DEPARTMENT OF THE ARMY

U.S. ARMY CORPS OF ENGINEERS

COMPLETE STATEMENT

OF

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BEFORE

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UNITED STATES SENATE

ON

New Approaches and Innovative Technologies to Improve Water Supply

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Thank you Chairman Inhofe, Ranking Member Boxer, and distinguished members of the Committee for the opportunity to present information about the U.S. Army Corps of Engineers (Corps) Civil Works Program activities related to drought and drought technologies.

I'd like to begin my statement with a short discussion about drought in general, and then tie this topic into the Corps mission and operations. Then, I'll provide some information on the actions that we have taken with respect to drought in the past, followed by some current efforts, touching on drought technologies that are being investigated for future implementation.

DEFINITIONS OF DROUGHT

Drought is a deficiency in precipitation over an extended period, usually over weeks, months, or years, resulting in a water shortage causing adverse impacts on vegetation, animals, and/or people. It is a normal, recurrent feature of climate that occurs in all climate zones, from very wet to very dry. Its impacts vary from region to region, and differ even within the same region based on the way that the affected people in the area use the water. Drought can, therefore, be difficult for people to understand as it is a lot more complex than just the lack of water.

Droughts are significant meteorological, social, and economic events in most parts of the world. Drought impacts include reduced water supplies, loss of soil by wind erosion and subsidence, saltwater intrusion into freshwater aquifers, an increased risk of fires, decreased water quality, other adverse ecological effects, and associated economic losses. A drought lasting from one to three months is considered short-term; a drought lasting from four to six months is considered intermediate; and a drought lasting more than six months is considered long term.

Although the type and severity of drought varies from place to place, it is generally characterized by below-normal precipitation over a period of months to years relative to the local normal condition. Drought intensity can be exacerbated by high evaporation rates due to excessive temperatures, high winds, lack of cloudiness and/or low humidity, decreased soil moisture, and falling water tables.

Droughts can be classified into three types:

- *Meteorological drought* is a period of months to years in which precipitation is below normal. It can be accompanied by above-normal temperatures and other factors such as increased wind and lower relative humidity. Meteorological drought can precede and cause the other two types of drought.

- *Agricultural* or *soil-moisture drought* results from a moisture deficiency in the shallow plant root zone, reducing crop production and plant growth. Agricultural

drought can result from below-normal precipitation, above-normal evaporation, or intense but less-frequent precipitation events. Susceptibility to soil-moisture drought can depend on crop or vegetation type.

- *Hydrologic drought* refers to a period when river streamflow and water storage in aquifers, lakes and reservoirs fall below long-term mean levels due to the amount and/or spatial and temporal distribution of precipitation. Hydrologic drought can have long-term effects on regional and local surface water and subsurface water supplies.

Drought is a relatively common phenomenon in North America, and occurs to some extent every year in some part of the United States. Weekly drought information is available in the U.S. Drought Monitor web site and it is produced jointly by the National Oceanic and Atmospheric Administration, the U.S. Department of Agriculture, and the National Drought Mitigation Center at the University of Nebraska-Lincoln.

CORPS MISSIONS AND OPERATIONS

As a water resources management agency, the Corps is concerned with hydrologic drought. On a regular basis, we monitor for conditions that might lead to or enhance meteorological drought, and use up-to-date information developed by other Federal and state agencies about agricultural drought. The Corps performs water management activities at its reservoirs consistent with the project-specific, congressionally authorized purpose or purposes for each reservoir. These purposes may include navigation, flood risk management, hydroelectric power generation, water supply, and recreation. The Corps must operate according to the authorities Congress has given us, along with all other applicable laws, regulations and Executive Orders. Generally, alternate water uses across purposes are studied during the feasibility study stage of a project, and serve as the basis for the project's initial congressional authorization. We conduct these studies with the participation of States, Tribes, local governments, various federal agencies, other stakeholders, and the public.

