US Army Corps of Engineers
Omaha District

DRAFT ENVIRONMENTAL ASSESSMENT
&
FINDING OF NO SIGNIFICANT IMPACT

Pilot Study for the Upper Missouri River Basin Water Management
Plains Snow and Soil Moisture Monitoring Network

January 2020

Prepared by:
U.S. Army Corps of Engineers, Omaha District
Environmental Resources and Missouri River Recovery Program Plan Formulation Section
Planning Branch, CENWO-PM-AC
1616 Capitol Avenue
Omaha, Nebraska 68102

DRAFT FINDING OF NO SIGNIFICANT IMPACT

Pilot Study for the Upper Missouri River Basin Water Management Plains Snow and Soil Moisture Monitoring Network

January 2020

In accordance with the National Environmental Policy Act (NEPA) and implementing regulations, an Environmental Assessment (EA) has been prepared for the proposed modification of three existing proof-of-concept monitoring stations in South Dakota, Wyoming and Montana as part of a pilot study for the soil moisture and plains snowpack monitoring network in the Upper Missouri River Basin (UMB) in Montana, Wyoming, North Dakota, South Dakota and northern Nebraska. The purpose of the proposed project is to field test efficacy of meteorological equipment and installation methods prior to a proposed basin-wide deployment of 500-600 snowpack and soil moisture monitoring stations. The basin-wide deployment of the mesonet would meet the intent of the Water Resources Reform Development Act of 2014, which dictated the need for a soil moisture and plains snowpack monitoring network to reduce flood risk and improve river and water resource management in the UMB. The large-scale deployment of these monitoring stations will be assessed in a later Programmatic EA

Two alternatives were analyzed, the No Action Alternative and the Action Alternative of updating three monitoring stations in Brookings, South Dakota, Sheridan, Wyoming and Bozeman Montana. The Action Alternative for the proof-of-concept pilot stations would provide additional and necessary information for the mass deployment of the larger mesonet. The No Action Alternative is carried through analysis in order to establish a baseline of present conditions and the future of the proposed project area without action.

The EA and comments received from the resource agencies were used to determine whether the proposed action would require the preparation of an Environmental Impact Statement. All environmental, social, and economic factors relevant to the proposal were considered in this EA. No significant adverse impacts to these resources are expected to occur. The proposed action will be in compliance with applicable environmental statutes.

It is my finding, based on the EA that the proposed federal activity will not have any significant adverse impacts on the environment and will not constitute a major federal action significantly affecting the quality of the human environment. Therefore, an Environmental Impact Statement will not be prepared.

Date: _____

_____

John Hudson, P.E.
Colonel, Corps of Engineers
District Commander

Table of Contents

List of Figures

List of Appendices

DRAFT ENVIRONMENTAL ASSESSMENT

Pilot Study for the Upper Missouri River Basin Water Management
Plains Snow and Soil Moisture Monitoring Network

January 2020

1. INTRODUCTION

The U.S. Army Corps of Engineers, Omaha District (Corps) has prepared this Environmental Assessment (EA) in accordance with the National Environmental Policy Act (NEPA) of 1969, as amended (42 U.S. Code [USC] 4321 et. seq.); the President's Council on Environmental Quality (CEQ) Regulations (40 Code of Federal Regulations [CFR] 1500 – 1508) (CEQ, 1992); and Engineer Regulation (ER) 200-2-2 (33 CFR 230) (USACE, 1988).

1.1 Project Background

Following the 2011 flood event on the Missouri River, the Corps and an Independent Review Team comprised of academic expertise and officials from various federal agencies, determined that the Corps substantially underestimated the wet soil conditions in the plains and the plains snowpack in its water supply forecasts. One finding from the 2013 *Upper Missouri River Basin Monitoring Committee: Snow Sampling and Instrumentation Recommendations* interagency report was to improve snowpack and soil moisture monitoring in plains area of the upper Missouri River basin, specifically Montana, North Dakota, South Dakota and Wyoming. This report described existing federal and state data collection networks (mesonet) in the upper Missouri River basin that provide some information about soil moisture or snowpack as well as existing data collection networks that do not currently collect data on soil moisture and/or snowpack but may be modified to do so. Presently, there are approximately 180 existing mesonet sites in seven networks in the upper Missouri River basin that collect soil moisture and snowpack data, or may be modified to collect these data. An estimated additional 360 sites are required in order to provide the necessary quality of data to better inform runoff forecasting.

From December 2018 through July 2019, instrumentation and measurement techniques were conducted by climatologists with the South Dakota State University (SDSU) in Brookings, South Dakota on SDSU's campus as funded by the Corps. This work was carried out in order to determine a variety of automated and manual observations to test the practicability and accuracy of different technologies before deployment of a full plains snowpack and soil moisture monitoring network in the UMB. Testbed experiments compared different technologies for measuring solar radiation, precipitation, snow depth, snow water equivalent and soil temperature and moisture. The complete SDSU Hydrologic Testbed Report may be found in Appendix A.

The second phase of this effort includes a pilot study as a "proof-of-concept" where one existing monitoring station within each of the five states would be upgraded to test recommended equipment and installation methodologies prior to basin-wide deployment. This EA will only assess the impacts of upgrading the stations in Brookings, South Dakota, Sheridan, Wyoming and Bozeman, Montana. The states of North Dakota and Nebraska have elected to upgrade their respective pilot stations without the assistance of federal funding in Carrington, North Dakota

and in Eagle, Nebraska and are therefore not subject to NEPA. Upon implementation of these pilot sites, and the lessons learned associated with the proof-of-concept process, the deployment of the larger system is planned. Currently, the Omaha District is developing a Programmatic Environmental Assessment (PEA) of that effort in order to assess the impacts of the deployment of the larger system, and to establish the process of deployment to minimize the potential effects to the human and natural environment.

1.2 Project Authority

The proposed project is authorized under the Water Resources Reform Development Act (WRRDA) of 2014, as amended by §1179(b) of the Water Infrastructure Improvements for the Nation Act (WIIN) of 2016. WRRDA14 included a requirement that the Secretary of the Army, in coordination with the Administrator of the National Oceanic and Atmospheric Administration (NOAA), the Chief of the Natural Resources Conservation Service (NRCS), the Director of the United States Geological Survey (USGS) and the Commissioner of the Bureau of Reclamation (BOR) to carry out snowpack and soil moisture monitoring in the Upper Missouri River Basin (UMB). This included soil moisture and snowpack monitoring in the UMB to reduce flood risk and improve river and water resource management, to restore and maintain existing mid- and high elevation snowpack monitoring sites operated under the NRCS snow telemetry (SNOTEL) program and operating streamflow gages and related interpretive studies in the UMB under the USGS cooperative water program and the national streamflow information program. WIIN16 modified WRRDA14, designating the Corps as the lead federal agency.

1.3 Project Location

The three pilot stations are located in Brookings, South Dakota on the SDSU Campus, Sheridan Wyoming on University of Wyoming (UW) property and Montana State University's (MSU) campus in Bozeman, Montana (See Figures 1 through 3 in Section 3.2).

2. PURPOSE AND NEED

The purpose of the proposed project is to achieve a proof-of-concept prior to basin-wide implementation of a soil moisture and plains snowpack monitoring network in order to provide sufficient data for various federal, state and local agencies to improve forecasting for respective operational needs. Specifically identified in WRRDA14, the need for a soil moisture and plains snowpack monitoring network is required to reduce flood risk by improving runoff prediction to better inform river and water resource management decision making in the UMB, restore and maintain existing mid- and high elevation snowpack monitoring sites operated under the SNOTEL program and to operate streamflow gages and related interpretive studies in the UMB under a cooperative program with USGS. The overall basin-wide deployment of the mesonet would be assessed under a PEA.

3. ALTERNATIVES CONSIDERED

As mentioned, SDSU conducted a testbed comparison of different instrumentation technologies to measure several meteorological variables. The purpose of this effort was to identify the most cost effective and accurate instrumentation to collect the desired level of meteorological data. This process and the proof-of-concept phase would assist in the development of the Preferred Alternative for basin-wide deployment by screening equipment and methodologies.

3.1 Alternative 1: No Action

Under the No Action Alternative, no deployment of three proof-of-concept pilot stations in South Dakota, Wyoming or Montana would occur. Without proof of concept, the capability and effectiveness of the larger system could be compromised to some degree. The approximate 180 existing sites would continue to be operated as currently designed. The Corps, NRCS, USGS, BOR and NOAA would continue to collect data provided by these stations for forecasting respective operations in the UMB. However, the No Action Alternative would not meet the purpose and need described in Section 2. The need for an accurate and adequate monitoring network is imperative for real-time weather detection and storm preparation.

The No Action Alternative is brought forward through analysis of environmental impacts as it provides a benchmark with which to compare environmental, social and economic impacts and benefits of an action alternative.

3.2 Alternative 2: Update Three Existing Monitoring Stations (Preferred Alternative)

The Preferred Alternative is Alternative 2, which includes the updating two existing monitoring stations and installation of one new monitoring station with the appropriate equipment in South Dakota, Wyoming and Montana, respectively.

3.2.1 South Dakota Monitoring Station

Proposed efforts for the pilot station on SDSU's campus include the addition or update of a data logger, 4G modem, camera, ultrasonic snow depth sensor, weighing precipitation gauge with shield, thermometer/hygrometer with shield, pyranometer, wind monitor and power system. Additionally, a corral panel fence will enclose the monitoring station and a 30-foot tower will be installed. Existing equipment includes soil moisture sensors and a foundation for the weighing precipitation gauge. The total footprint of the monitoring station is approximately 30 feet by 30 feet (900 square feet [sqft]). No ground disturbance is anticipated. See Figure 1 for the proposed siting location.

Figure 1. SDSU pilot station on campus property

3.2.2 Wyoming Monitoring Station

The existing monitoring station of UW presently has soil moisture sensors. Needed equipment to bring this station to the standards of plains snowpack and soil moisture mesonet include the addition or update of a data logger, 4G modem, camera, ultrasonic snow depth sensor, weighing precipitation gauge with shield, foundation for the weighing precipitation gauge, thermometer/hygrometer with shield, pyranometer, soil moisture sensor, wind monitor and power system. This site would also require a corral panel fence and a 30-foot tower to be installed. Minimal ground disturbance would be required to install the soil moisture probes to a 100cm depth. The total footprint of the disturbed area would be 900 sqft. See Figure 2 for the proposed siting location.

Figure 2. UW pilot monitoring station location on UW-owned property

3.2.3 Montana Monitoring Station

The location for the pilot monitoring station at MSU was selected as the area had been previously disturbed and utilized for a weather station. This monitoring station would be newly constructed and require all equipment. This includes a data logger, 4G modem, camera, ultrasonic snow depth sensor, weighing precipitation gauge with shield, foundation for the weighing precipitation gauge, thermometer/hygrometer with shield, pyranometer, soil moisture sensor, wind monitor and power system as well as a corral panel fence and a 30-foot tower to be installed. The proposed project footprint would also be 900 sqft. Minimal ground disturbance would be required to install the soil moisture probes to a 100 cm depth and pour the foundation for the weighing precipitation gauge. Additionally, two hand pits with approximate dimensions of 45X45X80 cm and 45X45X150 cm would be required to accommodate the monitoring equipment. See Figure 3 for the proposed siting location.

