WRITTEN TESTIMONY OF MARC D. WAAGE

Manager of Raw Water Supply
Denver Water
1600 West 12th Avenue
Denver, Colorado 80204-3412

U.S. House of Representatives
COMMITTEE ON SCIENCE
Environment, Technology, and Standards Subcommittee
H.R. 5136, National Drought Integrated Drought Information Act of 2006
May 4, 2006

Mr. Chairman and Members of the Subcommittee:

Thank you for inviting me to address the important issue of drought monitoring and preparedness. I manage the operation of a large water collection system and I am a regular user of drought information provided by federal agencies. From that perspective, I would like to address why federal drought preparedness is so important, how federal drought information is used now and how the proposed National Integrated Drought Information System (NIDIS) could provide the much needed improvements in drought information to help water managers better cope with droughts.

1. Why is Drought Preparedness and Monitoring Important to Denver Water?

I work for Denver Water which is a municipal agency that supplies water to 1.2 million people in the Denver area. We are the largest supplier of drinking water in the state, providing service to about one of every four residents of Colorado. We operate in a semi-arid climate characterized by low precipitation and variable streamflow. On average, Denver receives only 15 inches of precipitation per year. Snowmelt from the mountains to the west of Denver provides most of the city's supply. But that supply is highly variable. The natural streamflow of the South Platte River above Denver has ranged from 227% of average in wet years to 16% of average in drought years.

To reduce its vulnerability to drought, Denver Water collects water from 3,600 square miles of watersheds, transporting water up to 80 miles using 3 water tunnels under the Continental Divide to store water in 16 reservoirs, most of which are used for drought augmentation. [See Exhibit "A" – map of water system]. My job is to operate that water system and to make sure it does not run out of water.

Parts of Colorado have been in a drought for the last six years. In 2002, Denver's watersheds received the lowest runoff in approximately 200 to 300 years. Denver's storage reservoirs dropped to 43% of capacity — the lowest level in 38 years, and three years of drought restrictions were required to refill reservoirs to normal levels. Operating

through this experience has made me keenly aware of the value of timely, accurate, and understandable drought information.

2. What Drought Information Does Denver Water Use?

Most of Denver Water's supply comes from mountain snowmelt. During the recent drought, my staff and I made frequent use of snowpack, streamflow, weather, and forecast information from various federal agencies plus information from the state of Colorado and our own monitoring. Below is a list of the most frequently used drought data.

A. Snowpack Monitoring

1) **NRCS**. Manual and automated Snotel site information from the Natural Resource Conservation Service (NRCS) of the U.S. Department of Agriculture. The state office of the NRCS provides a wide array of web-based daily snowpack, weather data and useful displays that are heavily used throughout the state by all types of water interests. Denver Water provides manual measurements of snowpack and some funding for Snotel sites. These data are used in all levels of operations.

2) **NOAA**. Later in the drought we were made aware of a National Oceanic and Atmospheric Administration (NOAA) product called the Snow Data Assimilation System (SNODAS). As described by NOAA:

> "SNODAS is a modeling and data assimilation system developed by the NOHRSC to provide the best possible estimates of snow cover and associated variables to support hydrologic modeling and analysis. The aim of SNODAS is to provide a physically consistent framework to integrate snow data from satellite and airborne platforms, and ground stations with model estimates of snow cover."

SNODAS provides important visual information on snowpack conditions and holds promise for improving water supply projections.

B. Streamflow Monitoring

1) **USGS**. The U.S. Geological Survey provides near real-time web-based streamflow monitoring. Denver Water provides annual cost-share funding of the measuring sites. This system is heavily used by water interests throughout the state.

2) **State**. The State of Colorado provides near real-time web-based streamflow monitoring. It also incorporates USGS and other streamflow monitoring. This system is also heavily used throughout the state.

C. **Storage Reservoir Monitoring**. Data comes primarily from Denver Water monitoring, plus some state and federal reporting.

