Bureau of Reclamation
WaterSMART: Drought Resiliency Project Grants for Fiscal Year 2016
Funding Opportunity R16-FOA-DO-006

Upper Republican NRD Drought Mitigation and Groundwater Management Project

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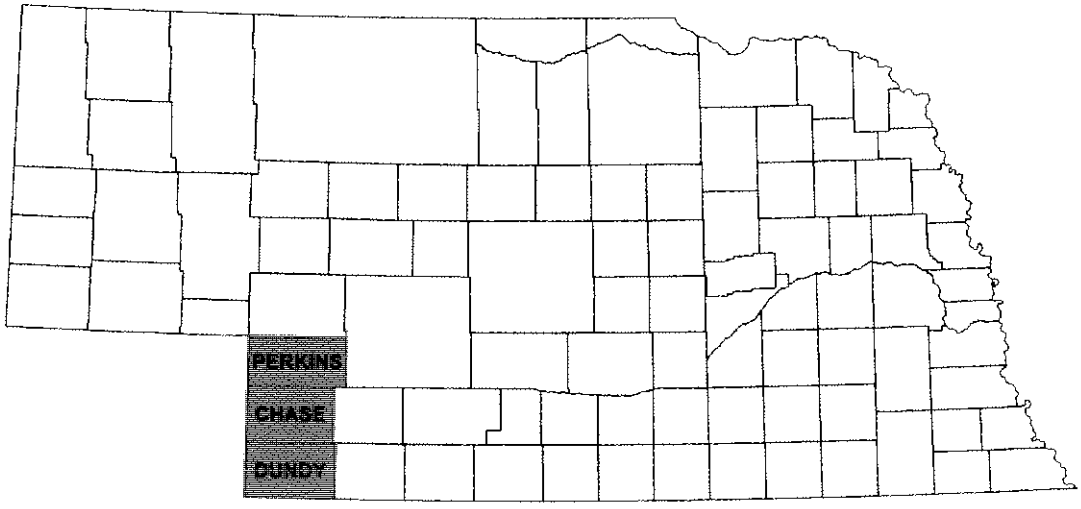
Executive Summary

March 25, 2016
Upper Republican Natural Resources District
Imperial, Nebraska
Perkins, Chase and Dundy Counties

The Upper Republican Natural Resources District (URNRD) wishes to utilize $300,000 of WaterSMART funds and $400,000 of its own funds to implement a groundwater management system to assure greater water availability during drought periods in a three-county region of southwest Nebraska that encompasses approximately 1.7 million acres. WaterSMART and URNRD funds are proposed to be used to develop a water management system and modeling tools using water measurement and monitoring devices that will allow for comparisons of crop water needs with actual irrigation water pumped by farmers, and corresponding impacts on the underlying groundwater aquifer. The URNRD, which regulates and limits groundwater usage in Perkins, Chase and Dundy Counties under State of Nebraska statutory authorities, will use the information and model to plan for adjustments in its regulations – namely by further restricting water usage – so that irrigation water applications do not exceed crop water needs, thereby ensuring greater water availability during drought periods when irrigation water demand is high. In addition to being the basis of possible new regulations designed to increase water availability, crop water needs using evapotranspiration data from weather stations across the URNRD will be made available to residents of the district via an online tool in an effort to prevent excess irrigation withdrawals. Potential regulations identified using near real-time water monitoring and measurement information will be used to create modeling tools that will aid the analyzation of groundwater responses and availability under pumping scenarios resulting from adjusted regulations. The project will help stabilize groundwater levels, making the region more drought resilient, and possibly help mitigate impacts on stream flow caused by groundwater pumping, aiding farmers, downstream irrigators, and fish and wildlife that rely upon surface water.

The project is estimated to take 1 ½ - 2 years to complete with a finish date in 2018 and is not located on a federal facility, but is located in near proximity to one – Enders Reservoir.

Upper Republican Natural Resources District Project Area



Background Data

The primary water supply in the URNRD and the foundation of irrigated agriculture is the High Plains Aquifer. Rules and regulations imposed by the URNRD since the late 1970's, including what are believed to be the first limits on agricultural use of groundwater in the U.S., have successfully slowed declines in the aquifer. Variably declining water tables throughout the URNRD, however, continue to persist and further efforts to slow the rate of decline with the goal of eventually stabilizing water levels are a primary objective of the URNRD. Meeting these goals and objectives is necessary so that sufficient water for irrigation is available during drought periods when access to groundwater for irrigation is imperative to meeting crop water demands, and at the same time can be compromised by high levels of usage and significant irrigation well drawdowns occurring during prolonged dry periods.