Figure 3. MSU pilot monitoring station on campus property

4. EXISTING CONDITIONS AND ENVIRONMENTAL CONSEQUENCES

The current environmental conditions and the resources listed below provide information where it exists and references important information from previous documentation regarding current conditions. The affected environment in the proposed project area was assessed through aerial photographs and literature searches.

Additionally, this section presents the probable consequences (i.e., adverse and beneficial effects) of the proposed action and its alternatives on selected resource categories as appropriate. An assessment of the environmental consequences provides the scientific and analytic basis for alternative comparison. Impacts are described in terms of duration and intensity:

Impact Duration: The following terms will be used to describe the duration of an impact.

1) Short-term: Temporary impacts caused by the construction and/or implementation of an alternative.
2) Long-term: Impact persists after the action has been completed and/or after the action is in full and complete operation.

Impact Intensity and Context:

1) Negligible: Impacts may occur, but the change would be localized and so small that it would not be of any measurable or perceptible consequence.

2) Minor: Impact could result in a change to a population or individuals of a species or to a portion of a habitat or resource. The change would be measurable but small, localized, and of little consequence to the resource.

3) Moderate: Impact could result in some change to a population or individuals of a species or habitat. The change would be measurable and of consequence, but would be of moderate scale and would occur over a limited area.

4) Major: Impact could result in a considerable change to a population or individuals of a species or resource or habitat. The change would be measurable, extensive, and would occur over a wide geographic area.

4.1 Resources Eliminated from Environmental Consequence Analysis

The following resources have been considered and not found to be affected by the proposed alternative. Where no potential effects have been identified, the resource has been eliminated from further evaluation and analysis.

4.1.1 Physiography/Topography

The localized footprints of the pilot monitoring stations on SDSU and MSU are located on previously disturbed campus areas. The monitoring station in Sheridan is located approximately 0.75 miles west of the Symons Airport on UW property. The Sheridan location and the SDSU location are existing monitoring stations that will require updating and replacement of equipment

as described in Section 3.2.1 and 3.2.2. The location at MSU has been utilized previously for a weather station but will require the installation of an entirely new monitoring station as no station currently exists. The proposed upgrading of equipment and installation of a new monitoring station at these sites is anticipated to have no effect on the physiography and topography of the localized and regional areas.

4.1.2 Climate

The upgrading of the equipment and installation of a monitoring station at the three locations is expected to have no effect on the climate.

4.1.3 Wetlands

All three locations are on previously disturbed, upland areas. No wetlands are within the proposed project footprints. Thus, no effect to wetland resources are anticipated.

4.1.4 Water Quality

The proposed upgrading of equipment and installation of a new monitoring station are located on previously disturbed areas and not near any water resources. No effect to water quality is anticipated.

4.1.5 Air Quality

The upgrading of equipment and installation of a monitoring station at the three locations would not require heavy machinery and the operation of the monitoring stations would not contribute to particulate matter or air pollution and thus would have no effect on air quality.

4.1.6 Noise

Installation of a new monitoring station and upgrading of equipment would require minimal ground disturbance and no heavy machinery. No effect to the noise condition of the proposed project location is anticipated.

4.1.7 Fish and Wildlife

Generalist wildlife likely occurs on these campus properties; however, generalist species typical of urbanized and residential locations would be accustomed to human presence and human activities. Installation of new equipment on these campus locations would have no effect on native fish and wildlife. The South Dakota Game, Fish and Parks (SDGFP) and the U.S. Fish and Wildlife Service (USFWS) South Dakota Ecological Services (ES) office, the Wyoming Game and Fish Department (WGFD) and USFWS Wyoming ES office were contacted on December 12, 2019 requesting comments on the proposed proof-of-concept stations. On December 12, 2019, SDGFP and WGFD stated they had no concerns. Montana Fish, Wildlife and Parks (MFWP) and USFWS Montana ES office were contacted on December 17, 2019 to provide information about the proposed proof-of-concept site at MSU. Montana USFWS provided an email response, dated December 18, 2019 stating their organization had no comments or concerns with the proposed proof-of-concept monitoring stations. WGFD and SDGFP responded on December 18 and December 12, 2019, respectively, indicating their respective agencies had no concerns with the proposed proof-of-concept pilot stations. MFWP responded on December 20, 2019 stating they had no concerns with the proposed updates to the proof-of-concept pilot stations. No response was received from the Wyoming or South Dakota USFWS.

4.1.8 Threatened and Endangered Species

As discussed above, the appropriate USFWS ES offices were contacted to provide information on the proposed proof-of-concept sites and solicit comments or concerns. The USFWS' Information for Planning and Consultation (IPAC) was consulted to determine potential threatened and endangered (T&E) species within the proposed project areas. No T&E species were noted as having potential to occur at the UW site. The Canada lynx (*Lynx canadensis*), grizzly bear (*Ursus arctos horribilis*) and North American wolverine (*Gulo gulo luscus*) were identified as having potential to occur at the MSU location. The northern long-eared bat (*Myotis septentrionalis*), red knot (*Calidris canutus*), Topeka shiner (*Notropis topeka*), Dakota skipper (*Hesperia dacotae*), Poweshiek skipperling (*Oarisma poweshiek*) and the western prairie fringed orchid (*Platanthera praeclara*) were identified as T&E species that have the potential to occur at the SDSU location. A *no effect* determination was made for all listed species at the MSU location and the SDSU location. It is not anticipated these species would occur on main campus areas, nor do these locations or adjacent areas support the appropriate habitat to meet the life requirements of these species. USFWS was contacted on December 12 and December 17, 2019 to inform the *no effect* determination and solicit comments and concerns from USFWS. Montana USFWS provided an email response, dated December 18, 2019 stating their organization had no comments or concerns with the proposed proof-of-concept monitoring stations. WGFD and SDGFP responded on December 18 and December 12, 2019, respectively, indicating their respective agencies had no concerns with the proposed proof-of-concept pilot stations. MFWP responded on December 20, 2019 stating they had no concerns with the proposed updates to the proof-of-concept pilot stations. No response was received from the Wyoming or South Dakota USFWS.

4.1.9 Socioeconomics and Environmental Justice

The proposed project would take place on main campus property at SDSU and MSU and on university property in Wyoming and would have no effect on the socioeconomic condition of the area nor would it adversely impact minority populations.

4.1.10 Recreation

Recreational areas do not exist within the proposed project areas and thus, no effect to this resource is anticipated.

4.2 Relevant Resources Brought Forward

The following contains a description of relevant resources that could be impacted by the project. The important resources described in this section are those recognized by laws, executive orders, regulations, and other standards of national, state, or regional agencies and organizations; technical or scientific agencies, groups, or individuals; and the general public.

4.2.1 Soils

NRCS' WebSoil Survey was consulted to determine the type and characteristics of the soils present at each monitoring station location. Soils at the SDSU location are comprised of Barnes clay loam on 0 to 2 percent slopes. The monitoring station at UW is comprised of Wyrano clay loam soils on 0 to 3 percent slopes. Soils at the MSU location are comprised of Blackmore silt loam on 0 to 4 percent slopes. These soils are representative of the desired soil characteristics

identified for the larger mesonet effort. This includes parent material type, percent of clay present which directly correlates to its moisture holding capability and on flat slopes with a well-drained drainage class.

4.2.1.1 No Action

Under the No Action Alternative, no proof-of-concept monitoring stations would be constructed or upgraded. A PEA would still be conducted for the proposed larger mass deployment of monitoring stations; however, it would not have the benefit of conducting a smaller pilot study prior to the investment of resources into the larger proposed mesonet. No anticipated impacts to soils would occur under the No Action Alternative.

4.2.1.2 Alternative 2 (Preferred Alternative)

Under the proposed project, work would involve minor clearing of ground cover and low-growing vegetation in order to accommodate necessary equipment upgrades and replacement within a 900 sqft area for each individual station. The station at MSU and SDSU are presently monitoring meterological data and require little ground disturbance, with the exception of installing soil probes to a depth of 100cm. The location at UW was previously used as a monitoring station; therefore, converting the area back to this land use will require minimum ground disturbance. Upon completion of installation of equipment, bare soil would be revegetated with a native seed mix resonant to the site location. Impacts are considered negligible and temporary.

4.2.2 Migratory Birds and Raptors

The bald eagle (*Haliaeetus leucocephalus*) was federally listed as a threatened species under the ESA (7 U.S.C. § 136, 16 U.S.C § 1531) in 1973 though they were officially declared as endangered prior to the ESA in 1967. On August 9, 2007, the bald eagle was removed from the federal list of threatened and endangered species but continues to be protected under the Bald and Golden Eagle Protection Act (16 U.S.C. § 668-668d), Migratory Bird Treaty Act (MBTA) (16 U.S.C. § 703-712, though §709 is omitted) and the Lacey Act (16 U.S.C. § 701). Bald eagles are known to inhabit riparian and lacustrine habitats. These birds tend to construct their nests in mature trees near aquatic habitats, especially in cottonwood trees. Bald eagle nests are typically easy to identify due to their large size and their height (they can be eight feet or more in diameter and 12 feet or more in height). They feed primarily on fish and crippled waterfowl, but may feed on upland game birds and other birds, carrion, and small rodents.

All federal agencies are subject to the provisions of the MBTA which regulates the take of any migratory bird species. If a Corps project is expected to impact any migratory bird species, coordination with the USFWS is typically initiated in order to minimize impacts to these species. The project locations fall within the Central Flyway Route which merges easterly towards the Mississippi Flyway as it follows along the Missouri River.

4.2.2.1 No Action

Under the No Action Alternative, no proof-of-concept monitoring stations would be upgraded or constructed. No direct or indirect adverse or beneficial impacts to migratory birds and raptors would be anticipated.

4.2.2.2 Alternative 2 (Preferred Alternative)

Several studies have correlated a direct impact between communication towers and avian mortality. Specifically, a variety of factors may contribute to or decrease the likelihood of bird collisions. These factors may include location of placement in the landscape, daily weather conditions, tower height, tower lighting and the use of guy wires.

The USFWS Migratory Bird Program has produced recommended best management practices (BMPs) for the design, siting, construction, operation, maintenance and decommissioning of communication towers (USFWS, 2018). USFWS recommends towers should not be more than 199 feet above ground level in order to provide adequate airspace between the top of a tower and average bird flight height. The tower height for the proposed proof-of-concept monitoring stations is 30 feet above ground level. USFWS also recommends using free-standing towers to eliminate the need for guy wiring. The tower type for the proposed proof-of-concept sites is a free-standing, tri-leg model that would not require the use of guy wires. Furthermore, the USFWS recommends no tower lighting where Federal Aviation Administration (FAA) regulations and standards permit. Lighting systems on towers may cause birds to become disoriented or may attract birds to the tower, thus increasing the likelihood of bird collisions. No lighting would be required for the towers at the proposed proof-of-concept monitoring stations. The proposed project would fit within these recommendations. Should the Preferred Alternative be implemented, negligible and long-term impacts may occur to migrating birds and raptors. It is anticipated that the BMPs and the placement of the towers in previously disturbed, upland locations would minimize the risk of adverse impacts to migrating birds.

