V(A). Planned Program (Summary)

Program # 7

1. Name of the Planned Program

Climate Change -- Water Quality and Use

V(B). Program Knowledge Area(s)

1. Program Knowledge Areas and Percentage

KA Code	Knowledge Area	%1862 Extension	%1890 Extension	%1862 Research	%1890 Research
111	Conservation and Efficient Use of Water			30%	
112	Watershed Protection and Management			30%	
610	Domestic Policy Analysis			10%	
903	Communication, Education, and Information Delivery			30%	
	Total			100%	

V(C). Planned Program (Inputs)

1. Actual amount of professional FTE/SYs expended this Program

Year: 2010	Extension		Research	
	1862	1890	1862	1890
Plan	0.0	0.0	20.0	0.0
Actual	0.0	0.0	14.6	0.0

2. Actual dollars expended in this Program (includes Carryover Funds from previous years)

Extension		Research	
Smith-Lever 3b & 3c	1890 Extension	Hatch	Evans-Allen
0	0	183916	0
1862 Matching	1890 Matching	1862 Matching	1890 Matching
0	0	763267	0
1862 All Other	1890 All Other	1862 All Other	1890 All Other
0	0	487016	0

V(D). Planned Program (Activity)

1. Brief description of the Activity

• An on-line, experiential course in the science of water quality for secondary science teachers who may be struggling with other time commitments is developed
• Better utilization of limited water resources in Montana
• Research results will be communicated in meetings with key organizations who impact decisions on water quality and quantity
• Results from research will help to mitigate potential economic losses or disasters from inadequate or excessive water related events

2. Brief description of the target audience

• U.S. Geological Survey (USGS)
• National Resources Conservation Service (NRCS)
• The Montana Department of Natural Resources and Conservation (DNRC)
• Irrigation districts, conservation districts and downstream and instream users
• Secondary education science teachers.

V(E). Planned Program (Outputs)

1. Standard output measures

2010	Direct Contacts Adults	Indirect Contacts Adults	Direct Contacts Youth	Indirect Contacts Youth
Plan	400	400	0	0
Actual	500	750	0	0

2. Number of Patent Applications Submitted (Standard Research Output)

Patent Applications Submitted

Year: 2010
Plan: 0
Actual: 0

Patents listed

3. Publications (Standard General Output Measure)

Number of Peer Reviewed Publications

2010	Extension	Research	Total
Plan	0	5	
Actual	0	26	26

V(F). State Defined Outputs

Output Target

Output #1

Output Measure

- Number of research citations.

Year	Target	Actual
2010	14	18

Output #2

Output Measure

- Successful external grants

Year	Target	Actual
2010	2	2

V(G). State Defined Outcomes

V. State Defined Outcomes Table of Content

O. No.	OUTCOME NAME
1	Number of devices and models created for measuring the transport and fate of compounds.
2	Improved management systems for water quality and quantity.
3	Educational programs that address water resource use.
4	Number of landscape scale datasets created.
5	Number of improved prediction capacity models for snowpack/runoff into rivers and for instream flow.
6	Number of land and water use policies and practices developed by providing a scientific basis.

Outcome #1

1. Outcome Measures

Number of devices and models created for measuring the transport and fate of compounds.

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Condition Outcome Measure

3b. Quantitative Outcome

Year	Quantitative Target	Actual
2010	2	1

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
Soil water is a primary limiting factor for plant growth in semiarid and arid regions like Montana. In order to provide sustainability to Montana producers and urban dwellers, several programs are in place to evaluate, monitor, accurately measure quantity (and some quality characteristics), and provide cropping and irrigation recommendations to agricultural and urban stakeholders. Improved ability to monitor soil water and chemical distributions in soils will contribute to better land management opportunities. Target audiences include scientists, graduate students, land managers, federal and state agency personnel, and commercial developers or vendors of sensors and instrumentation.

What has been done
Projects have been developed to improve methods to measure soil water and improve understanding of soil water dynamics. We are investigating critical drivers and relationships that govern catchment water, carbon, and gas behavior and movement. One project focuses on developing, evaluating, and applying innovative approaches to characterize and manage water and chemicals in soils, and on evaluating interrelationships among soils, vegetation, water, and related soil physical properties.

Results
Research fills critical gaps in our knowledge about soil water availability in space and time and the soil processes controlling carbon cycling, global change ecology, and soil gas emissions. New methods to characterize soil water status, solute transport, and related soil properties and processes have been developed.