The Ogallala geologic formation underlies all but the extreme southern and northwestern parts of the URNRD. It ranges in thickness from a feathered edge to more than 400 feet. The Ogallala Formation consists of beds of silt, sand, gravel, caliche, and clay, with considerable variability in the character of the formation within short vertical or horizontal distances. These variations are consistent with the fluvial environment in which the Ogallala was deposited. This environment was characterized by a series of braided streams carrying sediment eastward. Some of the sand and gravel deposits are weakly cemented by calcium carbonate into rocks ranging from friable sandstone to relatively hard, ledge-forming mortar beds. Except in a few areas, most notably western Perkins and Chase Counties, the Ogallala Formation is overlain by unconsolidated Quaternary deposits.

The unconsolidated Quaternary deposits, which comprise the land surface of most of the URNRD, consist of sand, gravel, silt, and clay of fluvial origin and sand, silt, and clay carried in by the wind. These deposits range in thickness from a feathered edge to more than 100 feet. These occur as alluvium and terraces in stream valleys and dune sand and loess deposits in upland areas.

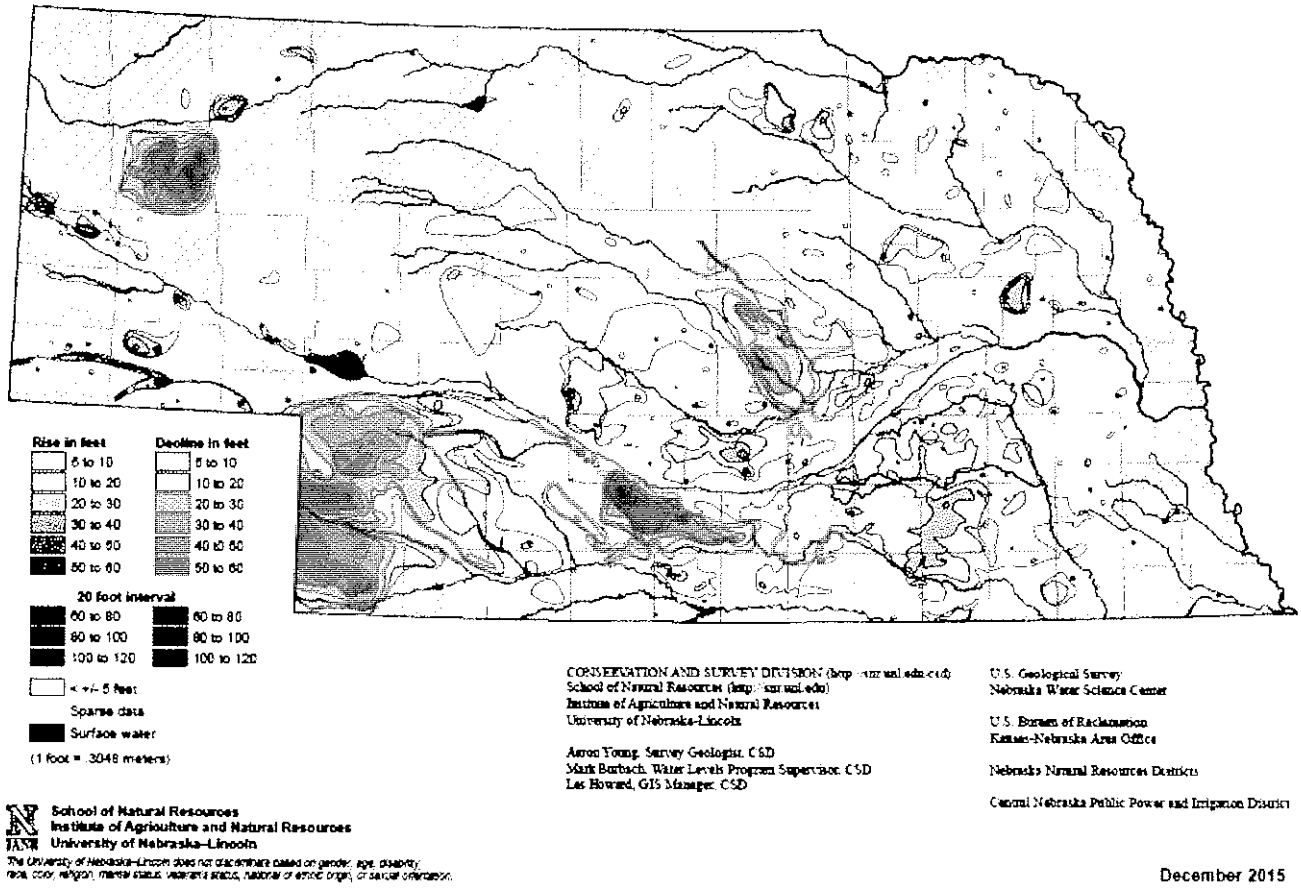
The High Plains Aquifer consists of the saturated parts of the Quaternary deposits and the underlying Ogallala Formation. The aquifer is unconfined. In general, the direction of ground-water flow is west to east except in the vicinity of the Republican River. Average ground-water-flow velocities range from less than 50 feet to more than 200 feet per year.

