracks this implementation.

To enhance the chance of successful implementation, it should be considered as a driving force, an integral component of the research process serving as a constant reminder for the conduct of the research. It is a process, not an event, and must be considered from the beginning and throughout each research project, with consideration to the three key implementation drivers: competency, organization, and leadership. The competency to implement the results and sustain them must be present or developed. MDT, as an organization, must be ready for the required changes. There must be leadership buy-in and support to effect any change. A culture of implementation needs to be encouraged within the philosophy and processes of an organization.

Implementation Integration in the Research Process

Implementation is first considered in MDT's research process with the submittal of the Stage 2: Research Topic Statement form (https://www.mdt.mt.gov/research/unique/solicit.shtml), with the following directions.

- Describe how the project will address the need
- Address the implementability of the expected results from the proposed project.
- Identify products that will facilitate implementation and how these products may be used.
- Identify any known implementation barriers and how these barriers might be eliminated or reduced.
- Identify MDT office or entity outside of MDT responsible for implementation.
- Describe initial implementation plan, include timeframe for implementation.

The topic statement also requires a Champion, who is involved in the daily aspects of the research project, and a Sponsor, who is ultimately responsible for the implementation of research results. The 15 people who can sponsor research are the Division and District Administrators, the Deputy Director, and the Director. These individuals are also members of MDT's high-level Research Review Committee, which determines which Research Topic Statements will be moved forward to technical panels. Stakeholders, including potential implementers, are included on each technical panel. This helps to ensure that the process seamlessly flows from project idea through implementation, performance measurement, and determining the value of the research.

Implementation is next considered at the first technical panel meeting, through scope of work (see Appendix B) development and in Part A of the Implementation Planning and Documentation form (Appendix H), with the following considerations.

- Linking of objectives and tasks to deliverables
- Describing how the research will address the need
- Identifying key decision-makers
- Identifying the area(s) responsible for implementation
- Identifying other cooperators, stakeholders, and partners
- Identifying barriers to implementation and the actions necessary to reduce or eliminate these barriers
- Describing how the results will be implemented
- Defining successful implementation
- Identifying the benefits of implementation
- Identifying the products necessary for implementation (including any technology/knowledge transfer, marketing, and/or training activities).

  Technology/Knowledge Transfer means those activities that can lead to the adoption of a new technique or product by users and involves dissemination, demonstration, training, and other activities that may lead to eventual implementation.

  Marketing is directed towards a larger, general audience. Products can include such things as newspaper, radio, and TV outreach.

The scope of work is developed and the Implementation Planning and Documentation form is completed by the research project manager for each project. The latter begins as a planning document, with the assumption that the research will be successful and that results of the research will be implementable and is updated as new information is available. Early implementation efforts, those occurring prior to project completion, are documented as well.

It is critical that implementation requirements are included in the scope of work as it the basis for proposal development. The proposal becomes a part of the project contract and is the standard to which consultants are held. Also, demonstrating the benefits of implementation will significantly increase the chances of successful deployment.

Implementation barriers, both internal and external, are considered early on so that the barriers can be eliminated or at least reduced. Considering these barriers early on in a project greatly increases the chances for a successful project and implementation. Also, providing the researchers with the knowledge of these obstacles may influence proposal development.

Typically, final reports are not implementable. Without engaged thought and a targeted deployment strategy, the research report will often die on the shelf or in the cyber world. Therefore, products necessary for implementation are identified so that these products can be added as deliverables in the project scope, proposal, and contract. If, as the research proceeds or as it is completed, there is a need for different or additional implementation products, the contract will be amended to include the appropriate and necessary deliverables, or a separate implementation assistance contract will be executed. To achieve a significant impact, products must be well specified, well matched to the needs of the users, implemented in a deliberate and adaptive manner, and supported by a hospitable environment and learning processes.

Implementation is next considered in the project proposal (https://www.mdt.mt.gov/other/webdata/external/research/docs/proposal.pdf), with directions to describe how research results can be applied, including the following, to the extent possible.