4. Associated Knowledge Areas

KA Code	Knowledge Area

111	Conservation and Efficient Use of Water
112	Watershed Protection and Management

Outcome #2

1. Outcome Measures

Improved management systems for water quality and quantity.

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Condition Outcome Measure

3b. Quantitative Outcome

Year	Quantitative Target	Actual
2010	1	1

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
Soil nutrients, crop rotation, and irrigation water need to be carefully managed for optimum economic return in crop production and environmental stewardship. Information is provided to producers, consultants, and agency personnel on soil fertility, crop rotation, and specialty crop production for Montana. Evaluating watersheds to determine the best integrated approaches for raising crops, grazing livestock, and other uses, will help protect riparian areas, will improve our State's fisheries and wildlife habitat, and will sustain recreational opportunities for Montana sportsmen and recreationalists. Land management coupled with an increased understanding of watershed processes influences future land management practices.

What has been done
Finding crops that require less water per acre and will grow in our short growing season requires innovative solutions. This is being partially accomplished through our extensive crop breeding programs, water management research, the introduction of new drought tolerant crops, along with other conservation practices. In addition, enhancing our knowledge of water quantity and quality will also influence water-related decisions. The development of critical research information on irrigated cropping systems by the cooperative installation, deployment, and use of precision irrigation systems is providing information on the role these systems play in improving water and soil quality.

Results
Irrigation management and cultural practices that promote water use efficiency, reduce negative effects of soil compaction, and enhance environmental benefits have been developed. The effect of farming practices and the interaction among irrigation methods, crop rotation, and tillage is generating quantitative data on yields, pest problems, and soil water movement. Water quality

and irrigation management bulletins are made available by crop to producers in Montana. The right combination of irrigation and fertilizer management practices can add significantly to yields of Montana crops when compared to dryland cropping.

4. Associated Knowledge Areas

KA Code	Knowledge Area
111	Conservation and Efficient Use of Water
112	Watershed Protection and Management

Outcome #3

1. Outcome Measures

Educational programs that address water resource use.

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Condition Outcome Measure

3b. Quantitative Outcome

Year	Quantitative Target	Actual
2010	2	5

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
By maintaining or improving watershed quality, we can protect human health and drinking water, ensure sustainability of irrigated agriculture within the watershed, and protect water quality and quantity. We are currently faced with a need to protect and promote water quality in pristine, agricultural, and impacted watersheds. Target audiences of outreach activities to date have been irrigators, the general public in communities near irrigation projects, and students enrolled in watershed management classes. Improving the quality of watersheds in Montana should be a goal of all rural and urban residents.

What has been done
The protection of riparian areas is one of our primary tools for increasing insight into the impact of human alteration of natural landscapes. MSU research projects include numerous experiments performed, watersheds instrumented, data collected, analysis completed, course taught, and graduate and undergraduate researchers trained.

Results
Research activities have been performed in four geographic areas in Montana and Idaho and

have included undergraduates and graduate students in these activities. These activities have lead to invited university and international meeting presentations. One research program is generating information on riparian zone buffering of upland runoff, stream-catchment connections, groundwater surface water mixing, the exchange of carbon and water between the land and the atmosphere, and the impacts on water of human encroachment in mountain watersheds.

4. Associated Knowledge Areas

KA Code	Knowledge Area
111	Conservation and Efficient Use of Water
112	Watershed Protection and Management
903	Communication, Education, and Information Delivery

Outcome #4

1. Outcome Measures

Number of landscape scale datasets created.

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Condition Outcome Measure

3b. Quantitative Outcome

Year	Quantitative Target	Actual
2010	2	2

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
Wetland and riparian zones provide a variety of ecological services that contribute to overall water management at local, watershed, and regional scales. Wetlands can effectively minimize sediment loss, control runoff volume, purify surface water, and enhance aquifer recharge. Wetlands and riparian areas are highly diverse ecosystems that have significant variability of physical properties. Excellent wetland management can positively affect agriculturalists as well as municipalities.

What has been done
The shape, size, and distribution of wetland and riparian zones are largely determined by geologic, topographic, and hydrologic conditions. We continue to develop a better understanding of the relationships among watershed factors and mapping the results. The results of our research provide valuable information and tools to Montanans who rely on water resources for agricultural and urban activities.

Results
Combining automated classifications with remote sensing data can quickly and accurately determine the location of small, isolated, and highly variable ecosystems, thus enabling systematic monitoring of watersheds, including riparian areas. Data collection and the utilization of effective sampling protocols for determining landscape variability have been investigated using remote sensing procedures and on-the-ground measurements.