Here, I will focus on two missions where we often balance competing needs during periods of drought: flood risk management and water supply, along with emergency response, which addresses components of each. It is important to keep in mind that most of the dams in the current drought areas were authorized solely for flood risk management. For example, in California, the Corps operates 30 dams, of which 17 have a single purpose for flood risk management, and 13 have multiple purposes.

One important factor that must be considered when adjusting operations during drought to enhance water supply is the potential for the occurrence of one or more intense rainfall events during a drought. Flooding and drought can occur simultaneously in a region. For example, in the Lower Mississippi Valley in 2011, flooding due to large winter headwaters snowpack and heavy rains in the Midwest coincided with extreme drought in Tennessee, Arkansas, Mississippi and Louisiana. Over Memorial Day

weekend in 2015, intense rainfalls occurred in Texas, causing some reservoirs with low pool elevations due to drought to rise into and beyond the top of the flood pool elevation. As a result, water control operations during drought must take into account the potential for a rapidly occurring flood situation.

Flood Risk Management

Although the Corps involvement in studies in response to flooding dates back to the 1850's, the Congress first authorized the Corps to construct projects for flood control in the Flood Control Act of 1917, which is often considered the foundation of what we now call flood risk management activities. Later, the Flood Control Act of 1936 declared flood control to be "a proper activity of the Federal government in cooperation with States, their political subdivisions, and localities thereof," which shall be prosecuted by the Army Department under direction of the Secretary of the Army and supervision of the Chief of Engineers.

Water Supply

Generally, the Corps will not construct a project for water supply, but may include water supply as a purpose in a project constructed primarily for one or more of the three main mission areas of the Corps, which are: flood and storm damage reduction, commercial navigation, and aquatic ecosystem restoration. The Flood Control Act of 1944 and the Water Supply Act of 1958, as amended[1] are the primary water supply authorities of the Corps. These statutes give the Corps authority to also use its reservoirs for municipal and industrial (M&I) water supply storage (the Water Supply Act of 1958), for withdrawals of surplus water (Section 6 of the Flood Control Act of 1944), and for agricultural water supply storage in limited circumstances (Section 8 of the Flood Control Act of 1944). Currently, 136 Corps reservoirs in 25 states provide 9.8 million acre-feet of storage for M&I water supply; and 39 Corps reservoirs in 12 states provide water for irrigation. The Corps is authorized to assist states and local interest in their water supply planning process (such as under Section 22 of the Water Resources Development Act of 1974 -- Planning Assistance to States).

The Corps water supply authorities recognize that states and non-federal entities have the primary responsibility in the development and management of their water supplies. The Corps may only participate in developing water supplies at a Corps project when certain conditions of non-federal participation are met, such as bearing the full financial burden of water supply. Water rights are the responsibility of states – the Corps does not own or sell water. Under applicable law, the Corps has the flexibility to accommodate the needs of state and local interests for water supply, in furtherance of, and not in conflict with, state water rights.

[1] E.g., Section 932 of the Water Resources Development Act of 1986, amends the Water Supply Act of 1958, applicable only to Corps projects.

Emergency Management

The Corps was given authority to provide disaster preparedness and emergency operations by Section 5 of the Flood Control Act of 1941, as amended, commonly known as Public Law (PL) 84-99. The 1955 Emergency Flood Control Funds Act and the Disaster Relief Act of 1974 broadened and defined federal responsibilities for providing disaster assistance, assigned responsibilities to agencies, and established coordination among federal agencies.

In areas designated as drought distressed, the Corps has limited authority under Section 5 of PL 84-99 to assist a state with the transportation of water for human consumption, but not the purchase or storage of water. Transportation is normally provided by tank trucks or small diameter pipelines, but all potential methods are considered. The Corps may also assist in well drilling at 100% sponsor cost if wells are not commercially possible. Assistance will only be provided to meet minimum public health and welfare requirements. Criteria that must be met include:

- Gubernatorial declaration of drought-distressed area.
- State and local agencies must make full use of their own resources, including the National Guard.
- Reasonable rationing and conservation measures have been implemented.
- A permanent solution is being actively pursued at the local level.
- Requests for assistance to the Corps must be initiated by the Governor or his/her authorized representative.