4.2.3 Vegetation

Vegetation of the proof-of-concept sites is comprised of manicured turf grasses. Two of the pilot stations would be located on the campus area of MSU and SDSU, and the third pilot station is located on university property where a weather station previously existed.

4.2.3.1 No Action

Under the No Action Alternative, no direct or indirect impacts are anticipated to occur to vegetation.

4.2.3.2 Alternative 2 (Preferred Alternative)

Under the Preferred Alternative, no woody vegetation would be removed and clearing and grubbing activities would be limited to the 45X45X80 cm and 45X45X150 cm hand-dug pits necessary for updating the monitoring station at MSU and potentially for ground-leveling purposes for pouring the foundation for the weighing precipitation gauge at UW. Seeding bare areas with turf grasses immediately following installation activities would occur. Should the Preferred Alternative be implemented, negligible and temporary impacts are anticipated to occur.

4.2.4 Cultural Resources

Cultural resources is a general term accounting for both the material and social fabric of the human environment. Tangible cultural resources include districts, sites, buildings, structures, and objects. Commonly, tangible cultural resources include prehistoric Native American archeological sites, historic archeological sites, both designed and coincidental landscapes—such

as public gardens or battlefields—structures such as bridges and trails, and buildings. When tangible cultural resources possess the quality of significance and the necessary aspects of integrity to convey their significance, as defined in 36 CFR 60.4, they are historic property. The National Historic Preservation Act of 1966 (NHPA) requires that an agency account for the effects of projects involving Federal land, funds, or permitting.

Compliance with the NHPA (Public Law 89 80-655), as amended, and other applicable laws and regulations requiring Federal agencies to take into account the effects of their undertakings on historic properties within the proposed undertaking's area of potential effect (APE), typically involve studies to identify historic property. These studies often require archival searches, remote sensing, and field surveys to identify if any tangible cultural resources are present. Any tangible cultural resources identified are evaluated for significance and integrity to determine if they are historic property. Where historic properties are identified, efforts are made to avoid them, avoid causing adverse effects, and preserve them in place. If any historic property cannot be avoided and would be adversely affected, an appropriate mitigation plan must be implemented.

4.2.4.1 No Action

Under the No Action Alternative, no proof-of-concept sites would be installed or updated with the necessary equipment. No impact to cultural resources is anticipated.

4.2.4.2 Alternative 2 (Preferred Alternative)

A file search was conducted by a Corps archeologist within the proposed project footprint in Wyoming, South Dakota and Montana on December 20, 2019. Given the project specifics, it was determined the proposed undertaking has no potential to cause effects to historic property. Therefore, no impact to cultural resources is anticipated under this alternative.

5. CUMULATIVE EFFECTS

The combined incremental effects of human activity are referred to as cumulative impacts (40 CFR 1508.7). While these incremental effects may be insignificant on their own, accumulated over time and from various sources, they can result in serious degradation to the environment. The cumulative impact analysis must consider past, present and reasonably foreseeable actions in the study area. The analysis also must include consideration of actions outside of the Corps, to include other state and federal agencies. As required by NEPA, the Corps has prepared the following assessment of cumulative impacts related to the alternatives being considered in this EA.

Past Actions

As discussed in Section 1.1, following the 2011 flood event on the Missouri River, the Corps and an Independent Review Team comprised of academic expertise and officials from various federal agencies, determined that the Corps substantially underestimated the wet soil conditions in the plains and the plains snowpack in its water supply forecasts. Presently, there are approximately 180 existing mesonet sites in seven networks in the upper Missouri River basin that collect soil moisture and snowpack data, or may be modified to collect these data. An estimated additional

360 sites are required in order to provide the necessary quality of data to better inform runoff forecasting.

From December 2018 through July 2019, instrumentation and measurement techniques were conducted by climatologists with the SDSU to determine a variety of automated and manual observations to test the practicability and accuracy of different technologies before deployment of a full plains snowpack and soil moisture monitoring network in the UMB. The complete SDSU Hydrologic Testbed Report may be found in Appendix A.

Present Actions

Following this localized study to conclude the appropriate required equipment, a secondary phase to implement the proposed proof-of-concept monitoring stations was determined on five sites in the five states prior to mass-deployment to refine installation techniques. The states of North Dakota and Nebraska determined to update their monitoring station without the use of federal funding. The remaining three states of Wyoming, Montana and South Dakota elected to utilize federal funding and thus are subject to environmental compliance laws and regulations required of federalized projects.

Reasonably Foreseeable Actions

The intent of the proof-of-concept monitoring sites is to be installed and updated by Summer 2020 so implementation of the overall larger mesonet may begin in late 2020. A PEA will be developed for the deployment of the larger mesonet effort. It is currently planned that approximately 30 of the existing 180 sites within the five states would be retrofitted to update equipment needs for the plains snowpack and soil moisture monitoring in fiscal year (FY) 2020. Following FY2020, dependent upon fiscal budgeting priorities, it is anticipated the existing monitoring stations within the UMB would be prioritized to be retrofitted first before any new construction of the approximately 360 sites would occur in subsequent FYs.

At the time of writing, it is still unknown who the federal or state partner(s) will be for the implantation of the larger mass-deployment effort and which agency would be responsible for Operation and Maintenance (O&M).

Cumulative Impacts

The proposed installing and updating of the proof-of-concept monitoring stations and the reasonably foreseeable mass deployment of the plains snowpack and soil moisture mesonet are not anticipated to have incremental or cumulative adverse impacts to the resource categories discussed in Section 4.2. Beneficial cumulative and incremental impacts may occur to certain resources should the proof-of-concept monitoring stations and larger mesonet project be implemented. Cumulative benefit to the socioeconomic condition in the UMB could occur as a result of the data obtained from the network which would be available for all federal, state and local agencies to use in the betterment of existing and new products for various efforts, such as river forecasting, flood outlooks, drought monitoring, water supply forecasts and fire hazard reporting. This would assist resource management agencies in making operational decisions to reduce the flood risk to communities within the UMB. Additional incremental benefit to resources such as soils, cultural resources and water quality may also occur as the ability to

minimize flooding risk increases. Flooding may induce excessive soil erosion, scouring and bank failure of the Missouri River or other streams and rivers that are managed by local, state or federal agencies within the UMB watershed. Flooding may also have negative impacts on water quality; as the water inundates urban and agricultural landscapes, debris, surface runoff and contaminants will often enter the waterway. With an increase in quality and quantity of data, managers may better forecast and offset potential flooding events.

6. COMPLIANCE WITH OTHER ENVIRONMENTAL LAWS

American Indian Religious Freedom Act (AIRFA) of 1978, 42 U.S.C. 1996. *In compliance*. AIRFA protects the rights of Native Americans to exercise their traditional religions by ensuring access to sites, use and possession of sacred objects, and the freedom to worship through ceremonials and traditional rites. Access to sacred sites by Tribal members would not be affected.

Bald and Golden Eagle Protection Act, 16 U.S.C. Sec. 668, 668 note, 669a-668d. *In compliance*. This act prohibits the taking or possession of and commerce in bald and golden eagles, with limited exceptions for the scientific or exhibition purposes, for religious purposes of Indian Tribes, or for the protection of wildlife, agriculture or preservation of the species. The proposed project would have no adverse effects on the bald eagle.

Clean Air Act, as amended, 42 U.S.C. 185711-7., et seq. *In compliance*. The purpose of this act is to protect public health and welfare by the control of air pollution at its source and to set forth primary and secondary National Ambient Air Quality Standards to establish criteria for states to attain, or maintain. No effect to ambient air quality conditions within the proposed monitoring site locations is anticipated.

Clean Water Act, as amended, (Federal Water Pollution Control Act) 33 U.S.C. 1251., et seq. *In compliance*. The objective of this act is to restore and maintain the chemical, physical, and biological integrity of the Nation's waters (33 U.S.C. 1251). The proof-of-concept monitoring stations are not water dependent and would occur in upland areas. No effect to water quality is anticipated from the installation and updating of the proof-of-concept monitoring sites.

Comprehensive Environmental Response Compensation and Liability Act (CERCLA). *In compliance*. Typically CERCLA is triggered by (1) the release or substantial threat of a release of a hazardous substance into the environment; or (2) the release or substantial threat of a release of any pollutant or contaminant into the environment which presents an imminent threat to the public health and welfare. To the extent such knowledge is available, 40 CFR Part 373 requires notification of CERCLA hazardous substances in a land transfer. This project will not involve any real estate transactions.

Endangered Species Act, as amended, 16 U.S.C. 1531, et seq. *In compliance*. Section 7 (16 U.S.C. 1536) states that all federal departments and agencies shall, in consultation with and with the assistance of the Secretary of the Interior, ensure that any actions authorized, funded, or carried out by them do not jeopardize the continued existence of any threatened or endangered (T&E) species, or result in the destruction or adverse modification of habitat of such species

which is determined by the Secretary to be critical. This project has been coordinated with the USFWS. A *no effect* determination was made for all the T&E species listed with potential to occur in the project areas of Montana, South Dakota and Wyoming. Montana USFWS provided an email response, dated December 18, 2019 stating their organization had no comments or concerns with the proposed proof-of-concept monitoring stations. MFWP responded on December 20, 2019 stating they had no concerns with the proposed updates to the proof-of-concept pilot stations. No response was received from the Wyoming or South Dakota USFWS.

Environmental Justice (E.O. 12898). *In compliance*. Federal agencies shall make achieving environmental justice part of its mission by identifying and addressing, as appropriate, disproportionately high and adverse human health or environmental effects of its programs, policies, and activities on minority populations and low-income populations in the United States. The project does not disproportionately impact minority or low-income populations.

Farmland Protection Policy Act (Subtitle I of Title XV of the Agriculture and Food Act of 1981), effective August 6, 1984. *In compliance*. This act instructs the Department of Agriculture, in cooperation with other departments, agencies, independent commissions, and other units of the federal government, to develop criteria for identifying the effects of federal programs on the conversion of farmland to nonagricultural uses. The proposed proof-of-concept monitoring stations would occur on previously disturbed soils on MSU, SDSU and UW university property. The soils identified at these three sites are not classified as prime farmland.

Federal Water Project Recreation Act, as amended, 16 U.S.C. 460-1(12), et seq. *Not applicable*. The act establishes the policy that consideration be given to the opportunities for outdoor recreation and fish and wildlife enhancement in the investigating and planning of any Federal navigation, flood control, reclamation, hydroelectric or multi-purpose water resource project, whenever any such project can reasonably serve either or both purposes consistently. The purpose of this project will not negatively impact recreational use of the river.

Fish and Wildlife Coordination Act, 16 U.S.C. 661, et seq. *Not applicable*. Coordination with USFWS under the Fish and Wildlife Coordination Act is applicable for water resource development projects. The proposed proof-of-concept monitoring stations are not water dependent projects and would occur in upland, terrestrial areas only.

