Evaluation of Effectiveness and Cost-Benefits of Woolen Roadside Reclamation Products

by

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PROBLEM STATEMENT

Successful highway right-of-way management following construction, reconstruction, and other disturbances of Montana Department of Transportation (MDT) lands requires the creation of the proper environmental conditions conducive to successful establishment and survival of reclamation plantings as well as the control of soil erosion, and the control of surface runoff and its sediment load into adjacent receiving waters (as regulated by the Clean Water Act). Woolen reclamation products have many promising attributes that may make them superior to existing standard materials. We seek to collaborate with Brookside Woolen Mill, and other willing businesses to develop and test the effectiveness of a variety of commercially viable woolen erosion control, soil retention and vegetation establishment blankets and related materials for roadside reclamation purposes. These products will be compared to the existing market's standard practice that often uses coconut fiber (coir)-straw erosion control fabric and other similar products that are imported to the U.S. and Montana from the tropical regions of the world or related synthetic non-biodegradable geotextile materials. This project will identify those products with superior characteristics that can be, or are, manufactured in small businesses in rural Montana and other manufacturers in the U.S. We will focus on woolen products that can be provided at sufficient quantities and cost effectiveness for deployment on MDT projects.

BACKGROUND SUMMARY

Erosion control fabrics generally meet the requirements established by the Erosion Control Technology Council and the U.S. Department of Transportation, Federal Highway Administration's standard specifications for construction of roads and bridges on federal highway projects [FP-03 2003 Section 713.17, Type 3.B]. There are several types of erosion control blankets: temporary, extended and semi-permanent. For example, one of the most commonly used erosion control blankets produced by the manufacturers is comprised of straw and coconut fiber. According to the manufacturer's information sheet, this erosion control blanket has a functional longevity of up to 18 months.

We intend to compare the performance of products such as the straw/coconut blanket with similarly constructed products utilizing wool as the fiber matrix. Research has shown that scoured weed-seed free wool can store up to 400% (Upton 2003) of its weight in water, which is much better than rock wool (synthetic product) or coco coir (Figure 1). Wool becomes saturated at 33 1/3% of its weight of moisture-free fibers (D'Arcy 1990). Thus, when scoured wool absorbs water greater than 33 1/3% of its weight, this moisture is more readily available for plant growth and adsorption. This could give a woolen erosion control blanket a decided advantage in harsher, drier climates if it meets FHWA standard specifications and is cost competitive. In addition, sheep wool contains up to 17% nitrogen and can act as a slow release fertilizer for plant growth and development.

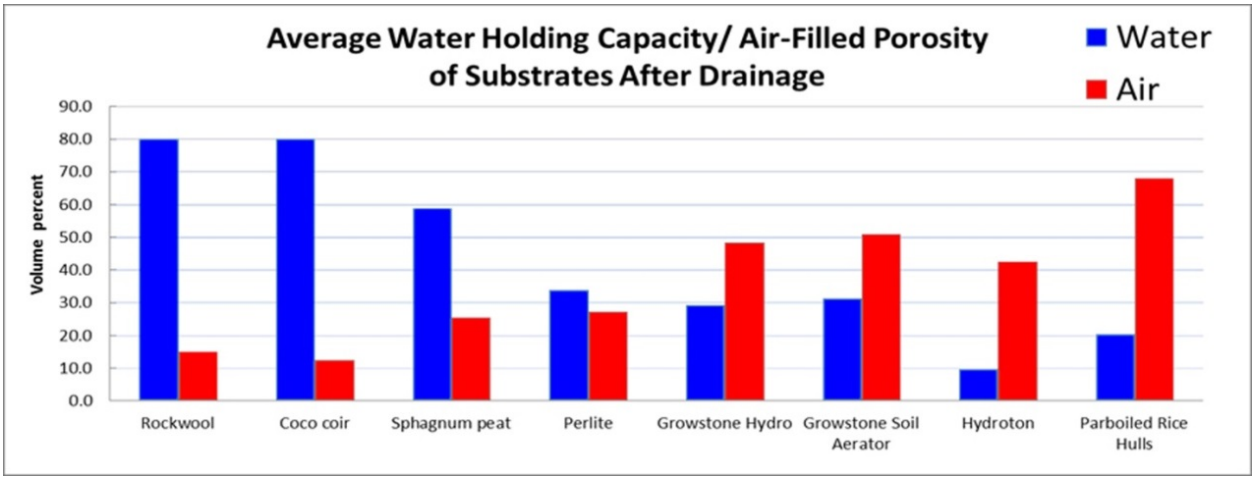

Figure 1: Average water holding capacity of a variety of natural and synthetic products. Source: Growstone Products,http://www.growstone.com/products/

Research from Europe evaluating the use of woolen fabrics for green roof applications (Figures 2 and 3) demonstrate a strong beneficial plant growth response from wool in comparison to tropical plant product – coconut fibers (Herfort 2010).