THE CORPS AND DROUGHT

The Corps has played a major role in federal response to drought since the drought of the late 1970s. It was at this time when the Director of the Corps Institute for Water Resources was asked by the White House to lead a drought study task force and produced the Presidential Drought Appraisal Study in 1977. This study led to the development of Corps guidance for drought contingency plans, which I will discuss in more detail below. Following the severe western drought of the 1980s, Congress authorized the Corps to lead a collaborative nationwide survey to find ways to improve water management during droughts. This National Drought Study resulted in a number of reports, including a report to Congress.

Despite lessons learned in earlier droughts and incorporated in federal, state and local planning, the findings of the National Drought Study indicated that the droughts of the late 1980s and early 1990s caused persistent and widespread conflicts among water users. The study broadly characterized drought responsibilities as follows:

- Federal agencies are responsible for ensuring that the authorized purposes of federal reservoirs are met.

- State agencies are responsible for defining different stages of drought and appropriate state-level responses, including invoking the emergency response powers of the governor. In some cases, states can prioritize water allocation by the type of use.
- Local (county, city or water utility) agencies are responsible for planning and implementing drought response measures at the local scale.

The basic division of responsibilities listed above has evolved over time, especially with the establishment of the National Drought Resilience Partnership (NDRP) in 2013 under the President's Climate Action Plan, which was reflected in the Presidential Memorandum: Building National Capabilities for Long-Term Drought Resilience signed in March 2016.

The 2012 drought, which continues today, affected about two-thirds of the continental United States and has caused large agricultural losses and increased occurrences of wildfires.

Although this discussion focuses on Corps actions related to flood risk management and water supply, drought affects all of our operations. For example, in late 2012-2013, prolonged drought conditions on the Mississippi River affected barge traffic downstream of St. Louis. To facilitate the movement of this traffic under the then occurring low flow conditions, the Corps increased routine and emergency dredging, and removed limestone "rock pinnacles" in two reaches of the river. The costs of all these measures were borne entirely by the Corps. The rock removal also improved our ability in the future to facilitate navigation in these two reaches during low-flow periods.

Reallocation Studies

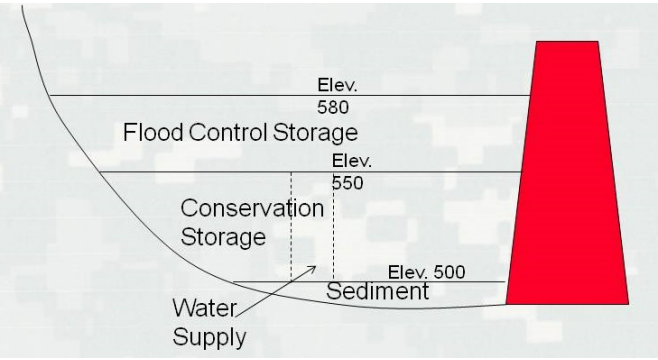
In some situations, water supply storage in a Corps reservoir is provided or can be made available to a non-Federal entity to augment its municipal and industrial (M&I) water supply. Non-Federal entities that do not have storage in a Corps reservoir or would like to increase their storage may request the Corps to study and consider reallocating some of the existing storage from another authorized purpose to water supply. Depending on the impact of the requested reallocation, Congressional reauthorization of the project may be required.

The Corps may conduct a water supply reallocation study in response to such a request. If the Corps determines based on this study that the requested reallocation is feasible given other authorized purposes for the reservoir, the non-Federal entity must enter into a water supply agreement before the Corps can reallocate the storage. These agreements require the local sponsor to repay the U.S. Treasury both the updated cost of storage (or, when higher, foregone benefits or revenue) and the annual operation and maintenance costs associated with that storage.

