12-2002

The Role of Climate in Modern Water Planning and Related Decisions: Nebraska Case Study

Donna L. Woudenberg
University of Nebraska-Lincoln

THE ROLE OF CLIMATE IN MODERN WATER PLANNING AND RELATED DECISIONS: NEBRASKA CASE STUDY

by

Donna L. Woudenberg

A THESIS

Presented to the Faculty of

The Graduate College at the University of Nebraska

In Partial Fulfillment of Requirements

For the Degree of Master of Science

Major: Natural Resource Sciences

Under the Supervision of Professors

Kenneth G. Hubbard and Steven J. Meyer

Lincoln, Nebraska

December, 2002

THE ROLE OF CLIMATE IN MODERN WATER PLANNING AND RELATED DECISIONS: NEBRASKA CASE STUDY

Donna L. Woudenberg, M.S.

University of Nebraska, 2002

Advisors: Kenneth G. Hubbard and Steven J. Meyer

Climate and weather play an integral role in the planning and decision-making processes for those involved in agricultural and natural resource fields. This project was conducted to determine whether climate and weather data are being efficiently and effectively used in these processes. A survey was mailed to those who work in water-related fields in Nebraska and post-survey interviews were conducted to obtain greater detail. Survey results were analyzed in the following three ways: as a whole; stratified by respondent's agency; and stratified by the educational background of respondents. It was found that climate and weather data are more likely to be efficiently and effectively used in the following situations: in larger agencies (with larger budgets and more staff); and/or by respondents with higher educational backgrounds. These findings were confirmed in post-survey interviews. The most frequently voiced questions during post-survey interviews concerned the availability, accessibility, interpretation, and accuracy of data. Users and potential users require relevant climate and weather data to reduce uncertainty in planning and decision-making processes and the training necessary to integrate the data into planning and decision-making processes. Recommendations include the creation of a climate and weather data 'clearinghouse' to guide users to the appropriate

data and information (thereby increasing the access to and use of such data), the creation of educational programs with materials that suit the range from novice to expert to reach individuals who work for smaller organizations and individuals who require training in interpretation and integration of data, and collaboration between agencies to address user needs for specialized equipment and increased accuracy in forecasts.

ACKNOWLEDGEMENTS

I would like to begin by thanking my husband, Maury, who has managed to (pretty successfully) juggle my needs for space and support, and who has consistently encouraged my efforts. To my daughters, Christine, Amy, and Andrea, who have provided moral support and have always applauded my accomplishments, I give my thanks and love. Thank you to my grandchildren, Cecily and Aidan, who accompanied me to school on more than one occasion, and tried their best to be quiet when grandma had to do homework. A loving and sincere thank you goes to my parents, Louise and Donald Easton, who have always believed in me.

I owe a great debt of gratitude to my committee, Dr. Kenneth Hubbard, Dr. Steven Meyer, and Mr. Robert Kuzelka. Dr. Hubbard has been accessible, accommodating, and a steadfast supporter, and I will always appreciate his time and advice. I am grateful to Dr. Meyer, the undergraduate professor who encouraged me to enter the graduate program, which has changed my life. I extend my gratitude to Mr. Kuzelka, also an undergraduate professor, whose unconventional style has always challenged me to do more than what was expected. I will be eternally grateful to all three.

I would like to thank my officemates, Hong Wu and Dalziza de Oliviera. Hong is a model of quiet strength and determination, and has provided a wonderful example for me to follow. Dalziza is a constant presence and source of energy, and very vocal in her support – even though she returned to her native Brazil halfway through my program. I owe my thanks to Sebastien Korner and Elaine Connelly, both of whom have repeatedly provided me assistance. I also extend my appreciation to Anne Patterson, who has

offered to take over the after-school care of my grandchildren on many occasions, allowing me to extend my work time.

This project was made possible in part by the High Plains Regional Climate Center.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

CHAPTER 1

INTRODUCTION

1.1 Background and Definitions

Weather and climate are the result of interactions that occur within a complex and interrelated global system. The components of the system are the atmosphere, the hydrosphere (the water portion of the planet), the cryosphere (ice and snow), the solid earth, and the biosphere (all life). Weather and climate are powered by solar energy. Though the components of the system are easily identifiable, and most frequently studied separately, they should be viewed as parts of a continuously interacting whole. A change in one component can produce changes in any or all of the other components. Understanding the nature of this system is essential in effectively managing natural resources, defined as the following: nutrients and minerals in the soil and deeper layers of the earth's crust; water; wild and domesticated plants and animals; air; and other resources produced by the earth's natural processes (Miller, 1998). Natural resource managers will enhance the outcome of their decisions by integrating climate and weather data and information into their planning and decision-making processes.

Weather is defined as the state of the atmosphere at a given time and place. Climate is defined as the statistical description of weather over some past period or an estimate of what the statistical characteristics of weather will be over some period in the future (Ackermann et al., 1982). Climate helps us describe a place or region, for example, as arid or tropical. Data refer to the numbers and symbols representing observations. Information refers to the interpretation of data for some specific purpose, such as the National Weather Service forecasts (Ackermann et al., 1982). A climate or

weather product refers to a tool that has been created for some specific purpose, such as software, a model, or a tailored forecast.

Three time frames of weather and climate data and information exist: historical, current or recent, and forecasts or predictions. 'Historical' refers to a compilation of past data or analyses of past data. Historical collections in the High Plains region range from a few years to over a century worth of observations. 'Current or recent' refers to data and information pertaining primarily to events which are occurring, or have recently occurred. 'Recent' is a relative term, and is interpreted by users in several ways. For example, 'recent' rainfall (within the past week or two) may be used by irrigators to schedule the next irrigation, where 'recent' snowpack (within the last season) may be used by water resource managers to estimate seasonal streamflow. 'Forecasts and Predictions' refer to projections of future conditions.

Numerous types of weather and climate data are available for use. These include air temperature, soil temperature, radiation, wind speed and direction, humidity, precipitation, degree days, evaporation, transpiration, and snow measurements. Weather and climate are considered resources, in light of the fact that we take advantage of favorable weather and climatic conditions in virtually all of our activities. They can, and should, also be viewed as risks, as we are subject to adverse weather and climatic conditions and events that we cannot precisely predict (Wittwer, 1981).

1.2 Nebraska's Public Sources for Data, Information, and Products

Climate and weather play an integral role in planning and decision-making processes for people and agencies involved in agricultural and natural resource fields. Access to accurate and timely weather and climate data, and improved use of weather and

climate data, will provide economic and environmental benefits (Changnon et al., 1990). Nebraska is fortunate to be the headquarters to several offices that provide climate and weather data and information, including the High Plains Regional Climate Center, the Nebraska State Climate Office, and the National Drought Mitigation Center.

The High Plains Regional Climate Center (HPRCC), headquartered at the University of Nebraska-Lincoln (UNL) campus, is part of a three-tier national climate services support program. The partners include the National Climatic Data Center (NCDC), six Regional Climate Centers (of which HPRCC is one), and the 47 existing offices of State Climatologists. The mission of HPRCC is to increase the use and availability of climate data in the High Plains region, to provide a regional structure for climate applications, carry out applied climate studies, develop improved climate information products, and provide climate services in the High Plains region (HPRCC, 2002).

The Automated Weather Data Network (AWDN) plays a central role in the data collection system at HPRCC. A description of an AWDN station can be found on the HPRCC website (see bibliography). The AWDN system records hourly data for air temperature and humidity, soil temperature, wind speed and direction, solar radiation, and precipitation. There are 165 active stations in the High Plains region. The data are available through HPRCC.

HPRCC provides primary services to six states in the region, and engages in monitoring efforts in ten states, including Montana, Wyoming, Colorado, North Dakota, South Dakota, Nebraska, Kansas, Minnesota, Iowa, and Missouri. Climate data from the Center have been used by a diverse group of individuals and agencies (Meyer, 1986;

Stooksbury & Curtis, 1995), including, but not limited to, federal, state, and local governmental agencies, researchers, construction companies, utilities, irrigation districts, law enforcement, and the media. Data and products are available on a self-service basis as well as on a staff assisted basis. Web based products of a static nature are available on an unrestricted basis, while 'user' interactive products are available on a fee-basis. The office can be contacted by phone, by mail, or over the Internet.

The Nebraska State Climate Office is also located on the UNL campus, and works in coordination with HPRCC. Data and products can be accessed as with HPRCC – by phone, by mail, or over the Internet. As with HPRCC, some data and products are available on a self-service basis, and some are available for a fee.

The National Drought Mitigation Center (NDMC) is headquartered at UNL, as well. The NDMC's mission is to help people and institutions develop and implement measures to reduce societal vulnerability to drought (NDMC, 2002). The NDMC stresses preparedness and risk management rather than crisis management. All data, information, and products are self-service. The U.S. Drought Monitor [a cooperative effort of the NDMC, the U.S. Department of Agriculture (USDA), and the U.S. Department of Commerce], a valuable product that has proven its worth in various sectors, can be accessed through the NDMC website. Current information and forecasts pertaining to drought are also available. The office can be contacted by phone, by mail, or over the Internet.

1.3 Nebraska's Water Resources

Nebraska has been blessed with abundant water resources. There are two principal aquifers underlying most of state, providing groundwater access to those in the

more arid western part of the state. The High Plains aquifer, historically known as the Ogallala aquifer, lies under the major part of Nebraska. The Great Plains Aquifer underlies a relatively thin strip of land, running north to south, close to the eastern edge of the state. Figure 1 illustrates the principal aquifers in Nebraska.

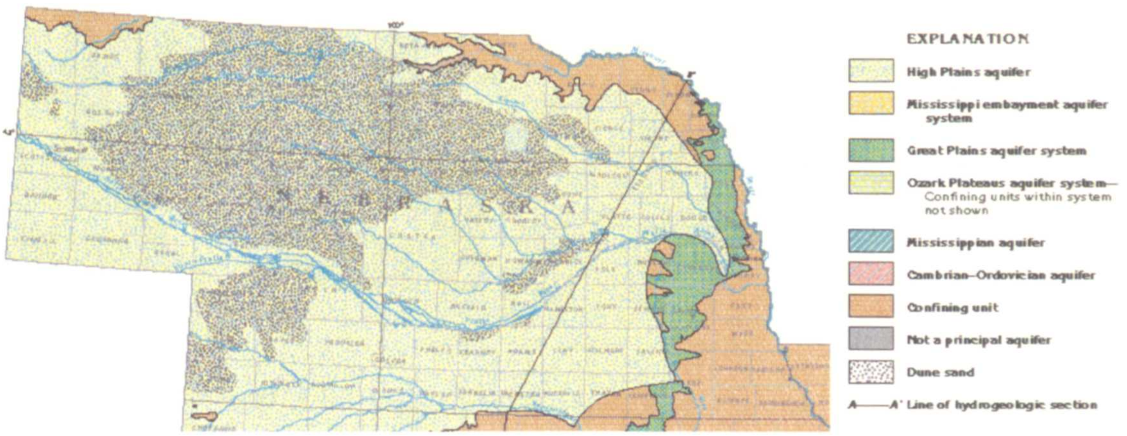

Figure 1: Principal Aquifers, Modified from USGS digital data, 2002

Approximately 24,000 miles of rivers and streams add to the surface water resources of Nebraska. Major rivers divide the state into 13 principal watersheds. Waters from these rivers, and stored water on the rivers and tributaries, supply farming, industrial, municipal, and recreational needs. Figure 2 illustrates Nebraska watersheds.

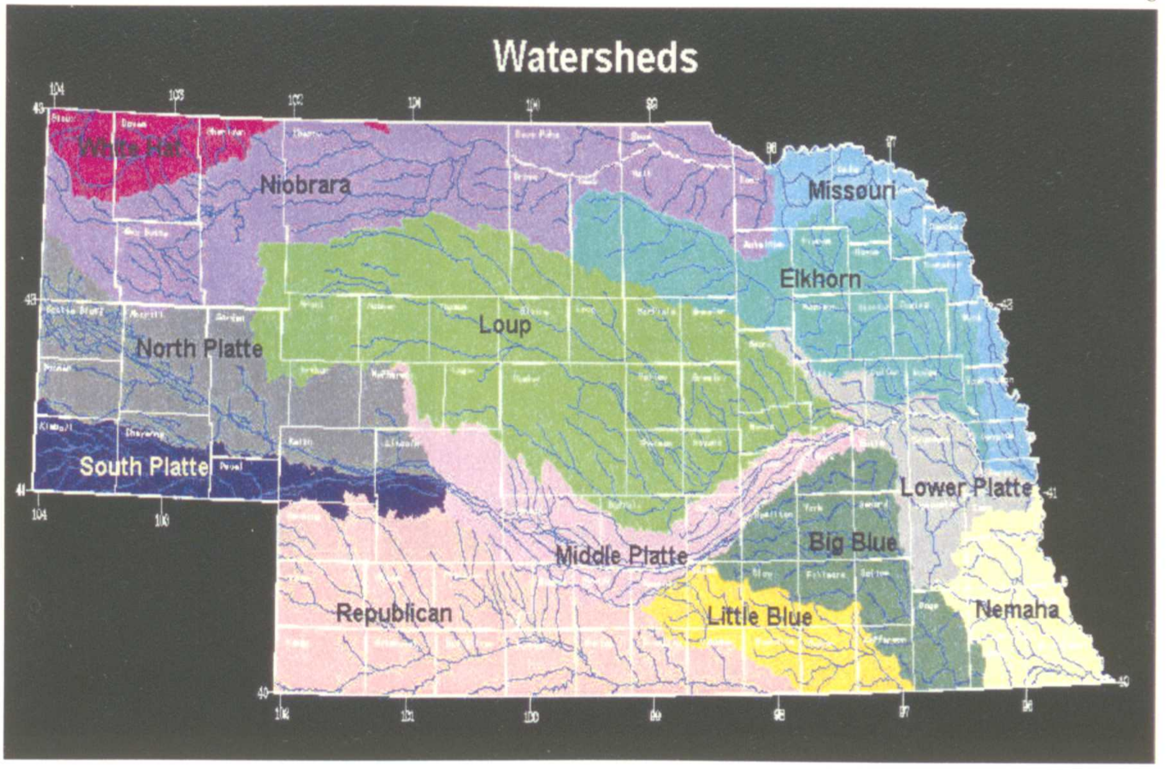

Figure 2: Nebraska Watersheds, from CASDE, 2002

Although Nebraska is relatively water rich, water quality and quantity are still major issues. Groundwater depletion, caused by increased agricultural and municipal use, is of major concern. In 1990, nearly 10 billion gallons of water per day was withdrawn from all the aquifers in the three state region of Nebraska, Kansas, and Missouri. Approximately 90% of the total was used for agricultural, primarily irrigation, purposes. Public supply comprised 5% of the total, domestic/community withdrawals totaled 1.5%, and industry, mining, and thermonuclear use totaled 2.5% (USGS, 2002). Figure 3 illustrates the fresh ground-water withdrawals during 1990.

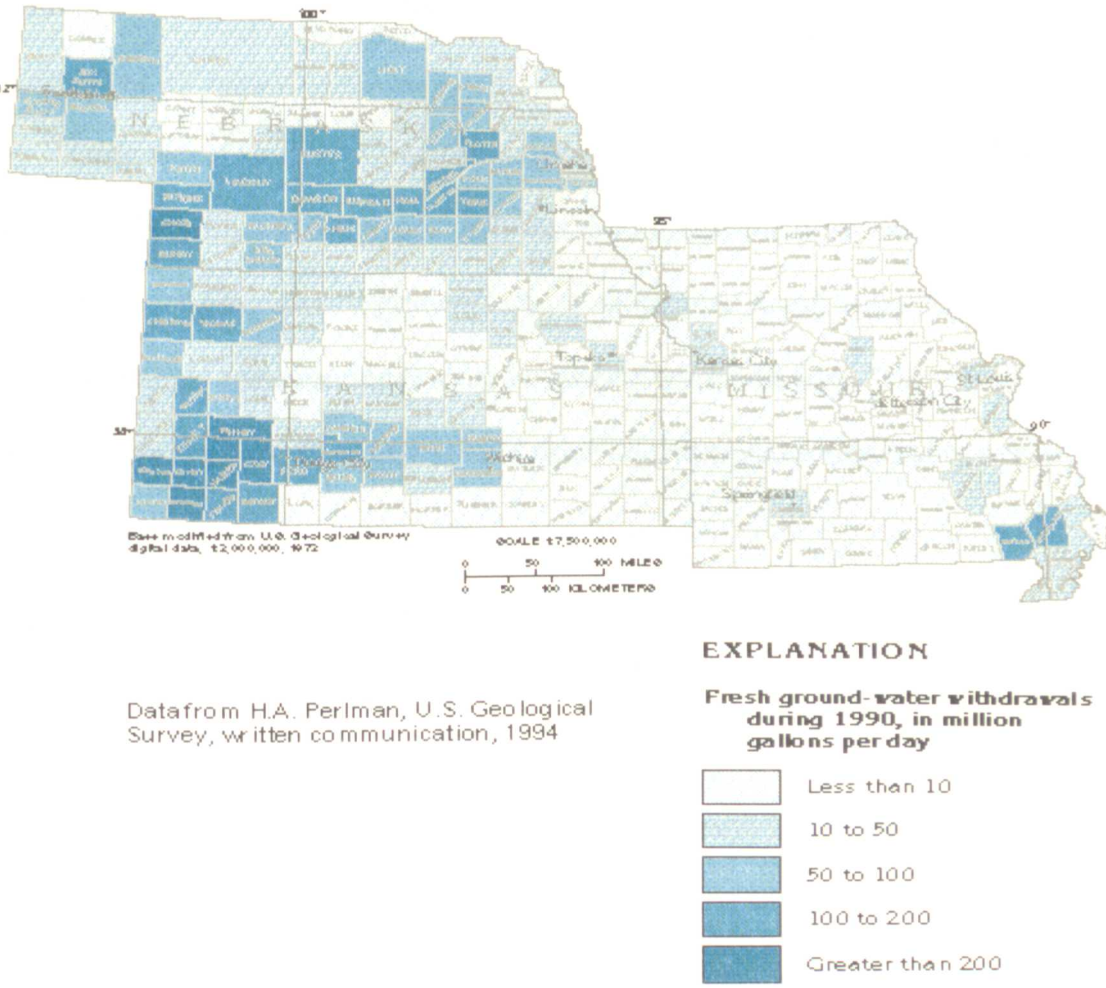

Figure 3: Fresh groundwater withdrawals, from H.A. Perlman, USGS, 2002

Administration of surface waters is a significant legal matter. The state has entered into four compacts, on the South Platte, the Niobrara, the Republican, and the Big Blue Rivers, as well as the North Platte Decree on the North Platte River, regarding administration of interstate waters – the state is currently involved in litigation with Kansas over the Republican Compact. Nebraska Governor Michael Johanns has created a statewide task force to study the interconnectedness of surface and groundwater. The results, which will be used in the administration of both surface and groundwaters, will

provide a clearer picture of the effects of groundwater pumping on surface water supply and depletion.

Depletion of surface waters, particularly in the western part of the state, is becoming a significant problem, primarily due to irrigation and development. Pollution of surface and/or groundwater, primarily due to agricultural runoff or leaching, is a serious problem in some communities and a concern across the state. These issues are being addressed by federal, state, and local agencies and organizations that have been included in this project.

One grouping of state agencies intimately involved in managing Nebraska's water resources are the Natural Resource Districts (NRDs), which are unique to the state. The Nebraska State Legislature created the NRDs in 1972 (LB 1357), as the "most efficient and economical method" of achieving conservation, protection, development and management of the state's natural resources (NARD, 2002). The state is divided into 23 Natural Resource Districts (NRDs), with divisions based on watershed boundaries. Each NRD is required to prepare a master plan concerning all natural resources in the district, as well as a groundwater management plan that must be approved by the Nebraska Department of Natural Resources (DNR) and the Nebraska Department of Environmental Quality (DEQ).

1.4 Project Rationale

A concern at the High Plains Regional Climate Center is that climate information is not being used to the extent that it could be, or is perhaps being used inefficiently. This project was proposed to address this concern. A survey was conducted to find out what questions people and agencies have about climate data and its uses, and what needs

people and agencies have pertaining to climate data. To the extent that a lack of knowledge of data sources and a lack of understanding of its uses is preventing many from fully integrating climate and weather data into planning and decision-making processes, an educational product(s) can be developed to aid in use or accessibility.

1.5 Project Objectives

The objectives of this project are:

1. To survey planners and decision-makers who work with natural resources within the State of Nebraska, particularly water resources, to see if and how they use climate and/or weather data in their work;
2. To interview selected survey respondents to gather more detailed information; and
3. To develop an end product that may help the respondents use climate and/or weather data more effectively and efficiently in their area of work.

CHAPTER 2

LITERATURE REVIEW

2.1 Uses of Climate and Weather Data and Information

Weather and climate data and information are valuable inputs in planning and decision-making processes in many sectors. Weather data and information primarily affect short-term decisions, for example, operational decisions that involve daily fieldwork or irrigation scheduling for the next several weeks. Climate data and information, however, are used in many long-term planning processes. Examples of sectors where climate data and information are used, or could potentially be used, include the following:

- Wind/solar energy & hydropower
- Structure design and construction
- Insurance
- Recreation
- Maintenance
- Farming/farmer investments
- Energy budgets (home/business)
- Transportation
- Legal
- Natural resource management
- Development
- Politics/government
- Research
- Industry (siting)
- Energy companies/public & private utilities (supply/demand/distribution)
- Manufacturing (product design/retailing)
- Impacts of, and on, humans (vulnerability/equity/disaster mitigation)

These examples give an indication of the myriad of uses for weather and climate data and information. The efficient and effective use of data, information, and products in planning and decision-making processes can maximize benefits and minimize costs in magnitudes ranging from a few dollars for individuals to billions of dollars for nations or regions (Wittwer, 1981).

2.2 Climate, Weather, and Water

Climate is a principal factor in determining the water resources of a region. Climate strongly influences both the supply of and demand for water. Precipitation is, in general, the major input to a watershed, except for sources of stored, fossil water such as the High Plains (Ogallala) aquifer. Climatic factors, such as insolation, temperature, humidity, and wind, govern water loss through evaporation and transpiration. Infiltration and runoff are determined by soil type, soil condition, and weather variables, such as antecedent precipitation (as it affects soil moisture), temperature, and rainfall intensity. Water quality depends on amounts of both water and pollutants. The distribution of pollutants is strongly influenced by climatic conditions, such as wind and type and frequency of precipitation (Ackermann, 1982).