4. Associated Knowledge Areas

KA Code	Knowledge Area
111	Conservation and Efficient Use of Water
112	Watershed Protection and Management

Outcome #5

1. Outcome Measures

Number of improved prediction capacity models for snowpack/runoff into rivers and for instream flow.

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Condition Outcome Measure

3b. Quantitative Outcome

Year	Quantitative Target	Actual
2010	1	1

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
The winter accumulation of snowpack in the Rocky Mountains is critical to the availability of water for agricultural irrigation during summer months when rainfall is often limited. Sustainable management of water is one of the biggest challenges we face in an era of increasing water demand (through population growth and better living standards) and climatic uncertainty and change. For improved forecasting and water resource management there is a need for quantifying factors affecting watersheds. The uncertainty of potential climatic changing scenarios increases the need for quantifiable results.

What has been done
The development and assessment of watershed models to describe the rainfall-runoff process has been a chief focus of hydrological studies for many decades. Projects at MSU have been established to monitor snowpack and runoff timing in several watersheds to develop relationship

models with key universal parameters. Hydrological models allow expansion and management of water resources, and ensure better interpretation or prediction of physical phenomena.

Results
Work is in progress to develop a model predicting snowpack/runoff into rivers and for in-stream flow. This project will take several years to collect, test, and refine collection methodologies and apply catchment and solute transport models. In mountainous areas across the western United States winter snowpack controls regional water resources partially because of the greater water deposition, accumulation, storage, and reduced evaporation until spring snowmelt. Hydrologic models play an important role in quantifying watershed processes, allowing hypothesis testing about watershed processes with observed data and forecasting of hydrologic variables under future predicted conditions. The project will develop tools for building and manipulating a range of hydrologic models under varying uncertainty.

4. Associated Knowledge Areas

KA Code	Knowledge Area
111	Conservation and Efficient Use of Water
112	Watershed Protection and Management

Outcome #6

1. Outcome Measures

Number of land and water use policies and practices developed by providing a scientific basis.

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Condition Outcome Measure

3b. Quantitative Outcome

Year	Quantitative Target	Actual
2010	2	1

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
Maintaining water quality is a priority of agriculture and industry. All Montanans have a well-defined connection to our water resources, whether it is for consumption, recreation, irrigation, or quality of life. We are faced with a need to protect and promote water quality in pristine, agricultural, and impacted watersheds. Protecting riparian areas is one of the primary tools we are investigating.

What has been done
Since coal bed methane is a potential source of diversified income for many of our Native American tribes and large landowners in sparsely populated eastern Montana, MSU is working with tribes, constituents, and other states to develop models that will establish policies for energy companies and land managers to appropriately reuse the water, protect surface and underground systems, and protect soil and plant resources.

Results
We have developed management guidelines for salinity and sodicity standards applicable to Montana climate, crops, and soil on Tribal lands. We have also established a benchmark research site to examine the impact that mountain resort development has on stream function and water quality. The results of our study will give insight into the impact of human alteration of natural landscapes. We are working on processes important to understanding the fate of organic contaminants in soils and the potential for contamination of surface and ground waters. Our role is to identify mechanisms by which pesticides and other organics interact in soils especially identifying those factors controlling microbial population dynamics and subsequent degradation of specific compounds present in contaminated soils.

4. Associated Knowledge Areas

KA Code	Knowledge Area
111	Conservation and Efficient Use of Water
112	Watershed Protection and Management
610	Domestic Policy Analysis

V(H). Planned Program (External Factors)

External factors which affected outcomes
- Natural Disasters (drought, weather extremes, etc.)
- Appropriations changes
- Public Policy changes
- Government Regulations

Brief Explanation

Snowpack in major western watersheds dramatically influences the availability of irrigation water during the summer months. Although current predictions are favorable, growers need to continue to judiciously monitor water resources.

V(I). Planned Program (Evaluation Studies and Data Collection)

1. Evaluation Studies Planned

- After Only (post program)
- Retrospective (post program)

Evaluation Results

Water management plans are being used by growers who irrigate small grains, row crops, and alfalfa/hay pastures. The plans are also important to livestock producers who graze livestock near riparian areas. The adoption of these plans is apparent in the reduction of the number of habitat disturbances in sensitive environmental areas.

Key Items of Evaluation

Water management innovations are being adopted by producers and land managers.