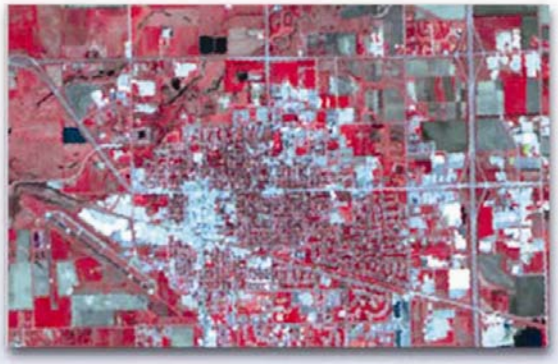
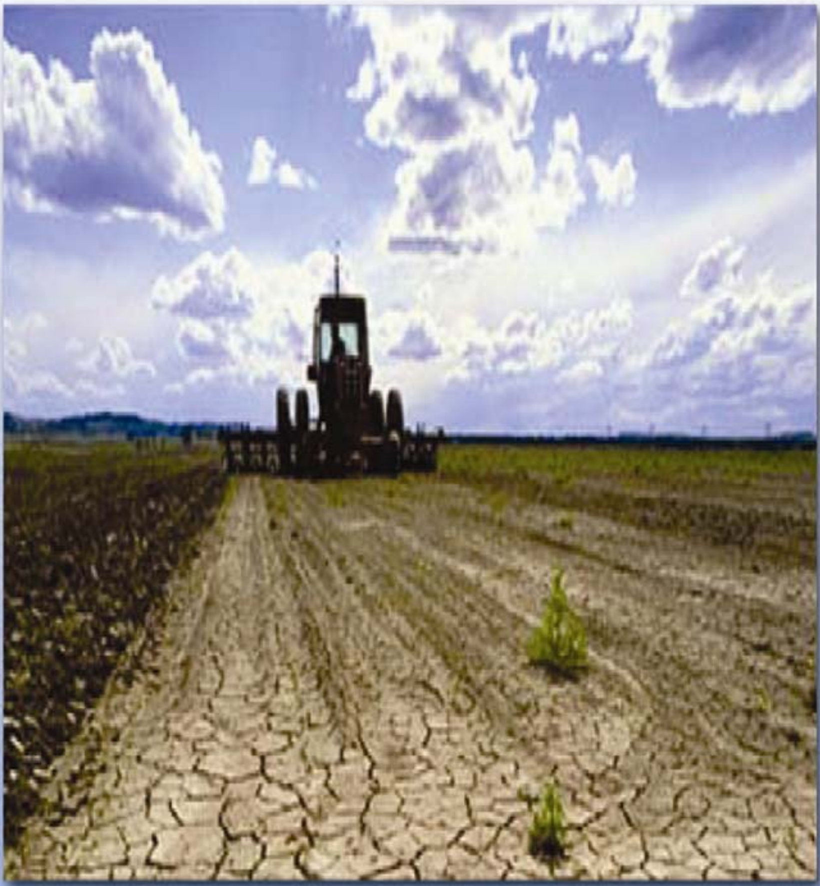
National Integrated Drought Information System (NIDIS) Near-Term Opportunity Plan

United States Group on Earth Observations





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1. PREFACE

This plan was prepared by the U.S. Group on Earth Observations[1] and is one of six near-term opportunities identified in the *Strategic Plan for the U.S. Integrated Earth Observation System*[2]. Near-term opportunities in this context are: identifying observing systems or integration of components that meet high priority societal needs, and making improvements to inadequate existing systems that can be completed within 5 years and have tangible, measurable results. Further, the plans provide a framework for prioritizing actions and addressing critical gaps that will maximize the return on investments. The near-term opportunities are:

- Improved Observations for Disaster Warnings (published September 2006);
- Global Land Observation System (in development);
- Sea Level Observation System (in development);
- National Integrated Drought Information System (published September 2006);
- Air Quality Assessment and Forecast System (published September 2006); and
- Architecture and Data Management (in development).

2. THE OPPORTUNITY

Drought is a persistent water deficiency that has adverse effects on vegetation, animals, and people. Though drought is a slow-onset disaster when compared to hurricanes, earthquakes, or other natural disasters, it is one of the most destructive natural events, and occurs somewhere in the U.S. every year. The Federal Emergency Management Agency estimates the annual direct losses to the United States due to drought to be $6-8 billion, making it, on average, one of the most costly of all natural disasters affecting our Nation.[3] The National Drought Policy Commission reported in 2000 that the Nation needed to initiate a process to improve collaboration among scientists and managers to enhance the effectiveness of observation networks, monitoring, prediction, information delivery, and applied research, and to foster public understanding of and preparedness for drought.

Numerous sectors require timely and accurate drought data, information, and forecasts to mitigate drought-related impacts. For example, the Bonneville Power Administration, like most utilities using hydropower, depends on water supply forecasts and drought information for hydropower management decisions. The Federal Energy Regulatory Commission considers federal drought monitoring analyses in the recertification process for U.S. power facilities. Moreover, in the Klamath Basin, lake-water supply forecasts are used to help plan lake outflows based on the competing needs of agricultural irrigation and the requirements of endangered fish species.

Agribusiness depends upon timely drought-related information to operate efficiently and mitigate drought-related losses. Purchasing decisions for hay and other feed supplies are enhanced through the use of drought information to identify areas of greatest demand and the potential for shortages. The USDA Agricultural Outlook Board depends on U.S. Drought Monitor analyses for long-term commodity projections, agriculture supply and demand estimate reports, and its Weekly Weather and Crop Bulletins. Drought monitoring and forecast information are used by the Kansas City and Chicago Boards of Trade in futures pricing of U.S. commodities, and brokering companies rely on similar information for assessing impacts to grain futures and for providing advisories to customers.

Also, municipalities and state agencies are dependent on drought-related data, information, and forecasts to allocate county-specific domestic and industrial water usage. Drought information, specifically U.S. Drought Monitor data and information, is used in allocating federal emergency drought relief for affected counties. Inadequacies in current monitoring networks and drought processes can compromise decisions that are made on a county-level basis.

2.1 WESTERN GOVERNORS' ASSOCIATION – THE NATIONAL INTEGRATED DROUGHT INFORMATION SYSTEM

In 2004, the Western Governors' Association (WGA) developed a set of requirements, through a broad-based team of Federal and non-Federal partners, for a National Integrated Drought Information System. These requirements were developed in conjunction with the National Drought Policy Commission's report to Congress and the pending National Drought Preparedness Act before Congress. This Near-Term Opportunity Plan was developed in response to the WGA

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[1] The United States Group on Earth Observations (USGEO) was established in March 2005 as a standing subcommittee of the National Science and Technology Council Committee on Environment and Natural Resources.
[2] http://usgeo.gov/docs/EOCStrategic_Plan.pdf
[3] Federal Emergency Management Agency, 1995. *National Mitigation Strategy: Partnerships for Building Safer Communities*. Washington, D.C.

report, *Creating a Drought Early Warning System for the 21st Century – The National Integrated Drought Information System (NIDIS).*[4]

In recognition of the drought prediction and management challenge, the President's National Science and Technology Council (NSTC) Subcommittee on Disaster Reduction (SDR) highlighted drought as part of its 2005 report, *Grand Challenges for Disaster Reduction*. In a follow-up 2006 publication, the SDR they called for specific NIDIS implementation actions based on the recommendations in the WGA report. Similarly, the IEOS Strategic Plan calls for the development of NIDIS.