High temperatures can increase the demand for water, in a cascading effect – high temperatures lead to increased use of air conditioning, leading to increased use of electricity, leading to increased need for water in hydro facilities and in cooling towers at thermal electricity-generation plants. According to Ackermann (1982), these increased demands unfortunately occur simultaneously with reduced water availability. This is particularly true in an agricultural state, such as Nebraska, where increased temperatures also lead to increased evaporation and transpiration, which leads to increased irrigation demands.

Water, or a lack of it, may constitute a hazard. Flooding affects broad segments of society and river ice affects navigation and power production (Ackermann, 1982). Drought seriously affects all sectors of the economy, including agriculture,

transportation, power generation, and recreation (Ackermann, 1982; Redmond, 2000; Wilhite, 1997).

Potential global climate change is a topic of concern for virtually everyone in the natural resource arena. Many scientists believe that a documented increase in certain atmospheric gases is due to the burning of fossil fuels, which began in the mid-1800s with the Industrial Revolution. The Intergovernmental Panel on Climate Change (IPCC) has issued statistics for the past century. These include: CO_2 levels have increased more than 30% since pre-industrial times and are still increasing at 0.4% each year; methane levels have risen by 150% since 1750; atmospheric nitrous oxide levels have risen 16% since 1750; sea levels have risen by 1.0 to 2.0 mm per year over the last century; and the average surface temperature of the earth has increased by 1.0°F over the last century (IPCC, 2001). These changes may result in changes in the hydrologic system.

Several models have been used to predict temperature and precipitation changes, given the changes in the atmosphere. Models agree on potential temperature changes, and show that temperatures in the Great Plains will likely increase during the winter months, and decrease during the summer months – a moderating of the seasons. Models do not agree on the average annual changes in precipitation (one model shows a slight increase, the other a slight decrease) for the Great Plains region, but a possible scenario concerning the timing of precipitation is of concern. The models show high confidence in peak streamflow moving from spring to winter in many areas where snowfall currently is an important component of the water balance (IPCC, 2001), which would include western Nebraska.

We cannot assume that the future hydrologic regime will be the same as in the past, and therefore need to add that uncertainty to planning and decision-making processes. Gleick (1993) states, "Large-scale water resource management is essential if sustainable biological resources are to be protected. Major issues in future management scenarios will be to: (i) provide adequate quantity and high quality water for human use and natural habitats; (ii) minimize alterations of natural ecosystem processes and losses of overall biodiversity and integrity; (iii) preserve remaining natural fresh water habitats that have high biodiversity and endemic species; and (iv) increase cooperative, multidisciplinary, international research projects on well selected sites that include regionally representative biotas and hydrologic regimes."

Climate and weather data and information are used, or the potential exists for use, in Nebraska in many water related fields. Uses include the following: administration; agriculture (irrigation, livestock); hydropower; structure design, construction, and maintenance, as it relates to storage and flood control; legal, as it relates to administration; research and public education; utilities; recreation; natural resource management, as it pertains to wildlife habitat, particularly for endangered species; drought mitigation; monitoring water quality and quantity; and emergency management.

2.2.1 Drought

Drought is a normal, recurring natural phenomenon. The economic, environmental, and social impacts of drought, such as harm to crops and livestock, forest fires and wildfires, decreases in surface and groundwater, and increased energy demand, are substantial. The Federal Emergency Management Administration (FEMA) estimates U.S. losses of six to eight billion dollars per year (Wilhite, 2000). It is difficult to

identify drought, as it has a slow onset, affects large spatial regions, and causes little structural damage. It is even more difficult to define drought, because it is relative to a region. A generalized definition is a shortage of water to meet present needs, which vary from sector to sector (Redmond, 2000).

Drought has historically been treated as a disaster or 'crisis,' and response has been of a reactive nature – crisis management. As human population has grown, however, more people have become vulnerable to the impacts of drought. Response to the 1987-1989 drought in the U.S. illuminated the ineffectiveness of using a reactive approach, as many impacts could have been prevented or lessened by implementing preparation and mitigation measures (Riebsame et al., 1991) – in other words, by moving from crisis management to risk management.

Nebraska established a drought response plan in 1986, under Governor Robert Kerrey. The emphasis, however, was on emergency response – a reactive approach. The plan was revised (1998-2000), placing emphasis on mitigation and risk management principles. The Nebraska Drought Mitigation and Response Plan was completed and adopted by the state's Climate Assessment and Response Committee in June of 2000 (Svoboda & Hayes, 2002). Many other states have followed suit, by revising existing plans or establishing new plans. Drought-related mitigative actions of state governments include water supply augmentation and development of new supplies, technical assistance on water conservation and other water-related activities, demand reduction and water conservation programs, and water use conflict resolution (Wilhite, 1997).

Monitoring for drought detection is an integral part of drought plans and an indispensable part of resource management. Monitoring is needed to determine the

current status of specific resources, to detect changes in long-term trends, to obtain knowledge of fundamental linkages and processes at work, to enable development and implementation of early warning indicators, and to assess the efficacy of regulatory and mitigative actions (Redmond, 2000). Climate and weather data and information frequently used include precipitation, evaporation and transpiration, soil moisture, snowpack, streamflow, and surface and groundwater levels. Vegetation health is also monitored, as an indicator of the intensity of the drought. Monitoring will continue to be important, as climatic behavior and consequences of climatic fluctuations cannot be predicted past a certain limit (Redmond, 2000). At the same time, quality control and quality assurance of the input data is essential to the goal of incorporating reliable and representative data.

2.2.2 Agriculture

Climate and weather data and information are used extensively in the agricultural sector. Climatic factors, such as annual rainfall, annual temperatures, length of growing season, and availability of water for irrigation, determines the type of crop that can be grown. Climate induced variability of global food production is more than 10%, and as high as 50% in arid and semi-arid regions. Climate information and the emerging ability to predict future climatic events are developing as powerful tools to assist planning and management (Hopkins et al., 1997). Weather data and information are vital in making daily and short-term operational decisions.

Nearly half of Nebraska's crops are irrigated. The Nebraska Agricultural Statistics Service's (NASS) 2002 listing of agricultural statistics shows that out of 19,263,000 acres of cropland planted in 2001, 8,175,000 acres, or 42%, were irrigated.

Scheduling improves the efficiency and effectiveness of irrigation. Better information about the weather and climate in a more timely fashion will help decision-makers to accurately assess the effects of weather and climate on their operations (Hubbard, et al., 1988). Commercial companies and university extension provide assistance to irrigators, helping them make decisions concerning proper timing and amount.

The use of irrigation scheduling, improved accuracy of evapotranspiration calculations and of weather and climate forecasts, improved irrigation products that decrease spray loss, integrated pest management, and the use of the AWDN system as a monitoring tool – the cost of maintaining the AWDN is minor compared to the benefits – have all led to improvements in agricultural operations. There is a major role for near-real time weather data to play in today's agricultural production on the High Plains, where a significant user audience in phenology, crop water use, livestock production, and crop status exists (Hubbard, et al., 1988).

2.2.3 Electric and Water Utilities

Hydropower is critically important in the economy of many regions and nations. It is clean and renewable, provided there is enough rain and snow. Managers of hydropower facilities use long-range weather forecasts and estimates of snowpack over drainage areas to derive estimates of the quantity of water likely to be available in the future (Battan, 1983). Nebraska's hydroelectric facilities contribute significantly to the state's public power supply and to the regions economy. It is in the state's best interest to maintain streamflow for the facilities.

Other types of electric power generation facilities (coal, gas, oil, and nuclear) are common in many regions of the world – Nebraska generates electricity using coal, gas,

and nuclear energy. All electric facilities are subject to outages when severe storms pass through. Lightning, freezing rain, and high winds, which can cause downed trees, can all disrupt power service (Battan, 1983). Predictions of severe storms allow electric utilities to plan and prepare.

The relationship between temperature and power consumption has been well documented. As the temperature increases during the summer, power consumption increases due to increased use of air conditioning. As temperatures drop during the winter, power consumption increases due to increased use of heating. A decision-maker can use historical comparisons between the temperature and consumption to predict demand and consumption for the next several days. The appropriate use of weather forecasts could prevent the unnecessary generation of more expensive power (Maunder, 1986), or, conversely, a shortage of power, which would necessitate purchase from another source – both scenarios could be very expensive for the producer and for the consumer.

Water utilities use climate and weather data and information in much the same way as electric utilities, as consumption is related to temperature. Water utilities are therefore able to make the same type of comparisons as electric utilities, and predict consumption for the next several days. Water utilities monitor rainfall, as well, as demand and consumption historically increase during dry weather. The main goals of Nebraska's water utilities are to provide adequate safe drinking water at competitive prices, to operate treatment, pumping, and storage facilities, and to treat wastewater. All goals are influenced by weather and/or climate related factors.

2.2.4 Emergency Management

Advances in science and technology have contributed to the disaster reduction process, through assessment of vulnerability and enhancement of community awareness of the nature of risks, operation of integrated warning systems, and preparedness and education programs. Satellites, both polar and geostationary systems, detect and track major storm systems and an extensive experimental buoy network in the tropical Pacific monitors sea surface temperatures, which aid in the prediction of El Nino/La Nina cycles (Rodda et al., 1999). The proactive approach of risk management (mitigation, preparation, and early warning) is slowly replacing crisis management (response) on a global scale (Wittwer, 1981; Wilhite, 2000). In many countries, disaster management bodies exist at all levels of government.

Climate and weather data and information play vital roles in global and local monitoring and early warning systems. In a little over a decade, significant increases in the accuracy and timeliness of early warnings have occurred. Forecast time and location of landfall of tropical cyclones improved by 24 hours, so that the accuracy of the 24-hour forecast in 1990 increased to 48 hours in advance by 1999. Warning time for tornados in 1990 was around eight or nine minutes -- it has nearly doubled to over 17 minutes. Improvements in building codes and standards in many parts of the world lessen the impacts of severe storms and geologic events. Analyses of the climatology of natural hazards have been used to produce maps of risk for many countries. Increased forecast lead times for flash floods has substantially improved evacuation times and reduced loss of life (Rodda et al., 1999). As stated earlier, drought plans, with their associated monitoring and early warning systems, have greatly reduced drought-associated impacts.

The Federal Emergency Management Agency (FEMA) is an independent national agency reporting to the President and tasked with responding to, planning for, recovering from and mitigating against disaster (FEMA, 2002). Several FEMA divisions are directly related to these functions: the Readiness, Response, and Recovery Division, the Federal Insurance and Mitigation Administration, and the U.S. Fire Administration. FEMA collaborates with other federal agencies, non-profit groups, and the private sector to accomplish its goals with a minimum of repetition and overlap. One of those agencies is the National Oceanic and Atmospheric Administration (NOAA). The vast majority of the climate and weather data and products used in FEMA's planning and decision-making processes come from NOAA line and program offices, including the National Weather Service (NWS), the National Environmental Satellite, Data, and Information Service (NESDIS), and the Oceanic and Atmospheric Research Office. FEMA's Emergency Management Institute (EMI) trains emergency managers to become familiar with NWS products so they can understand how to use and interpret forecasts, and encourages emergency managers to develop a partnership with the NWS well in advance of a threat (EMI, 2002).

States are required by federal law to have a FEMA approved Hazard Mitigation Plan tailored to the historical climate and weather patterns of the state. A detailed hazard analysis must be completed as part of the plan, requiring the extensive use of historical climate data (NEMA, 2002). In a phone interview conducted on 7/11/02, Cindy Newsham, of the Nebraska Emergency Management Agency (NEMA), stated that historical data are also used within the office as support for requests for assistance from FEMA, for example, snowpack levels as they relate to spring flooding. She said that

weather data, including a NWS data transmission network providing a continuous data feed, the weather channel, and several other sources, are used on a constant basis to monitor and respond to current conditions within the state.

Under the same federal law, local governments are also required to participate in a full-time emergency management program. The first response to a disaster should occur at the local level; if it cannot be handled locally, a request is made to the state for assistance. NEMA coordinates local emergency operation plans and has developed an exercise program to assist local jurisdictions in exercising their emergency plans (NEMA, 2002).

On the international level, developed countries are better prepared to handle emergencies than developing countries. Developed countries have more/easier access to necessary climate and weather data and have emergency response programs in place – some using a proactive approach, but many using a reactive approach. International cooperation has made global monitoring and early warning for emergencies, such as severe tropical storms and the effects of El Nino/La Nina cycles, available to developing countries. More often than not, however, developing countries have no mitigation or preparation measures in place and are vulnerable to the impacts.

Intergovernmental cooperation is crucial in developing greater understanding of natural hazards and the application of relevant sciences to reduce impacts. An ethical dimension is involved, as well, which should be reflected in training, organization, and motivation of actions (Rodda et al., 1999).

2.2.5 Decision-Making

Chechile (1991) states, "Complex decisions are difficult because it is hard for people to maintain a clear picture of all the options available and all the possible outcomes. People also have difficulty dealing with decisions that involve uncertainty, in determining the worth of all possible outcomes, and in setting criteria for choosing a course of action." Decomposing the problem of concern into its basic elements, making certain quantitative assessments, and then combining these assessments in a logical and rational manner can assist a decision-maker, and offers the advantage of a formal framework (Winkler, 1980). A technique that is frequently used to accomplish this goal is the 'decision tree,' which refers to visual portrayal of the entire structure of a decision problem, showing alternative courses for action and possible outcomes (Chechile, 1991). Both objective and subjective information can be used in decision-making processes.

Objective information used in the decision-making process includes probabilities and expected value. Probabilities refer to the chance that an event will occur, represented as a number between 0 (the probability of an impossible event) and 1 (the probability of an inevitable event). Decision analysts hold that probability assignments are an indication of our knowledge or our level of certainty about the defined situation. Expected value refers to the rationally appropriate value that a person should associate with a single trial; if the expected value is positive it is attractive (Chechile, 1991).

Subjective information refers to the utility of an alternative and/or the outcome. Utility is defined as the distinction between extrinsic monetary value and intrinsic subjective worth, or the perceived worth to the individual. It is relative; there is no absolute utility value independent of time, individual, and context. Utility is scaled on a

dimension relative to the variation of the alternatives on that dimension, and therefore has no true zero point (Chechile, 1991). It is important to include subjective information, available only in the form of human judgments, in decision-making processes when it is appropriate, as it is sometimes the piece of information that will make the difference between choices of alternatives and the ultimate outcome.

Climate and weather data, or objective information, play a vital role in the planning and decision-making processes for those involved in water related fields. Many decision-makers have become convinced that the real-time availability of pertinent weather and climate information is of considerable benefit in providing more relevant alternatives and enhanced outcomes (Maunder, 1986). A benefit can be defined as a marginal change in the outcome for a user, or set of users, which is welcomed by the user(s) and ascribed to the application of the climatological input (Nicholls, 1996). Benefits can be qualitative, as in specified improvements in the quality of a user's decisions, environment, output, etc., with the improvements expressed in descriptive, non-numerical terms. Benefits can also be quantitative, both in a change in outcome for a user of the information, which is not converted into economic value, such as improvements or loss reduction in yields, or improved prediction of demand, or a change in outcome, quantified economically, such as improved savings/reduced losses, or net financial savings or benefit to cost ratios (Nicholls, 1996).

Information, itself, is an economic good (Hofing et al., 1987), but the real economic value of weather and climate information is only realized when it affects the way decisions are made (Chechile, 1991; Maunder, 1986; Nicholls, 1996; Wittwer, 1981; Zhu, 2002). Climate information is used, but not uniformly (Hofing et al., 1987).

Effectiveness can be improved both in the usability of climate information and in the ability of users to obtain and analyze the information and then carry out decisions based on their analysis (Wittwer, 1981).

2.3 User Needs

User needs vary considerably, based on the intended use, but several generalizations can be made. According to Ackermann (1982) and Wittwer (1981), users need:

- Tailored probabilistic climate and weather information, with measures of accuracy and reliability, or in a form permitting users to compute probabilities and derive needed information;
- Access to raw data to derive information tailored to specific applications;
- Usable measures of climatic phenomenon, such as wind chill, and heating, cooling, and growing degree days;
- Non-standard climate data, such as radiation, soil moisture, evapotranspiration, runoff, snowpack, windiness, and synthetic data;
- Compatible climate data that can be used in conjunction with other types of technical, environmental, or social data;
- Adequate data coverage, to ensure sufficient representation of the conditions of concern;
- Current climate information for use in operational applications; and
- Tailored forecasts to permit planning and development

2.3.1 Forecasts

Forecasting is an uncertain science, due to the chaotic nature of the atmosphere (Legg & Mylne, 1999). Over the past decade, however, more realistic atmospheric models have been developed, and the importance of atmospheric predictability in general has been realized (Zhu, 2002). Ensemble forecasting has become a major component of weather and climate prediction, allowing weather and climate information to be arrayed in forms that enable decision-makers to fine tune activities to get the best possible outcomes (Stern & Easterling, 1999).

Historically, forecasting using a computer involved using observations to create an up-to-date analysis of the atmosphere, and then using a physically based model to predict its future development. Although increasingly accurate and reliable forecasts have evolved together with advances in models and analysis systems, forecasts beyond a few days can be completely wrong, due to the chaotic nature of the atmosphere (Legg & Mylne, 1999). In a chaotic world, events are non-linear, and as energy is injected or fed into a weather process, it both modifies the weather and is modified itself (Carr , 2000), which means that models can rapidly amplify small errors in the analysis into large differences in outcome. The limitations of the chaos theory cannot be overcome, but improvements in numerical models have been attained.

One such improvement is the use of 'ensembles' to create a forecast. The numerical model is run several times (approximately 50) from slightly different initial conditions, to take into account the uncertainties in the analysis. These individual forecasts are combined by a trained meteorologist/climatologist to form a single forecast, an ensemble forecast (Legg & Mylne, 1999). Ensemble forecasts can be post-processed as either deterministic or probabilistic forecasts.

Deterministic forecasts, which do not use probabilities, predict weather events at a specific location at a specific time. Deterministic forecasts basically present a yes or no forecast – yes, it will rain; no, it will not. Reliable deterministic forecasting can be done out to about five days (Carr, 2000). Probability forecasts use probabilities to give decision-makers more input into their decision-making processes. The forecast will no longer be yes, it will rain, but rather there is an 80% chance of rain. Probabilities enable each user to choose, depending on their estimated or known cost/loss ratio (expected

expense associated with the forecast system as related to potential loss), the decision criterion that offers the most value to them (Zhu, 2002).

Weather forecasts predict the state of the atmosphere a few days in advance. Upper air and surface data collected in standard formats from balloons, airplanes, satellites, and surface stations are transmitted to the Global Telecommunications System (GTS) where they become accessible to all national weather services. Global coverage and free distribution of data are vital aspects of this endeavor (Stern & Easterling, 1999).

Climate prediction involves the interaction of the atmosphere with a more slowly varying component, the ocean. Climate prediction models require initial data from the ocean, which can be derived from satellite images. This slow component of climate carries forward in time and allows predictions over time scales longer than weather time scales. Sea surface temperatures are combined with atmospheric data that are routinely collected for weather prediction, in a coupled atmospheric-ocean model. An ensemble of forecasts is made, as with weather forecasts. These forecasts can be made for seasons up to several years (Stern & Easterling, 1999).

As stated earlier, forecast accuracy has been increasing over the last several decades. According to John Pollack (2002), from the NWS office in Valley, Nebraska, increased accuracy is due to improvements in computer power and models and more and better information, such as objective measures from satellites and radar. Forecast accuracy is generally measured by a statistical comparison of predicted and actual values. The European Center for Medium-Range Weather Forecasts (ECMWF) has graphed the evolution of weather forecast skill (3-, 5-, and 7-day forecasts at 500hPa) for the extratropical northern and southern hemispheres, using archived monthly-mean scores for

the period from January 1980 to August 2001. Correlation coefficients, which are measures of linear association – in this case, between predicted and actual values – were plotted over the time period. In the northern hemisphere, skill for the 3-day forecast increased from approximately 0.85 to 0.95 over the period, from approximately 0.65 to 0.82 for 5-day forecasts, and from approximately 0.45 to 0.63 for 7-day forecasts (Hollingsworth et al., 2002). Forecast skill is expected to continue to rise as technology improves.

Users can take this information into consideration when making their decisions related to weather-sensitive operations. The use of ensemble-based probabilistic forecasts has the potential to substantially increase the overall economic benefit weather and climate predictions can deliver to society (Hammer, 2001; Palmer, 2002; Stern & Easterling, 1999; Zhu, 2002). Palmer (2002) actually states that the overall benefit/cost ratio of using ensemble forecasts, as opposed to deterministic forecasts, is 20:1. Many users who could potentially benefit from ensemble forecasts are unaware of this, however, because of negative experiences associated with past use of single control forecasts (Zhu, 2002).

2.3.2 The Role of the Meteorologist/Climatologist

As stated earlier, climate data and information are useful only to the extent that they provide information that people can use to improve their outcomes beyond what they would otherwise have done. Data and information are most likely to be effective if they address the recipients' specific information needs (Stern & Easterling, 1999).

If ideal weather and climate packages were made available, would users know how to use them? The greatest contribution a meteorologist/climatologist can make is to

find a way to establish real communication between decision-makers and the meteorological/climatological system (Hammer, 2001; Palmer, 2002; Maunder, 1986). A need exists for a human forecaster to interpret the results and most importantly to bolster the customer's confidence in making use of the numerical forecasts (Palmer, 2002). It is essential to educate both the producers of weather and climate information, and the potential users of these products, in the specific applications of weather and climate information to problems (Maunder, 1986).

To provide a better service for decision-makers, it is necessary to identify those activities directly or indirectly affected by the weather and the climate (Hammer, 2001; Palmer, 2002; Maunder, 1986; Stern & Easterling, 1999; Zhu, 2002). The meteorologist or climatologist must prepare and present the package, marketing the package to the consumer in the best possible way. Phillips (1992) states, "Marketing is not simply selling or advertising but involves the process whereby potential users learn what products and service are available and how they might put them to good use, but also realize the usefulness of the information and, hence their understanding of its broad utility and worth to them and their willingness to pay for it."