Floodplain Management (E.O. 11988). *In compliance*. E.O. 11988 requires federal agencies provide leadership and take action to reduce the risk of flood loss, minimize the impact of floods on human safety, health and welfare, and restore and preserve the natural and beneficial values served by floodplains. These requirements apply in carrying out its responsibilities for 1) acquiring, managing, and disposition of federal lands and facilities; 2) providing federally undertaken, financed, or assisted construction and improvements; and 3) conducting federal activities and programs affecting land use, including but not limited to water and related land resources planning, regulating, and licensing activities. This project would not adversely affect the flood holding capacity or flood surface profiles of any stream, as such the project is in compliance with the requirements of E.O. 11988.

Invasive Species (E.O.13751, E.O. 11987). *In compliance.* The project would be conducted in accordance with E.O. 13112, as amended by E.O. 13751. This E.O. seeks to prevent the introduction of invasive species and authorizes control of said species to minimize economic, ecological and human health impacts. This E.O. directs all federal agencies to address invasive species concerns and refrain from actions likely to increase invasive species problems. E.O. 13751 amends 13112 to direct continuation of coordination for federal prevention and control efforts. This order also maintains and expands the National Invasive Species Council and further incorporates considerations of human and environmental health, climate change, technological innovation and other emerging priorities into federal efforts to address invasive species in a cost-efficient manner. E.O 11987 directs agencies to restrict the introduction of exotic species into the natural ecosystems on lands and waters which they own, lease or hold for purpose of administration and encourage state and local governments as well as private citizens to prevent the introduction of exotic species in natural ecosystems of the United States.

This project would comply with the above E.O.s through the use of BMPs, such as cleaning and inspecting equipment prior to transportation to each individual location and after installation and updating activities have concluded.

Land and Water Conservation Fund Act (LWCFA), as amended, 16 U.S.C. 4601-4601-11, et seq. *Not applicable.* Planning for recreation development at Corps projects is coordinated with the appropriate states so that the plans are consistent with public needs as identified in the State Comprehensive Outdoor Recreation Plan (SCORP). The Corps must coordinate with the National Parks Service (NPS) to ensure that no property acquired or developed with the assistance from this act will be converted to other than outdoor recreation uses. If conversion is necessary, approval of NPS is required, and plans are developed to relocate or re-create affected recreational opportunities. No lands involved in the proposed project were acquired or developed with LWCFA funds.

Migratory Bird Treaty Act of 1918 as amended, 16 U.S.C. 703-711, et seq. *In compliance*. The Migratory Bird Treaty Act of 1918 (MBTA) is the domestic law that affirms, or implements, the United States' commitment to four international conventions with Canada, Japan, Mexico and Russia for the protection of shared migratory bird resources. The MBTA governs the taking, killing, possession, transportation, and importation of migratory birds, their eggs, parts and nests. The take of all migratory birds is governed by the MBTA's regulation of taking migratory birds for educational, scientific, and recreational purposes and requiring harvest to be limited to levels that prevent over utilization. E.O. 13186 (2001) directs executive agencies to take certain actions to implement the act. No tree clearing activities would occur for the proposed proof-of-concept monitoring stations and the proposed project complies with USFWS guidelines for BMPs of communication towers. No impacts to migrating birds are anticipated.

National Environmental Policy Act (NEPA), as amended, 42 U.S.C. 4321, et seq. *In compliance.* This EA has been prepared for the proposed action and to satisfy the NEPA requirement. An Environmental Impact Statement is not required.

National Historic Preservation Act, as amended, 16 U.S.C. 470a, et seq. *In compliance*.

A file search was conducted by a Corps archeologist within the proposed project footprint in Wyoming, South Dakota and Montana on December 20, 2019. It was determined the proposed undertaking has no potential to cause effects to historic property, as defined in 36 CFR 800.3(1). There is always the possibility that previously unsuspected archeological remains may be uncovered during the process of project construction. In the unlikely event of an unanticipated discovery of cultural resources, work will halt immediately and contact will be made with a Corps archeologist. The work would not continue until a qualified archeologist inspects the findings. If it is determined that the discovery requires further consultation, the Corps would consult with the respective SHPO.

Noise Control Act of 1972, 42 U.S.C. 4901, et seq. *In compliance*. There is no anticipated impact to the noise condition of the project areas under the Preferred Alternative.

North American Wetlands Conservation Act, 16 U.S.C. Sec. 4401 et seq. *Not applicable.* This act establishes the North American Wetlands Conservation Council (16 U.S.C. 4403) (NAWCC) to recommend wetlands conservation projects to the Migratory Bird Conservation Commission (MBCC). Section 9 of the act (16 U.S.C.4408) addresses the restoration, management, and protection of wetlands and habitat for migratory birds on federal lands. Federal agencies acquiring, managing, or disposing of federal lands and waters are to cooperate with USFWS to restore, protect, and enhance wetland ecosystems and other habitats for migratory birds, fish and wildlife on their lands, to the extent consistent with their mission and statutory authorities.

Protection of Wetlands (E.O. 11990). *In compliance*. Federal agencies shall take action to minimize the destruction, loss or degradation of wetlands, and to preserve and enhance the natural and beneficial values of wetlands in carrying out the agencies' responsibilities. No wetlands would be impacted under the Preferred Alternative.

Rivers and Harbors Act, 33 U.S.C. 401, et seq. *In compliance*. This act prohibits the unauthorized obstruction or alteration of any navigable water of the United States. This section provides that the construction of any structure in or over any navigable water of the United States, or the accomplishment of any other work affecting the course, location, condition, or physical capacity of such waters is unlawful unless the work has been recommended by the Chief of Engineers and authorized by the Secretary of the Army. A Section 10 permit is not required for Corps projects, nor would the proposed project alter navigable waters in any way.

Watershed Protection and Flood Prevention Act, 16 U.S.C. 1101, et seq. *In compliance*. This act authorizes the Secretary of Agriculture to cooperate with states and other public agencies in works for flood prevention and soil conservation, as well as the conservation, development, utilization and disposal of water. This act imposes no requirements on Corps Civil Works projects.

Wild and Scenic Rivers Act, as amended, 16 U.S.C. 1271, et seq. *Not applicable.* This act establishes that certain rivers of the Nation, with their immediate environments, possess outstandingly remarkable scenic, recreational, geologic, fish and wildlife, historic, cultural, or other similar values, shall be preserved in free-flowing condition, and that they and their

immediate environments shall be protected for the benefit and enjoyment of present and future generations. The area in which the proposed activity would occur is not designated as a wild or scenic river, nor is it on the National Inventory of Rivers potentially eligible for inclusion.

7. PREPARER

This EA and the associated Finding of No Significant Impact (FONSI) was prepared by Ms. Rebecca Podkowka, Environmental Resource Specialist. The address of the preparer is: U.S. Army Corps of Engineers, Omaha District; PM-AC, 1616 Capitol Avenue, Omaha, Nebraska 68102.

Prepared By: _____ Date: _____
Rebecca Podkowka
Environmental Resources Specialist

Approved By: _____ Date: _____
Eric Laux
Chief, Environmental & Cultural
Resources Section

South Dakota Mesonet-US Army Corps of Engineers
Upper Missouri River Basin Plains
Hydrological Testbed Report

Nathan Edwards, SD Mesonet Director, nathan.edwards@sdstate.edu
Ruben Behnke, SD Mesonet Research Climatologist

During the winter of 2018-2019, several instrumentation and measurement technique tests were performed in Brookings, SD (N44.3250, W96.7685, 499.9 m) as part of the Hydrological Testbed Experiment as described in the Statement of Work in the original agreement between the SD Mesonet and the United States Army Corps of Engineers (USACE). These data were collected beginning in December 2018 and continued until July 1, 2019. The specific variables and data are summarized below by meteorological variable.

Testbed Comparisons and Sensor Technologies

A major part of the testbed experiment was to compare different technologies for each of the variables. Many meteorological variables can be measured using a range of different methods, most of which involve different levels of technology, which are most often intended to increase the level of automation and improve accuracy. In general, the higher the degree of automation, the more an instrument costs. However, the accuracy of a particular weather instrument is not necessarily dependent on its technological sophistication.

Incoming Solar Shortwave Radiation (heated vs. unheated)
Solar radiation data were collected using a heated and an unheated pyranometer. The purpose of this comparison was to determine the effect of frost, snow cover, and dew on solar radiation readings. Typically, pyranometers are not heated due to power considerations and due to the fact that the demand for solar radiation historically is during the growing season only. Solar radiation, however, can add to the accuracy of the SNODAS (Snow Data Assimilation System) model used by NOAA's National Operational Hydrologic Remote Sensing Center. Recent instrumentation offerings draw just 15 mA at 12 Volts direct current allowing for accurate assessment of solar radiation even in winter when subject to snow without significant power consumption. Identical pyranometers (Apogee SP230 photovoltaic), one with the heater on and one with the heater off were deployed.

Precipitation
The typical mesonet station utilizes an unheated tipping bucket rain gauge. It is not designed to measure frozen precipitation. The portion of the snow retained in the funnel is recorded after the fact when it melts. The following automated sensors were deployed:

1. Unheated tipping bucket rain gauge (Texas Electronics TE-525 with 6" inch orifice)
2. Same as above but with a 20-inch extended funnel to retain snowfall until melt
3. Weighing precipitation gauge to measure precipitation at the time of fall regardless of freezing conditions (Hourly Precipitation Data Network Fisher-Porter)
4. A prototype weighing gauge with technology similar to above but at much reduced cost (Apogee SG-400).

All data was collected at 5-minute resolution with the exception of the Fisher-Porter which is 15-minute resolution.

Additionally, a daily manual measurement of precipitation (National Weather Service Coop station using the 8" standard rain gauge) was done at the testbed as well.

Snow Depth
Two approaches were taken to measure snow depth.

The first is the sonic snow depth sensor (Campbell Scientific SR50A sampled every 5 minutes). This was placed over a white snow board surrounded by unmowed grass as is common practice in manual observation. The reasoning is that white paint serves to reduce melt, the level board surface produces a cleaner signal and the unmowed grass surrounding it prevents scouring.

The second is the camera-monitored snow stakes. These six 40" tall stakes were marked with 1" bands separated by 1" and monitored by a camera (Campbell Scientific CCFC). The original intention was that the snow depth determined by imaging software could obtain more, albeit less precise measurements than the sonic sensor (manual interpretation of the images was done in lieu of automated processing for purposes of this test). Photographs were done on a daily basis.

Additionally, daily manual NWS Coop station measurements of snow depth were performed.

Snow Water Equivalent
While no automated instruments directly measured snow water equivalent (SWE), weekly manual observations were done using the USACE method for completeness.

Soil Temperature & Moisture
Soil temperature and moisture are most often measured using a combination probe (usually some type of reflectometer for moisture and a thermistor for temperature) that is inserted horizontally into the soil profile at a specified depth. While these sensor types have been thoroughly tested and are the industry standard, a new product that integrates nine sensors into a single 1-meter "screw-in" unit promising easier installation is now on the market (Campbell Scientific Soil VUE10). The unit uses similar technology for measurement (time domain reflectometer and thermistor).

Five conventional probes (Stevens HydraProbe II coaxial dielectric reflectometers) were installed at the common depths of 5, 10, 20, 50, and 100 cm to measure soil temperature and moisture (volumetric water content) at these depths.