As described below, observational tools developed for NIDIS will also provide scientists with important data to advance our understanding of climate variability and change. In particular, as observations of heat and moisture transfer between land and atmosphere improve, valuable information about changes in evaporation and soil moisture, which are important indicators of climate shifts, will be gained.

2.2 NIDIS Early Opportunities and Relationships to Business Processes and Requirements

The NIDIS plan is built around a series of "business requirements" outlined in the WGA document[5] and summarized in Appendix A. These NIDIS business requirements include: physical science and socio-economic research, observations, monitoring and predictions, analysis, informing, making decisions and taking action, risk reduction research, educating, planning, and NIDIS Operations. The relationship between these various functional business requirements is shown in Figure 1.

A NIDIS operations strategy serves to link all of the business requirements and to consider important data and information management needs that are common to all of the business requirements.

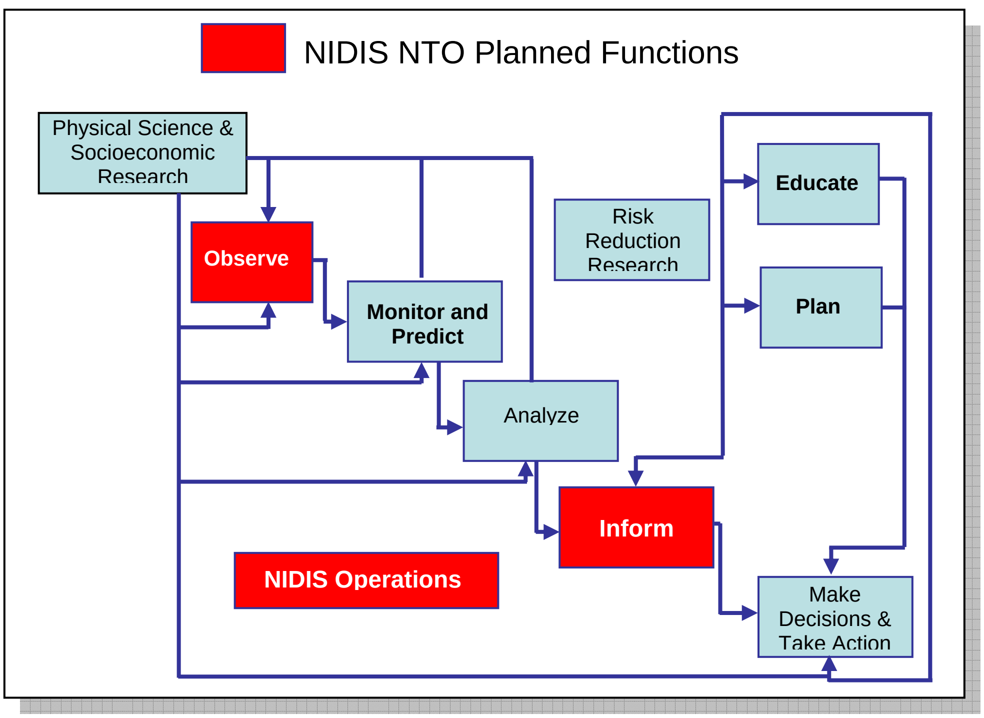


Figure 1. NIDIS business plan

[4] http://www.westgov.org/wga/publicat/NIDIS.pdf
[5] IBID

3. NEAR-TERM OPPORTUNITIES FOR NIDIS

Each business requirement of the NIDIS plan has been analyzed, and critical gaps have been identified that can be quickly and effectively closed by investing in research and technology development. These gaps currently pose serious limitations on the ability of national, regional, and local managers to prepare for, cope with, and mitigate the hardships and costs related to droughts in the United States, but can be remedied in the short term. Over the longer term, we intend to address the remaining gaps within the NIDIS plan so that all of the NIDIS business requirements can be fully implemented.

The Near-Term Opportunities (NTO), described below, include:

1) Improved Frequency, Timeliness, and Density of Key Observations (within the observations business function);
2) The development of a U.S. Drought Data Portal (USDP) (within the data management business function); and
3) Improved Coordination of NIDIS Operations (within the coordination business function).

3.1 IMPROVED FREQUENCY, TIMELINESS, AND DENSITY OF KEY OBSERVATIONS

The Need. Government agencies have developed and deployed a variety of observing networks over the past several decades to meet agency missions and measure drought-related parameters. Among their many uses, the data they provide are useful in retrospective analysis of drought. For those stations with the capacity to transmit near real-time observations, the data are used in forecasting activities that support drought planning, response, and mitigation efforts. However, many stations do not have near real-time reporting capabilities, and as such, the reporting frequency and timeliness for a large number of stations are not sufficient to support county-level and weekly drought monitoring and forecasting requirements in the 21st century. In addition, the density of some observing networks, most notably those that measure soil moisture, is inadequate for drought monitoring purposes.

Limitations inherent to these existing systems include (but are not limited to):

- Ground-water data are reported as infrequently as once every six weeks.
- Daily precipitation and temperature data are reported only at the end of each month.
- Reservoir water levels are made available only once per month.
- Soil-moisture data are routinely available but from a sparse national network.

These deficiencies interfere with our ability to fully understand or predict current or future conditions. For example, though the NOAA U.S. Cooperative Observer Network (COOP) collects thousands of daily temperature and precipitation measurements, only 15 to 20 percent of these observations are made available on a daily basis. Additionally, there is up to a 45-day delay in accessing these data points due primarily to the fact that these data are mailed to NOAA on a monthly basis and must be processed manually before being released. This delay makes it impractical to use these data for operational drought monitoring. Figure 2 illustrates the inaccuracies that can result from such a significant delay in data access.

In creating the weekly U.S. Drought Monitor, authors rely heavily on an objective indicator that blends a number of critical drought indicators into a depiction consistent with the final U.S. Drought Monitor. In some areas of the United States, the product created using preliminary data differs greatly from the product created weeks later when all the COOP reports are received by NOAA. This is especially evident in Montana, where preliminary data depict a condition that is as much as two categories less severe than that shown using final data available months later. Conversely, the network of preliminary data **over**estimates drought severity in large areas of the mid-Atlantic and Southeast. These inaccurate depictions can lead to poor decisions by water resource managers.