D. **Weather Monitoring**

1) **NWS**. The National Weather Service provides daily measurements of temperature and precipitation through its cooperative weather program. Denver Water is a cooperator and measures temperature and precipitation in the city and throughout its watersheds. These measurements are used to understand past water supply and use patterns and to make streamflow forecasts.

2) **NRCS**. Denver Water makes use of the Natural Resource Conservation Service's Snotel sites to track snowpack, precipitation and soil moisture in near real time. Denver Water financially supports a number of these sites and measures snowpack at other sites for the NRCS.

3) **CoCoRaHS**. This acronym stands for Community Collaborative Rain and Hail Study. CoCoRaHS provides high density daily precipitation data that helps us estimate short-term changes in water supply and use. The Colorado Climate Center runs this program with financial support from Denver Water and other users.

E. **Weather and Climate Forecasts** (Short and Long Range)

1) **NWS**. The National Weather Service provides short-term weather forecasts that are useful for projecting near term water supply and use.

2) **CPC**. The Climate Prediction Center (part of the Physical Science Division of NOAA's Earth System Research Laboratory) provides long-range temperature and precipitation outlooks and other endeavors. These forecasts give Denver Water an understanding of the weather that is expected during the next one to six months and helps us with our planning.

3) **CDC**. The Climate Diagnostic Center, which is jointly funded by NOAA and the University of Colorado, supports research on long-range weather forecasting and other endeavors. Denver Water uses experimental forecasts produced by the CDC.

4) **Private Meteorologist**. Denver Water monitors long-range weather forecasts provided by a meteorologist with HDR Engineering, Inc.

F. **Streamflow Forecasts**

1) **NRCS and NWS.** These two agencies provide joint forecasts of seasonal snowmelt volumes. These forecasts are vital for managing water in the West.

2) **CBRFC**. The Colorado Basin River Forecast Center (a division of NWS) produces valuable probabilistic daily streamflow forecasts.

G. Drought Indices

1) **NOAA**. The Drought Monitor and Drought Outlook are occasionally used to display the progression and the extent of drought to non-technical audiences.

3. How Is the Drought Information Used?

The drought information described above is used to prepare short- and long-term operating plans for Denver Water's system. These are the critical forecasts that are used to predict water supply availability, budget water use, and guide operations during droughts.

The drought information is regularly used by staff, board members, media, customers and the public to access the status of droughts. Below are examples.

A. Denver Water management staff and board members use the information to determine water use restrictions and set water rates and surcharge prices during droughts.

B. Large customers using water for parks, schools, golf course, car washes, and various manufacturing processes use the information to meet water budgets enacted during droughts.

C. Media, customers, and the public use the information to monitor water supply conditions during droughts.

D. Recreational interests, environmental interests, government agencies, and mountain watershed communities use the information to monitor streams, reservoirs, and supply conditions within Denver Water's system during droughts.

4. How Can NIDIS Improve the Quality and Usefulness of Drought Monitoring and Forecasting Information Provided by the Federal Government?

A. Create an Internet Portal of easily accessible and understandable drought information.

During the drought, my staff and I have spent countless hours combing the web to identify all the drought information that is spread across many federal agencies. Much of the information is in cryptic technical language. It is quite difficult for casual users to access and understand this information. Non-technical users would greatly benefit from an Internet portal. During the record drought year of 2002, my staff and I spent considerable time collecting and disseminating information on the drought to our management staff and board members, the media, water customers, watershed communities, environmental and recreational interests, and the general public. The Internet portal would promote much greater understanding by all those affected by drought. Denver Water's

customers live many miles from their watersheds and there can be a great disparity between the weather in the watersheds and the city. The Internet portal would help link city residents to the droughts affecting their watersheds. This portal could also reduce time my staff and I spend explaining drought conditions to board members, media, interest groups, customers, and the public.

B. Educate and Interact With Those Affected by Drought.
Drought information can be hard to find and understand. The Western Water Assessment (WWA) (a cooperative venture funded by the Regional Integrated Sciences and Assessments Program of NOAA) uses multidisciplinary teams of experts in climate, water, law, and economics to assist water-resource decision makers in the Intermountain West. This program has increased Denver Water's understanding and use of federally available drought information. This is done through water conferences and other contacts with water users in Colorado. The WWA has allowed us to interact with scientists working on drought issues to make better use of federal research and to provide feedback on research needs. The WWA program could be a model for NIDIS for expanding education and interaction with those affected by drought.