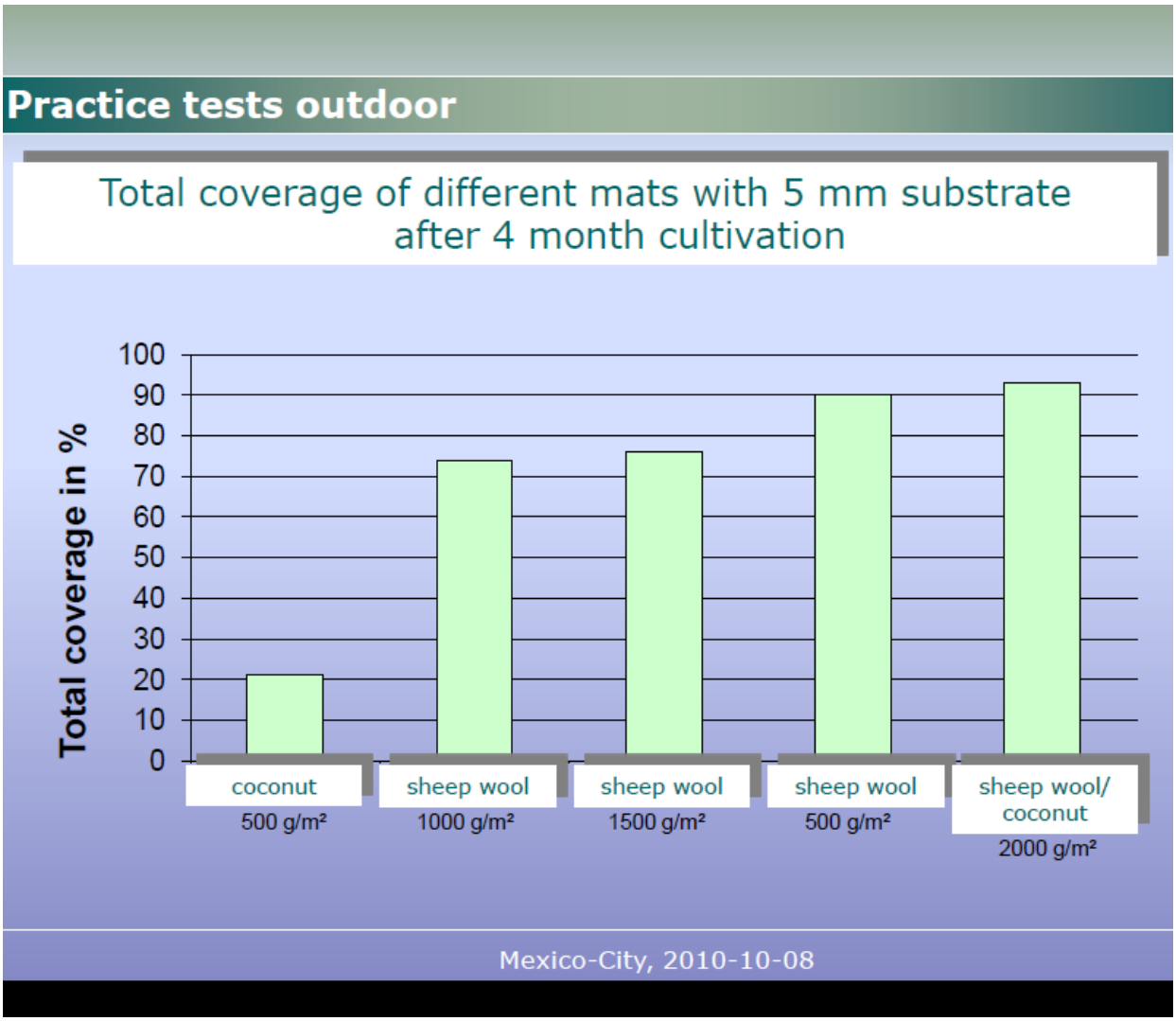

Figure 2: Plant response to various woolen and coconut mats for green roof applications (from powerpoint presentation, Herfort 2010).