2.3.3 Impediments – Real and Perceived

Several real or perceived impediments exist which prevent the effective and efficient use of climate and weather data and information in many decision-making processes. Some users/potential users are simply unaware of what's available on the open market. Some are unaware of where to go for more specific information. Some believe they are receiving all the information that is available. A significant impediment

to the use of climate and weather data and information is that many users/potential users doubt the accuracy of climate predictions and weather forecasts (Hofing et al., 1987).

There are many firm-related impediments to the use of data and information. These include a lack of time and/or budget constraints, both of which limit the potential for incorporating new decision-making techniques. Firms may have no employees trained in the area, management may be unsure of the quality of the data or information, and management may be unsure of how to integrate the data or information into their planning and decision-making processes (Hofing et al., 1987). Other firm-related impediments include a lack of flexibility in economic and decision-making models, perceived marginal impact of the use of information compared to the impact on input costs, information is received too late for use, and a lack of local experts to help users interpret and apply data and information (Nicholls, 1996).

A serious impediment to the access to and use of climate and weather data and information is related to equity. Stern & Easterling (1999) state that the "effectiveness of new information depends strongly on the systems that distribute the information (scientific organizations, private organizations, media), the channels of distribution (media, word of mouth), the recipients' judgments about the information source, and the ways in which the informational messages are presented." They believe that "useful information is likely to flow first to those with the most education and money" – a situation that will have "different effects on different regions, sectors, and actors." It is imperative that providers of climate and weather information, particularly in the public

sector, take this point into account – not only on local levels, but also on international levels.

2.3.4 Sources – Public vs. Private

Both government agencies and private organizations provide weather and climate services. A federal weather organization was created in the U.S. in 1870, to accommodate the needs of mariners on the Great Lakes and the eastern seaboard. The government established the organization, as opposed to a private group, as weather information was perceived as a public good, and the government possessed the resources to test the feasibility and value of a weather forecasting network. Several private organizations – Western Union and the Associated Press – also could have created a national reporting and forecast organization at relatively low cost, but did not believe that the creation and sale of such information was a profitable enterprise (Craft, 1999). The National Weather Service, as it is called today, is charged primarily with supplying forecasts to the general public and particularly concerned with violent weather that threatens life and property. They are obliged to furnish certain specialized weather service to pilots, mariners, and some agricultural interest (citrus growers), but the federal government does not provide tailored services (Battan, 1983). Global forecasts are made by public agencies from publicly gathered data and disseminated publicly (Stern & Easterling, 1999). Ordinarily, governmental agencies are non-commercial, and the basic level of service they provide is for the benefit of the population (Phillips, 1992).

There is a multibillion-dollar private weather forecasting industry in the U.S. that provides specialized weather services to a variety of private sources. These usually involve providing specific information to specific sectors of industry to guide resource

growth, distribution, and allocation (Stern & Easterling, 1999). People or groups with special weather concerns should seek the services of a skilled consulting meteorologist who could help maximize benefits and minimize losses. Certified consultants know how conditions affect a particular enterprise and can give the kind of help needed. They also keep their client's welfare in mind 24 hours a day (Battan, 1983). The American Meteorological Society keeps a list of certified meteorologists.

The private sector is both a user and a provider of information and services. Frequently, private-sector users turn to private consulting firms or individuals, as the consultants can provide climate services that are more carefully tailored to specific user needs (Ackermann, 1982). Some commercial meteorologists feel that the private sector's ability to efficiently provide the products and services required by business and the public lead it to play a larger role than it does today. Smith (2002) states, "Since the late 1990's, universities and government research labs partner, develop products, and create their own private sector organizations. In some cases, NWS has given these organizations a head start by allowing them to receive data unavailable to the private sector. The combined preferential treatment in data acquisition, access to federal funds, and the use of tax-supported infrastructure and resources creates an unlevel playing field in the view of many in the private sector."

The public sector is a major decentralized user of services, which are used to manage public lands and facilities, to advise economically important industries, and to plan responses to climate-related problems. Management in the public sector ensures continuity, quality control, accountability, and coordination with other agencies. Public sector organizations may be in the best position to coordinate gathering of climatological

data by state and local agencies, and to help in setting statewide policy. Private sector organizations might encounter problems of conflicts of interest, inadequate authority, and insufficient resources and recognition. This does not imply that private sector consultants should not be used whenever possible to support the work of the public sector. The public sector has a role in supporting information system requirements: climate monitoring; data analysis and quality control; research and innovation; coordination, communication and referral; dissemination and education; and maintenance of an adequate system for providing climate services (and monitor its own climate-related activities and those of others) (Ackermann, 1982).

A central issue in the continuing public vs. private sector debate is respective responsibilities and areas of activity. Neither sector alone can meet the varied needs of all users, however. Therefore, efforts to minimize these obstacles will likely help to increase private-sector participation in the provision of services (Ackermann, 1982). Smith (2002) feels that the U.S. Weather Research Program offers many opportunities for increasing the interaction of university-government-private sector researchers, in concert with existing government technology policy, to the benefit of all.

Resources are best managed by using an integrated approach – climate, weather, and water resources included. All stakeholders should be included in the process, a principle that has repeatedly been stated throughout the preceding literature review. Wondolleck & Yaffee (2000) state, "Collaboration provides a mechanism for effective decision-making through processes that focus on common problems and build support for decisions." Communication, cooperation, and coordination are essential in such a complex, uncertain, and changing system, and will lead to efficiency – from providing

basic services to tailoring and marketing forecasts to research issues – with an overall goal of improving water resource management in Nebraska.

It is obvious based on the information derived from the literature that many players are operating in a multifaceted and dynamic system. There is no substitute, in this case, to conducting a survey and personal interviews to find out what users want and/or need. That is the goal of this project.

CHAPTER 3

MATERIALS AND METHODS

3.1 Preliminary Activity

As part of a preliminary information gathering process, several people with expertise in the use of climate and weather data use and/or special knowledge about water related natural resource issues were interviewed prior to survey development. An interview with the State Climatologist and the High Plains Regional Climate Center's Climate Data Specialist yielded a list of agencies and organizations that request climate and weather data, as well as the types of requests that come into the office. This information was valuable in compiling a mailing list for the survey and for question development.

Interviews with two members of the University of Nebraska faculty yielded several suggestions for the project. Suggestions included: a differentiation be made between weather and climate in any final products; surveys should be sent to 'working people' instead of those involved in the academic community; final products should be distributed in various forms (printed materials, websites, etc.); and climate should be viewed as a 'hazard,' as well as a 'resource,' when the planning and decision-making process is used. It was also suggested that the case study be limited to the State of Nebraska, in light of potential differences in budget, policy, etc. in the surrounding region.

3.2 Survey

The survey was designed to provide anonymity, in the hope that respondents would be more willing to answer candidly. The survey has three sections. Questions in

the first section provide background information on the respondent, including the classification of job type, job title, zip code, and educational background (including climate, weather, and hydrology courses taken or training received in the same).

The second section provides information on whether or not a respondent uses climate and/or weather data on the job. If so, a series of subsequent questions supply information on the time frame, types, and sources of data used, how and/or why the data are used, and when or how often the data are used. An open-ended question was included to give respondents the opportunity to describe potential products that would be particularly helpful in their job. Questions were also included to indicate the use of short and long-term predictions, anticipated future uses of climate or weather data, and preferences for delivery of educational programs.

The second section also includes a question concerning forecast accuracy. Respondents were asked, "What degree of accuracy (percent) do you feed the NWS currently provides for the following: 1-3 day forecasts, 7-10 day forecasts, and long-term forecasts (monthly/seasonal)." Accuracy was not defined. Instead, the question was worded to be very general, in order to get an idea of the respondents perception of forecast accuracy.

The final section provides the respondents with contact information for any questions about the survey or questions about the availability of climate data. An addressed and stamped envelope was provided to allow the respondents to return the survey to the HPRCC office. Please see Appendix B for a copy of the survey.

The list of survey recipients consisted of natural resource planners and decision-makers, particularly those who work with water resources. The address list was limited

to the State of Nebraska, with the exception of the Environmental Protection Agency Regional Office in Kansas City, Missouri. Note: Nebraska's water and electric utilities are located in the same office in many cities and towns, and in separate offices in others. In order to reach all pertinent decision-makers, surveys were mailed to both water and electric utilities. Table 1 lists the agencies and organizations included in the survey.

TABLE 1: Agencies and Organizations Included in Survey	
Natural Resource Districts (NRDs)	Rural Water Districts
The Groundwater Foundation	Department of Natural Resources (DNR)
Irrigation and Reclamation Districts and Water Delivery Companies	Water and Electric Power Utilities and Public Power Districts
Department of Environmental Quality (DEQ)	Natural Resources Conservation Service (NRCS)
U.S. Geological Survey (USGS)	U.S. Army Corps of Engineers (USACE)
U.S. Department of Agriculture Farm Service Agency Offices (USDA-FSA)	U.S. Environmental Protection Agency (EPA)
U.S. Bureau of Reclamation	Nebraska Department of Roads
Nebraska Health and Human Services	Nebraska Emergency Response Agency
Nebraska Game & Parks Commission	Soil Conservation Service
UNL Conservation & Survey	National Weather Service
Nebraska Agricultural Statistics Service (NASS)	Nebraska State Fire Marshall

3.3 Interviews

A postcard was designed to go out in the same mailing as the survey. The postcard gave respondents the opportunity to request the results of the project. It also asked for a respondent's willingness to participate in an interview to discuss the questions presented in the survey. The postcard was also addressed and stamped to be returned to the HPRCC office and was to be mailed separately, in order to preserve the anonymity of the survey.

The design of a tool or product that may help respondents use climate and weather data more effectively and efficiently in their area of work will be based on the results of the surveys and interviews.

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Background

Approximately 300 surveys were mailed in November of 2001. Offices throughout the state were contacted, for statewide coverage of all uses and needs related to climate and weather data. Figure 4 illustrates the locations of survey recipients.

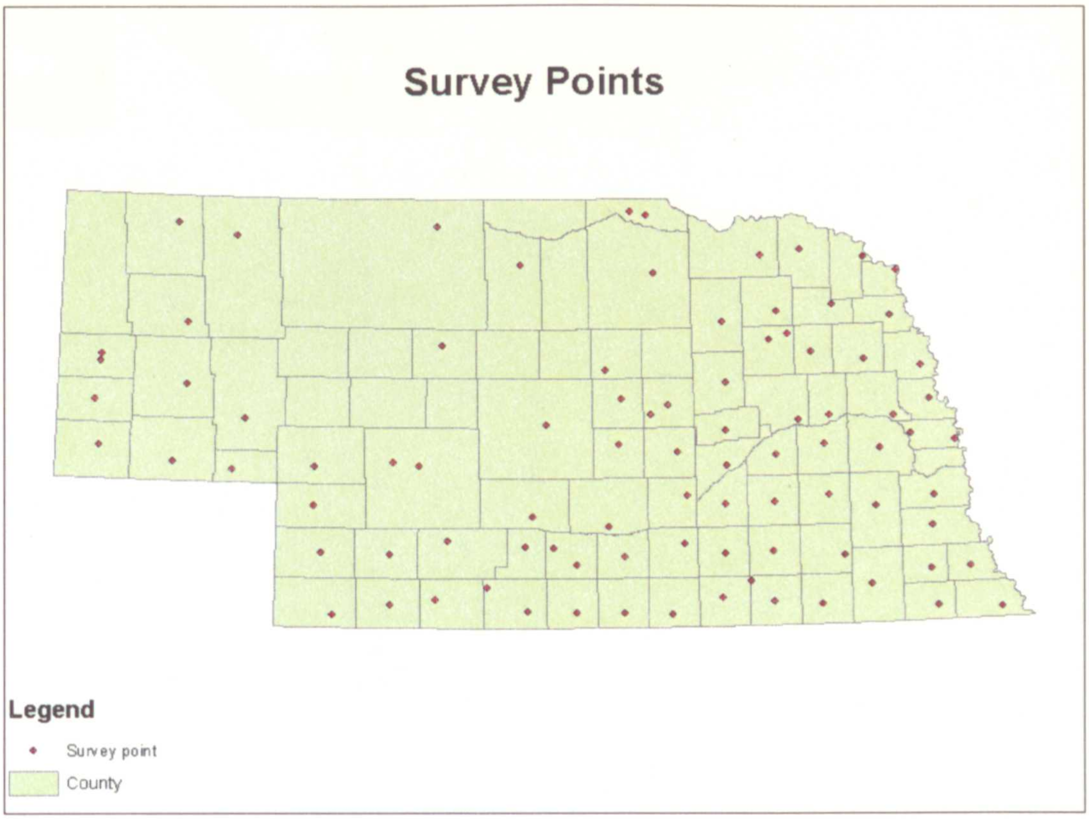

Figure 4: Locations of Survey Recipients

A total of 140 surveys (47%) were returned. Originally, only one analysis was run on the survey data, using the entire data set, resulting in a general overview of all respondents. These results can be found in Table 2, with a description of the results following the table.

In an effort to garner more information about how climate and weather data and information are used by respondents with differing backgrounds, two additional analyses were run. One analysis was run on the data set after it was stratified by the agency or organization with which the respondent is associated, with the following divisions: federal government; state government; Natural Resource Districts; other local government; education; irrigation district; and other agency/organization. In this stratification, the majority of the respondents who chose other agency/organization work for utility companies or combined utility/irrigation districts. The results of this analysis can be found in Table 3, with a description of the results following the table.

The last analysis was run on the data set after it had been stratified by the respondent's educational background, with the following divisions: high school degree; some college; college degree; technical degree; and other type of educational background. In this stratification, there were three respondents who chose other type of educational background; explanations included 25 years of experience, an accounting major at the CE School of Commerce, and a Civil Engineering degree. The results of this final analysis can be found in Table 4, with a description of the results following the table.

Note: Many questions in the survey allowed the respondents the option to choose 'other' as an answer, and then give an explanation or description of 'other.' A brief listing of these explanations and descriptions can be found immediately following each table, with the discussion of the information contained in the tables following these descriptions. A compilation of survey responses can be found in Appendix C.

TABLE 2: Analysis Of Data Set With No Stratification			
Agency/Organization	**(%)**	**Types**	**(%)**
Federal Government	42	Air Temperature	69
State Government	11	Soil Temperature	24
NRD	23	Radiation	8
Other Local Government	4	Wind Speed	29
Education	2	Wind Direction	20
Irrigation District	8	Humidity	20
Other**	9	Precipitation	96
		Degree Days	36
		Evapotranspiration	32
Education	**(%)**	Snow	25
High School Degree	8	Short-Term Predictions	40
Some College	14	Long-Term Predictions	21
College Degree	72	Other**	3
Technical Degree	4		
Other**	2	**How/Why**	**(%)**
		Planning	46
Time Frame	**(%)**	Decision-making	61
Historical	65	Design	11
Recent/Current	89	Education	14
Predictions	34	Research	14
		Regulatory Action	35
Sources	**(%) [O/O]***	Monitor Water Q/Q	34
NWS	25/36	Hydrology	22
NWS River	5/15	Irrigation	32
NCDC	14/37	Communication	10
CPC	7/16	Policy	15
HPRCC	21/34	Other**	14
State Climatologist	12/30		
AM/FM Radio	35/28	**When/How Often**	**(%)**
NOAA Radio	9/19	Daily	23
Television	36/23	Weekly	15
Newspaper	24/34	Monthly	10
Computer	36/30	Seasonally	37
Subscription	6/5	Annually	3
Other**	3/2	Drought	4
		Flood	2
		Other**	6

TABLE 2 (cont.): Analysis Of Data Set With No Stratification			
How Rate NWS Accuracy	**(%)**	**Long-Term Predictions**	**(%)**
1-3 Days	78	Yes	31
7-10 Days	61	No (why not below)	69
Long-Term	42	Obtain	
		Interpret	2
Short-Term Predictions	**(%)**	Integrate	13
Yes	58	Accuracy	30
No (why not below)	42	Other**	56
Obtain	6		
Interpret		**Educational Preference**	**(1st/2nd)*** **
Integrate	18	Workshop	47/8
Accuracy	3	Manual	11/10
Other**	73	Course	9/16
		Web Tutorial	19/6
Future Use	**(%)**	Video	15/17
Yes	65	DVD	4/3
No	35	CD Rom	14/10
		Other**	3/1

* Use Often/Use Occasionally
**Descriptions of "Other" categories follows table
*** First Choice/Second Choice

DESCRIPTION OF "OTHER" CATEGORIES

TABLE 2: Analysis Of Data Set With No Stratification

Agency/Organization –
Public power and irrigation district
Municipal joint action agency
Mutual irrigation company
Non-profit training center
City water system
Farmer
UNL Conservation & Survey
Irrigation district
Rural water project
Public power district
Utility (LES)
Public water utility

Educational Background –
25 years experience
Accounting major at CE School of Commerce
Civil Engineer

Sources –
NE Department of Water Resources (DNR)
Local reporting stations
Precipitation collection points
Weather stations within district
On-line UNL weather information and NASS
Federal government agencies & publications and USBR
Omaha NWS website, UNL website

Short-Term Predictions – Reason for Not Using –
No need
Crop water use
Only for driving conditions
Only during snowstorms

Types of Data Used –
Cloud cover
Storage reservoir data
Information in computer from 3 areas for County
Soil profile capacities
Lake evaporation

How And/Or Why Use –
USDA disaster programs
Collecting weather (rainfall) data
Drainage design
Legal
Predict electric loads
Water operations

When Or How Often Use –
Combinations of daily, weekly, monthly, seasonally, annually, drought, flood
During severe storm
Only to develop plans
Continuous updates from data collection platforms

Long-Term Predictions – Reason for Not Using –
No need
Fieldwork requires current weather forecast
Use climatology for models
No. 1 priority is intense rainfall, cannot predict long-term
Adjusting irrigation releases difficult – possibility of rain - plans based on historical probabilities

Educational Preferences –
Worthless unless proven, so far that is not the case
Internet based
Not sure

4.2 Results of Analysis of Data Set With No Stratification

Results of the first analysis show that 42% of the respondents work for the federal government, 23% for the Natural Resource Districts (NRDs), and 11% for the state government. The remaining categories (other local government, education, irrigation districts, and 'other' agency) each represent less than 10% of the respondents. The majority of respondents (72%) have college degrees, and another 14% have some college experience. The educational categories of high school degree, technical degree, or 'other' educational background each represent less than 10% of the respondents.

Respondents use recent and/or current data (89%) more often than historical data (65%) or predictions (34%). The most frequently used types of data are precipitation, air temperature, short-term predictions (daily to a week), degree days (heating, cooling, and growing), and evapotranspiration (ET). Respondents use climate and weather data most frequently for decision-making, planning, regulatory action, monitoring water quality and/or quantity, and to calculate ET. The most frequently used sources of climate and weather data are the computer, AM/FM radio, the National Weather Service (NWS), television, and the newspaper. Climate and weather data are used on a seasonal basis by 37% of the respondents, 23% use it daily, 15% weekly, and 10% monthly.

The respondents rated the accuracy of NWS 1-3 day forecasts at 78%, 7-10 day forecasts at 61%, and long-term forecasts at 42%. Responses ranged from 30% to 97% for 1-3 day forecasts, from 10% to 90% for 7-10 day forecasts, and from 5% to 85% for long-term forecasts. These numbers indicate that respondents do not have much confidence in long-term forecast accuracy, and some respondents have very low confidence in any type of forecast.

Short-term predictions (daily to weekly) are used by 58% of the respondents. The 42% who do not use short-term predictions cite 'no need' or 'unsure how to integrate' climate and weather data and information into planning and decision-making processes as the primary reasons. Only 31% of the respondents use long-term predictions (monthly or seasonal). The 69% who do not use long-term predictions cite 'no need' and 'accuracy' as the primary reasons.

The majority of respondents (65%) anticipate future uses of climate and weather data as new tools and products become available. Workshops, videos, courses, web tutorials, and CD's were listed as the preferred methods to receive educational programs.