Similarly, observing stations capable of providing daily measurements of other critical drought parameters such as ground-water, snowpack, and reservoir levels are, in many cases, not adequately equipped to transmit these critical observations with adequate frequency and timeliness.

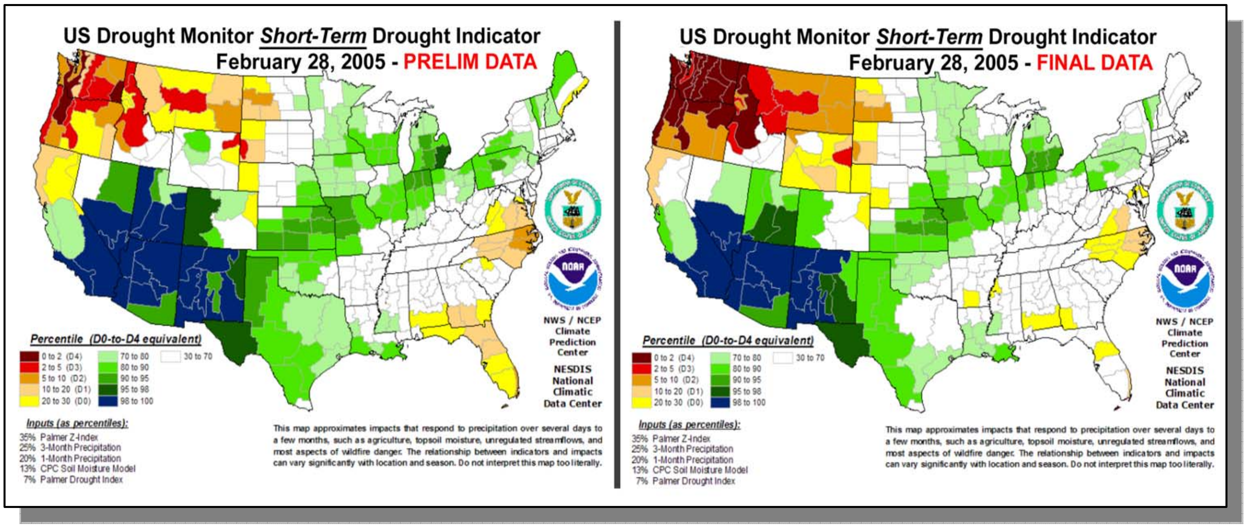


Figure 2. Due to the current time lag in receiving data, the severity of drought can be significantly under- or overestimated for many areas of the Pacific Northwest, and the Southeast as illustrated in this diagram. Colors reflect the severity of drought – deep red is exceptional drought, red is extreme drought, orange is moderate drought, and yellow is mild drought-like conditions

Inadequacies such as these compromise the ability of drought experts to quickly and accurately analyze drought conditions in core programs such as the U.S. Drought Monitor. They also result in the delayed release of water resource information such as monthly water supply forecasts, because these products cannot be produced until sufficient observations are made available for analysis.

An illustration of the importance of drought information occurs in the Columbia Basin, a classic example of a multi-purpose, international and multi-state river system that is highly dependent on drought-related climate information to meet the growing population and energy needs of the entire West.[6] The Bonneville Power Administration, which markets a projected $3 billion in annual revenues from both hydro and non-hydropower, is mandated by law to use the coordinated and final water supply forecasts issued jointly each month, January through June each year, by the Natural Resources Conservation Service and National Weather Service. During periods of increased climate variability, additional automated stations are required to initialize forecasts related to the timing and accuracy of water supply forecasts. This information is also used to settle United States-Canadian treaty obligations related to U.S. power benefits owed to Canada.

Another example is the Klamath Basin, where the Bureau of Reclamation uses Upper Klamath Lake water-supply forecasts to determine lake outflows that affect fish identified by the Endangered Species Act and irrigation water rights for agriculture throughout the basin. Rapid changes in water supply resulting from intra-month climate variability can have a severe economic impact on water management if anticipated water supply data are not available. Intra-month climate variability's effect on water supply forecasts has heightened the need for automated climate stations to track climate trends in real-time. Without the full suite of drought-related climate observations, the ability of managers to make appropriate water resource decisions is compromised, which can adversely impact agricultural and wildlife interests throughout large parts of the West. These deficiencies can be corrected by applying proven communication technologies to improve the reporting frequency of many existing stations, thus increasing the amount of real-time drought information available to the public, decision-makers, and drought experts.

Also, improved soil-moisture-sensing networks are needed and are especially important for agribusiness management. However, the number of stations in the soil-moisture observing network is too small to assess drought risk nationwide. The installation of soil-moisture sensors within the existing climatological monitoring network is required to integrate long-term climatology assessment with agricultural drought-risk monitoring.

[6] Seventy-three percent of federal firm energy resources – 6,985 average megawatts – include climate-dependent hydropower generated by 31 federal dams in the Columbia River Basin.

In meeting the needs of drought experts and decision-makers for timely reporting of drought-related observations, upgrades to existing meteorological, reservoir, ground-water, and soil-moisture-monitoring networks are recommended. By applying the appropriate technology to upgrade existing observing systems, the number of new systems required to fill gaps in spatial representation in future years will be greatly reduced. There is no single system that is best in all situations, so optimum solutions have been identified by network and the configurations of currently fielded systems. Three types of upgrades are proposed:

- Low-cost additions of transmitting equipment to stations already fitted with automatic monitoring equipment;
- Upgrades, consisting of automated observing and recording devices in addition to transmitting equipment, to those systems not already fitted with automatic monitoring equipment; and
- Installation of new sensors for soil-moisture and soil-temperature monitoring in an existing climatological monitoring network.

Major Components

Ground Water Monitoring. The "Ground-Water Climate Response Network," which monitors shallow ground water levels, was established by the U.S. Geological Survey in cooperation with other Federal, State, and local agencies to support climate and drought monitoring activities. The data from this monitoring network represent an important component of the hydrologic data needed for NIDIS. The Network includes 140 wells selected specifically to provide an accurate assessment of ground-water levels in relation to climate and drought.[7] For each of these wells, recent water-level trends can be quickly compared with long-term trends by season. These 140 wells fall into three different categories related to timeliness of data reporting as shown below:

- 63 wells have real-time satellite telemetry;
- 50 "Continuous" wells with continuous data-loggers require the installation of satellite telemetry; and
- 27 "Periodic" wells that measure water levels manually during periodic visits require installation of continuous data-loggers as well as satellite telemetry.