The White River Group and the Pierre Shale are relatively impermeable and form the base of the High Plains aquifer. The volume of ground water in storage in the High Plains aquifer is a function of the saturated thickness of the aquifer, the area that aquifer covers, and the porosity

of the aquifer. All groundwater cannot be withdrawn by dewatering or pumping because some water molecules cling to rock or soil particles due to the surface tension of water. The typical specific-yield value or recoverable, available water for the aquifer is in the range of 0.18. The saturated thickness of the aquifer ranges from approximately 50 feet to 400 feet.

Declines in water levels throughout the URNRD from the period before widespread groundwater irrigation development began in the 1960's until now have averaged approximately 22 feet, with the most significant declines being 60-70 feet. The average, annual decline in the water table throughout the URNRD has been approximately .75 feet. The map below shows changes in groundwater levels from predevelopment to spring 2015; the three counties within the URNRD are the three most southwesterly corresponding with the project area map on page 2 of this application.

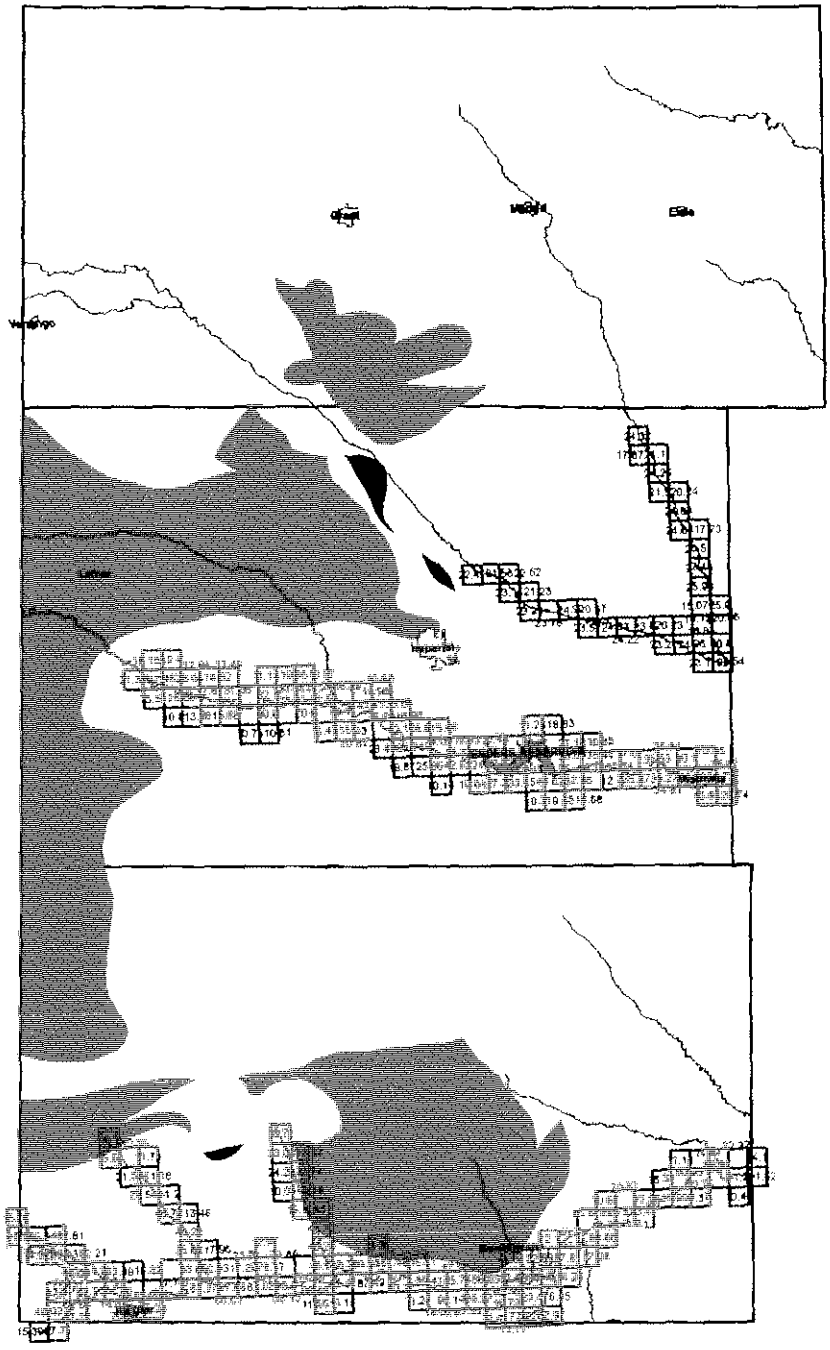
Groundwater-Level Changes in Nebraska - Predevelopment to Spring 2015