TABLE 3: Analysis Of Data Set Stratified By Agency/Organization							
	Federal (59)	**State (16)**	**NRD (32)**	**Local Gov (6)**	**Edu. (3)**	**Irrig. (11)**	**Other (13)**
Education (%)							
High School Degree	2	13	9	33		18	8
Some College	17		3			55	15
College Degree	76	81	81	50	100	9	77
Technical Degree	5		6			9	
Other *		6		17		9	
Time Frame (%)							
Historical	66	87	61	40	100	44	60
Recent/Current	95	73	89	100	67	78	90
Predictions	16	53	39		33	67	80
Types (%)							
Air Temperature	74	60	66	50	33	67	80
Soil Temperature	12	7	72			22	
Radiation	2	7	28				
Wind Speed	12	27	57			67	30
Wind Direction	9	13	41			67	10
Humidity	9		55			33	20
Precipitation	100	100	97	83	100	89	80
Degree Days	36	13	59			22	50
Evapotranspiration	17	53	62		67	22	10
Snow	21	53	14		33	56	20
Short-Term Predictions	14	53	62	33	33	67	90
Long-Term Predictions	14	40	14		67	44	30
Other *		7	3	17			10
How/Why (%)							
Planning	21	60	69	33	67	78	80
Decision-making	52	60	59	67	67	89	90
Design	5	13	24			11	10
Education	2	7	45		67		10
Research	9	20	24		67		10
Regulatory Action	53	40	17	33	33		10
Monitor Water Q/Q	14	33	66	33	67	56	30
Hydrology	14	40	35		33	11	20
Irrigation	10	13	69	17	67	100	20
Communication	7		28		33		
Policy	12	20	21		33	11	10
Other *	21	13		17		11	20

TABLE 3 (cont): Analysis Of Data Set Stratified By Agency/Organization							
	Federal (59)	**State (16)**	**NRD (32)**	**Local Gov (6)**	**Edu. (3)**	**Irrig. (11)**	**Other (13)**
Sources (%) [Use Often/Use Occasionally]							
NWS	27/31	25/31	16/50	17/67	0/67	46/9	31/31
NWS River	5/12	6/19	3/13	0/17	0/67	9/27	8/8
NCDC	22/48	19/19	0/38	17/17	0/100	0/9	23/31
CPC	12/20	13/5	3/16	0/17	33/33	9/0	0/31
HPRCC	27/39	31/13	22/34	17/17	0/100	0/18	0/39
State Climatologist	25/36	0/25	3/25	0/33	0/67	9/0	0/15
AM/FM Radio	29/22	44/25	34/44	17/67	33/33	46/18	54/7
NOAA Radio	10/12	13/25	9/25	0/16	0/67	18/27	0/15
Television	27/22	38/19	38/38	50/33	67/0	36/18	62/0
Newspaper	24/39	31/25	16/44	17/50	67/0	27/27	31/8
Computer	37/31	38/25	28/44	50/50	33/67	36/0	39/8
Subscription	7/5	6/0	3/6	0/0	0/33	9/0	15/7
Other*						9/0	8/8
When/How Often (%)							
Daily	13	17	9	33		100	50
Weekly	3	42	22	33	33		13
Monthly	10		17		33		13
Seasonally	45	42	39	33	33		25
Annually	5		4				
Drought	10						
Flood	3		4				
Other*	13		4				
How Rate NWS Accuracy (%)							
1-3 days	81	77	79	68	85	68	77
7-10 days	66	57	59	47	80	52	62
Long-Term	44	40	45	30	70	43	35

TABLE 3 (cont): Analysis Of Data Set Stratified By Agency/Organization	Federal (59)	State (16)	NRD (32)	Local Gov (6)	Edu. (3)	Irrig. (11)	Other (13)
Short-Term Predictions (%)							
Yes	32	87	77	50	33	91	77
No (why not below)	68	13	23	50	67	9	23
Obtain	5	33					
Interpret							
Integrate	10		75		100		
Accuracy						100	
Other*	87	67	25	100			100
Long-Term Predictions (%)							
Yes	25	38	29	17	100	27	46
No (why not below)	75	63	71	83		73	54
Obtain							
Interpret			7				
Integrate			47				
Accuracy	5	33	20	50		100	57
Other*	95	67	27	50			43
Future Use (%)							
Yes	64	60	74	50	100	60	58
No	36	40	26	50		40	42
Educational Preference (1st Choice/2nd Choice)							
Workshop	15/2	5/2	14/2	1/0	3/0	4/1	5/1
Manual	7/1	0/3	4/1	0/1	0/3		0/1
Course	2/5	1/1	4/5	0/1		0/4	2/0
Web Tutorial	11/4	1/0	4/2	1/0		1/0	1/0
Video	8/8		3/5	2/1		1/0	1/3
DVD	1/0	1/0	2/0				0/3
CD Rom	9/5	1/0	3/2	0/1		0/1	1/1
Other*	0/1	1/0				1/0	1/0

*Descriptions of "Other" categories follows table

DESCRIPTION OF "OTHER" CATEGORIES

TABLE 3: Analysis Of Data Set Stratified By Agency/Organization

Educational Background –
State Government – Civil Engineer
Other Local Government – CE School of Commerce
Irrigation District – 25 years experience

Types Of Data Used –
State Government – Lake evaporation
NRD – Soil profile capacities
Other Local Government – Information in computer from 3 areas for county
Irrigation District – Storage reservoir data
Other – Cloud cover

How And/Or Why Use –
Federal Government – USDA disaster programs
- Collect weather (rainfall) data

State Government – Legal
Other Local Government – USDA disaster programs
Irrigation District - Drainage design
Other – Predicting electric loads
- Water operations

Sources –
Federal Government – Local reporting stations
- Precipitation collection points
- Online weather info and NASS

NRD - Weather stations within district
Irrigation District– NE Dept of Water Resources (DNR)
Other – Federal government agencies & publications and USBR
- Omaha NWS and UNL websites

When Or How Often Use –
Federal Government – Combinations of daily, weekly, monthly, seasonally, annually, drought, flood
- Severe storm
- Continuous updates from data collection platforms

NRD – Combinations of daily, weekly, monthly, seasonally, annually, drought, flood
- Only to develop plans

Short-Term Predictions – Why Not Use –
Federal Government – No need
- Only for driving conditions
- Only during snowstorms

State Government – No need
- Snowstorm

NRD – Crop water use
- No need

Other Local Government – No need
Other – N/A

Long-Term Predictions – Why Not Use –
Federal Government – No need
- Adjusting irrigation releases difficult – possibility of rain – plans based on historical probabilities

State Government – No need
NRD – No need
- Fieldwork requires current prediction
- No. 1 priority concerns intense rainfall, impossible to predict long-term

Other Local Government – no need
Other – Use climatology for models

Educational Preference –
Federal Government – Internet based
State Government – Not sure
Irrigation District - Worthless unless proven, so far that is not the case

4.3 Results Of Analysis Of Data Set Stratified by Agency/Organization

For this analysis, the data set was stratified by the respondent's classification of the type of agency or organization they work for. Categories include the federal government (59 respondents), the state government (16), NRDs (32), other local government (6), education (3), irrigation districts (11), and other organizations (13) – which includes utilities – for a total of 140. The majority of respondents in all categories have college degrees, with the lowest proportion associated with irrigation districts (55% have some college).

The majority of those associated with government, the NRDs, or education use historical climate data and recent/current weather data most frequently. Irrigation districts and other organizations use recent/current data and predictions, which seems appropriate considering the nature of irrigation scheduling and decision-making within utilities (demand and consumption). Precipitation is the most often used type of data for all agencies/organizations with the exception of the 'other' category, which cited short-term predictions as the type most used – again, it would be appropriate for utilities. Air temperature, ET, and short-term predictions were the other types of data most frequently used by all agencies/organizations.

Respondents associated with the federal government most often use climate and weather data for regulatory action (53%), planning (21%) and decision-making (52%), and to implement disaster programs (21%), for example the USDA Farm Service Agency programs. Irrigation districts most often use data for irrigation scheduling (100%), planning (78%), and decision-making (89%). The NRDs cited planning (70%), irrigation (70%), and monitoring water quality and quantity (66%) as the primary reasons for using

data. The remaining agencies/organizations most frequently use data for planning and decision-making.

The computer was listed among the most frequently used sources for climate and weather data in every agency/organization. Other frequently used sources include AM/FM radio, television, NWS, and the newspaper. The exceptions in this case are the federal government and education, which list NCDC and HPRCC along with the computer as their most frequently used sources for data.

An interesting trend was found in this data. A larger agency or organization (larger budget, more personnel) tends to use a greater variety of sources on a higher percentage basis. For example, respondents who work for the federal government, in education, and for 'other' agencies/organizations use NCDC, the Climate Prediction Center (CPC), HPRCC, and the State Climatologist more often than those in other categories. The smaller the agency/organization (budget and/or personnel), the greater is the tendency to use the more visible sources of data – computers, the radio, television, and the newspaper.

All agencies/organizations use climate and weather data most frequently on daily, weekly, monthly, or seasonal bases, with the exception of the federal government. federal respondents cite 'other' (drought and support for disaster declarations) as one of the primary reasons for how and when they use data.

Those involved in education have the most confidence in NWS forecast accuracy, rating 1-3 day forecasts at 85% accuracy, 7-10 day forecasts at 80%, and long-term predictions at 70%. Ratings for other agencies/organizations for 1-3 day forecasts range

from 68% to 81% accuracy, ratings for 7-10 day forecasts range from 47% to 66%, and ratings for long-term forecasts range from 30% to 45%.

Most agencies/organizations use short-term predictions in their work, with the exception of the federal government and education, the majority of which do not (68% and 67%, respectively). Of those who do not use short-term predictions at all, the majority cited 'no need' as the reason. The remainder of those who do not use short-term predictions cite 'accuracy' or 'unsure how to integrate' climate and weather data into planning and decision-making processes as the reasons. The majority of respondents in all categories do not use long-term predictions, with the exception of those involved in education. NRD respondents who do not use long-term predictions cite 'unsure how to integrate' climate and weather data into planning and decision-making processes as the primary reason for not using them. The remaining respondents in all agencies and organizations who do not use long-term predictions cite 'accuracy' and 'no need' as the reasons.

The majority of respondents in all agencies/organizations anticipate the future use of climate and weather data as new tools and products become available. Workshops, courses, and videos were most often rated as the preferred methods to receive educational programs.

TABLE 4: Analysis Of Data Set Stratified By Educational Background					
	High School (11)	**Some College (19)**	**College Degree (100)**	**Technical Degree (6)**	**Other (3)**
Agency/Organization (%)					
Federal Government	9	53	44	50	33
State Government	18		13		
NRD	27	5	26	33	
Other Local Government	18		3		33
Education			3		
Irrigation District	18	32	1	17	33
Other*	9	11	10		
Time Frame (%)					
Historical	50	80	66	33	67
Recent/Current	100	93	87	100	67
Predictions	40	13	34	67	33
Types (%)					
Air Temperature	70	47	72	67	100
Soil Temperature	20	13	26	33	
Radiation			10	17	
Wind Speed	30	33	27	17	67
Wind Direction	40	27	17	17	33
Humidity	20	13	21	33	
Precipitation	80	100	98	83	100
Degree Days		47	39	33	
Evapotranspiration	30	13	33	67	33
Snow	40	40	20	17	67
Short-Term Predictions	70	20	42	17	33
Long-Term Predictions	50	7	21		33
Other*	10	7	2		

TABLE 4 (cont): Analysis Of Data Set Stratified By Educational Background					
	High School (11)	**Some College (19)**	**College Degree (100)**	**Technical Degree (6)**	**Other (3)**
How/Why (%)					
Planning	70	40	44	50	67
Decision-Making	70	67	59	67	33
Design	10	13	11	17	
Education	10		16	33	
Research			17	17	33
Regulatory Action	30	27	38	33	33
Monitor Water Q/Q	40	33	35	33	
Hydrology		13	24	33	33
Irrigation	30	40	32	33	33
Communication	10		10	50	
Policy		20	14	33	
Other*	20	20	13	17	
Sources (%) [Use Often/Use Occasionally]					
NWS	46/36	32/26	19/39	33/33	67/0
NWS River	9/9	11/11	4/16		0/33
NCDC	18/0	11/16	16/44	0/50	0/33
CPC	9/0	0/21	10/18	17/17	18/9
HPRCC	18/9	11/16	22/38	33/33	33/67
State Climatologist	0/9	11/21	13/31	17/17	33/33
AM/FM Radio	27/36	26/21	37/28	33/33	33/33
NOAA Radio	9/0	11/26	7/21	17/17	67/0
Television	36/18	21/21	38/24	50/17	33/33
Newspaper	27/18	26/32	24/35	33/33	0/67
Computer	36/27	26/16	38/32	50/33	0/33
Subscription	9/0		7/7		33/0
Other*		5/5	3/2		
When/How Often (%)					
Daily	38	36	16	50	67
Weekly	25		18		
Monthly	13	18	10		
Seasonally	25	18	40	50	33
Annually		9	3		
Drought		9	4		
Flood			3		
Other*		9	7		

TABLE 4 (cont): Analysis Of Data Set Stratified By Educational Background					
	High School (11)	**Some College (19)**	**College Degree (100)**	**Technical Degree (6)**	**Other (3)**
How Rate NWS Accuracy (%)					
1-3 days	78	78	78	85	74
7-10 days	66	61	59	75	55
Long-Term	44	45	40	59	40
Short-Term Predictions (%)					
Yes	82	47	57	50	67
No (why not below)	18	53	43	50	33
Obtain			8		
Interpret					
Integrate		25	19		
Accuracy		25			
Other*	100	50	73	100	100
Long-Term Predictions (%)					
Yes	27	29	32	17	33
No (why not below)	73	71	68	83	67
Obtain					
Interpret			3		
Integrate		20	13	50	
Accuracy	71	40	23		
Other*	27	40	62	50	100
Future Use (%)					
Yes	27	44	74	40	100
No	73	56	26	60	
Educational Preference (1st Choice/2nd Choice)					
Workshop		4/2	39/5	3/0	1/1
Manual	0/1		11/9		
Course		1/1	8/13	0/1	0/1
Web Tutorial	0/1	1/0	14/5	1/0	2/0
Video	2/0	2/0	11/14	0/1	
DVD			4/3		
CD Rom		1/1	13/7	0/1	0/1
Other*	1/0	1/0	1/1		

*Descriptions of "Other" categories follow table

DESCRIPTION OF "OTHER" CATEGORIES

TABLE 4: Analysis Of Data Set Stratified By Educational Background

Agency/Organization –
High School Degree – Rural water project
Some College – Non-profit training center
- Mutual irrigation company

College Degree –
- UNL Conservation & Survey
- Farmer
- Public power and irrigation district
- Irrigation district
- Municipal joint action agency
- Public power district
- Utility (LES)
- Public water utility
- City water system

Types Of Data Used –
High School Degree – Information in computer from 3 areas for county
Some College – Storage reservoir data
- Soil profile capacities

College Degree – Cloud cover
- Lake evaporation

How And/Or Why Use–
High School Degree – USDA disaster programs
- Drainage design

Some College – USDA disaster programs
College Degree - USDA disaster programs
- Collecting weather (rainfall) data
- Legal enforcement
- Predict electric loads
- Water operations

Technical Degree - USDA disaster programs

Sources –
Some College – NE Dept of Water Resources (DNR)
- Local reporting stations

College Degree – Precipitation collection points
- Weather stations within district
- On-line UNL weather information & NASS
- Federal government agencies & Publications and USBR
- Omaha NWS and UNL websites

When Or How Often Use –
Some College – Combinations of daily, weekly, monthly, seasonally, annually, drought, flood
College Degree – Combinations of daily, weekly, monthly, seasonally, annually, drought, flood
- Severe storm
- Only to develop plans
- Continuous updates from data collection platforms

Short-Term Predictions – Reason for Not Using –
High School Degree – No need
Some College – No need
College Degree – No need
- Crop water use
- Driving conditions
- Only during snowstorms

Technical Degree – No need
Other – No need

Long-Term Predictions – Reason for Not Using –
High School Degree – No need
- Fieldwork requires current weather forecast

Some College – No need
College Degree – No need
- Use climatology for models
- No. 1 priority is intense rainfall - impossible to predict long-term
- Adjusting irrigation releases difficult - possibility of rain – plans based on historical probabilities

Technical Degree – No need
Other – No need

Educational Preference –
High School Degree – Not sure
Some College – Worthless unless proven, so far that is not the case
College Degree – Internet based

4.4 Results Of Analysis Of Data Set Stratified By Educational Background

The data set was stratified by educational background for the third analysis. Categories include high school degree (11 respondents), some college (19), college degree (100), technical degree (6), and other educational background (3), for a total of 139. One survey respondent did not complete the educational background section, hence the discrepancy.

Respondents with high school degrees are scattered among all of the agencies/organizations represented, with the exception of the education category (all of whom have college degrees). Slightly over half of the respondents who have had some college (53%) are federal employees, and approximately a third (32%) work for irrigation districts. Just under half of the respondents who have a college degree (44%) work for the federal government, and approximately one-fourth (26%) work for the NRDs. Half of those with technical degrees work for the federal government; the remaining work for NRDs and irrigation districts. One respondent in the 'other' educational background category works for the federal government, one for other local government, and one for an irrigation district.

Recent/current weather data are most frequently used in all educational background categories. Historical data follows as the second most used time frame of data, for all except those with technical degrees, who use predictions more often. Precipitation is, again, the most used type of data, followed by air temperature, degree days, ET, and short-term predictions.

Those who have a high school degree most often use climate and weather data for planning (70%), decision-making (70%), and monitoring water quality/quantity (40%).

Those with some college most often use data for decision-making (67%), planning (40%), and irrigation (40%). Those with a college degree use data mainly for decision-making (59%), planning (44%), and regulatory action (38%). It is interesting to note that climate and weather data are used more often, and for a greater variety of reasons (including design, educational programs, research, monitoring water quality/quantity, hydrology applications, irrigation, communication, and policy), by those with a college degree than by those in any other category. Those with a technical degree use data for decision-making (67%), planning (50%), and communication (50%), and also use data for a greater variety of reasons, but not to as great of an extent as those with a college degree (percentages are lower). Respondents in the 'other' educational background category most often use data for planning (67%).

The most frequently used sources for climate and weather data are the television and AM/FM radio, which appear in the top five listing of sources for all five educational background categories. Computers and newspapers are frequently used as sources for data in four of the five categories. The NWS and HPRCC are frequently used as sources of data in three of the five categories. It is interesting to note in this case that as the degree of education increases, the variety of sources used tends to increase, and the more likely a person is to use a less visible source. For example, NCDC is frequently used as a source of data by 60% of those with a college degree, 26% of those with some college, and 18 % of those with high school degrees. The same pattern exists for CPC, HPRCC, and the State Climatologist.

As in the previous two analyses, climate and weather data are most often used on a daily, weekly, monthly, or seasonal basis. Those with some college or a college degree

use data at other times as well, expanding the range of uses to annual, during drought or flood, or some combination of the above.

Respondents with a technical degree had the most confidence in the accuracy of all NWS forecasts in this analysis, rating 1-3 day forecasts at 85% accuracy, 7-10 day forecasts at 75% accuracy, and long-term forecasts at 59% accuracy. Ratings for accuracy for all other categories ranged from 74% to 78% for 1-3 day forecasts, from 55% to 66% for 7-10 day forecasts, and from 40% to 45% for long-term forecasts.

The majority of those with high school degrees, college degrees, and other educational backgrounds use short-term predictions. Almost half of those with some college (47%) and exactly half of those with technical degrees use short-term predictions. Of those who do not use short-term predictions, the majority cited 'no need' as the reason. The remainder of the respondents who do not use short-term predictions fall into two categories – some college and college degrees. These respondents cite 'unsure how to integrate,' climate and weather data and information into planning and decision-making processes, 'accuracy', and 'unsure how to obtain' as reasons for not using short-term predictions. The majority of respondents in all categories do not use long-term predictions. Respondents in all categories cite 'no need' as a reason for not using long-term predictions, and respondents from three out of the five categories cite 'accuracy' as a problem. Respondents with some college, college degrees, and technical degrees also cite 'unsure how to integrate' climate and weather data and information into planning and decision-making processes as a reason for not using long-term predictions, and some of those with a college degree list 'unsure how to interpret' as a reason.

The majority of respondents with a college degree or other educational background anticipate future use of climate and weather data as new tools and products become available. Workshops, videos, and courses again rate high as preferred methods to receive educational programs.

4.5 Summary Of Survey Analyses

Several interesting trends appeared as a result of stratifying the data. In the case of the analysis stratified by agency/organization, results indicate that a larger agency or organization (larger budget, more personnel) tends to use a greater variety of sources on a higher percentage basis, and a smaller agency/organization (budget and/or personnel) tends to use the more visible sources of data, such as computers, the radio, television, and the newspaper. In the case of the analysis stratified by educational background, results indicate that as the degree of education increases, the variety of sources used tends to increase, and the more likely a person is to use a less visible source of climate and weather data and information.

These observations are supported by Stern & Easterling (1999), as quoted in section *2.3.3*, "useful information is likely to flow first to those with the most education and money" – a situation that will have "different effects on different regions, sectors, and actors." This leads to the conclusion that equity of access to climate and weather data and information is a matter of concern in Nebraska. This concern can be addressed through an effort described by Phillips (1992) in section *2.3.2*, "Marketing is not simply selling or advertising but involves the process whereby potential users learn what products and service are available and how they might put them to good use, but also realize the usefulness of the information and, hence their understanding of its broad

utility and worth to them and their willingness to pay for it." In the case of this project, a collection, or 'clearinghouse,' of sources of climate and weather data and information would provide users with a tool to access data and information that would be relevant to their particular needs.

4.6 Post Survey Interviews

105 postcards were returned, 55 of which (52%) indicated a willingness to participate in an interview. The postcards of those who were willing to participate in an interview were sorted by agency/organization, for a total of 20 separate agencies/organizations. Respondents from 13 of the 23 Natural Resource Districts and respondents from 17 of the 81 USDA Farm Service Agency county offices were willing to participate in interviews. An attempt was made to schedule interviews with the 18 remaining agencies/organizations, and limit the number of interviews with NRD and FSA personnel for a more balanced outcome. In total, 32 interviews were conducted, 31 in person and one by phone, between March and September of 2002, covering all sections of the State. Figure 5 illustrates the general locations of interviews.

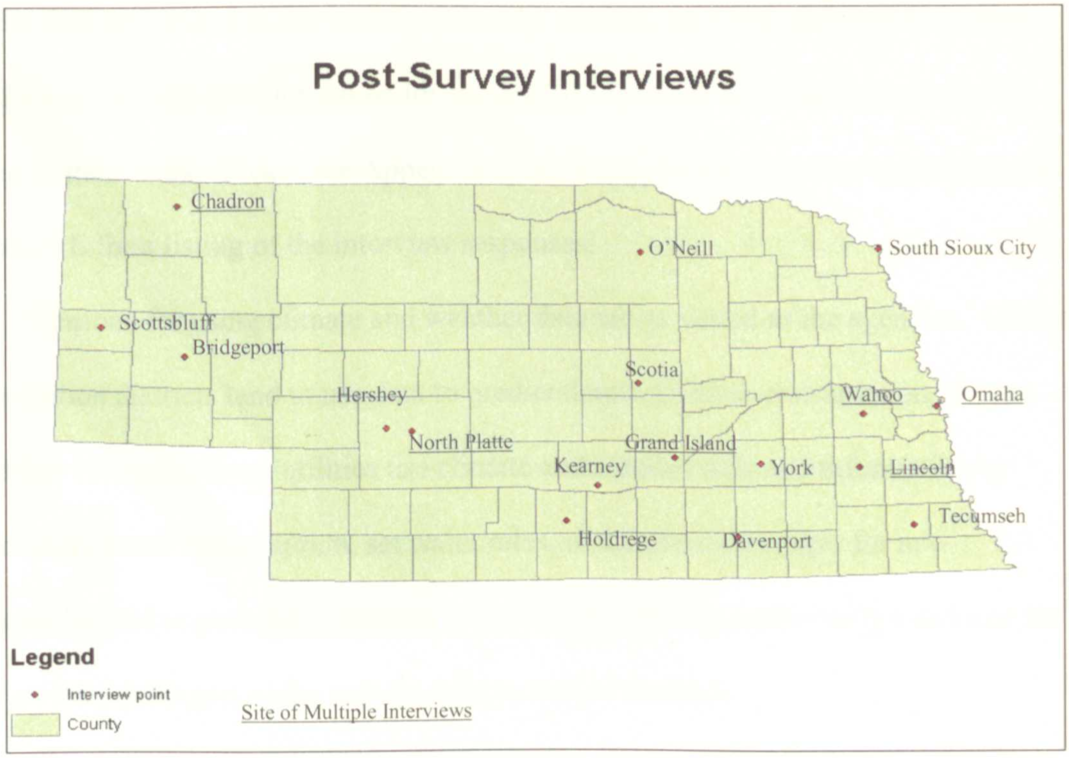

Figure 5: Locations of Post Survey Interviews

Table 5 below lists the agencies/organizations that participated in the interviews.