Deliverables / Milestones	Performance Measures
Install satellite telemetry at 50 continuous well sites (21 Western, 11 Central, 0 Southeast, 18 Northeast USGS regions)	Percent of stations reporting within one day of observation
Install satellite telemetry and continuous data loggers at 27 periodic well sites (9 Western, 13 Central, 2 Southeast, 3 Northeast USGS regions)	Percent of stations reporting within one day of observation

Table 1: Ground Water Monitoring Deliverables, Milestones, and Performance Measures

Cooperative Observer Network (COOP). To improve the timeliness of COOP reporting, this recommendation leverages two improvements in the COOP network already underway. First, roughly 2,000 COOP stations report daily observations utilizing either a telephone-based (IV-ROCS) or an Internet-based (Weathercoder) data-entry system. These observations are generally available within one day. These two daily data-entry systems are currently prototype systems supported regionally, not nationally. It is critical to ensure that these data-entry systems are operationally supported so that 2,000+ COOP stations can continue to report daily and be incorporated into national data centers for daily and weekly drought products such as the U.S. Drought Monitor.

The second improvement in the COOP network – already underway – involves NOAA's concerted effort to replace antiquated and broken equipment and to modernize COOP stations, which are vital to the longevity and accuracy of the climate record. These improvements include replacing manual mercury-in-glass thermometers and precipitation gauges with digital thermistors and gauges capable of automated data collection and transmission. However, with the exception of the fully modernized COOP sites (NOAA Environmental Real-time Observation Network or NERON sites), most of the stations with updated and improved observing equipment are not fitted with an automated communications ability.

[7] Characteristics of well construction that allow reliable water-level measurements include minimal interference pumpage, irrigation, canals, and other potential sources of artificial recharge; long-term accessibility, and lack of susceptibility to going dry.

A first step in improving the timeliness of data collection from COOP is to add automated communications capability to stations with existing capacity to automatically record observations of precipitation and/or temperature. This would lead to immediate improvements in the quantity of high-quality observations available for use by drought experts, and significantly reduce current data deficiencies that complicate drought analyses.

There are 397 COOP stations within the contiguous United States that already have automatic temperature and precipitation data recording devices and that could easily be outfitted with telecommunications equipment to facilitate daily transmission of data. This telecommunications capability could be provided by a cell-phone-based system, satellite-based communications, the meteor-burst technology employed by the SNOTEL[8] and SCAN[9] networks, with a communications capability via the Law Enforcement Telecommunications System that is in use in some state observing networks, or a combination of these systems for future deployment of COOP Modernization, as listed in Table 2 below.

Deliverables / Milestones	Performance Measures
Operationalize Weathercoder and IV-ROCS	Increase in the percent of stations reporting nationally within one day of observation
Install telecommunications equipment at 397 automated COOP sites	Increase in the percent of stations reporting nationally within one day of observation

Table 2: Cooperative Observer Network Deliverables, Milestones, and Performance Measures

Reservoirs. Reservoirs play an important role in managing water for a variety of purposes, including municipal water supplies, agricultural irrigation, power generation, endangered species management, and navigation. There are more than 70,000 registered dams in the United States (National Institute for Computer-Assisted Reporting, 2005). Their role in drought mitigation varies across the nation.

A number of Western reservoirs are designed to store water for periods beyond a specific water year, thus providing a measure of security in the event of a multiyear drought. Rapid population growth in the most arid regions of the West is taxing reservoirs beyond their initial designs – made in the middle of the last century. Changes in climate variability also challenge reservoir-management strategies developed during the last century.

Real-time monitoring of reservoir storage is more critical today than ever. The Natural Resource Conservation Service collects monthly data from 251 Western reservoirs, and the state of California collects data from 151 reservoirs. Of the 400+ Western reservoirs, approximately 200 are read manually each month. Automating the transmission of reservoir storage information would optimize reservoir management strategies and allow development of new drought-specific applications for water managers. Automating Midwest and Eastern reservoirs for real-time monitoring of reservoir storage is also important and will be addressed in future phases of NIDIS.

Deliverables / Milestones	Performance Measures
Install telecommunications equipment at 200 Western reservoirs (20 reservoirs/year)	Increase in the percent of stations reporting nationally within one day of observation

Table 3: Reservoir Deliverables, Milestones, and Performance Measures

Soil Moisture. While significant improvements in data availability and access to parameters such as temperature, precipitation, ground-water, and reservoir levels can be realized by enhancing the automatic reporting capacity of stations in these networks, the same is not true for soil moisture. The measurement of soil moisture is one of the most critical parameters for understanding the state of drought throughout the country. However, there is only one small national network of stations currently measuring soil moisture. The Soil Climate Analysis Network (SCAN) consists of 111 stations throughout 38 states, providing automatic reporting of daily observations via meteor-burst technology. Although all sites provide automatic reports of observations on a daily basis, the total number of sites is not sufficient for understanding soil-moisture conditions on a widespread basis.

[8] SNOTEL (for SNOwpack TELemetry) is operated by the USDA to collect snowpack and related climatic data in the Western United States. There are approximately 730 SNOTEL sites in 11 western states including Alaska.
[9] The Soil Climate Analysis network (SCAN) is operated by the USDA to monitor and record soil moisture and soil temperatures at approximately 110 stations across the United States focusing on the nation's agricultural regions.

In addition to supporting drought monitoring, preparedness, and response, observations of soil moisture are required in climate forecasting and modeling as well as reservoir management, irrigation scheduling, and crop-yield forecasting. The current network of point-based measurements is not sufficient for revealing large-scale soil-moisture patterns. Other options such as the use of satellite radiance data to infer soil moisture, while providing large-scale coverage, measures the skin surface conditions and is sensitive to many characteristics of surface soils and vegetation canopies. These parameters are difficult to estimate without extensive ground measurements that would allow calibration and validation of the satellite measurements.

The current soil-moisture network is an order of magnitude too small for adequately monitoring and forecasting soil-moisture conditions. As an initial start in the development of a suitable soil-monitoring network, we recommend leveraging NOAA's 114 existing and planned Climate Reference Network (CRN) sites in the United States (Figure 3). The addition of soil-moisture and soil-temperature sensors to this existing network effectively doubles the current number of soil-monitoring stations in the national network. It will provide soil-moisture measurements in all states not supported by the existing network of SCAN sites, while adding additional soil-moisture-measuring capacity in 70 locations in the Central and Western United States, areas of the country particularly vulnerable to drought.

In-situ soil-moisture measurements, as well as the ground-water well measurements discussed previously, are critical aspects of the nation's drought-monitoring capacity. They measure unique features not measurable from satellite-based sensors. Even if satellites are used, they still require robust *in situ* networks for calibration and validation. In addition, while satellite-based sensors measure soil moisture in the top inch or so of the surface (and, along with modeling efforts, can be extremely useful in providing higher spatial resolution of some important drought-related quantities), *in situ* soil-moisture sensors measure moisture at deeper levels, from the surface to below crop root zones (usually about 2 meters). These measurements are used to indicate moisture available for crops; and for operating computer models for forecasting stream flow, water supply, floods and weather, and for managing crop irrigation. Well-level measurements provide the level of the ground-water at depths typically well below crop root zones. These measurements are used to indicate water available at depths that can range from very deep to relatively shallow for irrigation and municipal and industrial water.