A 1-meter "screw-in" unit (Campbell Scientific SoilVUE10) with measurement depths of 5, 10, 20, 30, 40, 50, 60, 75 and 100 cm was installed as an addition late in the study.

All soil moisture and temperature data were sampled at 5-minute resolution.

Testbed Results

Incoming Solar Shortwave Radiation: Heated vs. Unheated
Solar radiation data from heated and unheated sensors were compared for both average 5-minute solar radiation (W/m^2) and total daily radiation fluxes ($MJ/m^2/day$). **Figure 1** shows an example of sensor shading as a result of snow accumulation.

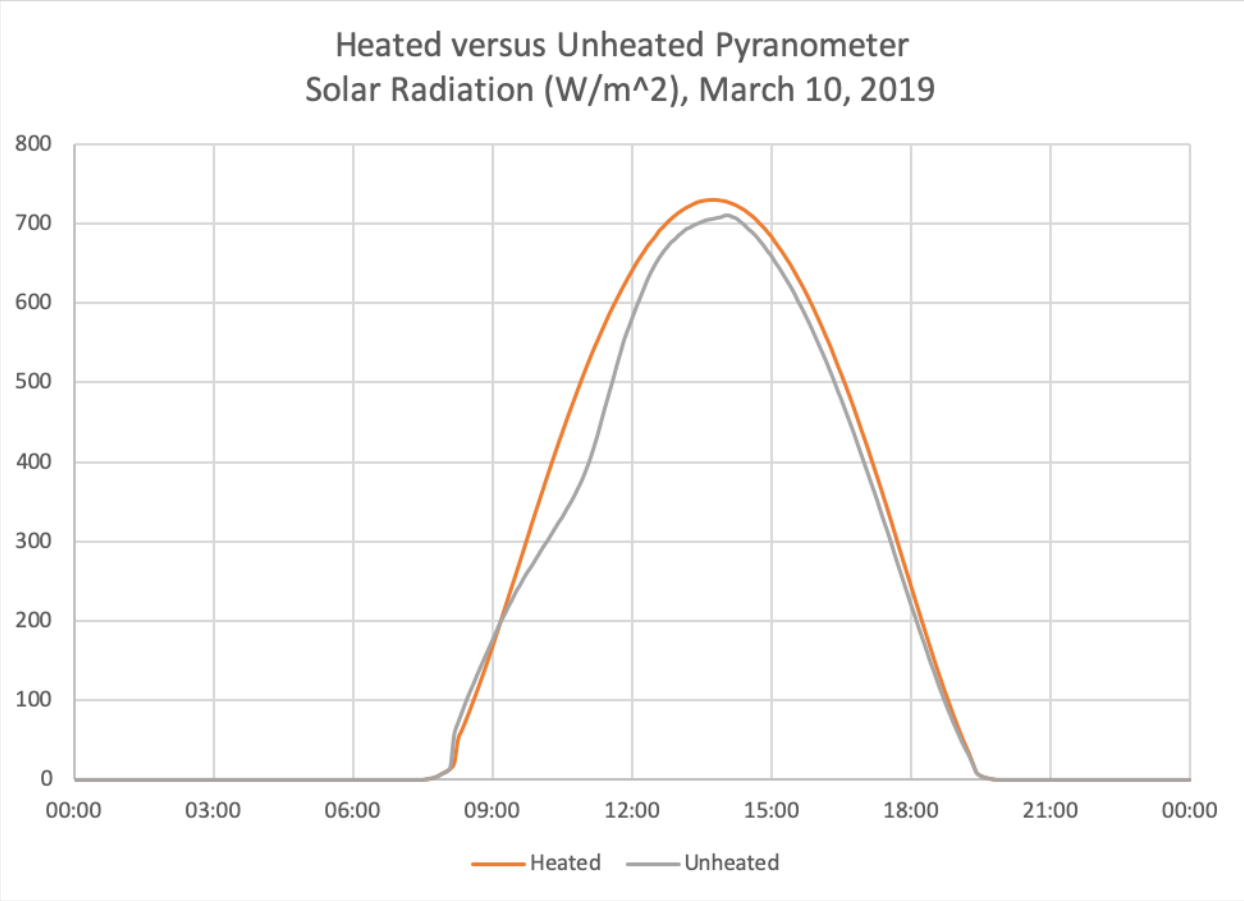

Figure 1. Example of underreporting of solar radiation following snowfall (7.8% daily total in this case following a 4.6 inch snowfall event).

Histograms of percent difference for average 5-minute observations and total daily solar radiation are shown in **Figure 2**. Variation between the pyranometers is much higher for average minute readings than for total daily radiation. Over 21% of average 5-minute observations vary by more than 5%, while this drops to less than 3% for total daily solar radiation.

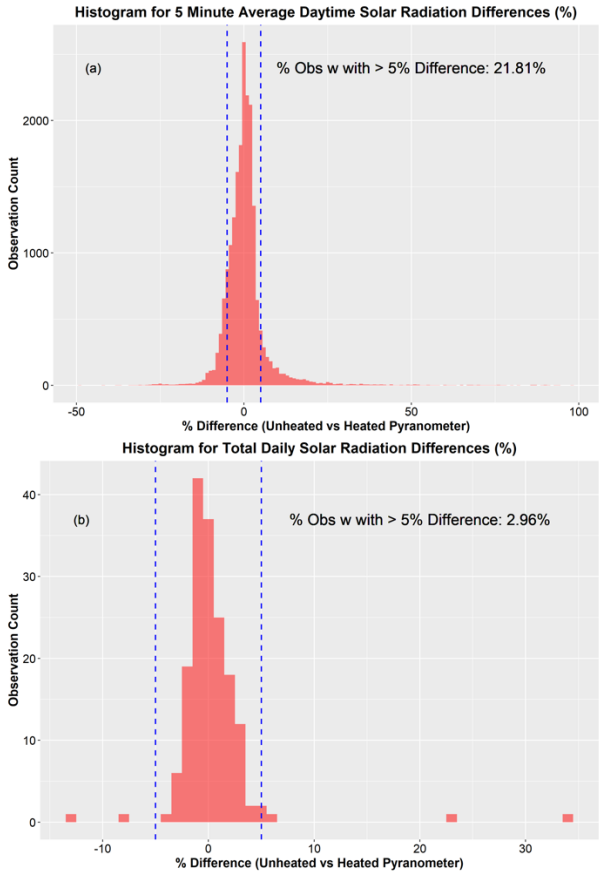

Figure 2. **(a)** Histogram of average 5-minute solar radiation differences (%) between the heated and unheated pyranometers, for daytime only. **(b)** Histogram of average total daily solar radiation differences (%) between the heated and unheated pyranometers. Variation between the two pyranometers is very high for 5-minute averages, but becomes much lower for daily totals, as biases among individual 15-minute periods are averaged out.

Tipping Bucket Rain Gauge Precipitation: Unmodified vs. Extended Funnel

A major complicating factor for precipitation is the fact that the Upper Missouri River Basin receives much of its annual precipitation in the form of snow. The liquid equivalent of frozen precipitation at the time of fall is desired. This is not possible with the common unheated tipping bucket rain gauge because frozen precipitation that is collected in the funnel is prone to being blown away before it melts. When it does melt, it takes place after the fact.

While it cannot address the delayed melt (impossible on solar power), the concept of an extended funnel was proposed to address the issue of loss of collected precipitation until it melts. **Table 1** shows monthly total precipitation as measured by the unheated tipping bucket gauges with and without a 20-inch funnel extension (as compared to the Fisher-Porter). **Figure 3** compares 15-minute performance of the two tipping buckets. While one would expect the winter precipitation totals of the unmodified gauge to be underreported, it should be noted that the catch of the unmodified tipping bucket rain gauge might have been impacted by its proximity to the extended funnel gauge (adjusted May 8).

Month	Actual (F-P)	Tipping	Tipping_Ext
Jan	0.42	0.05	0.42
Feb	0.6	0.23	0.42
Mar	5.26	4.90	5.35
Apr	5.8	3.88	7.26
May	3.12	3.35	3.59
June	2.01	2.08	2.18

Table 1. Monthly totals for unheated tipping bucket rain gauge with and without extended funnel (compared to Fisher-Porter). Precipitation in months with snowfall (January through April) is significantly underreported by the tipping bucket gauge as would be expected (see text). The gauge with the extended funnel generally did better; however, it significantly over-reported April precipitation.

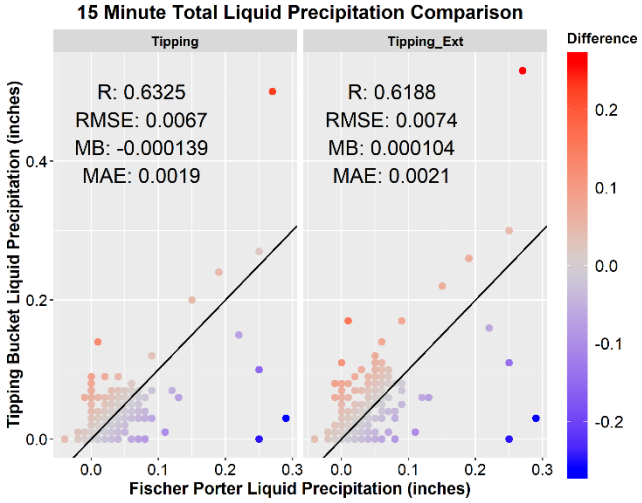

Figure 3. Bias and goodness of fit statistics between the Fisher-Porter and the tipping bucket rain gauges with and without the funnel extension.

Weighing Precipitation Gauge

The instrument of choice for measurement of precipitation both solid and liquid at the time of fall is the weighing precipitation gauge (in this case a Fisher-Porter). Weighing gauges use an oil to prevent evaporation and alcohol to lower the freezing point of the collected precipitation. This melts any snow that falls into the gauge, and the water equivalent is then measured by weight the same as rain.

Daily precipitation performance differences compared with the tipping bucket gauges (**Figure 4**) are significant. Note that on a daily time scale, the tipping buckets appear to under report precipitation during snowfall (as one would expect) and over report rainfall (when that snow melts).