TABLE 5: Agencies/Organizations Involved in Interview Process	
Six Utility companies	USACE
Two DEQ offices	Three DNR personnel
Eight NRD offices	Three irrigation districts
USDA-NRCS	UNL Conservation & Survey
USDA-NASS	NE Game & Parks Commission
Five USDA-FSA offices	

Post-survey interview questions were designed to gather more detail about the on-the-job uses of climate and weather data. Respondents were asked to describe the goals of their jobs, what time frames of climate and weather data are used in their work, and the reasons for using the data. Information regarding the frequency of use, benefits of making correct assessments and losses due to incorrect assessments, the process used to

incorporate data into the activities described, sources of data and types of data used, and how the data are related to the activity (directly, models, etc.) was gathered in further questioning. A final question asked for suggestions for tools or products that may be helpful in their work. Please see Appendix D for a copy of the interview questions and Appendix E for a listing of the interview responses.

Reasons for using climate and weather data are as varied as the agencies. Utilities and irrigation districts tend to use data to predict demand and/or consumption. It was found that Nebraska water utilities use climate and weather data and information to predict daily water consumption, set water rates, in the planning stages for new construction, and to plan daily fieldwork. As a rule, water quantity was not an issue for water utilities managers in the eastern third to half of the state.

The DNR is concerned with administration of water use, adjudication of rights, and administration of Compacts and Decrees. The Department of Environmental Quality (DEQ) focuses on surface water and groundwater quality and quantity, and air quality. The main focus of the NRDs in the eastern part of the state, particularly in the metro areas of Omaha and Lincoln, is flood control and warning, as is also the case for the U.S. Army Corps of Engineers (on the Missouri River). A primary focus of NRDs in the central and western part of the state is groundwater management, which is justified based on the trends toward aquifer depletion and increased nitrate levels in groundwater that are caused by irrigation and over-application of nutrients.

Climate and weather data are also used for watershed and wetland maintenance, for wildlife and fish surveys, in structure design, to develop educational programs for the

public, as support for documentation (USDA), in modeling, to determine trends in the chemical composition of rainfall, and to advise irrigators.

Sources were varied, as well. They ranged from TV, radio, newspapers, and word-of-mouth to the less used sources, such as the HPRCC and the State Climatologist. Several interviewees used private consulting companies, for example AccuWeather, DTN AgDayta, and Intellicast.

A pattern developed during the interviews that is similar to the patterns discussed in section 4.5 concerning the survey analyses – the larger the agency/organization, the more likely the employees are to use a greater variety of data sources for a wider variety of reasons, and the higher the level of education attained, the more likely one is to use a greater variety of sources for a wider variety of reasons. The utility companies provide a good example of the relationship between the size of the agency and the use of data and information. Interviews were conducted with utilities associated with Omaha, Lincoln, and several progressively smaller towns – in terms of population – in the central and western part of the state. The larger budgets, and larger number of employees, of the Omaha and Lincoln utilities allowed these companies to have state of the art equipment and access to all necessary data. As the budgets and number of employees decreased with the smaller utilities, so too did the access to, and use of, even basic data. Again, the issue of equity of access is a concern. The same recommendation is made here as that made in section 4.5 – the development of a clearinghouse for climate and weather data and information would provide users with an important tool, enabling them to access relevant data and information.

One striking commonality among all interviewees was the use of computers and the Internet. Many used the computer extensively to access climate and weather data, information, and products for planning and decision-making; others used it simply to check the weather for the day (or next day or two) before conducting fieldwork. The universal use of computer technology on-the-job was encouraging, because it indicates that all interviewees are aware of the benefits (and advantages) that the technology can provide.

Some interesting suggestions for tools and products were received. Several people asked for a listing of sources of climate and weather data, indicating the need for a compilation of sources. Many asked for historical precipitation and temperature data to use in analyses, most of which is currently available, indicating a need for a tool that may help users recognize data availability. Many people asked to have additional weather stations installed across the state for better coverage of weather events, and for more stream gauges, for the same reason, indicating a need for adequate data coverage. Several expressed a desire for more accuracy in forecasting, indicating a need for reliable data. Many asked for guidance on how to more effectively integrate climate and weather data into daily operations, indicating a need for training programs and/or local consultants.

CHAPTER 5

CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

Several observations were made based on the results of the survey analyses and the interviews. A number of respondents and interviewees had questions concerning data availability, data sources, data interpretation, the integration of data into planning and decision-making processes, data accuracy, and specialized equipment. An important observation concerns the issue of equity of access, as discussed in sections 4.5 and 4.6 – the larger the agency/organization, the more likely the employees are to use a greater variety of data sources for a wider variety of reasons, and the higher the level of education attained, the more likely one is to use a greater variety of sources for a wider variety of reasons. Several of these issues are within the scope of this project and are discussed in section *5.2.1*. The remainder will need to be addressed in the future, and are discussed in sections *5.2.2* and *5.2.3*.

5.2 Recommendations

5.2.1 Availability

Many survey respondents and interviewees did not know what types of climate and weather data, information, and products are available, and did not know about many of the existing sources of data. This leads one to conclude that development of a 'clearinghouse' of sources of climate and weather data is needed to facilitate user access to relevant data, a tool that would partially address the concern of equity of access.

A clearinghouse is being developed as a result of this project. The clearinghouse is being designed to provide users and potential users of climate and weather data,

information, and products a "user friendly" way to access known sources of data. The clearinghouse will be divided into three major sections, as follows: by time frame, by source, and by type of data or data need. The 'time frame' section will contain a listing of sources for historical data, current/recent data, and short and long-term predictions. The 'source' section will include a listing of public and private sources of climate and weather data, information, and products. The 'type of data or data need' section will be set up to accommodate those who are looking for a particular type of data or have some specialized need for data. Some examples include probabilities, snow, crops, and drought. A sample of the information that will be included in the clearinghouse can be found in Appendix A.

The information will be mailed to all survey participants who requested the results of the study. It will also be made available on the Internet, with links, for the same audience. Consideration will be given, as well, to other users and potential users who may benefit from the product.

5.2.2 Interpretation and Integration

Many survey respondents and interviewees did not know how to interpret climate and weather data, or how to integrate climate and weather data or information into their planning and decision-making processes. As a result, educational programs with materials that suit the range from novice to expert are recommended for individuals who work for smaller organizations, and for individuals who require training in interpretation and integration of data.

5.2.3 Specialized Equipment and Data Accuracy

Two additional points were frequently discussed. First, survey respondents and interviewees repeatedly requested the installation of more weather stations and stream gauges, in order to get better statewide data coverage. Secondly, they repeatedly expressed doubt in forecast accuracy, particularly with long-term forecasts. Collaboration between agencies is required to address user needs for specialized equipment and increased accuracy in forecasts.

REFERENCES

Ackermann, W. C., W. A. Baum, D. Clewell, H. E. Landsberg, T. B. McKee, N. J. Rosenberg, E. B. Weiss, and S. H. Wittwer, 1982: Meeting the Challenge of Climate, Report of the Panel on Intergovernmental Climate Change Programs, the Climate Board, the Commission on Physical Sciences, Mathematics, and Resources and the National Research Council, 66 pp.

Battan, L. J., 1983: Weather in Your Life. W. H. Freeman and Co., 230 pp.

Carr, M., cited 2002: Visualizing Weather, Part One. [Available online from http://www.sailnet.com/collections/articles/prt_article.cfm?artID=carrmi017.]

CASDE, cited 2002: Consortium for the Application of Spacedata for Digital Earth: Nebraska Watersheds. [Available online from http://www.casde.unl.edu/.]

Changnon, S. A., Jr., P. J. Lamb, and K. G. Hubbard, 1990: Regional Climate Centers: New Institutions for Climate Services and Climate-Impact Research. Bulletin of the American Meteorological Society, 71, 527-537.

Chechile, R. A. and S. Carlisle, Eds., 1991: Environmental Decision-Making: A Multidisciplinary Perspective. Van Nostrand Reinhold, 289 pp.

Craft, E. D., 1999: Private weather organizations and the founding of the United States Weather Bureau. Journal of Economic History, 59 (4), 1063-1071.

EMI, cited 2002: Emergency Management Institute. [Available online from http://training.fema.gov/EMIWeb/.]

FEMA, cited 2002: Federal Emergency Management Agency. [Available online from http://www.fema.gov.]

Gleick, P. H., 1993: Water in Crisis: A Guide to the World's Fresh Water Resources. Oxford University Press, 473 pp.

Hammer, G. L., J. W. Hansen, J. G. Phillips, J. W. Mjelde, H. Hill, A. Love, and A. Potgieter, 2001: Advances in application of climate prediction in agriculture. Agricultural Systems, 70 (2-3), 515-553.

Hofing, S. L., S. T. Sonka, and S. A. Changnon, Jr., 1987: Enhancing Information Use in Decision-Making: Agribusiness and Climate Information. NSF Small Business Innovation Research Program IS-8660497, 80 pp.

Hollingsworth, A., P. Viterbo, and A. J. Simmons, 2002: The Relevance of Numerical Weather Prediction for Forecasting Natural Hazards and for Monitoring the Global Environment. European Center for Medium Range Weather Forecasts, 27 pp.

Hopkins, J., H. Bhalme, and L. L. Estela, 1997: Reports to the Twelfth Session of the Commission for Climatology (Geneva, August 1997) and Report of Meeting of Experts on Climate and Human Health (Freiburg, Germany, 28-29 Jan 1997) WCASP 42, WMO/TD-No. 822, 50 pp.

HPRCC, cited 2002: High Plains Regional Climate Center. [Available online from http://www.hprcc.unl.edu/index.html.]

Hubbard, K. G., S. J. Meyer, J. J. Schmidt, and J. R. Hines, 1988: The Use of Climate Information to Support Irrigation Scheduling. Irrigation Scheduling, 5th ed. P. E. Fischbach, Ed., Cooperative Extension Service, Institute of Agriculture and Natural Resources, University of Nebraska, 264-293.

IPCC, 2001: Intergovernmental Panel on Climate Change: Climate Change 2001: Impacts, Adaptation, and Vulnerability. IPCC, 86 pp.

Legg, T. and K. Mylne, 1999, cited 2002: Predicting probabilities - the forecasts of the future. [Available online from http://www.met-office.gov.uk/research/nwp/publications/nwp_gazette/.]

Maunder, W. J., 1986: The Uncertainty Business: Risks and opportunities in weather and climate. Methuen & Co., 420 pp.

Meyer, S. J., K. G. Hubbard, N. J. Rosenberg, and D. A. Wilhite, 1986: Improving Nebraska's Near-Real Time Weather-Based Products Through User Interaction, Institute of Agriculture and Natural Resources, University of Nebraska-Lincoln, 239.

Miller, G. T., Jr., 1998: Living in the Environment: Principles, Connections, and Solutions. Tenth ed. Wadsworth Publishing Co.

NARD, cited 2002: Nebraska Association of Resources Districts. [Available online from http://www.nrdnet.org/guide/about_nrds.htm.]

NASS, cited 2002: Nebraska Agricultural Statistics Service: Nebraska Agricultural Statistics 2002. [Available online from http://www.agr.state.ne.us/agstats/2002book/contents.HTM.]

NDMC, cited 2002: National Drought Mitigation Center. [Available online from http://www.drought.unl.edu.]

NEMA, cited 2002: Nebraska Emergency Management Agency. [Available online from http://www.nebema.org/.]

Newsham, C., 2002: Nebraska Emergency Management Agency. D. Woudenberg, Ed.

Nicholls, J. M., 1996: Economic and Social Benefits of Climatological Information and ServicesWMO/TD-No. 780 (WCASP - 38), 38 pp.

Palmer, T. N., 2002: The economic value of ensemble forecasts as a tool for risk assessment: From days to decades. Quarterly Journal of the Royal Meteorological Society, 128 (581), 747-774.

Phillips, D. W., 1992: Climate Applications: On Marketing, Information and Publicity, 70 pp.

Pollack, J., 2002: NWS Forecast Accuracy. D. Woudenberg, Ed.

Redmond, K. T., 2000: Integrated Climate Monitoring for Drought Detection. Drought: A Global Assessment, D. A. Wilhite, Ed., Routledge Publishers, 146-158.

Riebsame, W. E., S. A. Changnon, Jr., and T. R. Karl, 1991: Drought and Natural Resources Management in the United States: Impacts and Implications of the 1987-89 Drought. Westview Press, 170 pp.

Rodda, J., R. Hallgren, and S. Malling, 1999: Statement from the Sub-Forum on Science and Technology in Support of Natural Disaster Reduction. WMO/UNESCO Sub-Forum on Science and Technology in Support of Natural Disaster Reduction, Geneva, Switzerland.

Smith, M. R., 2002: Five Myths of Commercial Meteorology. Bulletin of the American Meteorological Society, 993-996.

Stern, P. C. and W. E. Easterling, Eds., 1999: Making Climate Forecasts Matter. National Academy Press, 175 pp.

Stooksbury, D. E. and C. S. Curtis, 1995: High Plains Climate Center 1994 Clients Survey 95-1, 41 pp.

Svoboda, M. and M. J. Hayes, 2002: Strategies to Reduce Adverse Weather Impacts on Nebraska Agricultural Production. [PowerPoint]. Central Extension Education Program Workshop, Kearney, NE, Apr. 19.

USGS, cited 2002: U.S. Geological Survey: Groundwater Atlas of the United States: Kansas, Missouri, and Nebraska, HA 730-D. [Available online from http://capp.water.usgs.gov/gwa/.]

Wilhite, D. A., 1997: State Actions to Mitigate Drought: Lessons Learned. Journal of the American Water Resources Association, 33, 961-968.

Wilhite, D. A., M. J. Hayes, C. Knutson, and K. H. Smith, 2000: Planning for Drought: Moving From Crisis to Risk Management. Journal of the American Water Resources Association, 36, 697-709.

Winkler, R. L., A. H. Murphy, and R. W. Katz, 1980: Assessing the Value of Climate Information. Climate and Risk, Massachusetts Institute of Technology, The MITRE Corporation, McLean, VA, 8.

Wittwer, S. H., F. P. Bretherton, W. C. Burrows, D. H. Clewell, R. G. Fleagle, C. W. Howe, R. W. Kates, W. O. Roberts, M. Tribus, J. J. Waelti, and A. H. Murphy, 1981: Managing Climatic Resources and Risks: Report of the Panel on the Effective Use of Climate Information in Decision Making, 51 pp.

Wondolleck, J. M. and S. L. Yaffee, 2000: Making Collaboration Work: Lessons from Innovation in Natural Resource Management. Island Press, 277 pp.

Zhu, Y. J., Z. Toth, R. Wobus, D. Richardson, and K. Mylne, 2002: The economic value of ensemble-based weather forecasts. Bulletin of the American Meteorological Society, 83 (1), 73-83.

APPENDIX A: SOURCES OF CLIMATE AND WEATHER DATA

The following tables provide a generalized example of the information that will be contained in the clearinghouse that is being developed as a result of this project. The clearinghouse will supply data, information, and products in three sections, as illustrated below. Sources/resources may appear in one, two, or all three sections. Keep in mind that these lists are very generalized, and by no means exclusive.

SECTION 1 – BY TIME FRAME		
Historical	**Current/Recent**	**Predictions/Forecasts**
Climate summaries	Severe storms	Weather forecasts
Normals	Wind speed	Climate outlooks
Maps/tables	Temperature	
Extremes	Precipitation	

SECTION 2 – BY SOURCE	
Public Sources	**Private Consultants**
NOAA	U.S. Directory of Private Weather Services
NWS	Commercial Weather Providers Serving the U.S.
National Climatic Data Center	AccuWeather
HPRCC	Intellicast
State Climatologist	DTN AgDayta
National Drought Mitigation Center	

SECTION 3 – BY TYPE OR NEED	
Probabilities	Evapotranspiration
Natural resources	Drought
Water resources	Research
Snow	Irrigation
Crops	Wind/solar energy & hydropower

APPENDIX B: SURVEY

SURVEY OF USES OF CLIMATE AND WEATHER DATA BY PLANNERS AND DECISION-MAKERS IN NEBRASKA

SECTION 1 – BACKGROUND INFORMATION

1. Please circle the letter that best classifies you or your agency/organization.
   a Federal Government
   b State Government
   c NRD
   d Other Local Government (Please specify)
   e Education
   f Private agency/organization
   g Irrigation District
   h Other (Please specify) ______________________________

2. Please enter your job title. ______________________________

3. Please enter your zip code. ____________

4. What is your educational background? Please circle the appropriate letter.
   a High school
   b Some college (# of years) _____
   c College degree (Please specify degree(s) and major(s)) __________________
   d Technical degree (Please specify degree(s) and major(s)) ________________
   e Other (Please specify) ___________________________________

5. Please list any climate, weather, and hydrology courses you have taken.

   __________________________ __________________________
   __________________________ __________________________
   __________________________ __________________________
   __________________________ __________________________

6. Please list any training you have received in applying climate, weather, and/or hydrology information to problem solving and/or decision-making.

   __________________________ __________________________
   __________________________ __________________________
   __________________________ __________________________
   __________________________ __________________________

SECTION 2 – USES OF DATA AND INFORMATION

In your work:

If you currently use (or have used) climate or weather data and information, please begin here with question 1.

If you have considered using climate or weather data, but were unsure of how to access the data, please skip to question 6, then note Section 3.

1. What time frame of climate or weather data do you use? Please circle all that apply.
   a Historical climate conditions (ex: probabilities)
   b Recent/current weather information
   c Predictions for various time periods

2. What types of data do you use? Please circle all that apply.
   a Air temperature
   b Soil temperature
   c Radiation
   d Wind speed
   e Wind direction
   f Humidity
   g Precipitation
   h Degree days (HDD/CDD/GDD)
   i Evapotranspiration
   j Snow measurements
   k Short-term (daily/weekly) predictions
   l Long-term (monthly/seasonal) predictions
   m Other (Please specify) ________________________________

3. How and/or why do you use the data? Please circle all that apply.
   a Planning
   b Decision-making
   c Design
   d Education
   e Research
   f Regulatory action (ex: emergency declaration)
   g Monitoring water quantity/quality
   h Hydrology applications
   i Irrigation
   j Communication (newsletters/reports/etc)
   k Setting policy
   l Other (Please specify) ________________________________

   Please give a description of items circled above. (Use back of this page, if needed.)____

4. Please circle those sources of data that you use according to:

   a = never
   b = occasionally
   c = often

a b c National Weather Service Forecast Office
a b c National Weather Service River Forecast Center
a b c National Climatic Data Center
a b c Climate Prediction Center
a b c High Plains Regional Climate Center
a b c State Climatologist
a b c AM/FM Radio
a b c NOAA Weather Radio
a b c Television (news/weather channel/etc)
a b c Newspaper
a b c Computer
a b c Subscription (ex: Data Transmission Network)
Please specify ______________________________
a b c Other – (Please specify) ______________________

5. When or how often do you use climate and/or weather data in your work? Please circle your choice.

a Daily
b Weekly
c Monthly
d Seasonally
e Annually
f During drought
g During flood
h Other (Please specify) ____________

6. What degree of accuracy (percent) do you feel the National Weather Service currently provides for the following:

   a. 1 – 3 day forecast____________________________
   b. 7 to 10 day forecast__________________________
   c. long-term forecasts (monthly/seasonal)______________

7. Do you use short-term (1 –3 day or 7 – 10 day) predictions in your work?

_____ Yes
_____ No – Please circle the reason for not using:

a Unsure how to obtain
b Unsure how to interpret
c Unsure how to integrate into decision-making and planning processes
d Predictions are not accurate enough (if you choose this response, please answer the question below)

At what general level of accuracy would you begin using predictions?

1 – 3 days _____ %
7 – 10 days_____ %

e Other (Please specify) ________________________________

8. Do you use long-term (monthly or seasonal) predictions in your work?
   _____ Yes
   _____ No – Please circle the reason for not using:
      a Unsure how to obtain
      b Unsure how to interpret
      c Unsure how to integrate into decision-making and planning processes
      d Predictions are not accurate enough (if you choose this response, please answer the question below)
         At what general level of accuracy would you begin to use predictions? _____ %
      e Other (Please specify)________________________________

9. As new tools and products become available, do you anticipate future uses of climate or weather data in your area of work?
   ____ Yes (Please continue with question 10)
   ____ No (Please see Section 3)

10. Can you describe products that would be particularly helpful in your area of work?
   ____
   ____
   ____
   ____
   ____

11. If educational programs were developed to address the use of historical climate data and predictions in your area of work, what method(s) would you prefer? Please rate the top five where 1 is your most preferred, 2 your second choice, etc..
   _____ Workshops
   _____ Manuals
   _____ Courses
   _____ Web tutorials
   _____ Video
   _____ DVD
   _____ CD Rom
   _____ Other (Please specify)
   ____

SECTION 3 – CONTACT INFORMATION

If you have questions about the survey, please contact:

Donna Woudenberg
School of Natural Resource Sciences
University of Nebraska-Lincoln
246 LW Chase Hall
Lincoln, NE 68583-0728
(402) 472-9954
dwoudenb@unlnotes.unl.edu

For questions about the availability of climate data, please contact:

Brian Fuchs
High Plains Regional Climate Center
University of Nebraska-Lincoln
15 LW Chase Hall
Lincoln, NE 68583-0728
(402) 472-6709
bfuchs2@unl.edu, www.hprcc.unl.edu

APPENDIX C: SURVEY RESPONSES

The following is a summary of responses to Section 1:

****

1) Select the option that best classifies you or your agency/organization.