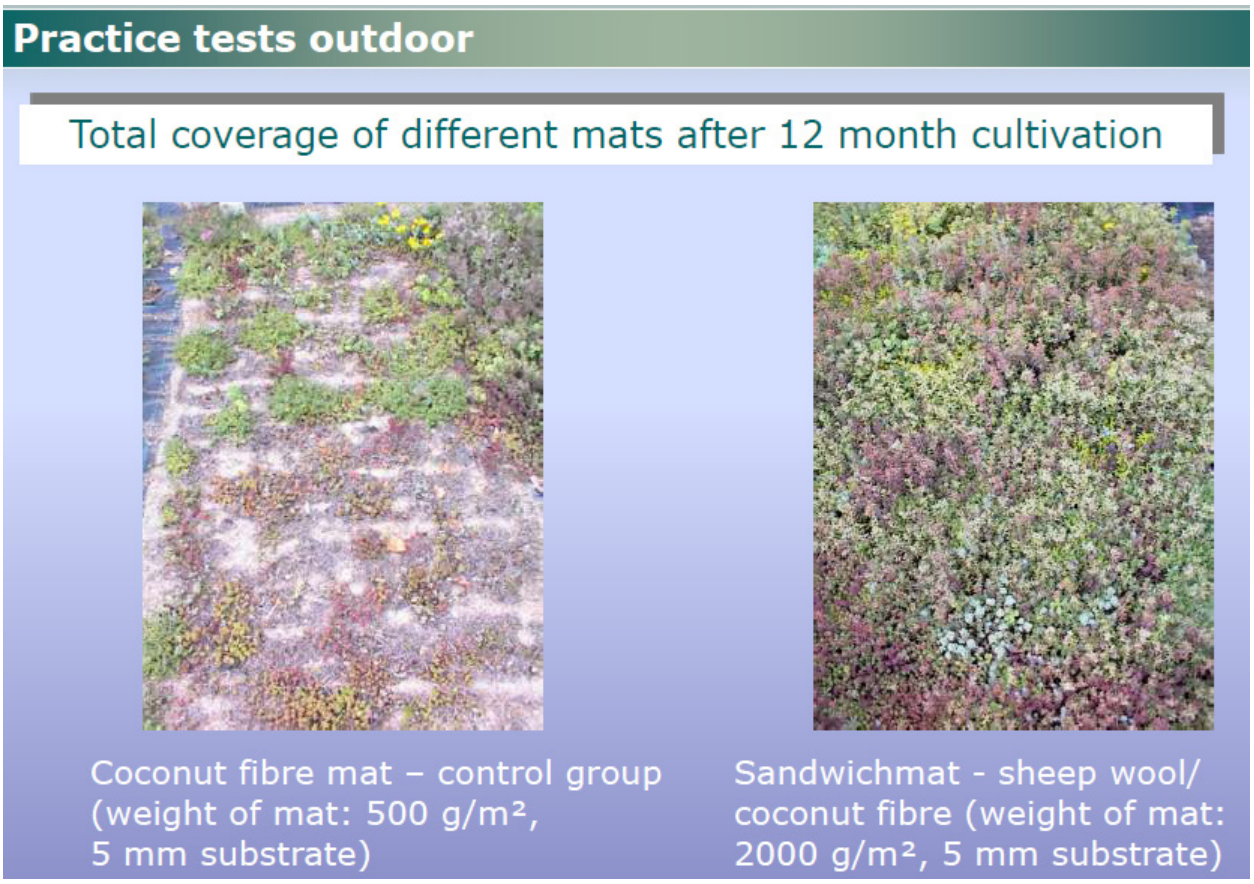

Figure 3: Vegetative response to coconut fiber versus sheep wool in a German field study (from powerpoint presentation, Herfort 2010).

Other products constructed of wool that will be evaluated include wattles (fiber rolls), revetment fabric protecting soils from erosion under rip rap slopes, silt fences, hydro-mulch fiber and other standard reclamation products made of coconut-coir fibers or synthetic materials that are non-biodegradeable.

The following links provide access to websites of companies in New Zealand that manufacture erosion control and plant establishment products constructed of wool. We intend to build upon this knowledge base and documented performances of the woolen products currently in use by these overseas companies.

- http://www.advancelandscape.co.nz/shop/Weed+Control+Products/EcoWool+Mulch+Mats+Biodegradable.html
- http://www.terralana.co.nz/other_products
- http://www.cirtex.co.nz/Cirtex-Solutions/Erosion-Control/BioWool---Wool-Matting
- http://www.geotechsystems.co.nz/Data/DefaultShowcase/Documents/Brands/Terramat/Terramat%20Wool%20and%20Wool%20J%20Blanket%20and%20Wool%20C%20Collar%20data.pdf

BENEFITS AND BUSINESS CASE

The results and analyses of this project will allow MDT to make informed decisions regarding effective revegetation and erosion control material specification and their performance and cost effectiveness. It is the purpose of this research to investigate the feasibility of incorporating a Montana-made product and other superior woolen reclamation products that utilize agricultural waste materials in a way that is economical and environmentally sound. If the woolen products perform to satisfaction, the public would benefit by creating a market and value to a locally made, biodegradable commodity. The project will identify sites and applications where the product's use will provide better performance than with materials currently in the commercial market.

OBJECTIVES

The objectives of this project are to evaluate existing wool products that are, or can be, used for roadside reclamation and revegetation projects by MDT. In addition, the project seeks to develop and test potential wool products that can be easily produced as complementary or replacement products to existing traditional best practices; especially if the wool products are more effective or cost efficient (e.g., using woolen fibers in place of paper, wood or cotton fibers in hydro-mulching and hydro-seeding slurry). We will also test in the laboratory promising wool products to assure they meet specifications for MDT and FHWA deployment and field test the products adjacent to standard practices to evaluate their effectiveness. Lastly, we will conduct a cost benefit analyses of the successful wool products from the lab and field testing phases and then develop a potential implementation plan for top performing wool products.