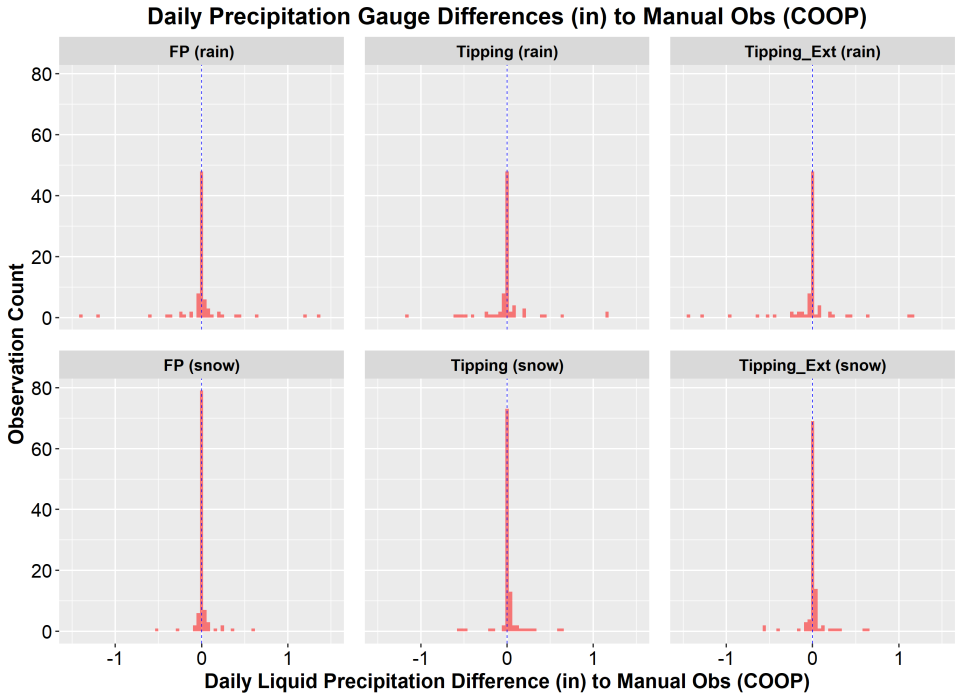

Figure 4. Histograms showing the daily variation in liquid water equivalent for both snow and rainfall events for the weighing gauge, the unmodified tipping bucket, and the extended tipping bucket in comparison to the manual measurement.

Weighing Precipitation Gauge: Apogee SG-400

A new gauge on the market, the Apogee SG-400 promises lower unit cost than a typical weighing precipitation gauge. The load cell that the manufacturer will be offering changed part way through testing. This unit has improved performance over the previous load cell but there is limited data collected from it. **Figure 5** shows its performance compared with the Fisher-Porter.

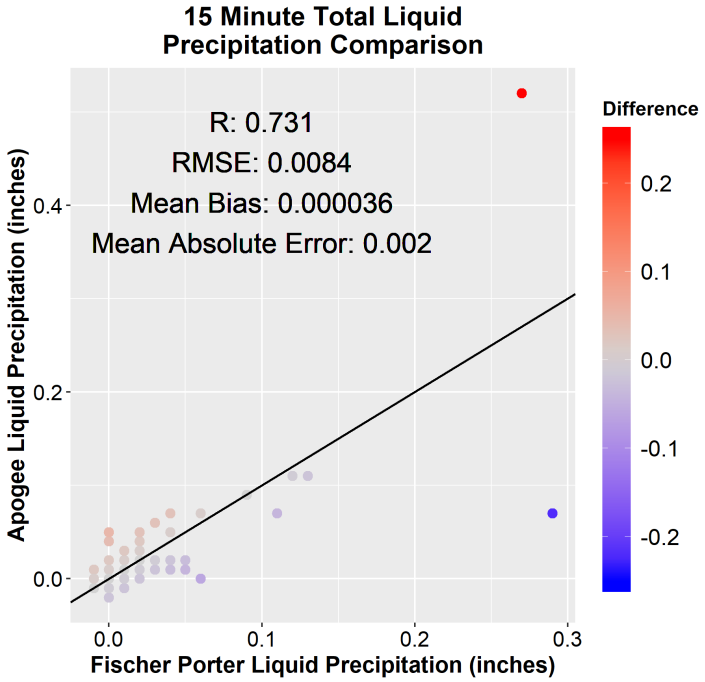

Figure 5. Bias and goodness of fit statistics between the Apogee SG-400 and the Fisher-Porter.

Sonic Snow Depth vs Snow Stake Snow Depth

Snow depth as measured by a single sonic snow depth sensor was compared against the depths as recorded by six snow stakes set 25 to 50 feet from the weather station, and recorded by a camera. The depths for each stake and hour were then recorded manually. **Figure 6** shows the results of this test. Nearly all the recorded sonic sensor depths were higher than the snow stake depths, by as much as 5". The exception was a group of lower values in April.

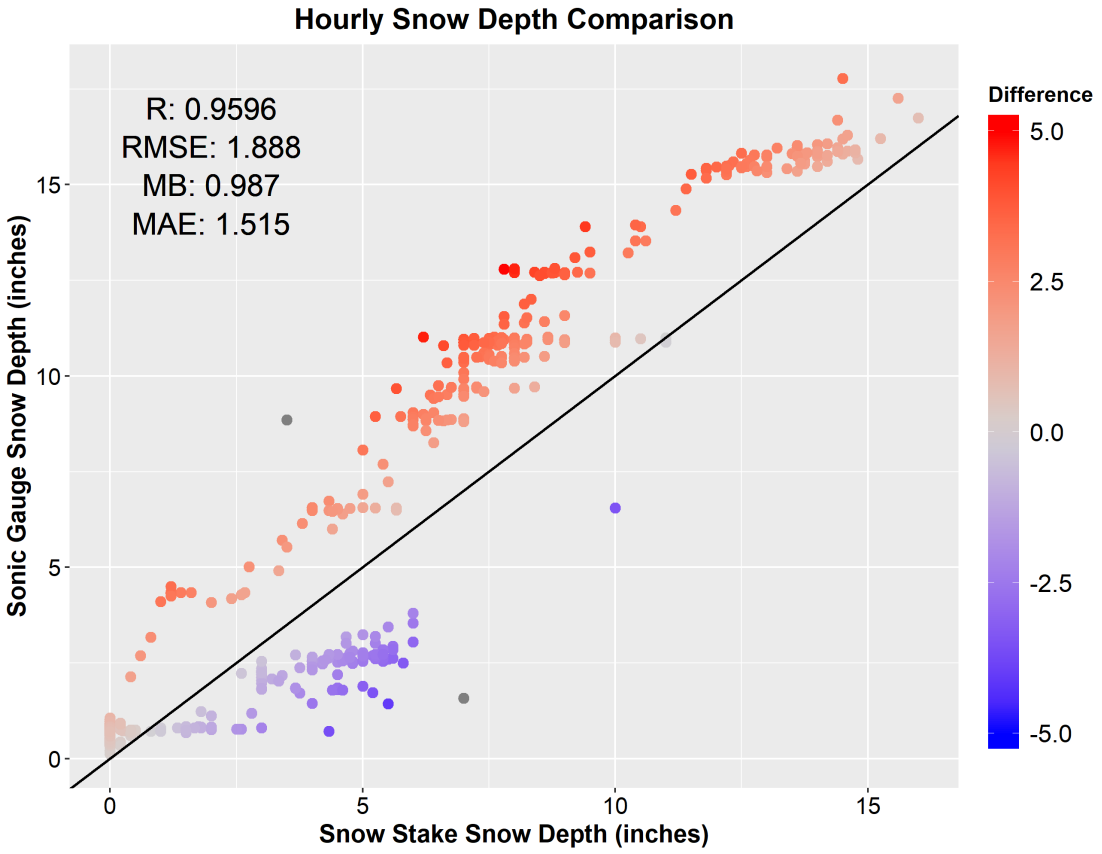

Figure 6. Scatterplot showing the difference between the sonic depth sensor and the ***average*** snow depth from the snow stakes. The sonic sensor nearly always recorded higher depths than the stakes.

As consistent and large as these differences are, it does not mean there is error in the sonic sensor. Snow depth varies significantly over short distances, as wind causes drifting and scouring of the snow. As is characteristic of the area of concern, the testbed was located in an open, grassy field, where winds were often significantly stronger than they would be in a more sheltered location. This resulted in very large variations in snow depth. The other possibility is the difference in measurement surface (snow board vs. grass).

To illustrate this variability, **Figure 7** shows snow depth among the snow stakes used for a period in mid-March when deep snow cover existed. Over the entire period, variations in the snow depth among the stakes ranged as high as 10". When the snow began to melt, some stakes were located on bare grass, while others had over 10" of snow remaining. The stakes were located a maximum of 25 feet from each other.

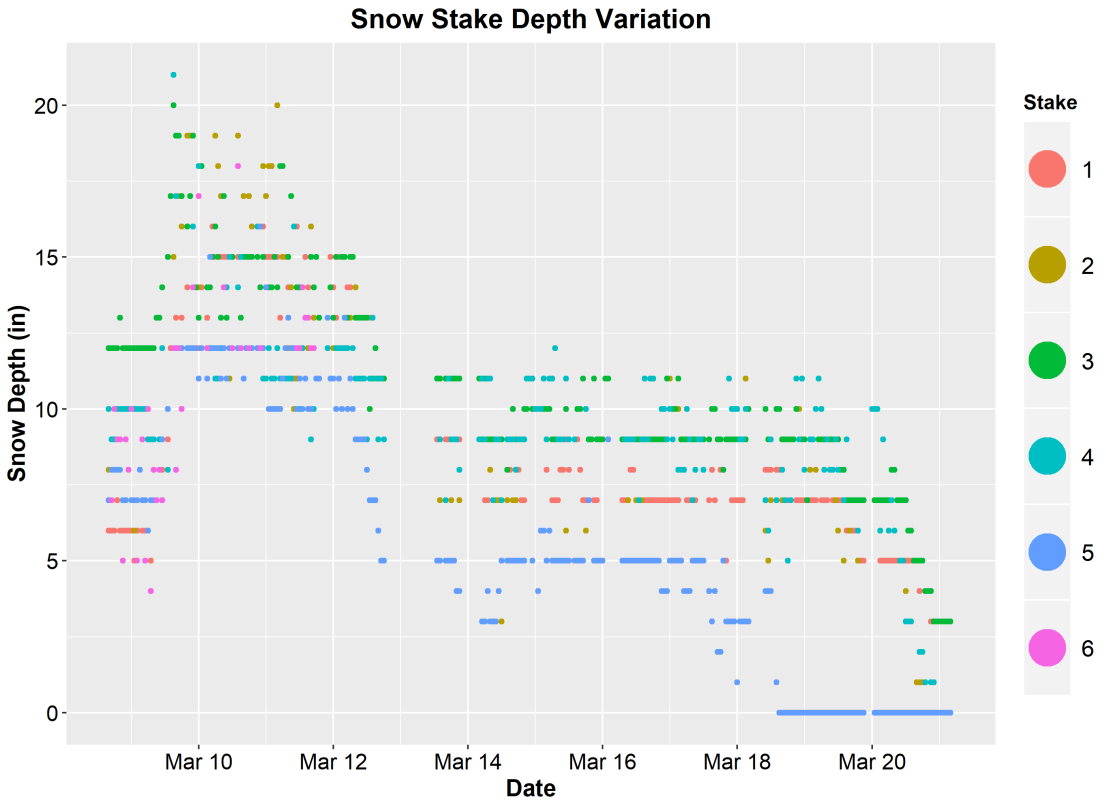

Figure 7. Scatterplot showing the variation in snow depths among the snow stakes. Variation up to 10" exists among the stakes, even though they were never more than 25 feet apart.

Daily Manual (COOP) Snow Depths vs Sonic and Snow Stake Instruments

Manual measurements of snow depth occur daily at 8:00 am. **Figure 8** compares this daily measurement against the average daily snow depths measured from the sonic sensors and the snow stakes. Here, the manual measurements are consistently lower than the stake measurements, and especially the sonic measurements by as much as 8".