****

Federal Government - 42.1%
State Government - 11.4%
NRD - 22.9%
Other Local Government (specify below) - 4.3%
Education - 2.1%
Irrigation District - 7.9%
Other (specify below) - 9.3%

Farmer
Regional Government/3 NRD's, 6 State Agencies
City Government
County Office USDA-FSA
Political Subdivision of State
City
County Office USDA-FSA
Public Power/Irrigation District
UNL Conservation & Survey
City
Irrigation District
Municipal Joint Action Agency
Rural Water Project
DNR
Public Power District
Mutual Irrigation Company
Utility (LES)
Non-Profit training center
Public Water Utility
City Water system

****

2) Job title:

****

County Executive Director
Water Department Manager
County Executive Director
Administrator, Nebraska Resources Development Fund
County Executive Director - Jefferson County
Lead Water Resources Technician
County Executive Director
County Executive Director
Supervisory Hydrologic Technician
County Executive Director
County Executive Director
General Manager
Water Specialist
County Executive Director
County Executive Director
Senior Lecturer
General Manager
Coordinator
County Executive Director
County Executive Director
Utilities Director
Executive Director
General Manager
County Executive Director
County Executive Director
President of Ditch 6
Assistant Manager
President, Board of Directors
Unit Supervisor
County Executive Director
County Executive Director
Water Technician
County Executive Director
County Executive Director
County Executive Director
County Executive Director
County Executive Director - FSA
Resource Conservationist
General Manager
Water Resources Manager
Assistant General Manager
County Executive Director
FSA - County Executive Director
District Geologist
County Executive Director
Interstate Streams Engineer
Statistician
Secretary/Treasurer
Manager of Water Operations
Sand Creek Project Coordinator Farmer
Water Resources Manager
Water Superintendent
County Executive Director
Water Resources Manager
County Executive Director
Lincoln Field Office Supervisor
Acting Unit Supervisor NPDES permits
State Executive Director-FSA
Manager
County Executive Director
County Executive Director
County Executive Director
Associate Professor
County Executive Director
Civil Engineer

Manager
Water Resources Coordinator
Assistant Manager
Hydrology Technician
County Executive Director
County Executive Director - FSA
County Executive Director - FSA
Water Resources Specialist
Hydrologist
Water Resources Coordinator
County Executive Director
County Executive Director
General Manager
Water Resources Specialist
Division Manager/Water Administration
County Executive Director
County Executive Director
Water Resources Specialist
Water Technician
County Executive Director
County Executive director
County Executive director
Hydraulic Engineer
Irrigation Team Leader
Professor & Research Hydrogeologist
Water/Wastewater Supervisor
Resource Conservationist
Head, Floodplain Management/Dam Safety
County Executive Director
County Executive Director
Bridgeport Field Office Supervisor
County Executive Director
Manager
General Manager
Field Representative
Field Representative
Agricultural Programs Manager
Chief, Emergency Management
Supervisory Hydrologic Technician
Resources Coordinator
Water Resources Manager
General Manager
Program Specialist
Manager, Electric Operations
County Executive Director
Plant Operator
Division Supervisor/Cambridge
County Executive Director
Canal Manager
County Executive Director
Water Resources Advisor
County Executive Director - Jefferson County
President - Board of Directors
Manager
County Executive Director
Deputy Director
Forecasting Analyst
Assistant Manager
Geologist/Ground Water
Program Specialist
President-Director
Environmental Engineer IV
General Manager
Hydraulic Engineer
County Executive Director
President of Board
Project Manager
Training Specialist
Chief Engineer
County Executive Director
Manager
Director of Utilities

****

3) Zip code – number of respondents from area:

****

66101 – 1
68025 – 1
68061 – 1
68066 – 4
68067 – 1
68102 – 2
68138 – 1
68310 – 3
68335 – 3
68352 – 1
68355 – 1
68361 – 1
68420 – 1
68446 – 1
68450 – 5
68463 – 1
68465 – 1
68467 – 4
68501 – 4
68502 – 1
68503 – 2
68508 – 3
68509 – 8
68509-4676 – 1
68510 – 1
68516 – 3
68588-0517 – 1
68632 – 1
68638 – 1
68651 – 1
68701 – 3
68718 – 2
68739 – 1
68755 – 1
68756 – 1
68763 – 1

68767 – 1
68770 – 1
68776 – 1
68777 – 1
68788 – 1
68801 – 1
68802 - 2
68803 - 2
68818 - 1
68822 - 1
68823 - 1
68826 - 1
68838 - 1
68842 - 1
68847 - 1
68848 - 1
68862 - 3
68873-0147 - 1
68875 - 1
68901 - 1
68920 - 2
68933 - 1
68949 - 5
68961 - 1
68970 - 1
69001 - 2
69021 - 1
69022 - 1
69032 - 1
69033 - 1
69101 - 6
69130 - 3
69138 - 1
69143 - 2
69145 - 1
69147 - 1
69153 - 1
69166 - 1
69201 - 2
69210 - 1
69301 - 1
69336 - 2
69337 - 2
69356 - 2
69357 - 2
69360 - 1
69361 - 1
69363-1500 - 1

****
4) What is your educational background?
****

High School - 7.9%
Some college (enter # of years below) - 13.7%
College degree (specify degree(s) and major(s) below) - 71.9%
Technical degree (specify degree(s) and major(s) below) - 4.3%
Other (specify below) - 2.2%

BS - Agricultural Economics
Associate – Agricultural Engineering
2 yrs.
M.S.- Life Sciences
Education
4.5 yrs., B.S. – Agronomy
Agricultural Economics
Industrial Management - Manufacturing & Construction
B.S. – Geography
Agricultural Economics
Agricultural Economics & Mechanical
Engineering
BS – Mathematics
AAS - Conservation and Environmental Systems
BS – Business Administration
BS – Business/Agri-Business
BS & MS – Civil Engineering
BS – Education - Geography & graduate studies in Natural Resources
BA – Political Science, MPA – Public Administration, PhD – Student Geography
BS – Agricultural Economics
BA – Finance/Banking
BS and ME
2 yrs. – Degree AAS
Chemistry/Biology
BA – Industrial Management
Agricultural Economics & Mechanical
Agriculture
BS – Natural Resources
2 yrs.
BA – Science Education, BS Geology, MS
Geology
4 yrs.
2 yrs.
BS – Water Science & Environmental Studies
BS – Agricultural Education
BS - Agricultural Economics
3 yrs.
BS – Agriculture
BA – Biology
Agronomy
BS – Agronomy
BS – Agricultural Engineering
BS & MS – School Administration
BS - Geology
BS – General Agriculture
BS – Civil Engineering, MS – Civil Engineering
Mathematics
1 yr. college, 250 + hrs. agricultural & associated

classes
BS – Civil Engineering
BS - General Agriculture
Geography Major, Spanish Minor
Accounting major at CE School of Commerce
BSCE – Environmental, MSCE – Water Resources
BS - Comprehensive Business Administration (emphasis in accounting)
BA - Geology
BS - Biology, MS - Microbiology, MS – Environmental Engineering
Agricultural Economics
BS - Business Administration
Electrician
BS - Industrial Engineering
BS - Business Administration
Ph. D. – Geology
1 ½ yrs., 20yrs. self-employed farmer, FSA-COT program
BS - Engineering
BS - Agriculture & Natural Resources Major
BS - Natural Resources, Major: Wildlife Biology
2 yrs.
GI School of Business - Secretarial Degree
Ag Economics, Ag Education, English Minor
BS - Agricultural/Animal Science
2 yrs.
Geography, with Environmental minor
Agricultural Engineering
BS – Agronomy, Crop Production option
Associates in Agricultural Business, BA – Organizational Management
MBA
BS - Natural Resources
Agricultural Education
BS - Business Administration & Education
BS - Business Administration
BS - Business Administration
BS - Agriculture & Natural Resources Major
Natural Resources/Water Sciences
BS - Business Administration
1 yr.
BS - Business Administration
BS - Civil Engineering
25 yrs. experience
BS - Business Administration & Management
BS - Geology, MS - Groundwater Geology
BA - Biology, Technical in Civil Engineering
Environmental Studies
BS - Civil Engineering
BS - Business Administration; BS - Forest Management
4 yrs.
30 + years working for the department
BS - Agricultural Administration
BS – Geography, MA Geography
BS - Business Administration, BS – Agriculture (wildlife), MS - Biology
BS & MS - Agricultural Engineering, MS – Water Resources, MS – Public Admin.
BS - Environmental Monitoring
BS - Civil Engineering
BS – Agricultural Natural Resources
BS - Natural Resources
Geography
BS – Forestry, Fisheries & Wildlife
BS - Business Management, Tech Degree-Associates Electronic Eng
2 yrs.
Obtained Class 2 water operator certificate
BS - Computer Business Administration
2 yrs.
BS - Business Administration   BS - Forest Management
BS - Civil Engineering
Veterinary Technology
1 yr.
BS - Biology, Post-graduate course in Business & Technology
Ph.D. - P.E. - Civil Engineering
MA & MBA – Economics
Natural Resources and Agricultural Economics
BA – Geology; MS - Soil Science
BS – Biology; Associates in Auto Technology
BS – Construction Management
1 ½ yrs.
BS - Civil Engineering
BS - Economics, Accounting
1 ½ semesters
MS - Biology/Ecology
1 yr.
BS & MS - Civil Engineering
BS - Business Administration
Automotive Technology
Associates in Civil Engineering

****
5) List any climate, weather, and hydrology courses you have taken.
****

None

None

None

None

None
----

1 Meteorology in college

None

Principles of Surface Water
Ground Water Principles
Water Quality Principles

None

None since college

None

None

None
----
5 classes - GW hydrology
4 classes - SW hydrology
2 classes - open channel hydraulics
1 class - climatology

Meteorology
World climates/geography
Water science
Earth sciences
Several other courses in geography

None

None

None

None since 1970

None

Attended a couple of short courses through UNL dealing with CWU calculations.

Geology 1 (3hr) class

None

Meteorology
Climatology
Hydrology

Basic Science Courses

Hydrogeology

N/A

None

Meteorology
Ground Water Hydrology
(May be some more, I can't remember)

None

None

None

None

None

Limnology

Soil Courses

CE - Hydrology Basics
CE - River Engineering
AE - Hydrology

N/A

None

Meteorology

Hydrology
Small Watershed Modeling
Introduction to Hydrology

None

Introduction to Meteorology at UNL

Meteorology
Physical Geography

Introduction to Hydrology
Hydrologic modeling of small watersheds

No specialized courses, basic required classes only.

Ground Water
Environmental Geology

None

N/A

Fluid Mechanics
Hydraulics Lab

Water Resources
Flow Design Systems
Water Resources Development
Groundwater Engineering

Entry Level Climatology

None

None

Only as it pertained to basic agronomy courses and chemistry, etc.

Hydrology
Physical Geography
Meteorology
Environmental Science

Groundwater Hydrology
Surface Water Hydrology
Ag Meteorology

Climatology
Meteorology

Hydrology courses in house, not at college.

Climatology

NRES 281 Hydrology
GEOG 252 Meteorology

Climatology

Hydrology/Hydraulics

Basic Climatology
Basic Hydrology
Basic Groundwater Geology-Hydrogeology
Advanced/Graduate Courses

Course in Climate - USD
2 engineering classes

Meteorology
Physical Geography
Geographic Techniques & Thought
Geomorphology
Soils
Irrigation Systems Planning

Engineering Hydrology

Forest Hydrology
Introduction to Weather
Fire Weather

Just received the John Campanion Holm Award from Weather Services.

Meteorology
Climatology
Fluvial Geomorphology
Hydrology

Meteorology, Soil Physics, Irrigation, Hydrology, Hydraulics, Sediment Transport, Numerous environmental water pollution courses, Public Administration
----
Meteorology, Ground Water

Meteorology
Various classes on weather, climate

Severe weather reporting/training

Several Hydrology courses

Numerous hydrology courses

Over twenty years ago

Hydrogeology
Soil Physics
Physical Geography

Hydrology

Hydrology

Basic Hydrology

Hydrology

****

6) List any training you have received in applying climate, weather, and/or hydrology information to problem solving and/or decision-making.

****

None

None

None

None

None

None

None

Basic Hydrology
Surface Water Data Computation

None

None

None

None

None
----
2 training courses for several SW hydrology models

Several workshops related to water resources management/science.
6 years of teaching experience jr/sr high school
22 ½ years of NRD Management

None

None

None

No Formal Training

None

Attended a couple of short courses through UNL dealing with CWU calculations.

None

The only training I have been associated with comes with a close relationship working with the Natural Resources Conservation Services in erosion and water quality. Our agency implements programs designed to encourage farmers to improve environmental attributes.

College courses
Seminars
On-the-job training

Our land borders North Platte River. Experience with water issues over a lifetime.

Disaster related programs

None

Zero

None

None

None

None

N/A

Crop H_2O use
Soil Characteristics

N/A

None

Modflow
Isotope geology
Ground Water Geochemistry
Ground Water/Surface Water Relationships

Made a living for 45 years by applying such information

Water Table levels
River flows
Soil Characteristics

On-the-job training.

Only in-house training

Limited – 1 air pollution course in college.
Worked 4 yrs. in Air Quality Compliance

Comparison of recent data to historical data to determine extent of drought, etc.

Optimization of hydroelectric operations, water and power management.
Modern methods in canal operation and control.

None

Platte River Cooperative Agreement water management Committee Member
Nebraska COHYST Technical Committee Member
Local Drainage within TBNRD district

Records training

Only as it pertained to basic agronomy courses and chemistry, etc.

Irrigation Short Course
Soil Conservation Service rainfall-runoff
Crop water use – evapotranspiration methods

Irrigation scheduling

Statistics
On-the-job training
Training in computer models/analysis

USGS Training Sessions
NADP-NADA Training Sessions
Site Operators School

NRCS Hydrology Training as part of wetlands determination training.
Engineering training to determine watershed hydrology.

Advanced Hydrology

Fire Behavior

Daily Administrator
Runoff for both South Platte & North Platte watersheds
I have been an observer for the weather services for 30 yrs.

On-the-job training dealing with drainage disputes and irrigation management.

Controlled burning

Controlled burning

Several

On the job prescribed burning, review of hydrograph data collected by the NRD.

Classwork

Severe weather reporting/training

See above

Various conferences and meetings
On-the-job training.

Numerous engineering applications for water management

We deal with issues related to runoff on a daily basis.
We operate a flood warning system.

Continuing Education Courses:
Hydrogeology
Ground Water monitoring
Courses that directly incorporate climatological information into the discussions.

Storm water management
Wastewater lagoons

On the job training

Indirect use of weather, climate, etc. data.

Water distribution of hydraulic models
Well field hydraulic models
River flow/Ground water hydraulic models
Well design

The following is a summary of responses to Section 2:

****

1) What time frame of climate or weather data do you use?

****

(percent - time frame)

64.8% - Historical climate conditions (ex: probabilities)
89.1% - Recent/current weather information
33.6% - Predictions for various time periods

****

2) What types of data do you use?

****

(percent - data type)

68.5% - Air temperature
23.8% - Soil temperature
7.7% - Radiation
28.5% - Wind Speed
20.0% - Wind Direction
20.0% - Humidity
96.2% - Precipitation
36.2% - Degree days (HDD/CDD/GDD)
31.5% - Evapotranspiration
24.6% - Snow measurements
40.0% - Short-term (daily/weekly) predictions
20.8% - Long-term (monthly/seasonal) predictions
3.1% - Other (specify below)

Cloud cover
Storage reservoir data
Info in computer from 3 areas for County
Soil profile capacities
Evaporation - lake

****

3) How and/or why do you use the data?

****

(percent - data use)

46.2% - Planning
60.8% - Decision-making
10.8% - Design
13.8% - Education
13.8% - Research
35.4% - Regulatory action (ex: emergency declaration)
33.8% - Monitoring water quantity/quality
21.5% - Hydrology applications
32.3% - Irrigation
10.0% - Communication (newsletters/reports/etc
14.6% - Setting Policy
13.8% - Other (specify below)

USDA disaster program applications
Setting policy and irrigation are limited
To determine disaster program eligibility
FSA Emergency programs
Disaster conditions
Collecting weather (rainfall) data
Request/justify disaster assistance
Crop conditions for program applications
Eligibility for disaster programs
Implement federal programs for losses due to weather
Decisions on disaster conditions, such as drought
Disaster program reports
Eligibility for disaster programs
Drainage design
Legal enforcement
Predicting electric loads
FSA Farm Programs
Water operations

****

Give a description of the items checked above.

****

(List of answers separated by dashed lines)

Primarily used to support implementation of FSA disaster-related programs such as the livestock assistance program and emergency release of CRP for haying and grazing. Also used to justify extension of seeding period for Conservation Reserve Program (CRP) cover crops.

----

a, b: Planning daily field activity so we know where we can and can't work.
a,b,c,d,e: Design of dams and other water resources projects.
d,i,j: Inform or educate irrigator on proper water use and soil temperature for fertilizer application.
a,b,f,k: Develop and monitor regulation concerning fertilizer application based on soil temperature.

In the event of natural disaster (e.g. drought, flooding, etc.) I use the weather data to determine and justify the use of Federal Disaster Programs to help local agricultural producers offset crop losses.

Precipitation records are important relative to watershed yield, flood history and groundwater levels.

The county office files reports of disasters due to weather. These reports can result in disaster designations, which activate emergency loans and emergency grazing, etc.

We primarily use climate data for irrigation scheduling and to plan daily activities.

----

a & b: In farming
f & l: Filing data and requesting USDA programs for disaster relief under USDA livestock and conservation programs and disaster programs.

We use weather records to help us determine river flows during winter periods and for peak flow computations.

Used mainly for emergency declaration of disaster programs through the Federal Government.

This data is used to determine whether county would qualify for emergency programs offered by Federal Government through USDA.

----

a: Groundwater management plan
d: Design of windbreaks & species selection
Water expos for students
g: Water level monitoring
j: We keep year-to-year reports of temperature & precipitation in our district.

Soil temperature is used for educating/communications/setting policy for fall application timing of anhydrous ammonia fertilizer.

Weather/climate information/data used for project planning-budget decisions, etc. (For example, construction of dams)

Drought or flooding or early freeze, severe weather: damaging crops, livestock, buildings or land.
Information and data used to request implementation of emergency programs administered through USDA/FSA.

Planning - Sizing of electric and water production facilities
Decision - Daily projections of water and electric demand

Precipitation and degree days are used for disaster declarations.

Provide a crop water use program for irrigators in the District.

Rainfall amounts over past periods - usually 4 months - used to qualify for additional USDA-Farm Service Agency Programs, i.e. - haying cropland.

We are responsible for implementing emergency programs as the result of natural weather disasters. To justify eligibility for farmers in our county we must assemble information from NASS to determine if drought or heavy rain has caused crop losses.

Irrigation Scheduling, monitoring ground water levels, reservoir recharging

----

We want to give our irrigators the best service through the whole season.

We use precipitation (annual average) in regional ground water quality reports as background material. We also use general precipitation information to estimate groundwater recharge.

To monitor loss thresholds and or crop losses which may qualify for USDA assistance.

Too much or too little precipitation determines eligibility for various emergency programs.

----

g & e: In relation to our monitoring wells
i: Irrigation records

Needed to qualify for various FSA programs.

Qualifying for federal disaster programs is based on temperature and precipitation data for the County – comparing disaster year data to historical averages.

Haying and grazing of CRP (Conservation Reserve Program), implementation of various disaster programs
1. Crop Disaster Program (CCDP)
2. Livestock Assistance Program (LAP)
3. Emergency Conservation Program (ECP)

Federal Emergency Assistance Programs for agricultural producers.

Collecting weather (rainfall data) to determine above average, normal, below average rainfall for completing wetland determination.

Use information for primarily irrigation purposes for producers

----

We work with irrigators to get them evapotranspiration data in a timely manner; we use data for our groundwater management plan to help us understand our hydrogeology and set policy; we use data to interpret effects of precipitation on our monitoring well and stream gauge information.

Primarily use for stream & river flood information or for flash flood on Papio Creek.

Information is used to determine whether a recommendation to authorize haying or grazing of CRP acres should be made.

Information used to determine rainfall & temperature to see if county eligible for drought programs.

Understanding historical precipitation records is integral to analysis in hydrologic settings.
Also use precipitation as input to groundwater models.

Use annual weather data to compute estimated irrigation applied. Use historic ET values to estimate conveyance losses for rivers. Will use forecasted data in a future decision support system for predicting streamflow.

Communication: Weekly crop/weather report published by USDA.
Decision Making: Use data in objective process of forecasting crop yields.

Deferred maintenance.
Ask customers to reduce consumption.

I farm on the side and use weather data as a tool for farming.

Set up schedules for tree planting or weed barrier. Determine areas of intense irrigation. Support water level data. Plan dates for certain demonstration projects. Weather offsets fieldwork.

We use precipitation & temperature data when we are making crop disaster determinations.

Weather and climate conditions have a direct impact on crop and livestock conditions. Information is used to complete weekly crop reports to NASS and to support qualification for special USDA programs in times of emergency.

County offices use recent/current precipitation levels to determine if a county would qualify for CRP grazing or to recommend an emergency declaration.

Set policy: to determine if county is eligible for disaster programs.

This information is used to help determine the need to request disaster programs related to drought.

Data collected for general planning documents, actions to monitor crop production efficiencies and utilization of available data, and educational efforts for operator training.

Holding capacities of soils is valuable information in estimating field run-off and nitrate leaching, as well as groundwater recharge potential.

Used to the extent needed for recommending the implementation of disaster assistance through various programs

----

Lake evaporation, ground water elevation changes.

I have done water resources planning for the NRD and Bureau of Reclamation. This work includes designing cross drainage, spillway structures, and floodways, using storm event precipitation to estimate runoff or flood flows.
I have used daily climate data to estimate crop water use, irrigation plumage and groundwater recharge.

The NRD wants to educate cooperators in using best management practices to help protect water quality.

Drought declarations in particular, emergency programs such as haying & grazing (CRP acres, also disaster programs, such as payments for lost

crops due to shortages of moisture, wind damage, hail, or other natural disasters.

Used information for developing groundwater management plan.

Education training for farmers through operator training
One-on-one with farmers for irrigation scheduling

----

a: We try to use predictions to determine whether we may receive precipitation & not have to administer water rights in near future.
b: We have hearings to determine whether water rights should be cancelled. Excusable reason is sufficient rainfall. Use records to determine this.
f: If river flow is on cusp of going into regulations, rain is predicted, wait one day to send out regulatory practices.
h: Do determinations of unappropriated water for surface water rights. Need to include both dry & wet years (historical data). Hearings held. Precipitation shown to be major factor in groundwater levels.
k: Same as first one

Use data when requesting disaster related or emergency farm programs.

We generally use current rainfall data and compare it with the normal. It is usually based on a month-to-month basis, but we sometimes look at daily activity. This is used for emergency declarations. The weather information is also used to determine the need for other federal programs. Qualifications for most disaster related programs are based on weather data. The county does not need an emergency declaration for all disaster programs. The programs include; disaster, livestock feed assistance, emergency conservation, and releasing CRP for haying & grazing.