- Describe how the research will address the need.
- Describe the form in which the findings may be reported, such as a mathematical model, a laboratory test procedure, or a design technique. Describe these results in terms of the user (e.g., practicing engineer, administrator).
- Link the objectives and tasks to deliverables and successful implementation.
- Describe activities necessary for successful implementation.
- Identify who would logically be responsible for applying the research results, such as the American Association of State Highway and Transportation Officials (AASHTO), FHWA, MDT, or a particular office within MDT.
- Identify specific standards or practices that might be affected by the research findings, such as AASHTO or MDT specifications, MDT policies and procedures, legislation, or fiscal requirements.
- Submit an implementation plan tied to performance measures describing how to implement the results. If an IT component is part of the implementation submit a work plan for update and maintenance.
- Provide an estimate of the costs of implementation.
- Identify the long-term implementation activities and costs.
- Identify barriers of implementation and how these barriers might be reduced or eliminated.
- Describe the criteria for judging the progress and consequences of implementation.
- Describe the benefits of implementation
- If the findings of a study are not suitable for immediate application in practice, the proposal should specify additional steps needed before application can occur (e.g., additional research, field testing, changes in policy, etc.).

The proposal instructions continue with the following text: *It is understood the research may produce unanticipated findings, making changes in the implementation plan necessary. This is acceptable. The proposal selection, however, will be greatly influenced by the practicality and direction of the implementation plan presented in the proposal.*

As each research project progresses, from the project kick-off meeting through the conduct of research, the Implementation Planning and Documentation form (Appendix H) is updated. The following items are discussed at the project kick-off meeting.

- Research project process
- Key contractual requirements
- Research objectives, and link to tasks and deliverables
- Research approach to meet objectives
- Data requirements
- IT requirements
- Researcher needs of the technical panel
- Implementation barriers and actions to reduce or eliminate barriers
- Products, including those necessary for implementation
- Implementation process, including key players
- Benefits and impact of research (Both qualitative and quantitative performance measures will be captured and documented in the Performance Measures Report)
- Research performance measures
- Research timeline

Also, as research results are available, implementation can occur at any time in the research process and early implementation is enhanced with the requirement of project task reports. However, implementation recommendations and an implementation plan defining the procedure to introduce the results into practice are documented in final deliverables.

These recommendations are discussed at the project implementation meeting, along with MDT's response to each recommendation. This information is summarized in the implementation report, which requires a review and approval by the technical panel and the Sponsor. The final researcher presentation to the technical panel is also given at this meeting.

This triggers the completion of Part C in the Implementation Planning and Documentation form (Appendix H), which includes the following information for each implementation activity.

- Implementation Activity Description
- Required Resources, including an itemized cost for implementation, source of funds, tools, and any approvals needed
- Continuing Barriers, Planned Resolution, and Results
- Individual Responsible for Activity
- Begin Date
- Deadline

- Follow-up Schedule
- Updated Date
- Update Description
- Implementation Status
- Comments

Implementation Categories are listed below. These categories are not mutually exclusive and are updated with each update to the Implementation Planning and Documentation form (Appendix H).

- Change in practice (e.g., business practice, design, methods, plan, policies, procedures, process, regulation, rule, specification, standard)
- Current Practice Validation
- Data Collection and/or Processing
- Decision Support Tool, Simulation, Model, or Algorithm: New or Improved
- Demonstration
- Developmental: The research produces a new or modified material, method, device, system, or technology, including design and development of prototypes and processes.
- Equipment, Technology, or Tool: New or Improved
- Feasibility/Proof of Concept
- Field Guide, Guidelines, Handbook, or Manual: New or Improved
- Further Work Needed
- Information-Only/Knowledge Gained
- Information Dissemination/Training: New or Improved
- Product Evaluation

The implementation stages or statuses are listed below; these statuses are mutually exclusive and are updated with each update to the Implementation Planning and Documentation form (Appendix H).

- **Further Work Needed:** Further research, such as another phase or an Experimental Features project, and/or further preparation, such as an organizational change, are needed before implementation can begin.
- **Implementation Pending:** Implementation is planned but has not yet begun.
- **Implementation in Progress:** Implementation is actively proceeding.
- **Partially Implemented:** The implementation activity is not and will not be fully implemented.
- **Fully Implemented:** The implementation activity is complete as described or modified and is in wide use.
- **Not Implemented:** The implementation activity will not proceed to implementation.
- **Not Applicable for Implementation:** The project did not produce an implementable activity.

Research results indicating the current situation is the best alternative should be considered as implemented. Also, projects initiated to only provide information to staff are also considered implemented when the information is provided.

At this time, the champion presents the research, results, and planned implementation to MDT's high-level Research Review Committee.

Implementation for each research project is tracked as described in the Implementation Planning and Documentation form (Appendix H) until all implementation activities are complete or it is clear there will be no additional implementation. At this point this form is finalized, with a sign-off by the project champion and sponsor.