The estimated water supply within the URNRD based on current estimates of aquifer saturated thickness and average annual water uses that have reduced the saturated thickness vary greatly and the estimates need refinement. Improvements in our understanding of remaining years that localized portions of the aquifer can yield water sufficient to fully irrigate crops will be made possible with groundwater modeling that will be conducted as part of this proposed project at the expense of the URNRD. However, current estimates indicate that under current water usage rates the aquifer underlying areas totaling approximately 70,000 acres within the URNRD will not be able to provide a full irrigation supply within approximately 40 years. Of those 70,000 acres, approximately 20,000 acres have a water supply under current usage rates of 20-30 years and 50,000 acres have a useful irrigation life of 30-40 years. The remainder of the URNRD has a water supply estimated to last between 40 and 500 years given current rates of usage.

Declining water supplies in areas of relatively little saturated thickness pose water availability problems during periods of drought when irrigation is especially vital to sustaining crops. In periods of average and above-average precipitation, wells that can yield approximately 400 gallons per minute are often sufficient to meet crop water demands. In times of severe drought, however, such as 2012, wells of such a capacity are insufficient to meet water consumption requirements of crops such as corn. Wells yielding at least 500-600 gallons per minute are necessary in drought periods and that level of production is becoming difficult to achieve in some areas of the URNRD. The proposed project will provide valuable information needed to inform development of new regulations that will help ensure wells are of sufficient capacity to meet crop water demands during drought periods.

The map on the following page shows areas of the URNRD (in red) where at least 25% of the saturated thickness of the underlying aquifer has been depleted and are at risk of having insufficient irrigation supplies during drought periods.



There are approximately 435,000 irrigated acres in the URNRD watered by approximately 3,300 groundwater irrigation wells. Residential and commercial water use in the URNRD is minimal; the total, combined population of Perkins, Chase and Dundy Counties is about 9,000 residents. Approximately 2,000 acres within the URNRD are irrigated by surface water. These acres receive variable water supplies depending on stream flow and are not managed by the URNRD. The average annual water use by irrigators over the last 36 years has been approximately 12 inches per irrigated acre. This has been documented and verified by URNRD staff over that time period utilizing flow meters which are required on all irrigation wells. The average, annual amount of groundwater applied to crops over the same time period has been about 430,000 acre feet. The predominant irrigated crop in the URNRD is corn, with approximately 300,000 acres of irrigated corn annually planted in the URNRD. Irrigated dry-edible beans and soybeans are the next most common irrigated crops, but the total amount of irrigated acres planted with either of those crops is only about 10 percent of the irrigated-corn total. The total number of farmers in the URNRD who irrigate cropland with groundwater is approximately 750.

Correlative rights govern the use of groundwater in the URNRD and throughout Nebraska. Correlative rights allow landowners to drill wells and extract groundwater from an underlying aquifer for beneficial purposes subject to management by the public. All irrigation wells must be registered in Nebraska and landowners must first obtain a permit to drill a well. The correlative rights doctrine has been adopted into state statute with some modifications. State law provides that every landowner shall be entitled to reasonable and beneficial use of the groundwater underlying his or her land subject to the provisions of the Nebraska Ground Water Management and Protection Act and the correlative rights of other landowners when the groundwater supply is insufficient for all users. In enacting this basic doctrine, the Nebraska Legislature made broad findings about the need to manage and regulate groundwater use for the long-term benefit of the public and the state's economy.