Water Management

Corps reservoirs are operated according to water control manuals, which by policy include reservoir rule curves and, where appropriate, include Drought Contingency Plans (DCPs). The purpose of a DCP is to provide a basic reference for water management decisions and responses to a water shortage in a basin due to drought. DCPs outline the process for identifying and monitoring drought at a facility, inform decisions by Corps water operations staff to reduce drought effects, and define the coordination that the involved Corps District or Districts take to manage the water resources. Because of the duration of a drought is unknown while the drought is occurring, and other uncertainties of the specific problems that may result, DCPs specify a minimum suite of actions that must be carried out related to water control, leaving open opportunities for additional action as the situation warrants, for example, through deviations.

In general, water control manuals and rule curves include consideration of monitored meteorological data, including snowpack, in operational decision making. A water control manual generally describes how a reservoir will be regulated by managing water elevations between conservation storage and flood control storage, as shown in the figure below. These manuals incorporate allowable flexibility for a broad variety of runoff and climatic conditions to address the authorized project proposes. A water control manual regulates the project over the entire regime of pool elevations and conditions. The manual does this through a water control plan, which includes schedules for project regulation under a range of water conditions, provisions for collection and dissemination of data, guidelines for preparation of detailed operating guidelines to assure project safety, and actions to fulfill regulatory requirements.



Over time, Corps water management operations have proved reliably robust to observed changes in flow patterns, which have resulted from changes in land-use and land cover, as well as observed climate variability and associated changes. When combined with the deviation process (described in more detail below), there is a great deal of flexibility to respond to short-term and long-term needs based on best available information and science.

It is important to note that the Congressionally-authorized purpose or purposes of a dam, and the associated reservoir rule curves for operating the dam, are the primary

drivers of water management. Dams with a primary purpose of flood risk management, or with multiple purposes including flood risk reduction, retain a certain volume of the pool to provide flood storage capability that minimizes downstream flooding. Some dams also have an exclusive flood storage capacity that may only be encroached for the purpose of flood storage.

Corps Deviation Process

Water control manuals contain a provision authorizing the operating District or Districts of the Corps to deviate temporarily from operations prescribed in the project's approved water control plan. Deviations may be pursued when necessary to alleviate critical situations or to realize increased benefits during an operation season, without significantly affecting the fulfillment of the project's authorized purposes. These deviations are intended to address special and unique circumstances including dam safety issues, drought, flood, and other issues. The basic tenets of deviation must be adhered to for safe operation and include: operational and structural integrity of the facility components, not endangering the dam, mitigating the risk of downstream flooding, not unnecessarily storing water in the pool, and not compromising the safety of persons or property downstream.

Deviations are grouped into three categories: emergency, unplanned, and planned deviations.

- *Emergency deviations* from the approved water control plan are required to mitigate an immediate threat to public health and safety, property, project or the environment.
- *Unplanned deviations* deal with a wide range of unplanned occurrences that are not considered emergencies. The need for unplanned deviations can arise due to unforeseen conditions that do not allow sufficient time for a full analysis prior to deviation. These could include construction, maintenance, inspection, or flood control needs.
- *Planned deviations* consist of other deviations not addressed by an emergency or unplanned deviation. Planned deviations could be minor or major. Planned deviations for dams classified as Dam Safety Action Classification (DSAC) 1, 2 and 3 have a higher risk, and shall comply with Engineer Regulation (ER) 1110-2-1156, chapter 24 – Dam Safety Considerations for Storage Allocation, Reallocation, and Related Studies. A major deviation that would result in increased water storage at a DSAC 1, 2 or 3 dam requires approval by Corps Headquarters.

For dams that do not typically store water, the Corps can consider temporary deviations from authorized flood operations in response to drought conditions. Temporary deviation processes incorporate environmental compliance, ensure that dam safety guidelines are met, and evaluate associated flood risk management issues. Should a

significant precipitation event occur that triggers a deviation request, the Corps is prepared to issue a timely response.