Beyond MDT Research: Implementing the Research Results and Innovations of Others

In addition to the implementation of MDT research results, MDT Research makes a deliberate and focused effort to identify the implementation of innovations from MDT staff and the innovations and research results from other organizations and programs, such as the AASHTO Innovation Initiative (AII), FHWA Accelerated Innovation Deployment (AID), FHWA Every Day Counts (EDC), FHWA Exploratory Advanced Research (EAR), TRB Innovations Deserving Exploratory Analysis (IDEA) programs and other research programs, that can either directly or with some additional work be implemented within MDT. There is no need to reinvent the wheel. In many cases, the research results and innovations from other entities can be directly implemented or implemented with little additional effort. MDT Research documents and quantifies the value of doing so as they result in a large cost savings to MDT, leveraging the funds from others. There are a number of key questions related to this implementation, including the following:

- Is the innovation implementation ready or does additional work need to be conducted to make it so? Is it feasible to deploy within MDT's environment?
- What are the qualitative and quantitative impacts of this implementation? Is data available or can it be generated to quantify the benefits?
- How does the innovation apply to MDT's mission, strategic goals, and performance measures?
- How is the innovation an improvement over the as is condition?
- What is the timeframe for implementation?
- What resources are required for implementation and to sustain the implementation of the innovation?
- How broadly does the innovation apply to MDT?
- What are the barriers to implementation and how can they be overcome?
- What are the risks?

There are a number of efforts to capture this information on research results and innovations that can be implemented by MDT.

- On a continuing basis, MDT Research identifies the implementation of innovations. For those innovations that can be quantified, data is collected to calculate value such as benefit/cost and return on investment. This ongoing effort is supplemented with an annual survey.
- When customers request literature searches from library staff, they are asked if they found that which they were seeking. If so and results will be implemented, implementation is documented,

and performance measures identified, documented, and those quantitative performance measures are calculated.

- ★ When MDT staff participate on panels for pooled fund and TRB Cooperative Research Programs, such as NCHRP, they are required to complete a Partnering Project Close-Out form (Appendix E) to identify MDT implementation efforts that will follow, from which performance measures are identified, documented, and those quantitative performance measures calculated. Also, staff are notified of the NCHRP Implementation Support Program, which provides funds to facilitate the implementation of the results of NCHRP projects.
- ★ As external research reports are distributed to staff, staff are asked if they plan to implement any of the results. In addition to research final reports, many funding programs also publish implementation reports, successes, and other documents, such as TRB's Paths to Practice and Ready Results, which can facilitate implementing the results of research. If staff are planning to implement research results and innovations, implementation will be documented, and performance measures identified, documented, and those quantitative performance measures will be calculated. Also, staff are notified of the NCHRP Implementation Support Program, which provides funds to facilitate the implementation of the results of NCHRP projects.

A concerted effort is made to identify and document the implementation of research results and innovations, from both internal and external sources, to communicate and facilitate the practical use of these results and innovations, and to determine the value of this implementation value.

Implementation Funding

Implementation in itself is not an SPR-B-eligible activity. However, SPR-B funds can be used to facilitate implementation. SPR-B funds are the most common funds available for these activities. However, there are other sources of funds, such as the NCHRP Implementation Support Program, AASHTO Innovation Initiative (AII), FHWA Accelerated Innovation Deployment (AID), FHWA Every Day Counts (EDC), FHWA Exploratory Advanced Research (EAR), TRB Innovations Deserving Exploratory Analysis (IDEA) programs, and the State Transportation Innovation Councils (STIC).

Implementation Tracking

Implementation program-wide is also tracked and is an aggregation of project (both MDT Research and non-MDT Research) implementation. Implementation is tracked by project as detailed in the Implementation Planning and Documentation form for each project. It is aggregated annually in the MDT Research Annual Report.

Implementation Reporting

Implementation plans and results are reported in a number of documents, including: Project Summary, Implementation, Implementation Planning and Documentation, and Annual Research Reports.

Appendix H: Implementation Planning and Documentation

Montana Department of Transportation
Implementation Planning and Documentation

Print Form

RESEARCH PROGRAMS

INSTRUCTIONS:

Implementation of research results is the goal of MDT Research. This form will be a living document through the life of each research project. Each field should be completed as information is available. Click in the field to enter data.

Part A: Project Information

Date:	Champion:	Technical Panel Members:
Solicitation Number:	Sponsor:	
Project Number:	Research Project Manager:	
Other Cooperators, Stakeholders, Partners:	Principal Investigator & Organization:	

Project Begin Date:		Project End Date (as amended)	

Project Title:

Project URL:

Project Type: (Please check as many boxes as apply. If Other, please specify. Also, please add detail in the text box.)