C. Increase Monitoring in Watersheds.
In 2002, Denver's watersheds produced the lowest runoff in approximately 200 to 300 years. Winter snowpack levels were low but not as low as in previous drought years. However, the spring was exceptionally hot and dry. Rather than producing streamflow, much of the snowpack was consumed by sublimation (evaporation), vegetation, and soil recharge. Unfortunately, there was very little scientific monitoring of the watersheds to know the extent to which this was occurring. Without watershed monitoring, there was little early warning of the severe drought to come. As a result, watering restrictions were not fully enacted until well into the summer. Also, there was little warning that spring conditions in the watershed would produce the Hayman forest fire in June which was the worst in Colorado's recorded history. Along with record low streamflow, the massive fire caused serious water quality problems for Denver Water. Using NIDIS to monitor soil moisture, wind speed, humidity, solar radiation and model-based analysis of these data would help provide an early drought warning for our watersheds. Watershed monitoring could also be incorporated into forecast products as described below.

D. Improve Existing Products.

Below are examples of how NIDIS could be used to improve existing drought information products.

1) Improve Streamflow Forecasts. Streamflow forecasts are key indicators for managing water supplies in the West during

droughts. Below are examples of improvements that could be made to forecasts provided by federal agencies.

(a) **Incorporate New Watershed Monitoring**. The data from better watershed monitoring as described above could be incorporated into streamflow forecast models to fill a critical gap in dry year predictions and provide a much needed early warning system.

(b) **Upgrade Models Used by the River Forecast Centers**. Denver Water has had a long partnership with the Colorado Basin River Forecast Center (CBRFC) of the NWS to demonstrate the value of daily probabilistic streamflow forecasts in water system operations. The benefits include helping recover endangered fish, improving environmental and recreational conditions on rivers, maximizing hydropower and reducing the risk of flooding in non-drought years. Improving and incorporating SNODAS data described above into the CBRFC streamflow model could increase forecast accuracy in the smaller sub-basins of the Colorado River in which most of the water systems operate. The Missouri Basin River Forecast Center is developing a daily streamflow forecast model for the South Platte River above Denver. The model holds promise for improving Denver Water's water operations in the South Platte Basin much as it has in the Colorado River Basin.

2) **Improve Drought Indices**. Making the indices more understandable, accurate and relevant to drought management will increase their use with both technical and non-technical users. Plain language should be used to explain the indices.

3) **Improve Long Range Weather and Climate Forecasts**.

(a) **Seasonal Climate Outlook**. Developing a more understandable format than the tercile method and providing a plain language explanation of the accuracy and skill of the product could improve confidence in and use of the product.

(b) **Localized Forecasts**. Developing smaller scale prediction models may increase the accuracy, skill and usefulness of long-term weather forecasts. The Climate Diagnostic Center of NOAA produces an experimental seasonal weather forecast for southwestern states including Colorado. These forecasts are carefully followed by water users and the media. Denver Water funded research at the University of Utah to use sea and atmospheric conditions in the fall to produce a probabilistic prediction of the volume of the spring runoff. In the fall of 2001 the model predicted

a low runoff in the spring of 2002. This forecast supported our decision to stop releasing reservoir water for hydropower generation, saving precious water before what turned out to be the driest year on record. Overall, forecasts of drought onset, duration, severity, and end could be extremely helpful in the future.