RESEARCH PLAN

TASKS

Task 1: Meetings: kickoff, annual, implementation and final

The kickoff meeting (year 1) will be in conjunction with the project's technical panel to review what the research team and the MDT reclamation specialist have agreed would be the best work plan for the project. The research team consists of reclamation scientists at the Western Transportation Institute (WTI) and KC Harvey Environmental, LLC (KCH).

Annual meetings (year 1 and 2) will occur with the Technical Panel. These will be held either in Helena at MDT headquarters or by video conference. The mode of the meeting will be determined each year, subsequent to its scheduling.

After the final report is written, a meeting will be held to review and finalize an implementation plan, this will be held at MDT headquarters in Helena, MT.

The final meeting (year 3) will be in person at MDT headquarters in Helena, where the research team will present its findings, conclusions and recommendations.

NOTE: Meetings may be by tele-conference or in person at MDT headquarters in Helena, MT, whichever prove most effective.

Task 2: Identify and develop wool products with potential for roadside applications

A review of existing woolen reclamation materials and products the project will seek to have refined and developed by a Montana wool producer to make them more applicable for roadside reclamation purposes. There are three general areas where these products will be explored.

1. There are some woolen roadside reclamation products produced abroad (i.e., New Zealand) that are not available in the U.S. These products will be procured and a Montana producer (e.g. Brookside Woolen Mill, Thirteen Mile Lamb and Wool Company, Sugarloaf Wool Carding Mill LLC) will be sent the material to determine whether they can make a similar product for testing in the project.

2. Other promising woolen products are made in the U.S. for horticultural or residential purposes. This project will explore their use for roadside reclamation. For example Woolmulch is used in gardening but may have roadside applicability. Another is that blow in wool insulation for homes may be ideal for incorporating in to roadside hydromulching applications.

3. Another area that will be explored is the production of new woolen reclamation materials that could be readily produced by Montana wool producers (Figure 4) or other manufactures. For example, a strong felted wool material could be used to replace non-

biodegradable silt fence. This product would not have to be removed at the end of the construction project and could add nitrogen to the area as it decomposes.

Task 2 will review, explore, develop and secure those woolen materials that are most promising for roadside reclamation. Task 2 will also assure that there is an adequate supply for the wool material for the transportation sector, assuming the product proves to be successful after lab, field, and cost-benefit evaluations.

Figure 4: Ad hoc test of carded wool batting produced by 13 Mile Lamb and Wool Company to determine penetrability by seedlings (2013). Photo: Stuart Jennings, KCH.

Task 3: Lab Tests: Evaluate key geotextile material characteristics of woolen products

This task seeks to compare existing specifications of reclamation products to their woolen equivalents. The results will assure transportation agencies that woolen materials tested in this project are similar or comparable to existing reclamation products. First, a review of lab tests of products currently being used by MDT will be collected and synthesized. Then, the research team, working with the Technical Panel and a WTI geotextile specialist, will make a narrow selection from an array of possible technical specifications for the various woolen products to be tested. These tests of specifications will be aligned as closely as possible with the MDT geotextile standard specifications.

A review of the US Army Corps of Engineers requirements for products used in water or below the high water mark will be conducted. The review will occur prior to lab testing of silt fencing,

revetment blankets and other wool products potentially deployed in areas under the purview of the Clean Water Act. We will analyze whether wool products meet USACE requirements.

The laboratory tests will be conducted by a suitable commercial lab used by MDT for other geotextile material testing and MDT geotextile standard specifications.

For Erosion Control Blankets (ECBs) the following list of specifications, although not exhaustive, will be selected from:

- tensile strength and elongation
- thickness
- resiliency
- water absorbency
- maximum flow velocity
- mass per unit area
- maximum permissible shear stress
- longevity (life span)
- ultraviolet light stability
- plant available water holding capacity
- total nitrogen and plant available nitrate-nitrogen

For silt fence and revetment fabric for rip-rap, the following list details possible attributes to select for laboratory tests:

- grab strength
- puncture strength
- permeability
- UV Stability
- apparent opening size
- tensile strength and elongation
- thickness
- maximum permissible shear stress
- maximum flow velocity
- mass per unit area

As other woolen reclamation materials are developed that are different from the above three product types - ECBs, silt fence, revetment blankets – a similar review of specifications for each product will be developed and important attributes will be selected for laboratory testing in conjunction with the Technical panel.

Task 4: Field Tests: Evaluate woolen product performance for plant establishment and/or erosion control in comparison to existing standard materials.

The proposed research would primarily be a series of "side-by-side" tests of a new or commercially available woolen reclamation products produced by Montana wool producers or secured from other manufacturers. These would be tested in the same environment, either at active highway reclamation projects selected by the MDT Reclamation Specialist or at the WTI's Transcend in Lewistown, Montana where a steep slope test site (3:1) has been constructed for experiments. For active MDT roadside projects, slopes other than 3:1 may also be tested,

depending on the woolen product. For woolen products used to line roadside ditches or for silt control, test slopes may be negligible.

The following variables will be controlled for field tests: site preparation, seed mix and application rates (when needed), moisture and other weather conditions. Controlling for these variables would allow the dependent variables to be calculated for the woolen and existing standard products as measures of product performance: amount of erosion and vegetative cover (when appropriate).