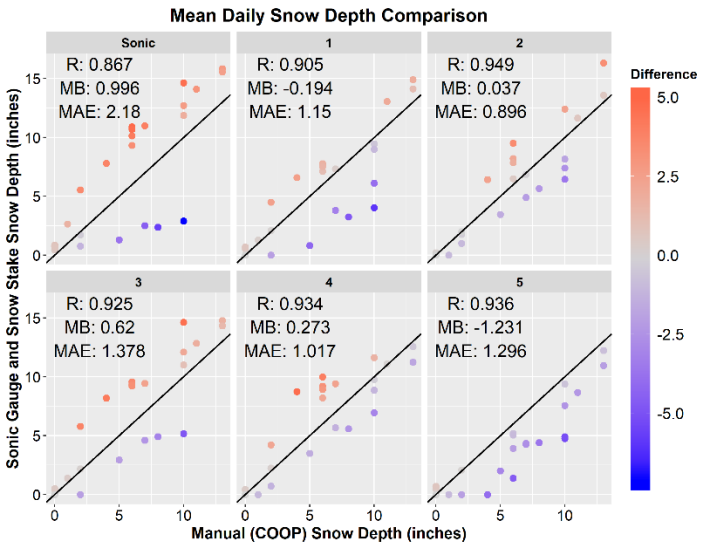

Figure 8. Scatterplots comparing the sonic snow depths and the daily stake snow depths (1 to 5) to the manual observations made every morning at 8:00 am. The manual observations are consistently 4" lower than the sonic snow depths and 2" lower than the stake depths.

Soil Temperature and Soil Moisture

The Campbell SoilVUE10 was installed as a late addition alongside the Stevens HydraProbes at depths of 5, 10, 20, 50, and 100 cm (SoilVUE10 data from other depths were recorded but not used). The HydraProbes have performed without incident. The SoilVUE10 does not yet have enough data collected from which to draw a conclusion.

Discussion

Incoming Solar Shortwave Radiation

The difference in measured solar radiation on 5 minute intervals between an unheated and a heated pyranometer is significant, where over 21% of daytime observations varied by greater than 5%. While it is important to consider the fact that not all observed differences are likely due to a heated/unheated instrument, and may be due to slight differences in how accurate the leveling of the pyranometers was, little else would cause such a large difference.

Although correlations were high and mean biases and other goodness of fit statistics showed excellent agreement, the threshold of 5% difference was not met. The added cost in both price and power of the heated sensor is low and the gains are measureable. The use of a heated solar radiation sensor seems well advised.

Precipitation

The standard instrument for measuring rainfall is a weighing gauge. The old, but proven Fisher-Porter gauge was used as the control for most comparisons in this study. The current mark of the Apogee SG-400 looks promising, but more data is needed. The largest problem with this gauge's measurements is the tendency to lose mass, either from evaporation from the bucket or from errors in the instrumentation. The manufacturer has stated that the next iteration of the instrument will solve this issue by firmware compensation. It will take little time to validate this.

The Fisher-Porter and – to some degree – all other gauges of this type, show similar variations in its data. Uncertainty in long-term accumulations can be offset by resetting accumulations daily (a common practice with this instrumentation) and not permitting negative daily values. The addition of a low-power precipitation detection sensor could differentiate small but real precipitation totals from spurious signals and warrants further investigation.

The tipping bucket gauges performed as expected compared to the Fisher-Porter. The rainfall biases tend to be negative, as the tipping bucket gauge requires enough rain to: 1) wet the gauge, and 2) cause the tipping bucket inside to record at least 0.01". Further, tipping buckets are well known to underestimate total rainfall during high rainfall rates. However, given the uncertainty in a weighing gauge, a tipping bucket produces a more certain observation of rain than does a weighing gauge (for small events, or during the beginning of a long event). Continued use of a tipping bucket alongside the weighing precipitation gauge is relatively inexpensive and serves a purpose. In addition, it adds some redundancy to an important and difficult-to-quality-control variable.

Snow Depth

The most accurate and common method to measure snow depth is manual assessment of depth at multiple locations. This is the NWS COOP method and the method used in this study. As seen in this study, very high spatial variation in snow depth is common. Therefore, if an observer measures snow in a consistent location, but that location is not representative of the area, a non-representative depth will be reported. The same problem exists with the stakes and the sonic snow depth sensors.

The solution to this is to obtain as many samples as possible from as large an area as possible. This could consist of multiple sonic sensors or snow stakes. An important issue with snow stakes, however, is that a "snow well" can develop around the stake, leading to what will likely be a biased low depth recording (top picture below, front stake). In other cases, such as in the bottom picture below, snow will collect on one side of the stake, making determination of the exact snow depth difficult. While manual interpretation of camera pictures can be time consuming, it is the most accurate and can be reserved for cases where two sonic sensors at a station disagree. It is recommended that two sonic sensors with a camera for quality control be used for the determination of snow depth. Only the most recent photos need to be kept in this scenario, which greatly reduces data handling. Having these images available on the mesonet's public website is advisable to allow data users to validate reported snow depths that are questionable. Snow stakes that can survive long-term deployment in the sun and elements will be needed.

Figure 9. Snow stake field as viewed by Campbell CCFC camera (cropped images). Stakes use 1-inch black bands with 1-inch spacing.

As expected, the sonic sensors performed very reliably, but two important installation issues arise: 1) maintenance of the grass around the snow board, and 2) installation of the snow board so that it stays in place year-round. One reason the testbed sonic sensor recorded higher snow depths than the stakes was that the snow board lifted up well over an inch through the winter, and did not maintain a level profile. Further, very tall grass that falls over the board may be read as snow by the sensor or cause drifting on a board situated deep inside the grass canopy. Despite these issues, the sonic sensor is a very reliable instrument when installed properly and consistently. The snow board should be surrounded by natural ground cover that is uncut except when heights reach over 18 inches. Additionally, a pristine snow observation field with a radius of about 15 feet around the station is well advised. Corral panel fencing is suggested to maintain the integrity of the snow observation field and introduce minimal drifting.

A camera with an adequate operating temperature (-40 C), low power consumption for solar applications, a wide field of view for snow stake viewing and affordable cost is an issue. The Campbell Scientific CCFC that was used for the testbed study was satisfactory, albeit expensive. Other options are being investigated.

Additionally, both snow depth and snow water equivalent should be measured at the mesonet station manually by local personnel on a weekly or biweekly basis.

Tipping Bucket Rain Gauge Extension
The testbed included an unheated tipping bucket with 20-inch extension. This is intended to address only long-term totals (e.g. monthly totals). With just 4 months of data, a conclusion cannot be drawn as to its utility.

Soil Temperature and Moisture
Not enough data has been collected from the SoilVUE10 to make conclusions. It offers the potential to provide highly accurate readings, but more testing is needed. At this point, large-scale deployments of more traditional sensors (Campbell Scientific CS-655, Stevens HydraProbe II, Dynamax ML3 Theta Probe, etc.) at standard depths of 5, 10, 20, 50, and 100 cm is advisable. The HydraProbe's extensive deployment nationally and in the basin and its reliable track record make it particularly well suited for this application.

Equipment Recommendations
See appendix for complete sensor and equipment recommendations. Listed for some are more than one option with preferred options in green. A tri-leg will work better for some mesonets and a truss tower will work better for others. Sensor continuity within any given mesonet will also be important to its efficient operation, so options that have little or no impact on data quality or inter-comparability have been offered. Sensors not adequate to the mission (e.g. thermometers that do not record below -40°C) are assumed to be replaced. What follows are items of particular note.

Pricing
All pricing presented here is without any education or bulk discount and in many cases includes the approximations of what a particular network will need to conform. Shipping is not factored in either.

Precipitation
While a shield was not included in the testbed study due to the fact that gauges used for validation were unshielded, it is requested by National Weather Service personnel that gauges be deployed with Alter shields. These devices add complexity to installation as well as cost (around $1000) but improve catch, particularly of snow and during windy conditions.

Figure 9. Weighing precipitation gauge.

The Apogee SG-400 has undergone some revisions but is entering production. It has a lot in common technologically with the OTT Pluvio2 L and should be considered for its considerably lower cost. This will be outweighed for some networks by the efficiencies that equipment continuity within their networks affords (NDAWN and AgriMet already field OTT Pluvio2 L gauges).

Temperature/Humidity
As was seen last winter, thermometers that operate only to -40 C are not sufficient. The table contains two options for temperature and humidity, both of which would be able to measure a record low CONUS temperature (previously recorded in Montana).

Figure 10. Temperature and relative humidity sensors with aspirated shield (credit: Apogee Instruments)

Solar Radiation
Daily totals of unheated pyranometers were seen to be impacted slightly in the testbed study. The cost difference is negligible. Considering an upgrade to heated pyranometers would be well advised for a mesonet pondering significant changes but is not necessary.

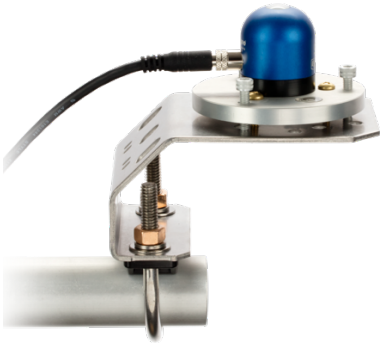

Figure 11. Heated solar radiation sensor (credit: Campbell Scientific).

Wind Speed/Direction
All mesonets in the UMRBP field RM Young wind monitors that are identical or nearly so. That said they will need retrofitting for deployment at 10 m.

Figure 12. Wind speed/direction sensor (credit: Campbell Scientific).

Snow Depth

The sonic snow depth sensor used in the study performed well, but numbered only one. NWS personnel have requested dual snow depth sensors with a camera for human verification.

Figure 13. Snow depth sensor (credit: Campbell Scientific).

Soil Temperature/Moisture

Three very similar sensors are deployed in the UMRBP. Additionally, almost all soil stations are instrumented at 5, 10, 20, 50 and 100 cm.

Figure 14. Soil temperature/moisture sensor (Stevens Water).

Tower

A traditional tower and quick-deploy, concrete-free tri-leg tower were evaluated. The tri-leg is significantly more expensive but saves money in concrete work, excavator rental fees and labor.

It may also be more landowner friendly with its lower visual footprint and its lack of concrete. There are Mesonets (NDAWN, etc.) that have made the traditional tower work well, however.

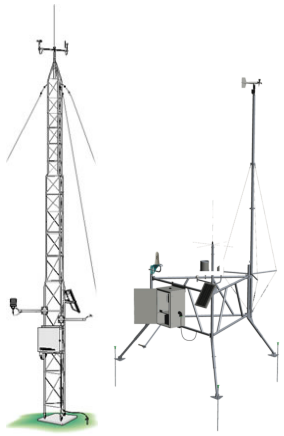

Figure 15. Towers (credit: Campbell Scientific, Forest Technology Systems)

Power
100 Watts of solar panel backed by 220 Amp hours of battery were selected. This ensures flexibility with camera options.

Camera
The different approaches taken with cameras in the testbed were not conclusive. It is suggested that a decision on selection of cameras be deferred until more cost effective, but workable solutions can be found.