Irrigation Scheduling

I do some water quality work - sampling, water levels.

Use data to determine county eligibility for disaster programs.

We prepare past precipitation reports to determine eligibility of county for disaster programs.

----

f: Determining implementation of emergency programs for possible benefit payments or loans.
k: Establishing loss percentages & reasons for losses based on weather conditions.

Watershed planning, floodplain mapping, wetland determination, structural design, irrigation system planning

----

Planning work on the canal in preparation for irrigation season

----

All the above are included in regional modeling & currently in Republican River Basin modeling & defending NE interests in litigation in Kansas over the Republican River compact, also in resolving Platte River issues as part of COHYST study.

For installing water & sewer lines, land application of sludge, water service freeze-ups, sewer machine freeze-ups and water main breaks.

Rainfall data (historic) for wetlands determination
GDD/ET for irrigation water management

Hydrology for Floodplain Studies
Climate data for ice-jam assessment

Counties must meet certain drought or excessive rain conditions in order to be eligible for disaster programs.

Water appropriators administration

We use precipitation and temperature (historical data) of previous months to determine if disaster assistance is needed.

2&3: Utilize short-term forecasts to plan work schedules. Evapotranspiration, short-term & mid-term (5 to 15 day) forecasts utilized for estimating irrigation delivery requirements. Long-term forecasts considered when planning/estimating seasonal storage water requirements. Historical data can have relevance when planning drainage construction and placements. In addition, construction of irrigation districts does not normally take place where historical data indicates adequate rainfall.

My planning & decision making is based on short-term weather forecasts. Most of my job

requires work in the field. Rainfall amounts are used a lot. We maintain several hundred watershed dams, including a few high hazard structures that would require evacuation of people in the event of a breach.

The type of work we do depends on weather at any time of year.

Monitoring wildlife regulations. Use data as agency representative on Drought Task Force.

My office supports state & local disaster preparedness for the entire Missouri River basin to Rulo, NE. We use climate & weather data to plan for construction of temporary flood control works (a,c) when there are forecasts of unusual flooding such as the spring of 1997 in the Plains states, and for flood fighting (b,f,g,h) such as the protection of Hamburg, IA from flooding on the Nishnabotna River in June 1998.

Burn prescriptions, planning fieldwork (Monitoring, decommissioning, etc.)
Comparison with hydrographs

We use weather data to assist local producers in what they can expect their crops to use with respect to water and its availability. We plan irrigation scheduling with weather data and expected crop use to assist, educate, and design irrigation plans for producers. Increased irrigation efficiency helps increase our quantity and quality of water. All aspects of items listed in question 3 are involved in preparing the information for producers.

----

b: time to lower livestock waste control facilities (LWCF)
i: show able time to lower LWCF

Use after the fact load data and project loads for next day with days that have like temperature patterns.

I use high and low temperatures during winter months; this helps me decide if fluctuations in gauge readings on surface water gauges are from additional flow or backwater from ice. I also use precipitation and snow measurements to verify additional flow to the system.

Information is used to determine when to ask for disaster assistance programs & loans.

I use weather predictions in planning our water orders for short-term needs - 7 to 10 days.

I use this data to determine if our counties qualify for various federal programs we administer.

All apply to irrigation demand supply forecasting, planning and management. Also identification of historic trends, climatic patterns & climate variability.

When we are requesting CRP haying, grazing or disaster drought assistance we must have data for the last 3 years.

We use near term forecasts for burning, spraying and to try to predict water demand.

Groundwater modeling, evaluating water supply, routing water in stream, predicting stream flow

----

We use the weather data to explain past electricity sales, demand and averages to predict future sales and demand. The scale and timing of new generating resources are based on the sales and demand forecast.

Most of our activities relate to flooding and storm water management.

I use historical rainfall data to analyze groundwater levels, and how that might influence groundwater quality.
I also use evapotranspiration, precipitation, evaporation (radiation), and short-term predictions to analyze water balance equations. I use precipitation, short-term predictions, and long-term predictions to analyze storm water runoff designs and regulations.

Planning field investigations and inspections.

Lagoons, storm water - we use long-term data most of the time.

----

a: Work up annual operating plans based on expected inflow & evaporation at reservoirs
b: Determine water availability based on projected reservoir storage, also release from dams based on flood inflows
e: Use historical data in estimates
g: Monitor quantity of water coming into the reservoir
h: Estimating runoff from storms based on streamflow

i: Irrigation is the primary function for reservoirs in our projects
j: Presentations and reports to public and other agencies.

We use this information occasionally for flash reports regarding severe weather.

----

b: When & how much water to use
g: Same as b
j: Managing an irrigation district

****

4) Specify how often you use the following sources of data:

****

***

National Weather Service Forecast Office:

***

No answer - 17.9%
Never - 21.4%
Occasionally - 35.7%
Often - 25.0%

***

National Weather Service River Forecast Center:

***

No answer - 34.3%
Never - 45.7%
Occasionally - 15.0%
Often - 5.0%

***

National Climatic Data Center:

***

No answer - 25.7%
Never - 22.9%
Occasionally - 37.1%
Often - 14.3%

***

Climate Prediction Center:

***

No answer - 31.4%
Never - 43.6%
Occasionally - 16.4%
Often - 8.6%

***

High Plains Regional Climate Center:

***

No answer - 23.6%
Never - 22.1%
Occasionally - 33.6%
Often - 20.7%

***

State Climatologist:

***

No answer - 29.3%
Never - 30.7%
Occasionally - 27.9%
Often - 12.1%

***

AM/FM Radio:

***

No answer - 23.6%
Never - 13.6%
Occasionally - 27.9%
Often - 35.0%

***

NOAA Weather Radio:

***

No answer - 32.9%
Never - 38.6%
Occasionally - 19.3%
Often - 9.3%

***

Television:

***

No answer - 24.3%
Never - 16.4%
Occasionally - 22.9%
Often - 36.4%

***

Newspaper:

***

No answer - 24.3%
Never - 17.1%
Occasionally - 34.3%
Often - 24.3%

***

Computer:

***

No answer - 26.4%
Never - 7.9%
Occasionally - 30.0%
Often - 35.7%

***

Subscription - details below:

***

No answer - 45.7%
Never - 42.9%
Occasionally - 5.0%
Often - 6.4%

No specification given
No specification given
No specification given
NASS
N/A
National Agricultural Statistics Service
DTN
Own meteorologist
DTN
Internet

***
Other - details below:
***
No answer - 85.0%
Never - 10.0%
Occasionally - 2.1%
Often - 2.9%

Nebraska Department of Water Resources
On computer, does that mean the above sources?
Local reporting stations
Precipitation Collection points
Weather stations within district
On-line UNL Weather information & NASS
Federal Government Agencies& Publications
and USBR
Omaha NWS website, UNL website

****
5) When or how often do you use climate and/or weather data in your work?
****

Daily - 23.0%
Weekly - 15.0%
Monthly - 10.0%
Seasonally - 37.0%
Annually - 3.0%
During drought - 4.0%
During flood - 2.0%
Other (specify below) - 6.0%

Depends on weather conditions
Monthly in job/daily in farming
During drought & flood also
During drought and flood
During floods
Use them all, especially during flood
During drought
Drought, flood, severe storms
During drought
During drought
Weekly, drought & flood
Drought & excessive precipitation
Drought & required reports
Use weather history only
During drought & flood
Daily/Weekly during growing season
Monthly and seasonally
Drought, flood, snowstorms
Weekly/Seasonally
See 3 F
Seasonal, drought, flood
Drought/flood
Daily/seasonally
Drought/flood
Monthly/drought/flood
Only to develop plans
Drought/flood
Any weather related loss.
Seasonal, drought, flood
Drought/flood
Annually/drought/flood
Weekly/flood
Drought/flood
All times
Weekly/Seasonally
Seasonally, during drought
Continuous Updates – data collection platforms
Annually/drought
Weekly, drought & flood
During drought and flood
During flood
Weekly/drought & travel
Monthly and seasonally
Weekly/drought
Seasonally/annually-drought
Seasonally/drought
Drought/flood/after storms
Seasonally/drought & flood

****
6) What degree of accuracy (percent) do you feel the National Weather Service currently provides for the following:
****

(HI/LO/AVG in units of percent)

1 - 3 day forecast:

HI - 97
LO - 30
AVG - 78.3

7 to 10 day forecast:

HI - 90
LO - 10
AVG - 60.8

Long-term forecasts (monthly/seasonal):

HI - 85
LO - 5
AVG - 42.0

****
7) Do you use short-term (1-3 day or 7-10 day) predictions in your work?
****

58.0% - yes
42.0% - no

***
If no, select the reason for not using:
***

Unsure how to obtain - 6.1%
Unsure how to integrate into decision-making and planning processes - 18.2%
Predictions are not accurate enough (answer the level of accuracy question below) - 3.0%
Other (specify below) - 72.7%

Reports are filed "after the fact".
No need
We are interested in what has already happened, not what is going to happen.
Mainly need actual precipitation for past 4 months for declarations
Disaster occurrence is required before applications for programs may be submitted.
N/A
Not required or necessary
For crop water use
In my farming, so is not involved with work
Use only to determine driving conditions
We just don't use that data.
No need
Our work is affected by historical occurrences more than predictions.
Don't need.
Not applicable to my use.
No need
Somewhat - during snowstorms
No need
Weather data used to request federal emergency programs for farmers & ranchers
Not yet but will soon
We use historic data only.
Don't need.
No need
Use statistics to qualify counties for disaster aid
– only check to see if outlook would change
Not applicable to my use.
Do not need predictions only historical data.
Need actual data
Don't need.
N/A as we address problems after they happen.
Occasionally - as needed. Doesn't often apply to what we have going on.
Disaster programs are always after-the-fact
No need
Not applicable to my use.
No need
No need
No reason to use predictions, our agency deals only with actual data.
Need actual data
Not needed.
Not needed
Not in the short-term prediction business, use statistics for life of project
Not needed
We work in an office/more or less a preference for wanting to know the weather
No need
Not relevant for long-term planning.
NOTE: not nearly as often as historical data, however.
Don't need except for snowstorm
Very short term only, because of accuracy
Not applicable
No need

***
If you selected that the predictions are not accurate enough, at what level of accuracy would you begin using predictions?
***

(HI/LO/AVG in units of percent)

1 - 3 days:

HI - 90
LO - 40
AVG - 72.3

7 - 10 days:

HI - 80
LO - 20
AVG - 52.1

****
8) Do you use long-term (monthly or seasonal) predictions in your work?
****

30.7% - yes
69.3% - no

***
If no, select the reason for not using:
***

Unsure how to interpret - 1.9%
Unsure how to integrate into decision-making and planning processes - 13.0%
Predictions are not accurate enough (answer the level of accuracy question below) – 29.6%
Other (specify below) - 55.6%

Reports are filed "after the fact".
We don't really need to plan that far in advance
No need
Mainly need actual precipitation for past 4 months for declarations
Disaster occurrence is required before applications for programs may be submitted.
N/A
Not required or necessary
No specifications given
Not necessary for job
N/A
FSA only uses historical data.
No need
No need
We just don't use that data.
Don't need now
N/A
No need
No need
No need
No need
Weather data used to request federal emergency programs for farmers & ranchers
Use historic data only
Don't need
Doesn't apply
Not applicable to job
Need actual data.
N/A
As needed
Disaster programs are always after-the-fact
Not applicable to job
Not required or necessary
No need
No need
No reason to use predictions, our agency deals only with actual data.
No need
Need actual data.
Not needed
Not needed
Not in the short-term prediction business, use statistics for life of project
Not needed
Not sure what government would require for accuracy levels.
Not needed
Fieldwork requires a current weather forecast.
Primarily use observed data.
Looking at past rainfall
Generally no need for long term
Not needed
Not needed
Not unless we are in drought, very wet period or a disaster strikes (when benefits are requested)
No need
I use climatologic because I deliver 30-year models.
No. 1 priority is concerns about intense rainfall, impossible to predict long-term.
Adjusting irrigation releases difficult/possibility of rain – plans based on historical probabilities
Not applicable
No need

***
If you selected that the predictions are not accurate enough, at what level of accuracy would you begin using predictions?
***

(HI/LO/AVG in units of percent)

HI - 90
LO - 25
AVG - 68.5

****
9) As new tools and products become available, do you anticipate future uses of climate or weather data in your area of work?
****

65.4% - yes
34.6% - no

****
10) Can you describe products that would be particularly helpful in your area of work?
****

(List of answers separated by dashed lines)

Information on the availability of weather data on the computer

----

The current use of weather station data is adequate for our needs.

Choosing crop types to plant in farming.

For FSA determine expectations of any relief of agricultural disasters affecting crops and pastures.

Precipitation amounts available to current date.

I don't know

Long-term temperature and moisture prediction

Being able to request temperature or moisture data for an individual collection site with totals by month for time frame desired or entered.

More up-to-date information on the web

County specific information

The "Net" is very helpful - better mapping

Forecast graphs for short to long term for GIS users, along with climate data in standard easy to read form

----

N/A

Accurate daily temperature and humidity for forecasting electric and water demands

----

Nothing essential

Unsure, but you have to be open-minded regarding technological advances.

More accurate forecasts if possible

Specific local area weather data

Products that provide historical data on precipitation and temperature for local areas - county-wide

----

Past precipitation and temperature - actual data

Technology to measure evapotranspiration inexpensively on a local scale, methods to measure precipitation amount and location in large areas, such as watersheds (to help pinpoint where runoff is occurring), measuring and predicting groundwater recharge

----

Anything that helps with flood forecasting

More accurate precipitation & evapotranspiration maps will be critical to refining groundwater models.

GIS ready products such as grids of precipitation
One to three day estimated precipitation & estimated ET

Soil moisture/rainfall/temperature/growing degree day correlations with crop conditions & yield

----

Unless tools are proven first

My project is a watershed project and weather data is important in design of such products.

Wireless Internet for vehicle to check regions of precipitation, and reported precipitation amounts.

We mainly use historical data - not predictions.

Any tool that will let us predict the streamflow. We need to know when to expect a rise, how high it will go and how long it will last.

Soil moisture profile data.

Graphical data where you have better ability to modify & change variables.

Decision support system for Platte River
Improved area precipitation totals.

Long-term trends - participation (historical)
Soil temperature - historical trends

ET rates specific to the MNNRD. I know these are currently available, but it's a matter of getting local producers to understand & use the info.

Real-time local area soil profile levels

We use current weather information to plan field trips around the weather and roads during winter. We use monthly data for assessing the weather for working river records for winter months.

N/A to FSA at this time

Estimates of groundwater recharge & surface water runoff from precipitation events.

Up to date data on historical and current precipitation and temperature data

----

The current products are a comfortable fit – seasonal temperature & precipitation figures.

Better predictions

Web based software

Most of our emergency programs are based on weather data & percent of normal. It is based on the weather stations in the county. It would be nice to have the current information available on the site. The posting of data appears to be a couple of months behind.

Flood Prediction, crop water use

Access to information if you need it

Soil moisture profile data.

Almost all reports we use are to determine disaster conditions.

Additional local weather stations

Better long term forecast 1-3 months

Stream forecasts, recharge related to rainfall, crop water use forecasts, seasonal predictions, drought data (prediction & impacts on surface water and groundwater.

Unsure what products are out there

Prediction of crop water use & GDD

Precipitation & temperature data that is current (to the nearest month)

Projecting current data for crops.

The information we use most often is the past several months of temperature and precipitation data.

Contour maps of rainfall distribution after storm events

GIS maps which contour forecasted flood depths in real time mode.

Temperature & precipitation predictions and possible implications to nutrient management and wetland restoration work
Understanding fluctuations in ground water levels, impacts to new plantings

----

ET devices for irrigation efficiency
Soil temperature probe

Flood forecasting

Access to weather moisture recordings faster than 2-month delay we see now.

Information that quantifies the effects of precipitation events & routes runoff; better forecasting

----

Accurate rainfall predictions & amounts

Any tools to help predict streamflow would be helpful.

Predicting floods.

(Long-term) historical precipitation databases available on the Internet - statewide locations

----

The advent of real-time data (data collection platforms) and the Internet have been very helpful to date. Expect these products to increase in number & use. If accuracy in predicting weather events could be improved they may be of more use.

Computerized maps with soil moisture, etc, stream flows.

Computerized forecasts/trends
Short term, intermediate, long-term forecasting
Historical forecasting 5-10-25-50 year

****
11) If educational programs were developed to address the use of historic climate data and predictions in your area of work, what method(s) would you prefer?
****

(Rank - number selecting this rank)

***
Workshops
***

1 - 47
2 - 8
3 - 15
4 - 4
5 - 5

***
Manuals
***

1 - 11
2 - 10
3 - 12
4 - 15
5 - 9

***
Courses
***

1 - 9
2 - 16
3 - 5
4 - 11
5 – 7

***
Web tutorials
***

1 - 19
2 - 6
3 - 15
4 - 9
5 - 10

***
Video
***

1 - 15
2 - 17
3 - 8
4 - 5
5 - 10

***
DVD
***

1 - 4
2 - 3
3 - 2
4 - 2
5 - 1

***
CD Rom
***

1 - 14
2 - 10
3 - 5
4 - 10
5 - 14

***
Other (details below)
***

1 - 3
2 - 1
4 - 1

Worthless unless proven, so far that is not the case

Internet based

Not sure

APPENDIX D: INTERVIEW FORM

Name: ______________________________ Date: ________________

Job Title: ___________________________

What are the main goals of your job?

Do you (or those who work with you) use climate and/or weather information?

Historical climate?
Current or recent?
Forecasts or outlooks?

For what reason(s) do you use climate and/or weather data? For example, what decisions or operations are sensitive to weather? What activities in your operation require that you take the weather conditions into account?

1.

2.

3.

4.

5.

Activity: ______________________________
Short-term decision?
Long-term planning?
Policy implementation?

When and with what frequency is this addressed? (i.e., is it a weekly activity that requires daily attention or an annual cycle that requires you to make a decision six months ahead of time, or other)

How long before the activity do you assess the weather/climate related component?

What is the benefit of making a correct assessment (what is saved in terms of money, resources, time, etc.)?

To whom do the benefits accrue?

What is the possible loss due to an incorrect assessment (profit, investment, resources, etc.)?

Who incurs the loss?

What is the process that is used to incorporate the weather/climate data or information into the decision, planning, or policy area identified above?

Where do you get the weather/climate data? What types do you use?

How do you relate it to this activity? (Do you relate it directly, do you analyze it for probabilities, do you use any models, etc.)

Are there any further elements of the process that you can describe?

From the Survey – Can you think of any tools or products that would be helpful in your area of work?

APPENDIX E: SUMMARY OF RESPONSES TO INTERVIEW QUESTIONS

This appendix does not include the summaries for all questions, only those that contained information of interest.

Question 1 – Do you (or those who work with you) use the following data or information: Historical climate? Current or recent? Forecasts or outlooks?

Historical – 30-year normals (71-00) – NWS
Current or recent – Temperature/dew point/wind (weather effective temperature)/degree days
Forecasts or outlooks – Climatology (normals/averages)
*****
H – Use comparisons to set water rates
C/R – Record rainfall – use (annual) bar graph to track demand and consumption
F/O – Do not use, as no problem with capacity (always an excess) – water rates seem to limit consumption
*****
H – Compare past conditions to present (short-term) – planning (short and long-term) – (EX: how snowpack is related to spring runoff)
C/R – Daily – responsible for emergency management procedures in 9 states, as well as for daily field operations
F/O – Precipitation forecast – pre-flood preventative measures (EX: sandbags)
*****
H – Trends in streamflow and groundwater
C/R – Administration
F/O – Predict water supply for upcoming year (snowpack/predictions)
*****
H - Yes
C/R – Yes
F/O – Not extensively – inaccurate
*****
H – Yes
C/R – Yes
F/O – Only as relates to short-term fieldwork
*****
H – Yes
C/R – Not too much – at a higher level in agency
F/O – As above
*****
H – Yes
C/R – Yes
F/O – Sometimes
*****
H – Precipitation
C/R – Precipitation

F/O – Short-term for fieldwork
*****
H – 100-year storm predictions and normals
C/R – Both
F/O – Short-term for flood warning/control
*****
H – Yes
C/R – Recent
F/O – No answer
*****
H – Averages for publication
C/R – Weekly summary for publication
F/O – No
*****
H – For disaster relief
C/R – Storm reports
F/O – CARC member – but from FSA standpoint, only a heads up for what may happen – FSA normally uses information on a day-to-day basis
*****
H – Minimal – related to project design
C/R – Yes
F/O – No – feed data directly to NWS in Valley – they use information in forecasts (NRD does not issue watches/warnings directly to public)
*****
H – Yes
C/R – Yes
F/O – Yes – but in short-term
*****
H – In the database – used to predict daily water consumption
C/R – Day to day decisions
F/O – For next day or two – a week would about be the limit
*****
<u>3 Interviewees answered as follows:</u>
H – Yes
C/R – Yes
F/O – No
*****
<u>13 Interviewees answered as follows:</u>
H – Yes
C/R – Yes
F/O – Yes

Question 2 – For what reason(s) do you use weather data?