Erosion will be measured using the Bureau of Land Management's (BLM) standard methodology as described by Clark (1980). This is a classification system using estimates of sheet erosion, rills and gullies.

Vegetation establishment and growth will be measured using two parameters:

- Plant density (stems per square meter)
- Plant canopy cover – The vertical projection of the crown or shoot area of a species projected on the ground as a percent of the reference area (Mueller-Dombois and Ellenburg 1984).

A list of woolen reclamation products that are currently under consideration and appear highly promising for testing are:

- Silt fence
- Woolen revetment fabric to separate soil and rip-rap materials along streams
- Erosion control blankets of varying densities, thicknesses and strength
- Hydro-mulching or hydro-seeding using cut wool fibers as slurry additive
- Water and soil erosion wattles (rolled materials)

Many of these woolen product tests will be replicated, where practicable, for statistical evaluation. For erosion control blankets, the ideal sample size will be ten 1 m^2 test plots randomly placed across a 10 X 10 meter grid at the Transcend test site or at an active MDT roadside reclamation project. A T-test could then be used to determine whether the difference in the mean of each set of data is significantly different. Thus, allowing the research project to determine if a woolen product performs better or worse than its equivalent commercially available coconut-coir-straw or synthetic product.

Plots will be constructed ideally in the spring of 2014. Field tests will be conducted in the growing seasons of 2014, 2015 and 2016 to assure performance is tested for at least 24 months. Measurements of vegetation establishment and growth, as well as erosion and other factors deemed essential for comparison purposes, will be measured during the growing seasons for at least a 24 month period. Photos of all study sites and plots will be taken during each sampling event. An analysis of the performance of each woolen product will be compared to the performance of current standard commercial non-woolen products.

Task 5: Conduct analyses of field data as well as cost-benefit analyses of woolen reclamation products in comparison to existing standard products.

Analyses of the field data and the costs and benefits of tested woolen products will be conducted and incorporated in to the final report.

For wool products that are studied by placing them adjacent to current erosion control or re-vegetation products on active MDT highway reclamation projects, measurements of vegetation cover and erosion will be collected for two years. These data will be used to document performance. In addition, photos will be taken to assist in documenting difference in wool and standard products.

For products where side by side comparisons are replicated multiple times (n=7 or greater), statistical tests will be used to evaluate any significant differences in performance between woolen and standard products.

For large treated areas where only one side by side treatment is conducted (i.e., silt fence or hydro-seeding with wool fibers) sub-sampling of vegetation cover or erosion will be conducted and compared to performances that have been measured in other studies or compared to MDT reclamation requirements (i.e., the MT Highway 84 research project on vegetation cover for steep cut slopes).

Task 6: **Reporting**

Quarterly reports will be prepared and submitted to MDT every 3 months after the signing of the contract summarizing progress made by the project, deliverables provided, and any problems that may arise that the researcher team would like to alert MDT. The WTI-KCH Team will use the MDT guidelines for quarterly reports.

A report will be prepared within a month after Task 2, 3, and 4 are completed.

A final report will be submitted in lieu of a quarterly report and the Task 5 completion report, as appropriate.

A draft of the final report will be sent to the Technical Panel for review and they will be given 30 days to return comments, collated by MDT, to the research team. Then the research team will respond to each comment in writing and produce the final report after 30 days. The final report will include a photo for its cover. After the final report is accepted by MDT, a project summary report will be completed.

An implementation plan will be developed by the research team with support of MDT after the completion of the final report and summary report. A meeting will be held with MDT and the Technical Panel and a report of that meeting will be submitted to MDT by the research team.

A final presentation will be made to summarize the findings of the project to MDT employees and the Technical Panel.

DELIVERABLES

Task 1: Meetings

The WTI-KCH research team will coordinate and assure the kickoff, annual and final meeting are held in Helena, Montana or by tele-conferencing. They will organize meetings that will include key MDT personnel and the Technical Panel.

- Kickoff meeting will be held within 30 days of the signing of the research project's contract by WTI.
- Annual meetings will be held after Year 1 and Year 2.
- Final meeting, if MDT requests, will be held within 30 days of acceptance of the Final Report by MDT.
- A meeting will be held to review the implementation plan and WTI-KCH Team will take notes of the meeting.

Task 2: Selection of Woolen Products for Evaluation

A final list of woolen products that are selected for evaluation for the project will be sent to MDT and the Technical Panel for their approval.

The final list will identify which woolen products currently exist and can be purchased for testing, which exist and will be repurposed from other sector uses, and which will be developed by Montana wool producers or other woolen manufacturers.

Task 3: Lab Tests: Evaluate key geotextile specifications and other material characteristics of woolen products

A summary of the results of all laboratory tests for each woolen product will be submitted to MDT and the Technical Panel upon their conclusion. Results will be incorporated into the final report.

Task 4: Field Tests: Evaluate woolen product performance for plant establishment and/or erosion control in comparison to existing standard materials.