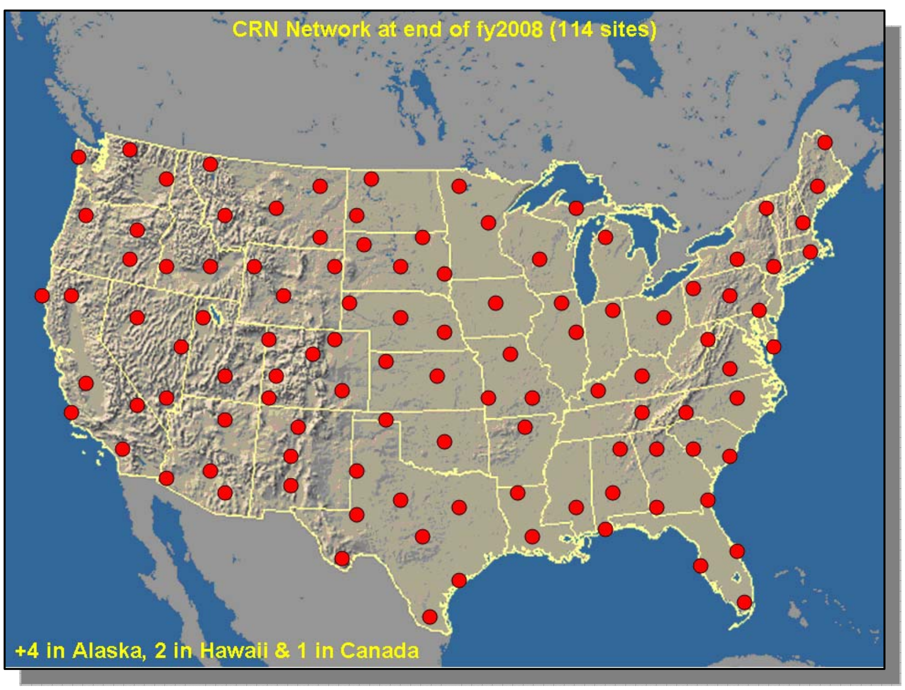


Figure 3. Locations of Climate Reference Network

Several factors support the selection of the CRN as the network of choice for enhancing soil-moisture-measurement capacity throughout the United States.

- The CRN network is well-established and designed to provide the highest quality long-term record of climate conditions coupled with real-time access to current conditions, while being specifically engineered for easy augmentation with new sensors.
- The existing infrastructure is well-suited to supporting the addition of extremely precise, highly calibrated soil-moisture and soil-temperature sensors at a reasonable cost.
- The CRN maintenance program, which was designed to ensure the continued accuracy and reliability of every CRN station, will guarantee the continued integrity of soil-moisture and soil-temperature measurements throughout the network's 50- to 100-year lifetime.

Deliverables / Milestones	Performance Measures
Install soil-moisture and soil-temperature sensors at 114 CRN sites	Number of soil-moisture measurement stations reporting nationally in real-time

Table 4: Soil Moisture Deliverables, Milestones, and Performance Measures

3.2 U.S. Drought Portal

Internet access to a "drought early warning and forecast system" capable of providing accurate, timely, and integrated information describing drought conditions on a county, regional, and national scale is the cornerstone and most visible element of NIDIS. An Internet portal for drought information will provide relevant spatial and temporal drought-risk information to three distinct user communities: 1) the general public who need to know the status of drought and what actions to take if the drought worsens where they live and work; 2) decision-makers and businesses at state and county levels that need to plan for and mitigate drought; and 3) drought experts and scientists tasked with developing more refined decision-support systems.

The U.S. Drought Portal (USDP) will provide user communities with a critical link to information, products, and service providers, and will support the USGEO concept "to provide seamless, timely access to integrated Earth observations data, information, and products within the next decade" as shown in Figure 4. The interagency nature of the USDP necessitates common data and metadata standards to assure optimal interoperability. To this end, the USGEO linkage to Federal Enterprise Architecture (FEA) for both governance and operational guidelines will need to be fully leveraged by the USDP.

While the USGEO concept is necessary for the success of the USDP, it is not sufficient. As shown in Figure 4, the USDP rests upon a foundation of mature data management systems and standards, which are also needed to ensure efficient data collection, analysis and formatting for incoming and outgoing data to and from the USDP. While the responsibility for metadata and quality control ultimately resides with the individual data providers, standards and extensions in the context of open systems will assure interoperability without sacrificing creativity.

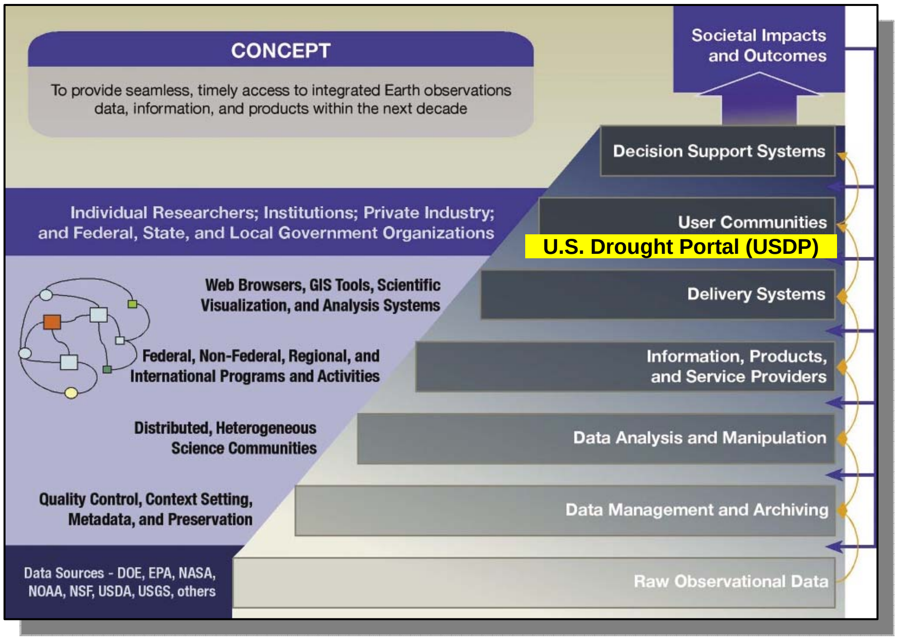


Figure 4. The U.S. Drought Portal and its relationship to the flow of data and information.

The U.S. Drought Portal will be an authoritative source for drought data, information, and tools among those who use it and for those who contribute data and products. Products retrieved from this drought portal can be used for agricultural risk assessments, water-resource management, environmental risk assessments, efficient energy management and many other decision-making purposes that prepare the Nation for drought.