☐ Data Collection/Analysis ☐ Demonstration ☐ Developmental (new/improved material, method, device, system, tech)
☐ Feasibility ☐ Implementation ☐ Information-Only (e.g., synthesis) ☐ Practice Evaluation
☐ Product Evaluation ☐ Technology Transfer

If other, please specify. Also, please add more detail:

Project Application: (Please check as many boxes as apply. If Other, please specify.)

☐ Administration ☐ Aeronautics ☐ Bridge ☐ Civil Rights ☐ Construction ☐ Design
☐ Engineering ☐ Environmental ☐ Finance ☐ Freight ☐ Geotech ☐ Highways
☐ Human Resources ☐ Hwy Traffic Safety ☐ Hydraulics ☐ IT ☐ Legal ☐ Maintenance
☐ Materials ☐ Motor Carriers ☐ Occ Health & Safety ☐ Photogrammetry, Survey, & Mapping
☐ Planning ☐ Research ☐ Right of Way ☐ Road Design ☐ Traffic & Safety ☐ Transit
☐ Other

If other, please specify:

Project Description: (include objectives and tasks linked to deliverables; describe how this project will address the research need, how the results of the project will be implemented, key decision-makers, and describe successful implementation. Include IT involvement.)

Montana Department of Transportation
Implementation Planning and Documentation

Print Form

Final Product/Tool Types: (Consideration should be given to the products/tools needed for implementation of the research results. This is in addition to the standard final products: Final, Project Summary, Implementation, and Performance Measures Reports, and Poster. Please check as many boxes as apply. If Other, please specify. Also, please add detail in the text box.)

- ☐ Decision Support Tool, Simulation, Model, and/Algorithm
- ☐ Guide/Guidelines/Handbook/Manual
- ☐ New/Improved Design Procedure, Specification, or Standard
- ☐ New/Improved Material, Method, Device, System, Tech
- ☐ New/Improved Practice (could also validate current practice)
- ☐ New/Improved Product
- ☐ Technology Transfer/Training
- ☐ Video
- ☐ Website
- ☐ Other

If other, please specify. Also, please add more detail:

Identify the barriers to implementation of the project results and the actions to reduce or eliminate these barriers. Barriers can include such things as communication, economic, institutional, and resistance to change. Identify if there are any prerequisites for implementation, such as legislation, rule, policy, procedure, and/or specification changes. (Add as many rows as is needed): ☐ N/A

Add Issue/Action

-	Issue:	Action:

Part B: General Implementation Information

Date: Research Objective(s) Fulfilled? ☐ Yes ☐ No

Research Produced an Implementation Solution? ☐ Yes (includes validation of current situation) ☐ No

Implementation Report? ☐ Yes ☐ No Implementation Recommended? ☐ Yes ☐ No

If implementation is not recommended, why not (e.g., Further work is needed)?

If implementation is recommended, what problem was solved? Include a summary of the research findings.

What are the benefits/impact of this research? (Please check as many boxes as apply. If Other, please specify. Also, please add detail in the text box.) Performance measures, both qualitative and quantitative, will be captured and documented in the Performance Measures Report for each project.

- ☐ Aesthetics Improved
- ☐ Congestion Reduction
- ☐ Convenience Improved
- ☐ Cost Savings
- ☐ Economic Development
- ☐ Efficiency Gains
- ☐ Environmental Gains
- ☐ FTE Reduction
- ☐ Increased Life-cycle
- ☐ Infrastructure Gains
- ☐ Materials Savings
- ☐ Process Improvement
- ☐ Quality Gains
- ☐ Safety Gains
- ☐ Service Improved
- ☐ System Reliability Gains
- ☐ Time Savings
- ☐ User Benefits
- ☐ Other

If other, please specify. Also, please add more detail:

Part C: Implementation Activities
(Include necessary Technology/Knowledge Transfer, Marketing, and Training Activities)

Add Implementation Activity

- Implementation Activity: ▲ ▼

Montana Department of Transportation
Implementation Planning and Documentation

Print Form

Description (link to project objectives and products; indicate if an activity must occur prior to another activity; include strategies and tactics):

Required Resources (include an itemized cost for implementation, source of funds, tools, and any approvals needed)

Continuing Barriers, Planned Resolution, and Results:

Responsibility: | **Begin Date:** | **Deadline:**

Follow-Up Schedule:

Updated:

Update:

Implementation Status:

☐ Pending Implementation ☐ Implementation in Progress ☐ Partially Implemented
☐ Fully Implemented ☐ Not Implemented

Comments:

Part D: Approval

Champion	☐ Yes ☐ No Champion Approval	Date
Sponsor	☐ Yes ☐ No Sponsor Approval	Date