Corps Drought Contingency Plans

Following the Western droughts of the 1970's, the Corps published ER 1110-2-1941, titled "Drought Contingency Plans" in 1981. Systematic preparation of DCPs was last undertaken in the 1980s and early 1990s, though some DCPs were finalized in 2011 and others are currently in the planning stage. The National Inventory of Dams reports that the Corps operates and maintains 707 dams at 557 projects, including 173 dams with navigation locks. DCPs are typically only completed for projects with controllable storage, and thus are not developed for most of our lock and dam projects, nor the approximately 10% of the dams at Corps projects that do not maintain normal storage levels and typically have dry reservoirs.

A team was formed to assess the current status of DCPs and to develop methods to update DCPs to account for a changing climate. The team identified and reviewed 142 DCPs covering 301 projects, representing approximately 95% of projects which require a DCP. A summary report compiled as part of this effort contains an overview of climate, climate change, and drought in the United States to aid in planning for current and future droughts at Corps projects. The team is working on methods and web tools to assist in understanding of projected hydrologic droughts (i.e., projecting future areas that will likely experience droughts due to decreased precipitation) and how these will impact Corps projects. The results of this work will serve as a guide for developing a strategy to update existing DCPs. The team is also conducting pilot studies testing methods and processes to update DCPs to account for changing climate. Pilots are planned or underway in the Lakes and Rivers Division, Mississippi Valley Division, Southwestern Division, South Pacific Division and Northwestern Division.

CURRENT EFFORTS AND DROUGHT TECHNOLOGIES

The U.S. National Climate Assessment published in 2014 reported that the climate is changing and is projected to continue to change. The expected changes vary regionally and include warming temperatures, resulting in altered precipitation patterns, increasing heat waves (particularly in the West), changing snow patterns and droughts. Increases in summer drought are likely across the northern tier of states, including the Northeast, Northwest and Alaska, while increases in drought are likely in the southern Plains, Southeast and Hawaii. The already arid Southwest is anticipated to see large increases in drought frequency and severity. The Midwest and northern Plains, however, are anticipated to experience little change in drought frequency, and reductions in drought are anticipated in northern portions of these regions.

Two current efforts underway enhance our ability to manage water resources for climate preparedness and resilience. The first effort is developing and implementing methods to update drought contingency plans to account for climate change. The objective of the second is to enhance reservoir sediment information to assist in climate preparedness and resilience. The reservoir sediment information can help identify current and future reservoir sediment volumes, which can affect flood and water supply storage.

The Forecast-Informed Reservoir Operations (FIRO) research in Lake Mendocino is a pilot study that would use atmospheric river (advanced hydro-meteorological) forecasting data to inform water management decisions in a manner which reflects current and forecasted conditions. The study was scoped in 2014, and began in 2015. The research is projected to be a five-year effort, and the results may indicate whether this technology can be applied in actual operations of certain projects. The Corps is participating on this pilot project with a consortium led by Scripps Center for Western Weather and Water Extremes, along with the Sonoma County Water Agency, California Department of Water Resources and State Climate Office, Bureau of Reclamation, NOAA's National Weather Service, Earth Systems Research Laboratory, and Restoration Center, USGS, and the private sector.

Improved short-term and long-term weather forecasts would improve our confidence in the range of appropriate adjustment of operations in the future. Weather forecasts are the responsibility of the National Weather Service. The Corps is participating in efforts to better understand capabilities in improved forecasting.

SUMMARY

The hydrological processes that influence droughts and floods are complex. The Corps water management operations, nationally, have endeavored to account for these complexities, with the result that operations have proved reliably robust to extreme events of flood and drought. The combination of water control manuals and deviations provides a great deal of flexibility to respond to short-term and long-term needs, based on best available information and science consistent with each project's congressionally authorized purposes.

Thank you for the opportunity to be here today and I look forward to your questions.