Given these goals, the USDP will:

- Provide user-friendly Internet navigation from national to county levels;
- Be populated with historical and real-time drought data and products from a variety of partners; and
- Support easy-to-understand interpretations of relevant drought products, similar to the way an individual can obtain information on a particular stock from a variety of financial web pages.

Examples of products to be included in the USDP are the following:

- **Observed data.** Observed elements at multiple time and spatial scales as both station and gridded datasets: precipitation, snowpack, streamflow, reservoir levels, ground water, crop moisture, soil moisture, temperature, anomalies, and drought impacts;
- **Derived products and indexes.** U.S. Drought Monitor, Palmer Drought Severity Index (PDSI), Standardized Precipitation Index (SPI), Objective Blends, Surface Water Supply Index (SWSI), Vegetation Drought Response Index (VegDRI), and the Keetch-Bryam fire index;
- **Forecast products.** Water supply, streamflow, climate, snowpack, and U.S. Drought Outlook; and
- **Educational products.** Information that educates the user on what data are used to construct specific products, indices, and forecasts, as well as reasons for uncertainty in the observations. It also will provide examples of which products should be used to make specific decisions.

Examples of core web sites whose data and applications would be aggregated and made available via the USDP include:

- ***National Drought Mitigation Center (NDMC)***: This site hosts the *Drought Monitor* and *The Drought Impact Reporter*. NDMC helps people and institutions develop and implement measures to reduce societal vulnerability to drought. http://www.drought.unl.edu/dm/index.html and http://droughtreporter.unl.edu/
- ***Applied Climate Information System (ACIS)***: ACIS is supported by the National Climatic Data Center (NCDC) and operated by the six Regional Climate Centers. ACIS provides both real-time and historical climate data from a variety of networks. ACIS also allows execution of user-adjustable programs to support

drought risk analysis.
http://rcc-acis.org/

- ***National Water Information System (NWIS)***: NWIS is operated by the USGS and provides both real-time and historical surface streamflow, reservoir, and groundwater information.
http://water.usgs.gov/waterwatch/
- ***Joint Agricultural Weather Facility (JAWF)***: This joint USDA/Department of Commerce operation provides production agriculture predictions for the United States and the world.
http://www.usda.gov/oce/waob/jawf/
- ***National Climatic Data Center (NCDC)***: NCDC is the national archive for climate data and products.
http://www.ncdc.noaa.gov/oa/ncdc.html
- ***Climate Prediction Center (CPC)***: CPC provides a variety of climate analysis and prediction products.
http://www.cpc.ncep.noaa.gov/
- ***National Water and Climate Center (NWCC)***: NWCC provides access to Western water supply forecasts along with SNOTEL and SCAN data.
http://www.wcc.nrcs.usda.gov/
- ***National Weather Service – Hydrology***: The River Forecast Centers provide streamflow forecasts for the United States.
http://www.nws.noaa.gov/oh/index.html

The USDP also will: 1) support the ability to graph relevant data and products spatially and temporally, and interactively compose maps; 2) allow users to arrange and save selected products for a specific geographic area for easy return visits; and 3) support links to specific decision support systems.

The USDP is dependent on leveraging activities with the USGEO Archive Data Management (ADM) Working Group to develop consistency across near-term opportunity portals.

Deliverables / Milestones	Performance Measures
Establish, operate, and update U.S. Drought Portal	Number of user accesses Number of products available Number of seamless links to drought cooperators User feedback
Applied Climate Information System (ACIS)-IDP Integration	Number of climate stations in ACIS Number of climate products related to drought Capability for gridded climate product generation
National Water Information System (NWIS)-IDP Integration	Number of streamflow and ground-water stations in NWIS
Integrate climate forecasts with IDP Products	Specific product integration to meet user needs
Integrate remotely sensed data with *in situ* data	Data in areas not covered by terrestrial network

Table 5: U.S. Drought Portal Deliverables / Milestones and Performance Measures

3.3 NIDIS Operations Office

To coordinate the NIDIS business functions and activities there must be a comprehensive management strategy and personnel dedicated to meeting the goals of the NIDIS plan. A NIDIS Operations Office was created on August 1, 2006 and is directed by personnel from the National Oceanic and Atmospheric Administration (NOAA). It will help deliver the NIDIS contribution to the IEOS vision in a timely and cost-effective way. Deliverables for this office include the near-term goals discussed above as well as the infrastructure required to complete the NIDIS business plan.

In addition, the NIDIS operations office provides guidance, ensures appropriate linkages, and in many cases, performs critical preparatory groundwork enabling goals to be achieved. Specific responsibilities include:

- Monitoring network performance;
- Ongoing analysis and recommendations to optimize observing-system maintenance, communications, integrated data flow and configuration (e.g., spatial density, frequency, and timeliness of measurements);

- Facilitating cooperative agreements with both Federal and non-Federal partners for NIDIS implementation, including possible cost-sharing and implementation activities;
- Coordinating drought educational outreach;
- Tracking NIDIS progress;
- Administering external contracts to address NIDIS goals including the development, improvement, and maintenance of the U.S. Drought Portal;
- Enabling communication among expert teams to address the major goals of the WGA's NIDIS document with participation across agencies and partners; and
- Outreach to user communities to improve NIDIS and update requirements.

NIDIS Partnerships. The operations office will work with USGEO agencies to help assess the state of existing networks, determine the optimal spatial density to guide the number and location of new stations, and help determine what type of observing systems are scientifically and economically feasible. This includes:

- Identifying and documenting what is required to successfully meet the requirements of NIDIS;
- Identifying and documenting activities, new data, and products that can contribute to NIDIS;
- Working to implement and track the progress of NIDIS;
- Assisting as appropriate in the development of agreements and activities to further enhance NIDIS;
- Communicating actions and status to the USGEO agencies; and
- Reviewing and updating documents and plans for currency and relevance to NIDIS.

The operations office will accomplish goals through joint efforts across Federal, state, and local agencies, Native American tribes and appropriate non-governmental partners. Non-Federal partners may include the Earth System Information Partners, the American Association of State Climatologists, regional climate centers, and the Alliance for Earth Observations. For the purpose of this document as related to this short-term implementation plan, the major federal agencies included in this effort are the Department of Interior (DOI), the U.S. Department of Agriculture (USDA), NOAA, and the National Aeronautics and Space Administration (NASA). There is significant leveraging of existing data systems and products produced by these operating agencies as described directly below.