Test plots will be constructed in 2014. Field tests will be conducted in the growing seasons of 2014, 2015, and 2016. Measurements of vegetation establishment and growth as well as erosion and other factors deemed essential will be measured in both growing seasons. Photos of all study sites and plots will be taken during each year.

Task 5: Conduct analyses of field data as well as cost-benefit analyses of woolen reclamation products in comparison to existing standard products.

The analyses and their results will be incorporated in to the Final Report for the project. They will include statistical tests, when appropriate.

Task 6: Reporting: quarterly, annual and final reports

Reporting deliverables will be as follows:

- Progress reports will be provided on a quarterly basis on research project that will be sent electronically to MDT Research staff.
- A Task Report will be provided one month after Tasks 1, 2, 3, 4 and 5 are completed.
- A Draft Final report will be sent to MDT Research staff and Technical Panel for review and comment. It will include a cover photo in JPG format.
- The Final Report will be sent to MDT Research staff and Technical Panel. It will include a cost-benefit analysis and implementation plan.
- A project summary report will be provided upon approval of the Final Report.
- An implementation meeting will be held with the WTI-KCH team, MDT and Technical Panel to review the implementation plan. WTI-KCH will then provide a report to MDT on the results of the implementation meeting.
- A performance measures report will be prepared at the conclusion of the Final report.
- A final presentation of the project will be given to MDT and the Technical Panel, as requested. The presentation will either be in person, a webinar, or other communications technologies.

PRODUCTS

1. Reports

- Quarterly Progress reports
- Task 2, Task 3, and Task 4 Completion Reports
- Annual Report for 2014 and 2015
- Final Report
- Photo in JPEG for Final Report
- Implementation Plan and Meeting Notes
- Performance Measures Report

2. Photographs of the research sites and the test plots constructed for the materials evaluated during 2014, 2015 and 2016

MDT INVOLVEMENT

This project will require some limited MDT assistance.

The project will benefit from the MDT geotextile specialists in the following ways:

- Support in the development of the specifications that should be laboratory tested for each woolen product
- The list of the commercial laboratories that MDT uses for its geotextile laboratory tests.

The project will benefit from the MDT reclamation specialist in the following ways:

- Support in the development and selection of woolen products for both laboratory tests and field tests.
- Selection of highway research sites to test woolen products, either at active or recently completed MDT reclamation or revegetation projects.
- Recommendation of the seed mix to use to test woolen products for revegetation purposes.

IMPLEMENTATION

The research project's results will identify those woolen products that outperform standard products and also meet the necessary specifications for that class of reclamation or revegetation material. Other woolen products may perform equally as standard products but may be more economical than products currently on the market. The MDT Reclamation Specialist with Environmental Services will develop an implementation plan. The plan will detail:

1) A list of the successful woolen products, their specifications, and the purpose of their use by MDT for erosion control and revegetation projects.
2) A list of the producer/manufacturer of each successful woolen product and the quantity available for MDT contractors to use each year.
3) The types of sites and applications successful woolen products would be best suited to prescribe for their use.
4) A schedule for incorporating the products into future MDT highway projects.
5) The monitoring that may be needed for the new woolen product's performance after deployment on MDT projects.

SCHEDULE

Table 1: Project Schedule

MDT WOOLEN RECLAMATION PROJECT		1st Quarter 2014	2nd Quarter 2014	3rd Quarter 2014	4th Quarter 2014	1st Quarter 2015	2nd Quarter 2015	3rd Quarter 2015	4th Quarter 2015	1st Quarter 2016	2nd Quarter 2016	3rd Quarter 2016	4th Quarter 2016
Task	Task Title												
1	Meetings: kickoff, annual, final												
2	Identify, develop and obtain high potential wool reclamation												
3	Lab Tests: for selected woolen reclamation products												
4	Field tests of woolen reclamation products												
5	Field data analyses and cost-benefit analyses												
6	Reporting												