Contigency
A contingency of 10% was included.

Total Equipment Cost
$31,100
(not including bulk discount, educational discount, shipping or labor)

Labor
It is estimated that a station could be prepped and installed in a week by an experienced crew of three (slightly more without the tri-leg tower).

Siting
For best results, new stations mesonet stations should be located cooperatively by mesonet managers to ensure proper weather siting and NRCS personnel for proper soil siting. Mesonet land use agreements will need to be made with landowners. NRCS soil pits will need to be dug to characterize the soil of the site.

Travel
Lodging, meals and miles must be included as well.

APPENDIX

Sensors (recommendations highlighted in green)

Parameter	Interval	Observations	Sensor Height/Depth	Sensor Type	Sensor Example	Pricing	Comments
precipitation	5-minute	total	1 - 1.5 m	weighing precipitation gauge, shielded	OTT Pluvio2 L, shield, mount, pedestal	$4800	NDAWN and AgriMet sensor
precipitation	5-minute	total	1 - 1.5 m	weighing precipitation gauge, shielded	Apogee SG-400, NovaLynx shield, pipe, concrete	????	new, possible low cost alternative
temperature/humidity	5-minute	average of 3 s samples	1.5 - 2 m	PRT thermometer, capacitive hygrometer, shielded, fan aspirated	Apogee ST-300-SS, EE08-SS, fan aspirated shield	$1100	-60 to +80 C, fan aspirated, more accurate for about the same cost
temperature/humidity	5-minute	average of 3 s samples	1.5 - 2 m	integrated PRT thermometer/capacitive hygrometer, shielded	Vaisala HMP155A, shield	$1000	-80 to + 60 C, accurate enough, NDAWN, NE Mesonet sensor
solar radiation	5-minute	average of 3 s samples	-	heated thermopile pyranometer, mount	Campbell Scientific CS320	$500	more accurate, heated, same cost
solar radiation	5-minute	average of 3 s samples	-	silicon cell pyranometer, mount	LI-COR LI200	$500	accurate enough, NDAWN, NE Mesonet, AgriMet sensor
wind speed/direction	5-minute	unit vector average direction, maximum speed and average scalar speed of 3 s samples	10 m	integrated propeller anemometer/vane	Young 05108 (or 05103)	$1400	all use the 05108 except AgriMet which uses the similar 05103, all would need to be recabled for 10 m
snow depth	5-minute	sample	2 m	sonic distance sensor	Campbell Scientific SR50AT (set of 2)	$2250	over snow board surrounded by unmowed grass
soil moisture/temperature	5-minute	sample	5, 10, 20, 50, 100	integrated coaxial impedence dielectric reflectometer/thermistor	Stevens HydraProbe II (set of 5)	$2100	SD Mesonet sensor
soil moisture/temperature	5-minute	sample	5, 10, 20, 50, 100	integrated time domain reflectometer/thermistor	Delta-T ThetaProbe ML3 (set of 5)	????	NE Mesonet sensor
soil moisture/temperature	5-minute	sample	5, 10, 20, 50, 100	integrated time domain reflectometer/thermistor	Campbell Scientific CS655 (set of 5)	$1300	NDAWN sensor
					SUB-TOTAL	12,150	

Other Equipment

Equipment	Details	Pricing	Comments
tower	Universal Towers UT30 10 m truss tower with base, guys, grounding kit	$1500	excavation and 1.5 yards of concrete needed (likely to add $2,000 plus labor)
tower	FTS 10 m tri-leg tower with grounding	$5500	no concrete needed
mounting structures	sensor crossarms, hardware, etc. for either tower	$700	
precipitation gauge base	OTT 1.5 m precipitation gauge pedestal, shield, mounting hardware, base for either gauge	$1900	18"Lx18"Wx40"D concrete foundation needed (likely to add $500 plus labor), potential for saving here without decreased performance
fencing	12 ft corral panel fencing	$1500	
modem	Sierra Wireless RV50(X), data cable, antenna cable, high gain antenna, mount	$900	
wind cabling	Young surge suppression junction box, cable	$250	needed to recable 05108 (or 05103) to 10 m
power	2x50 W solar panels with mounts (FTS), regulator (Morning Star), 2x110 Ah deep cycle batteries	$2000	
datalogger	Campbell Scientific CR6 (or CR1000X), terminal strip	$2000	needs will require further discussion on a network-by-network basis
enclosure(s)	enclosures (depending on the tower)	$400	
camera	make and model to be determined	$1000	
contingency	10%	$2800	
	SUB-TOTAL	$18,950	

WYOMING GAME AND FISH DEPARTMENT

5400 Bishop Blvd. Cheyenne, WY 82006

Phone: (307) 777-4600 Fax: (307) 777-4699

wgfd.wyo.gov

December 18, 2019

WER 14313.00a
U.S. Army Corps of Engineers
Programmatic Environmental Assessment
Upper Missouri River Basin Water Management
Plains Snow and Soil Moisture Monitoring Network
Statewide

Rebecca Podkowka
Department of the Army
Corps of Engineers, Omaha District
1616 Capitol Avenue
Omaha, NE 68102

Dear Ms. Podkowka,

The staff of the Wyoming Game and Fish Department (Department) has reviewed the notice for the proposed Programmatic Environmental Assessment Upper Missouri River Basin Water Management Plains Snow and Soil Moisture Monitoring Network. We have no terrestrial wildlife or aquatic concerns pertaining to this project.

Thank you for the opportunity to comment.

Sincerely,

Amanda Withroder
Habitat Protection Supervisor

AW/mf/ap

cc: U.S. Fish and Wildlife Service
Chris Wichmann, Wyoming Department of Agriculture

From: Meyer, Hilary
To: Podkowka, Rebecca L CIV USARMY CENWO (USA)
Subject: [Non-DoD Source] USACE UMB Snowpack and Soil Moisture Monitoring Stations
Date: Thursday, December 12, 2019 1:07:29 PM

Hi Rebecca-

My colleague, Casey Heimerl, forwarded me a message you sent about a snowpack and soil moisture monitoring station proposed to be built in Brookings, South Dakota. I have reviewed the proposed location, and we do not have any concerns related to threatened and endangered species. Please let me know if you need an official letter from GFP on this matter.

Casey was temporarily covering my work duties while I was out of the office. If you have any future correspondence related to environmental review clearances, feel free to send them directly to me. Thank you!

Hilary Meyer | Environmental Review Senior Biologist

South Dakota Game, Fish and Parks

523 East Capitol Avenue | Pierre, SD 57501

605.773.6208| Hilary.Meyer@state.sd.us <mailto:Hilary.Meyer@state.sd.us>

From: O"Neill, Deb
To: Podkowka, Rebecca L CIV USARMY CENWO (USA); Berglund, Jeff
Subject: [Non-DoD Source] RE: USACE UMB Snowpack and Soil Moisture Monitoring Stations (UNCLASSIFIED)
Date: Friday, December 20, 2019 2:37:31 PM

Hi Rebecca-

FWP does not have any concerns with the proposed proof of concept site on MSU campus as shown in your attachment.

Happy holidays!
Deb

Deb O'Neill
Planning and Policy Specialist
Responsive Management Unit
Montana Fish, Wildlife & Parks

P.O. Box 200701
Helena, MT 59620-0701
Ph: (406) 444-3755 | C: (307) 231-3881
Montana FWP | Montana State Parks | Montana Outdoors Magazine

-----Original Message-----
From: Podkowka, Rebecca L CIV USARMY CENWO (USA) <Rebecca.L.Podkowka@usace.army.mil>
Sent: Tuesday, December 17, 2019 1:21 PM
To: O'Neill, Deb <DONeill@mt.gov>; Berglund, Jeff <jeff_berglund@fws.gov>
Subject: [EXTERNAL] USACE UMB Snowpack and Soil Moisture Monitoring Stations (UNCLASSIFIED)

CLASSIFICATION: UNCLASSIFIED

Good Afternoon,

As you are aware, the Corps is presently the lead federal agency for the deployment of a plains snowpack and soil moisture mesonet across the UMB, I have received both coordination letters from your agencies (attached for reference-Thank you!).

An additional layer of complexity has been added to this project; initially the intent was for 5 "proof of concept" sites to be conducted in each of the five states (Montana, North Dakota, South Dakota, Nebraska and Wyoming) prior to mass implementation of the basin-wide system. These proof of concept sites have already been identified as presently existing monitoring stations within their respective state and would be updated ahead of basin-wide deployment to ensure the efficacy and accuracy of the equipment selection. These proof of concept sites were initially going to be assessed within the draft Programmatic EA (PEA) that I am currently working on and set to be released for public and agency review in April. However, the schedule of the PEA is not accommodating the timing needs for updating these proof of concept sites. Thus, it has been decided these 5 sites will be assessed in a stand-alone EA, which would be released prior to the PEA (estimating the draft EA would be available by the end of January 2020 for public and agency review).

As such, I have included the proposed proof of concept site location in Montana (see attached KMZ and proposed project description). This station, a previously existing monitoring station on the campus of MSU, would be updated with the necessary equipment, none of which requires ground disturbance.

Reviewing IPaC, listed species with the potential to occur within the area include the Canada Lynx, Grizzly Bear and North American Wolverine. The proposed update to this pilot site is anticipated to have No Effect on these listed species. No ground disturbance or clearing and grubbing activities would be required, the existing monitoring station is on previously disturbed campus-owned property and the proposed project location and adjacent areas do not support the appropriate habitat needs for these species.

Please let me know if either USFWS or MFWP have any concerns with potential impacts to T&E and fish and wildlife resources that the proposed updates may have. Additionally, if you require additional information on this separate proof of concept effort or have any concerns please let me know.

I appreciate your coordination on this effort,

Rebecca Podkowka
Environmental Resource Specialist
U.S. Army Corps of Engineers
CENWO-PM-AC
1616 Capitol Avenue
Omaha, NE 68102
Phone: 402-995-2677

CLASSIFICATION: UNCLASSIFIED

From: Martin, Jacob
To: Podkowka, Rebecca L CIV USARMY CENWO (USA)
Cc: Jeff Berglund
Subject: [Non-DoD Source] USACE UMB Snowpack and Soil Moisture Monitoring Stations
Date: Tuesday, December 17, 2019 5:24:46 PM

Dear Ms. Podkowka,

Thank you for your December 17, 2019, email to Jeff Berglund regarding the proposed updating/retrofitting of an existing weather monitoring station on the Montana State University campus in Bozeman, Montana. This email represents our official response to your inquiry for your records. The U.S. Fish and Wildlife Service reviewed the brief project description and map and has no comments or concerns regarding federally-listed or proposed threatened or endangered species or other trust species. Thank you for the opportunity to comment. If you have any questions or comments about this correspondence please contact Jeff Berglund at jeff_berglund@fws.gov <mailto:jeff_berglund@fws.gov> or 406-449-5225, extension 206.

Sincerely

Jacob M. (Jake) Martin

MT ES office Assistant Field Supervisor

U.S. Fish and Wildlife Service

585 Shephard Way, Suite 1

Helena, MT 59601

(406) 449-5225x215

jacob_martin@fws.gov <mailto:jacob_martin@fws.gov>