Early Opportunities. Leveraging the following programs and observing systems, dependent on observing, data management and analysis systems infrastructure already in place, will help anticipate and mitigate drought severity across the United States:

- USGS National Streamflow Information Program;
- USGS Ground-Water Climate Response Network;
- USDA Snow Survey Program (710 SNOTEL stations);
- USDA Soil Climate Analysis Network (111 stations);
- NOAA Climate Reference Network (114 stations), Cooperative Legacy Sites (8,000 stations), Cooperative Modernization Program, and Automated Surface Observing System;
- NOAA Operational and Hydrological Research and Services
- NOAA National Climatic Data Center and National Climate Prediction Center Drought Monitoring Teams;
- NOAA Regional Climate Centers;
- FAA Automated Weather Observing System; and
- NASA Applied Sciences Program

3.4 SUMMARY

The following is a summary Table of all near-term NIDIS Deliverables, Milestones, and Performance Measures that have been described previously in this implementation plan.

Deliverables / Milestones	Performance Measures
Install satellite telemetry at 50 continuous well sites (21 Western, 11 Central, 0 Southeast, 18 Northeast USGS regions)	Percent of stations reporting within one day of observation
Install satellite telemetry at 27 periodic well sites (9 Western, 13 Central, 2 Southeast, 3 Northeast USGS regions)	Percent of stations reporting within one day of observation
Install telecommunications equipment at 397 automated COOP sites, and operationalize Weathercoder and IV-ROCS	Increase in the percent of stations reporting within one day of observation
Install telecommunications equipment at 200 western reservoirs, 20 reservoirs/year.	Increase in the percent of stations reporting within one day of observation
Install soil-moisture and soil-temperature sensors at 114 CRN sites	Number of soil-moisture-measurement stations reporting in real time
Establish, operate, and update Drought Portal	Number of user accesses Number of products available Number of seamless links to drought cooperators User feedback
Applied Climate Information System (ACIS)-IDP Integration	Number of climate stations in ACIS Number of climate products related to drought
National Water Information System (NWIS)-IDP Integration	Number of streamflow and ground-water stations in NWIS
Integrate climate forecasts with IDP Products	Specific product integration to meet user needs
Integrate remotely-sensed data with *in situ* data	Data in areas not covered by terrestrial network
Coordinate NIDIS operations	Number of NIDIS goals and objectives achieved

Table 7: Summary of Deliverables, Milestones, and Performance Measures

The success of delivery on these near-term opportunities, milestones, and deliverables will provide the foundation for further advances through the entire process that will ultimately deliver a comprehensive and fully integrated drought information system for the nation. USGEO will conduct long-term planning with this goal in mind that combines the immediate objectives with follow-up activities in the 5 to 10-year timeframe. The mid- and long-term plans include further development of observing networks, which will ultimately comprise a Benchmark Drought Monitoring Network; development of a next-generation drought-monitoring system; and research supporting drought risk assessment and management. These efforts will enable full implementation of the NIDIS Business Process Requirements shown in Figure 1 and described in Appendix A.

4. ELEMENTS OF A COMPREHENSIVE NIDIS BUSINESS PLAN

4.1 BENCHMARK DROUGHT MONITORING NETWORK

As previously discussed, a major focus of the early opportunities is increasing the transmission and reporting capabilities of existing networks to improve timeliness and frequency of data availability. But to fully achieve a monitoring system that will provide the quality and quantity of information required for drought monitoring and forecasting in the coming decades, a Benchmark Drought Monitoring Network (BDMN) is required. It has long been known that, in addition to the inadequate distribution of soil-moisture-monitoring sites, the quantity of data collection for other variables including precipitation, ground-water levels, and snow pack are insufficient in many parts of the United States. Determining the most appropriate locations for new stations requires careful study and research, based the analysis of a combination of current station density, susceptibility to drought, and ecological and societal risk caused by drought in those areas. To capture the intensity and spatial variability of drought will also require observed simulation experiments. This essential preparatory study will be accomplished in the near-term through the leadership of the NIDIS Operations Office and will set the stage for deployment of surface observing systems in the succeeding years that will fulfill the goal of establishing a fully integrated Benchmark Drought Monitoring Network.

4.2 Model Analysis

While today's drought monitoring is partly based on subjective, regional-scale depictions of national drought conditions based on a combination of drought indicators and supplementary field reports, there is a growing recognition of the need for a next-generation drought-monitoring system that more fully exploits the rich information content of observational data through reanalysis. We envision a system that will query new, more accurate atmospheric and land-surface climate model reanalysis and provide interactive drought-monitoring tools. These tools will allow individual users (e.g., agricultural, fire danger, water supply) to answer their own specific drought questions for their chosen regions and times. In addition to improving the dissemination of user-specific drought information, such a system will improve drought nowcasting and forecasting and provide a new tool for understanding how and why droughts occur.

At the heart of this envisioned drought system is an improved model reanalysis of the climate system as called for in the *Strategic Plan for the Climate Change Science Program 2003*.[10] Datasets have emerged as critical to the advancement of our understanding of how and why the climate has varied during the last half century. They are produced using a fixed data assimilation/forecast system that synthesizes quality-controlled data from disparate observational systems together with a state-of-the-art model forecast. Using this approach, major climate modeling groups have produced long time series of comprehensive, high-quality global and regional climate analyses. For drought monitoring, the NOAA and NASA co-led Land Data Assimilation System (LDAS)/North American Land Data Assimilation System (NLDAS) is producing retrospective reanalyses and near real-time estimates of the land-surface state and surface-energy budgets. Since soil moisture is difficult to observe directly, dynamic land-surface models use atmospheric data, including observed precipitation and short-wave radiation, to derive the soil-moisture state. Current-generation LDAS models still have errors, so LDAS is also actively involved in research on how to reduce the errors in the calculation of soil moisture and energy reservoirs, in particular through the use of data assimilation techniques.

Implementation of a comprehensive model-based analysis strategy for providing drought information in support of NIDIS is likely to be a multi step process. Existing regional reanalysis datasets will need to be examined to determine whether there is useful information for drought attribution and diagnostics. In addition, work is needed to develop an interactive drought-monitoring tool that is flexible enough to process any future pertinent reanalysis data. Feedback from early adopters can guide NIDIS in future drought-tool development.

Through a range of efforts, it is possible to improve and extend the land-surface reanalysis datasets, while diagnostic evaluation of these datasets can guide more advanced model development. The existing patchwork of separate land-surface, ocean, and atmospheric reanalysis products would be made more efficient through an integrated, dynamically consistent reanalysis product. This integration requires basic research, but could ultimately lead to development of a long-term, physically consistent reanalysis dataset encompassing the land, ocean, and atmosphere. A primary benefit of this product is improved, consistent analyses of the near-surface and land-surface state that are needed to improve drought diagnosis, analysis, and attribution.