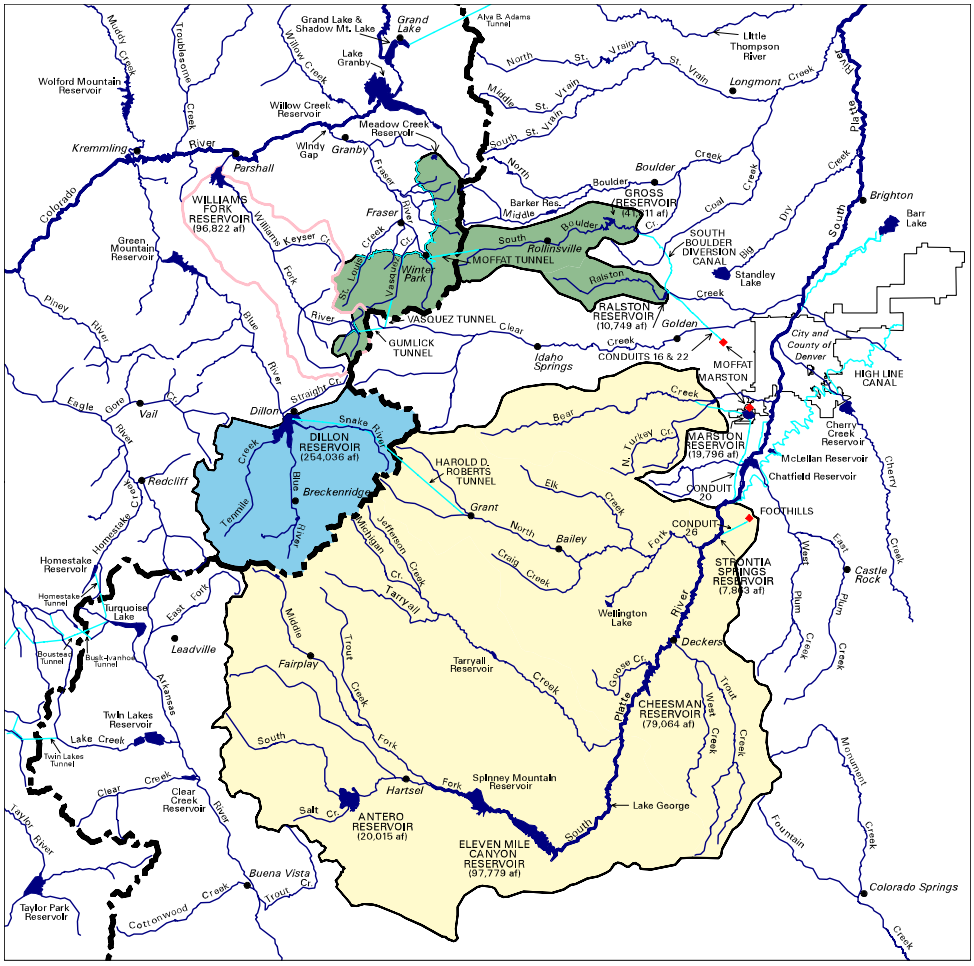
5. How Can NIDIS Help with Population Growth and Climate Change?

The need to provide water for the booming population of Colorado and other areas in the West is stressing natural stream systems and available water resources. The adverse impacts include the transfer of water from agricultural to municipal use. The demand for improved river environments and recreational opportunities increases with population growth. Climate change threatens to exacerbate these problems by making droughts longer and more severe.

A common response to the problems of population growth and climate change is to increase water conservation goals. When conservation is used by cities that depend on surface water to supply their growing populations, the increased efficiency of water use can greatly lower their ability to reduce water use in droughts. In other words, there is less non-essential water use to be cut off during droughts, thereby making the cities even more vulnerable to drought. This could lead to more frequent and more severe water use restrictions and water rationing.

NIDIS would provide the proactive and coordinated federal approach to droughts that water managers need to cope with the added impacts of population growth and climate change.

City and County of Denver
Board of Water Commissioners
Water Collection System



LEGEND

N

S

- South Platte Collection System
- Roberts Tunnel Collection System
- Moffat Collection System
- Williams Fork Reservoir Watershed
- Denver Water Treatment Plant
- Continental Divide
- Major Stream or River
- Major Canal or Tunnel
- Major Lake or Reservoir
- Town

Scale 1:1,000,000

0 5 10 20 40

Miles

June 2000

DENVER WATER