BUDGET

Table 2: Proposed Project Budget

	Budget	WTI			KC Harvey Contracted Services			Other Direct Expenses			Totals
		Rob Ament, Road Ecology Program Manager	Eli Cuehlo, Geotextiles Lab	Carla Little, Technical Writer	Stuart Jennings, Principal, KCH	Monica Pokorny, Ecologist, KCH	Loren Franklin, Reclamation Scientist, KCH	Travel	Materials	Laboratory Testing	Total Costs
Task #	Task Title	$54.25	$58.58	$33.28	$122.19	$100.50	$89.92				
1	Meetings: kickoff, annual, final and implementation. 3 trips to Helena from Bozeman	40				40					
		$2,170.00	$0.00	$0.00	$0.00	$4,020.00	$0.00	$500.00			$6,690.00
2	Identify, develop and obtain high potential wool reclamation products; 5 trips to MT wool manufacturers - i.e., Malta, Drummond, Belgrade	80			40						
		$4,340.00	$0.00	$0.00	$4,887.60	$0.00	$0.00	$1,200.00	$4,000.00		$14,427.60
3	Lab Tests: for selected woolen reclamation products including a review of Corps of Engineers requirements near or in water	40	30		4	10	40				
		$2,170.00	$1,757.40	$0.00	$488.76	$1,005.00	$3,596.80			$6,000.00	$15,017.96
4	Field tests of woolen reclamation products; 3 seasons of trips to various highway reclamation sites (TBD) and Transcend in Lewistown, MT	260			0	160	110				
		$14,105.00	$0.00	$0.00	$0.00	$16,080.00	$9,891.20	$5,000.00	$4,000.00		$49,076.20
5	Field data analyses and cost-benefit analyses;	80			12	16	30				
		$4,340.00	$0.00	$0.00	$1,466.28	$1,608.00	$2,697.60				$10,111.88
6	Reporting - Quarterly, Task(s), Annual (s), Summary, Draft and Final Reports; Implementation Plan and Meeting Report, Performance Review	150		40	8	95	20				
		$8,137.50	$0.00	$1,331.20	$977.52	$9,547.50	$1,798.40				$21,792.12
	TOTAL HOURS	650	30	40	64	321	200				
	TOTAL DIRECT COSTS (includes ben.)	$35,262.50	$1,757.40	$1,331.20	$7,820.16	$32,260.50	$17,984.00	$6,700.00	$8,000.00	$6,000.00	$117,115.76
0.25	Indirect Costs at 25%	$8,815.63	$439.35	$332.80	$1,955.04	$8,065.13	$4,496.00	$1,675.00	$2,000.00	$1,500.00	$29,278.94
	Total Project Costs	$44,078.13	$2,196.75	$1,664.00	$9,775.20	$40,325.63	$22,480.00	$8,375.00	$10,000.00	$7,500.00	$146,394.70

Table 3: Budget for state and federal fiscal years.

Item	Total Budget	State Fiscal Year				Federal Fiscal Year			
		2014	2015	2016	2017	2014	2015	2016	2017
Salaries	28,620	4,770	9,540	9,540	4,770	7,155	9,540	9,540	2,385
Benefits	9,731	1,622	3,244	3,244	1,622	2,433	3,244	3,244	811
In-state travel	6,700	1,117	2,233	2,233	1,117	1,675	2,233	2,233	558
Contracted Services	58,065	9,678	19,355	19,355	9,678	14,516	19,355	19,355	4,839
Expendable supplies	8,000	1,333	2,667	2,667	1,333	2,000	2,667	2,667	667
Lab fees	6,000	1,000	2,000	2,000	1,000	1,500	2,000	2,000	500
Total Direct Costs	**117,116**	**19,519**	**39,039**	**39,039**	**19,519**	**29,279**	**39,039**	**39,039**	**9,760**
IDCs (25%)	29,279	4,880	9,760	9,760	4,880	7,320	9,760	9,760	2,440
Total Project Cost	**146,395**	**24,399**	**48,798**	**48,798**	**24,399**	**36,599**	**48,798**	**48,798**	**12,200**

STAFFING

Table 4: Project Staffing

Name of Principal, Professional or Support Classification	Role in Study	Task							Percent of Time vs Total Project Time	Percent of Time on an Annual Basis
		1	2	3	4	5	6	Total		
Rob Ament, Program Mgr, WTI	Principal Investigator	40	80	40	260	80	150	650	51%	10%
Eli Cuehlo, WTI, Geotextiles Eng.	Testing Support for Materials			30				30	2%	0%
Monica Pokorny, Botanist, KCH	Co-Principal Investigator	40		10	160	16	95	321	25%	5%
Stuart Jennings, Principal, KCH	Materials Development and Analyses		40	4		12	8	64	5%	1%
Loren Franklin, Field Technician, KCH	Field Evaluations and Analyses			40	110	30	20	200	16%	3%
Editor, Technical Writer, WTI	Report Preparation						40	40	3%	1%
TOTAL HOURS		80	120	124	530	138	313	1305	N/A	N/A

Robert Ament, WTI

Rob Ament, M.Sc., Biological Sciences, is the Road Ecology Program Manager at the Western Transportation Institute at Montana State University. He has more than 25 years of experience in field ecology, natural resource management, environmental policy and organizational development. He manages over 20 active road ecology research projects throughout the western United States and currently serves on five national or international committees/boards of directors. His expertise is in plant ecology, where he has over 15 field seasons in conducting vegetative studies in MT, ID, OR, AK, UT and OR. He has been a principal investigator for roadside reclamation and vegetation projects for MDT, MT DEQ, the Idaho Transportation Department and the Federal Highway Administration.

Rob will be the PI for the project, in charge of overall project management, reporting, and research. He will work on all tasks and his time is usually the equivalent for the combined KCH staff's time for many of the tasks, thus WTI will be splitting most of the hours dedicated to the project nearly evenly across all aspects of the project with KCH.