5. BEYOND THE NEAR-TERM: RESEARCH SUPPORTING DROUGHT RISK ASSESSMENT AND DROUGHT RISK MANAGEMENT

NIDIS users will benefit from early warning subsystems: monitoring and forecasting, risk assessment, preparedness, communication and public awareness, evaluation, and feedback. Enhanced understanding leading to improved predictions of drought (onset, termination, duration, and severity) requires research to improve both monitoring and analysis systems, and representation of the water cycle in earth system models (climate, water, vegetation). Improved understanding of the mechanisms and predictability of decadal drought also requires research on leading sources of potential skill, such as the impacts of sea surface temperature (SST) variability, deep soil moisture/ground-water variability, and global change trends. Improved assessments of societal, economic, and environmental vulnerability and their impacts and response capacity to drought can help provide more reliable risk-reduction efforts. Research to develop objective quantification of drought and associated economic impacts can improve the accuracy of the quantitative calculations of the monetary benefits of improved drought prediction and mitigation. In addition, research focused on how drought predictions with limited skill can be used to improve operational decision-making for water supply, transportation, hydropower, and irrigation will increase the number of products and services available for use in public and private sector planning and policymaking.

[10] http://www.climatescience.gov/Library/stratplan2003/final/default.htm

APPENDIX A: NIDIS FUNCTIONAL BUSINESS MODEL

In 2004, the Western Governors' Association (WGA) developed a set of requirements, through a broad-based team of Federal and non-Federal partners, for a National Integrated Drought Information System. These requirements were developed in conjunction with the National Drought Policy Commission's report to Congress and the pending National Drought Preparedness Act before Congress. This Near-Term Opportunity Plan was developed in response to the WGA report, *Creating a Drought Early Warning System for the 21st Century – The National Integrated Drought Information System (NIDIS),*[11] which described NIDIS and the following intended goals:

- Develop the leadership and partnerships to ensure successful implementation of an integrated national drought monitoring and forecasting system;
- Foster and support a research environment that focuses on impact mitigation and improved predictive capabilities;
- Create a drought "early warning system" capable of providing accurate, timely, and integrated information on drought conditions at the relevant spatial scale to facilitate proactive decisions aimed at minimizing the economic, social, and ecosystem losses associated with drought;
- Provide interactive delivery systems, including an Internet portal, of easily comprehensible and standardized products (databases, forecasts, GIS-based products, maps, etc.); and
- Provide a framework for interacting with and educating those affected by drought on how and why droughts occur, and how they impact human and natural systems.

These goals have been translated into a Business Plan which includes:

Physical Science and Socioeconomic Research. This process includes research in the physical sciences necessary to establish appropriate scientific techniques used in other processes and to provide guidance on such things as what to observe and what to analyze as well as where observing coverage is sufficient or deficient. Other essential elements of research include determining the optimum frequency at which observations should be recorded and reported.

Observe. This process involves observing physical and socioeconomic parameters, and includes the archiving, maintaining and accessing the observed parameters. The process uses information guided by and techniques developed for the Physical Science and Socioeconomic Research process.

Monitor and Predict. This process includes monitoring observations for relevant changes in state as well as prediction of future states. The process uses information from the Observe process and is guided by and uses techniques from the Physical Science and Socioeconomic Research process.

Analyze. This process analyzes the raw predictions and changes of state from the Monitor and Observe process to produce useful information. The process is guided by and uses techniques from the Physical Science and Socioeconomic Research process.

Inform. This process provides useful information from the Research, Observe, Monitor, and Predict processes and makes it available for use by interested parties. The process is heavily focused on data-management-related activities.

Make Decisions and Take Action. This process involves making drought-mitigating decisions and taking action based on those decisions. It uses information provided in the Inform process as well as plans prepared in the Plan process and takes advantage of education of the process users in the Educate process. The process includes decision-support tools that result from the Risk Reduction Research and Physical Science and Socioeconomic Research processes.

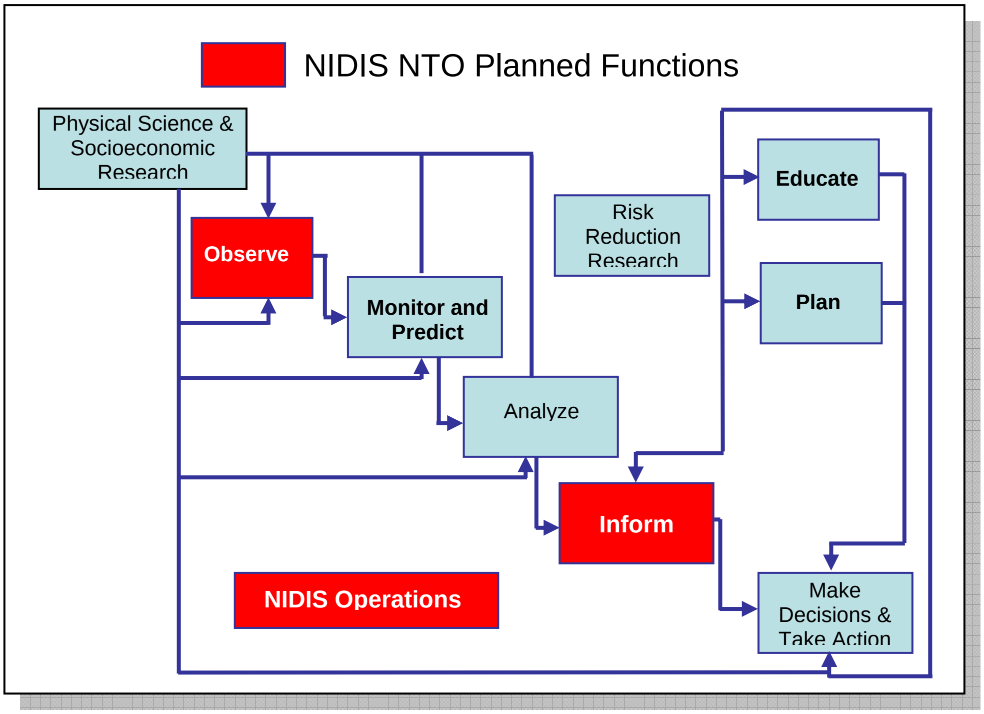
Risk Reduction Research. This process includes research into how to mitigate the effects of drought. It is somewhat related to socioeconomic research, but is drawn separately for the sake of simplifying this diagram. Later iterations of the diagram may better reflect the relationship.

[11] http://www/westgov.org/wga/publicat/NIDIS.pdf

Educate. This process involves educating affected parties on issue associated with drought and drought mitigation. The process uses the results of the Risk Reduction research process.

Plan. This process involves making plans for mitigating drought that can be implemented based on information provided in the Inform process and by triggers provided by the decision-support tools in the Make Decisions and Take Action process.

NIDIS Operations. This process is end-to-end. It helps ensure that NIDIS leverages and optimizes existing cross agency, state, local and private sector observations and information delivery. It provides day-to-day monitoring of the flow of data, information, and products among agencies throughout the entire process.



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