Energy; Demand; Retail Sales
*****

Groundwater mgt; wellhead protection; groundwater clean-ups; underground injection
*****
Flood warning/control; planning/developing (structures/easements)
*****
Watershed planning; WRP (fed program – for private landowners and individuals); wetland determination
*****
Forecast end of season yield; weekly for publication
*****
USDA disaster assistance programs; flash reports
*****
Flood warning/control; guidance in municipal development
*****
Basin/wetland maintenance; wildlife surveys; fish surveys; insect levels; predict what may happen with Conservation Programs; climate change concerns (how affect fish and wildlife)
*****
To analyze/predict consumption; water alert system
*****
River flow; graph and track demand and consumption; to set rates
*****
Groundwater mgt; instream flow on Platte; structure design/maintenance
*****
Flood assessment and mitigation; hydrological analyses; forecast conditions for inflow into dam projects (flooding); daily for fieldwork; structure construction/repair
*****
Administer surface water use; monitor streamflow; regulate groundwater for surface water rights; administer Compacts and North Platte Decree
*****
Adjudication of water rights; water administration; determine trends
*****
Electric power supply analysis; to project electric load
*****
Planning construction of dams; to advise irrigators of crop water use; admin groundwater; inform public
*****
Planning construction of wastewater treatment facility; monitor water consumption and well drawdown caused by irrigation
*****
Flood control structure design; daily fieldwork; lake sampling; automatic stream sampling
*****
Flood control structure construction/operation/maintenance; groundwater recharge/management; soil erosion mgt; Compact administration (KS/NE Big Blue)
*****

Education (irrigators/nitrates); monitor ET for irrigators; static water program; wind erosion

*****

Planning (construction/maintenance); for daily operations; anticipate water use/demand by irrigators

*****

USDA disaster programs

*****

Administration of surface waters

*****

Groundwater recharge/management; crop water use; daily fieldwork; erosion and runoff program (in development)

*****

USDA disaster programs

*****

Groundwater levels as affects quality; surface water monitoring as affects quality; air quality monitoring

*****

USDA disaster programs; flash reports

*****

Estimate how much water to expect in normal years; shut canals if water not needed (recent rain); snowpack in WY mountains as affects predicted streamflow for coming season

*****

Groundwater modeling (movement, recharge, conjunctive use); acid rain; dioxin samples

*****

Streamflow; groundwater levels and recharge; precipitation as affects streamflow; ongoing estimate of ET and crop water use for irrigators

*****

Current/recent for irrigation, to make daily adjustments depending on rainfall, temperature, wind (affects ET, evaporation); Historical and forecasts/outlooks for annual plan for coming year, long-term planning; All types for strategic planning – legislation (interstate compacts/decrees, ESA, etc.), competition for water supply, interstate relationships, recurrence of flood/drought

*****

Historical and current/recent for disaster programs, livestock programs, haying and grazing of CRP land; Current/recent and forecasts to determine whether or not to continue certain programs; Current/recent for flash reports

Questions 6 – What is the benefit of making a correct assessment (what is saved in terms of money, resources, time, etc.)? To whom do the benefits accrue?
Question 7 – What is the possible loss due to an incorrect assessment (profit, investment, resources, etc.)?

Benefits:
Users appropriately remain open or are appropriately shut down

Money and time saved, conflicts avoided
Benefits accrue to:
Agency, Users
Losses:
Loss of water supply
Loss of tax money on inappropriate structure construction
Who incurs loss:
Agency, Users, Public
*****
Benefits:
Time and money saved by agency
Users appropriately lose/retain rights
Benefits accrue to:
Agency and users
Losses:
Incorrectly closing a user could cause economic loss for user
Agency loses credibility
Who incurs loss:
Agency and users
*****
Benefits:
Accurate demand projections prevent under or over-generation of power
Benefits accrue to:
Public/users and Department
Losses:
If not enough power, must purchase
Who incurs loss:
Department and public/users
*****
Benefits:
Significant savings to farmers – pump less when know crop needs
Less intrusive way to manage water use
Assures all structures are appropriate
Benefits accrue to:
Farmers, Public/taxpayers
Losses:
Opposite of above
Who incurs loss:
Farmers, Public/taxpayers, Agency loses public trust
*****
Benefits:
Do not need to run wells when not necessary
Benefits accrue to:
City and the public
Losses:
Running wells when not necessary expensive and may damage

Who incurs loss:

City

*****

Benefits:

Structure size/design appropriate for use

Efficiency in daily fieldwork saves money and time

Benefits accrue to:

Taxpayer and agency

Losses:

Inappropriate structure design could result in property damage

Fieldwork inefficiency costs taxpayers money

Who incurs loss:

Public and agency

*****

Benefits:

Properly sized structures handle most likely events

Groundwater management – extend life of aquifer

Benefits accrue to:

Public

Losses:

Waste tax money and lose respect of public

Who incurs loss:

Public and policy makers

*****

Benefits:

Reduce amount of nitrates reaching the groundwater

Reduce the amount of groundwater used in irrigation

Benefits accrue to:

Public and irrigators

Losses:

Incorrect information to producers may lead to yield reduction

Who incurs loss:

Farmer, Agency loses credibility

*****

Benefits:

Time fieldwork with favorable weather (spraying, concrete work, etc.)

Calculate correct amount of water to keep canal at same level

Benefits accrue to:

Irrigators and office

Losses:

Lose money on construction or operations

Who incurs loss:

Irrigators and office

*****

Benefits:

By using hard records received by the state, there is no further need for documentation

Benefits accrue to:

Producers

Losses:

Resources and profit

Who incurs loss:

Producers

*****

Benefits:

Large amounts of money can be involved in knowing how much water is available – time to make decisions

Benefits accrue to:

Producers, environment, groundwater recharge

Losses:

Opposite of above

Who incurs loss:

Farmers and then 3rd party effect on down to the local level

*****

Benefits:

Save time and money

Save water, crops not stressed

Extend aquifer life

Benefits accrue to:

Office, producers, and public

Losses:

Opposite of above

Who incurs loss:

All of above

*****

Benefits:

With best information and interpretation, producers receive relief when needed

Benefits accrue to:

Local farmers and ranchers

Losses:

Process slowed by weeks

Who incurs loss:

Local farmers and ranchers

*****

Benefits:

Accurate water quality data

Cost-benefit – assessment higher

Benefits accrue to:

Public and regulated community, agency

Losses:

Inaccurate data = inaccurate regulatory decisions

Who incurs loss:

Regulated community, Agency

*****

Benefits:

Being able to implement programs to compensate for losses

Benefits accrue to:

Producers

Losses:

No implementation of programs

Who incurs loss:

Producers

*****

Benefits:

The more advance notice given to producers, the better – gives them a chance to make decisions

Benefits accrue to:

Producers

Losses:

Bad year = bad crop

Who incurs loss:

Producers

*****

Benefits:

Groundwater – models can help designate control areas and determine allocations – extend life of aquifer

Benefits accrue to:

Everyone

Losses:

If aquifer drops, irrigation base destroyed

Who incurs loss:

Everyone

*****

Benefits:

Conserve water

Better management = more hydropower production

Benefits accrue to:

Irrigators, electric ratepayers, recreation

Losses:

Loss in hydropower production

Irrigators may not have sufficient water

Who incurs loss:

Same as above

*****

Benefits:

Annual operation plans – estimate probable scenario and plan accordingly

Long-term plan – estimate all possible scenarios and plan to operate through any event

Sufficient water for irrigators on daily basis

Benefits accrue to:

Irrigators, Ratepayers

Losses:

Lose ability to generate sufficient power

Crop loss

Who incurs loss:

Irrigators, Rate-payers, State

*****

Benefits:

Declarations correct and faster – puts money in hands of producers

Benefits accrue to:

Producers

Losses:

If declarations not timely, producers lose out, livestock may suffer

Who incurs loss:

Producers

*****

Benefits:

Optimize operations – point forecasts/band width (high/low into model)

Optimize resource planning

Benefits accrue to:

Company – reduce costs as much as possible

Public – lower rates

Losses:

High forecast – company losses/higher rates

Low forecast – forced to buy energy on market – company losses/higher rates

Who incurs the loss:

Company & public

*****

Benefits:

Wellhead protection – municipalities save money on construction of new wells

Non-point source pollution identified, remediation can take place

Benefits accrue to:

DEQ, municipalities, land owners in case of wellhead protection

NRDs & DEQ in case of groundwater management

Losses/who incurs loss:

Basically opposite of above

*****

Benefits:

Flood control – saves lives – longer lead-time gives thousands time to get out

Millions of dollars in resources and property could be saved

Benefits accrue to:

Public entities and private citizens

Losses/who incurs loss:

Opposite of above

*****

Benefits:

Watershed planning – if the model is correct, the watershed will be planned properly
WRP – document legitimate use (EX: actually was a wetland in the past)
Dispute resolution – compare recent and historical data to show neighboring property owners correlation/no correlation to a problem
Benefits accrue to:
Property owners, Agency
Losses:
Wetlands/WRP – legal – appeals/time/money
Who incurs loss:
Wetlands/WRP – landowners and agency (must deal with appeals)
*****
Benefits:
Stability in the market place
Numbers are speculative in area of Board of Trade
Benefits accrue to:
Farmers (planning)
Agricultural community
Those in the market
Railroads (must decide in advance how many cars they need for harvest)
Losses:
Harmful to someone who has taken a position in the market
Not tolerant of agency making errors – expect a great deal of accuracy
Who incurs loss:
Many people – 1 in 4 or 5 in the Midwest depend on agriculture for their livelihood, either directly or indirectly
*****
Benefits:
Counties become eligible for farm programs
Benefits accrue to:
Producers
Losses:
There have been cases in which weather stations are located in a section of the county that is not representative of the whole county, resulting in the county not being eligible for farm programs
Who incurs loss:
Producers
*****
Benefits:
Time and money for people where flooding may occur
Keep people out of flood prone areas
On Platte and Elkhorn – give people time to move livestock and belongings
Appropriate structural design for flood control (using historical data)
Saves time/money/resources
Saves lives
Benefits accrue to:
General public, Public/private industry, Agency

Losses/who incurs loss:

Opposite of above

*****

Benefits:

Surveys – fuel, lodging, and vehicle wear and tear – pool all fish and wildlife survey participants, and savings could be substantial over time

Population studies and Farm Bill – all after the fact

Benefits accrue to:

The resources of the state and thereby the citizens

Losses/who incurs loss:

Opposite of above

*****

Benefits:

Avoid a water alert – avoid time on agency's part and inconvenience to the public

Correct assessment of consumption – can save substantial amount of money annually

Benefits accrue to:

Agency and customers in case of water alert

Agency in case of consumption and predictions

Losses/who incurs loss:

Opposite of above

*****

Benefits:

Less impact on water users – no controls set on use

Benefits accrue to:

Users

Losses:

Political dissatisfaction

Small reduction in revenue

Inconvenience to users

Who incurs loss:

City and Users

*****

Benefits:

Groundwater quality – if water not contaminated, no need for treatment

Groundwater quantity – an adequate supply alleviates overpumping

Flood control – assessing floodway, saves in insurance costs, benefits people downstream

Benefits accrue to:

Public

Losses:

Groundwater quality – if incorrect recharge calculations, may have to treat water

Groundwater quantity – if too much drawdown, may have to take land out of production – loss to producer

Flood control – if floodplain outline incorrectly assessed, property damage, human safety a problem

Who incurs loss:

Public

*****

Benefits:
Emergency management – save lives, reduce/prevent property damage
Benefits accrue to:
Public, Agency
Losses:
Property damage/loss, possible loss of human life
Loss of money by agency and loss of public trust
Who incurs loss:
Public, Agency

Question 8 – What is the process that is used to incorporate the weather/climate data or information into the decision, planning, or policy area identified above?

Models (basically regression)
- demand forecast – hourly observations (MW) – in-house model
- energy forecast – degree days – in-house model
- retail sales – annual degree days – model from Electric Power Research
- Short term demand – buy 3 to 5 day forecasts from Weather Corp, try to match forecast to a historical weather profile, then try to predict MW load based on past MW use – in-house

*****

EPA model – an actual recharge component included in the model

*****

Six automated stations are located on streams/creeks coming into Lincoln, with stream gauges and rain gauges located at each station. Readings are transmitted to the City County Bldg every 15 minutes, 24 hours a day. In addition, readings are transmitted (same as above) from eight AWDN stations. These readings are monitored as part of the flood warning/control system. Severe storms are monitored, as well.

Does not have any models – but working with Corps to develop better triggers for more effective warning. EX: Streamflow enters Lincoln at three locations, and all must be monitored for combined flow in the city. Would like to be better able to estimate when/how much/etc during storms.

*****

Climate data are used in watershed planning and wetland determination on a real-time basis during planning process.

*****

For weekly publication on Mondays, HPRCC provides soil temperature and precipitation data (remainder of publication – a subjective survey is made of planting progress and crop condition by FSA and Ag Extension). For monthly crop yield predictions, crop models are used to predict yield; weather/climate data are used as support, not actually used in models.

*****

Emergency loan program – County Director forwards information to Lincoln Office
- Lincoln office forwards to State Emergency Board

- Forwarded to Governor's office
- Forwarded to Secretary of Agriculture
- Disaster Designation requested from Congress
- After designation, FSA fills out applications, using climate/weather info as support, to determine who qualifies for programs

*****

Flood warning – automated gauging stations send data to NWS, NWS interprets and issues warnings
Flood control/project design/policy applications – historical data are used in hydrologic models and publications from the Corps of Engineers

*****

Climate and weather data are used in statistical analyses and research concerning impacts on wildlife, vegetation, and water bodies. Use short-term forecasts to plan fieldwork. Most use is after-the-fact. Would like to incorporate more, be more pro-active.

*****

Water alert – if consistently high temperatures and dry conditions are predicted, will issue an alert to curb excess consumption. To predict daily consumption – weather predictions for the next several days are compared to in-house historical database, and consumption predictions are made based on historical use under similar circumstances.

*****

Water production supervisor compiles a report of rainfall and streamflow information. Monitor daily for capacity related issues.

*****

Instream flow – monitoring minimum flow requirement
Long-term policy – use climate and weather data during planning process

*****

Used on a real-time basis for emergency management. For long-term planning, use historical data in models.

*****

Weather and climate data are incorporated into groundwater models. Daily precipitation is monitored for regulation. Surface water routing programs require data.

*****

Staff hydrologists use climate and weather data in their work. Temperature and precipitation trends are plotted against streamflow.

*****

Use for daily load forecasting; subscription with AccuWeather is used in-house. For long-term planning, HPRCC data used.

*****

For watershed planning – engineering department downloads data from Internet. For crop water use – HPRCC data relayed to farmers and public by local newspaper, local radio station, and the NRD website.

*****

Long-term planning (construction) – in planning stages. For daily fieldwork – used on a real-time basis by employees and daily at main headquarters for record keeping.

*****

For fieldwork and policy implementation – use on a real-time basis. For long-term planning – data are incorporated during planning stages for structure design.

*****

For structure design, data collection and modeling taken care of by engineers. For groundwater management, collect and analyze data, using historical and current, as current has a bearing on nitrate leaching. Rely on other agencies for most climate and weather data, but do have some precipitation reporting stations.

*****

All information is used on a real-time basis.

*****

Historical data are used to plan appropriate structures; forecasts are used to contract crews. Current and short-term forecasts are used for daily operations.

*****

Disaster relief – the office receives a summary from the state each month. If assistance is requested, monthly summaries are reviewed to see if 40% thresholds have been exceeded during the preceding four months – if so, summaries are used to support documentation. The request is then forwarded to the state office, and from there to DC for approval or rejection. The process takes 3 to 4 days, except when requests are widespread; turn around time can then be as brief as one day.

*****

A printout of current conditions is sent to the Bureau of Reclamation. The Bureau uses historical and current data to make predictions.

*****

Daily and weekly forecasts are used to schedule fieldwork. Data are downloaded from weather stations on a weekly basis, and used in crop water use reports (radio, e-mail, website, newspaper, direct contact, posted at Co-op).

*****

Data used as support as developing reports.

*****

For surface water, more short-term – forecasts and short-term observations used to describe the conditions when sampling took place. For groundwater, more long-term – historical data used to understand fluctuations and to plan design of groundwater monitoring systems.

*****

Some programs require current year and the two previous years for document support. For emergency declarations, 40% below or above normal for current month and previous four months – exceptions – hail, tornado, freeze, severe storm.

*****

Board of directors uses many sources and pools information to try to determine what's going on this year and what it's going to be like next year. Decisions made based on information.

*****

Climatological data used in models.

*****

Historic flows used to make estimates for the future. Models used in studies to represent historical changes in groundwater levels, interconnections, and how to offset the effects of wells.

*****

Used on a real-time basis for strategic planning. Used daily to monitor conditions for daily operations. Used annually for annual operation plan – use historical parameters to quantify next years water, use predictions of precipitation amounts based on past year (trend related), and extrapolate from current conditions. For long-term planning, use historical data and predictions in planning process.

*****

Standards for use are set by NASS handbook.

Question 9 – Where do you get the weather/climate data? What types do you use?

NOAA/NWS (max/min T, degree days, 30 year normals); hourly data from Lincoln ASOS (temperature, dew point, wind speed); WeatherCorp (3 to 5 day forecast)

*****

From the Internet – not sure of site, probably NOAA

*****

Automated stream/rain gauges (readings every 15 min); 8 AWDN stations; USGS website (streamflow); Corps of Engineers website (dams); NWS (severe storms); not sure where historical data from

*****

HPRCC (recent); USDA NRCS Water and Climate Center in Portland (historical)

*****

HPRCC (precipitation and soil temperature); NWS in Valley (max/min/mean/departures for temperature)

*****

State Climatologist (precipitation); Flash reports (from county offices)

*****

Corps of Engineers (precipitation/streamflow); USGS (river stage); NWS (precipitation/streamflow); in-house data collection (stream gauges, manual collection)

*****

TV, Internet, Newspaper, Ag. Groups have a subscription (temperature, precipitation, dew, wind, ice, snow)

*****

Subscription – DTN AgDayta Service (weather and climate info is from NWS)

*****

In-house observations; rain gauges in city; NRD referred to NWS website (precipitation); USGS (streamflow)

*****

HPRCC; NWS; automated weather stations; USGS (streamflow and groundwater); stream gauges – use precipitation, temperature, wind (calculate ET)

*****

NWS; USGS; Corps satellite data collection platforms; Corps network for discharge and stage (streamflow) – use many types of data, mainly precipitation and streamflow

*****

NWS; USGS (streamflow); In-house stream gauges

*****

NWS; DNR and USGS (streamflow); USGS (snowpack)

*****

AccuWeather; Local weather; HPRCC for planning; NWS

*****

DNR (total rainfall, intensity, streamflow); HPRCC (crop water use, weekly forecast) Internet; TV, radio; word of mouth

*****

NOAA; weather.com; University websites; Health and Human Services – use precipitation and temperature

*****

HPRCC and Conservation & Survey (precipitation and temperature); USGS (groundwater levels); NCDC; stream gauges (streamflow); precipitation reporting stations

*****

HPRCC; 3 weather stations; Ainsworth station data use precipitation, ET, wind direction, and historical

*****

Weather Underground; Nexrad (next couple of hours); Lower Loup NRD (ET/crop water use); Farmers Almanac used in board meetings – use wind, radiation/cloud cover, precipitation, temperature, and relative humidity

*****

State Climatologist

*****

Gather own; Cheyenne, North Platte, and Hastings weather bureaus – use min/max temperature, precipitation, snowpack, wind, evaporation

*****

HPRCC; Weather Channel; Radio – use precipitation, temperature, ET calculated at weather station, wind

*****

Chadron airport; Weather stations; NWS; HPRCC; State office – use temperature, precipitation

*****

Radio, newspaper, Internet (surface water monitoring); historical data from NWS (groundwater monitoring) – use precipitation, barometric pressure

*****

North Platte weather station (airport); 8 reporters in 3 counties; Internet; State office (from State Climatologist)

*****

DNR in Bridgeport (daily reports of streamflow/predicted flow); Newspaper, TV, radio (precipitation, temperature, wind)

*****

Collect own; State Climatologist; NWS; HPRCC – use precipitation, temperature, freeze

*****

CNPPID weather stations; HPRCC weather stations; USGS; NPPD (diversions and deliveries); Intellicast – use precipitation, temperature, wind, RH

*****

NWS (Internet radar, national forecasts, historical data, predictions); DNR (streamflow); Check upstream (phone, e-mail) to see what's going on (share info); use temperature, precipitation, wind (ET/evaporation), SNOTEL

*****

HPRCC data used by State office, which sends reports to county offices (official data that must be used in documentation); keep up with current conditions in County by doing informal surveys with producers as they come into the office; use precipitation and temperature

Question 12 – Are there any tools or products that would be helpful in your area of work?

Radiation – to determine effect on buildings

*****

a. Listing of where different kinds of climate and weather data can be found
b. Precipitation amounts for particular cities (historical/normals)

*****

Streamflow model – working with Corps

*****

Hourly data from Concord (can be found on HPRCC website where "Northeast" would have appeared in the past in alphabetical listing – 20 years of data available)

*****

Wind speed data and graphics (affects ET; affects insect damage)

*****

List of sources of climate and weather information

*****

a. More precipitation gauges
b. More stream gauges on Platte and Elkhorn
c. Better way to get information to the public to be educational/informational, but not alarming – public has many questions – need to have better way to supply answers
d. More data on ice events on Platte and Elkhorn – can only monitor by helicopter now

*****

Get predictions down to county basis – better chance to be proactive

*****

Information on global warming – how will it affect Missouri and Platte – can use for long-term planning

*****

More historical data to plot daily water consumption against precipitation and temperature (only a few years – Kearney)

*****

More gauges, weather stations, etc.

*****

a. Anything that would increase the accuracy of forecasts

b. Hydrologic models that provide depth of inundation, rather than just outline (flood)
a. More weather stations/good quality weather stations
b. More gauging stations
*****
a. More weather stations – rainfall very localized
b. Better handle on groundwater recharge
c. Why isn't NADP more incorporated in studies?
*****
a. Longer-term precipitation and temperature data for Rocky Mountains
b. Patterns that predict snowpack
c. Commercial software is not very helpful – customized software for Platte River
*****
a. Good accurate predictions
b. Real-time data for day-to-day operations
*****
a. The FSA offices have a pretty narrow focus, and available data works well for their purposes
b. For producers – accurate long-term probabilities/forecasts would be extremely helpful
*****
Comfortable with available products
*****
Increased accuracy
*****
More weather stations (closer together) – quality of interpretation between stations tends to be poor
*****
Can't think of anything - Internet is good tool
*****
a. Weather station in every town
b. Real-time rainfall gauges
*****
a. More weather stations
b. More precipitation reporting stations (reporting network within smaller watersheds)
*****
a. Greater accountability by climatologists – what will happen in 5 yrs? 50 yrs?
b. Remote sensing tools for producers to assess irrigation demand and determine own ET/crop water needs
c. Flow meters on irrigation wells
*****
a. Accurate weather forecasts
b. Site-specific 3 to 10 day forecasts
c. More automated weather stations
d. Good, accurate soil moisture profiles available in the spring on a valley basis
e. Remote weather data sites
*****

More "official" weather stations/monitoring sites in each county (for fed paperwork) – not always representative of entire county if only use one or two

*****

Can't think of anything

*****

Explain how to more effectively integrate climate and weather data into work – would like both workshop and manual

*****

Can't think of anything - Biggest improvement to date has been Internet

*****

Precipitation amounts for the last 10 years for specific counties

*****

a. Easier access to weather conditions – postings sometimes 30 to 40 days later
b. Additional reporting sites – areas not covered are not considered "official"

*****

Accurate long-range forecasts