Monica Pokorny, KCH

Monica Pokorny, M. Sc., Land Resources and Environmental Sciences is Senior Ecologist and Project Manager with KC Harvey Environmental. Monica has 17 years of professional experience in ecology and project management. Monica's work experience is broad and includes ecological restoration, invasive plant management, land management, wetland restoration,

botany, and wildlife habitat analysis. Monica has been involved in hundreds of acres of restoration/mitigation projects. Monica has extensive experience researching and implementing strategies to convert weed dominated uplands to desired plant communities using revegetation and restoration techniques. Her technical interests include native habitat restoration, plant-animal interactions, and plant community ecology.

Monica will be the co-PI on the project and will work on all of the tasks, except product development (Task 2) which Stuart Jennings will do for KCH. She will work closely with Rob Ament on developing all reports and attending all meetings.

Stuart Jennings, KCH

Stuart Jennings, M.Sc., Land Rehabilitation, is a Principal Scientist with KC Harvey Environmental, LLC based in Bozeman. He formerly was employed by Montana State University, Reclamation Research Unit as a Research Scientist. He has 25 years of experience in disturbed land revegetation, soil geochemical analysis, native grassland reestablishment and storm water control, principally and large scale disturbances in Montana and the Western United States caused by mining and transportation corridor development. He is a project manager on several projects with emphasis on soil bioengineering for vegetation development for Federal and State agencies. He was the Principal Investigator on the earlier work performed for MDT by MSU.

Stuart will be working on product development (Task 2) to get the project up and running, and help the WTI-KCH Team with key reviews and support throughout the duration of the project, including the final report, implementation plan and performance measurement report.

Loren Franklin, KCH

Loren has a M.Sc. in Land Rehabilitation from Montana State University. Her past project experience emphasizes human and ecological risk assessment, both as a research scientist at Reclamation Research Group and as a research associate at Montana State University. Her most recent projects include several for the U.S. Forest Service: construction oversight at Riley Pass, South Dakota (abandoned uranium mine), staff training on soil bioengineering and native plant re-vegetation, and risk assessment at the Forest Rose Mine Site, near Missoula, Montana. Loren's specialties include GPS mapping, GIS data analysis, and database compilation.

Loren's technical expertise will be provided primarily for the project's lab and field test tasks (Tasks 3 and 4). She will help collect data, conduct analyses and summarize the data collected and analyzed for the various reports required by the project.

Eli Cuelho, WTI

Eli Cuelho, P.E., is a Research Engineer and the Program Manager of the Infrastructure Maintenance and Materials program area at WTI. Mr. Cuelho is a licensed professional engineer in the state of Montana and is currently involved with a number of research projects related to the design and maintenance of transportation infrastructure. He has over 15 years of experience

on a variety of research topics including geotechnical engineering, geosynthetic design, pavement design and analysis, subgrade stabilization, cost-effectiveness and cost–benefit analyses, large-scale field tests and remote sensing and data acquisition equipment. He is currently a member of ASTM committee task group to develop new test procedures for geosynthetics in transportation applications and is a member of the Geosynthetics committee AFS70 at TRB.

Eli will help provide his expertise in selecting geosynthetic material tests that will help meet the product evaluation needs of transportation agencies. He then will help the WTI-KCH Team interpret the results, and write the Task Report for Task 3, Laboratory Testing.

Carla Little, WTI

Ms. Little has more than 20 years of experience writing and editing publications for both technical and non-technical audiences. With a background in government relations and public policy, she has extensive experience presenting complex issues in a variety of clear, concise formats to professional organizations, government officials, the media, and the general public. In the field of transportation, she has written reports, proposals and promotional materials covering such diverse issues as tourism, infrastructure development, transit, wildlife mitigation, and advanced technology applications. Her current focus is providing writing and editing support for transportation research grants and projects, and producing outreach materials such as newsletters, journal articles, and annual reports.

FACILITIES

The WTI-KCH Team will not use their own facilities to laboratory test any of the woolen products to assure they meet critical material performance specifications.

The WTI-KCH Team will use WTI's test facility Transcend for some of the woolen products. This will allow the greatest degree of control for the field tests. Transcend's test slope – 2:1 slope, north/south aspects - serves to minimize environmental variables, has known soil properties and nutrition (soil tests completed), allows the WTI-KCH Team to water the test plots in the extreme case that a drought would kill test plot vegetation, and it is in a secure location that will protect test plots from vandalism or other unforeseen disturbance (e.g., off road vehicles) that may potentially destroy all or portions of the field plots.

Figure 5: North-facing, ten meter long test slopes (2:1) with a watering system constructed at Transcend, October 2012.

TRANSCEND is a rural transportation research facility located in Lewistown, Montana where researchers study multi-disciplinary transportation challenges in a full-scale environment without interfering with or affecting the traveling public. Located on 230 acres at the Lewistown Municipal Airport, including four miles of paved test track, its many other features will include: data acquisition and communication infrastructure, heated garage space and a place to handle study participants for human factors research. Furthermore, because the TRANSCEND facility is secluded from traffic, has wide paved areas, and is under the direct supervision and guidance of WTI staff, it is the ideal place to conduct research in a safe and controlled manner.

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