The Groundwater Management and Protection Act approved by the Nebraska Legislature in 1976 gave Natural Resources Districts such as the URNRD the authority to regulate groundwater use. The URNRD is a political subdivision of the State of Nebraska, along with 22 other Natural Resources Districts. They are local government entities with broad responsibilities and significant authorities to protect natural resources including water. Major Nebraska river basins form NRD boundaries, enabling districts to respond best to local needs. Elected boards of directors govern districts. Much of the funding comes from local property taxes. Some Districts, including the URNRD, also have the ability to levy a tax on the practice of irrigation. The URNRD currently levies such a tax, called an occupation tax, at the rate of $10 per irrigated acre. It generates more revenue than property taxes.

Plentiful water supplies and fertile soils helped create rapid development of irrigated cropland within the URNRD in the 1960's and 1970's, before NRDs in the state were granted the authority to regulate groundwater use in 1976. The URNRD quickly took advantage of its new authorities to preserve water in the area, requiring flow meters on all irrigation wells in 1978-1979 and at the same time becoming the first NRD in Nebraska and possibly the first entity in the U.S. to restrict agricultural groundwater using an allocation system that limits the amount of water irrigators can pump. The URNRD has steadily reduced the allocation over time and the current allocation is about 40% less than it was when allocations were first implemented. The number of irrigation wells drilled in the 1980's and 1990's was significantly curtailed by restrictions approved by the URNRD on how close irrigations wells could be to each other. In 1997 the URNRD became the first NRD in the state to prohibit new irrigation wells and the moratorium is still in place.

The URNRD currently restricts the amount of groundwater that can be applied using a five-year allocation applied to all irrigators in the URNRD. The current allocation is a total of 65 inches that can be applied over the five-year allocation period. Annualized, the allocation is 13 acre-inches per year. Irrigators can disperse their 65 inch allocation as they wish throughout the five-year period so long as they do not exceed a total of 65 inches of use over the five-year period. For example, an irrigator who applied 15 inches each of the first four years of the allocation period (60 inches) would be restricted to 5 inches of use in the last year of the allocation period to prevent exceeding the 65 inch allocation. Allocation unused by irrigators during an allocation period can be "banked" for future use. In 2013, however, the URNRD established new restrictions on how much banked allocation can be used during an allocation period without being penalized.

Additionally, the URNRD has a goal of reducing groundwater pumping by 20 percent from 1998-2002 baseline pumping volumes in years of average precipitation. With the Nebraska Department of Natural Resources, the URNRD will annually evaluate trends in long term groundwater depletions over typically wet and dry cycles, approximately 12 years, and jointly assess if additional management actions are needed to accomplish the objective.

The URNRD employs three technicians who, among other duties, twice annually measure static groundwater levels at approximately 400 wells across the district. Additionally, they annually read mechanical flow meters on all 3,300 irrigation wells to determine water usage on individual fields for the year. This information is largely used to ensure irrigators are complying with URNRD water use restrictions.

The surface-water system in the URNRD consists of streams, reservoirs, and one surface water irrigation district, the Pioneer Irrigation District. These components, along with the aquifer system, form a complex hydrogeological system. The Republican River is the major stream system in the URNRD. The Republican River and the North Fork of the Republican River have several tributaries within the URNRD, including: Stinking Water, Frenchman, and Spring Creeks in Chase County, and Buffalo, Rock, Horse, Spring, Indian, and Muddy Creeks in Dundy County.

Enders Reservoir is the only surface-water impoundment in the URNRD with storage capacity greater than 1,000 acre-feet. Numerous small impoundments also exist. There are no permanent natural lakes in the URNRD. Enders Reservoir, on Frenchman Creek, has an average surface area of 1,242 acres and is used for storing irrigation water. The Pioneer Irrigation District is a surface water appropriator on the North Fork of the Republican River, an interstate stream, in Dundy County. Pioneer holds a water right for 47.39 cubic feet per second (cfs) of water with a priority date of April 4, 1890. The water is diverted into a canal called the Pioneer Ditch, which runs from Yuma County, Colorado across the state border into Nebraska. Pioneer's right to divert water in Colorado to irrigate Nebraska lands has been memorialized by the Republican River Compact, an interstate agreement between the states of Colorado, Kansas and Nebraska.

Technical Project Description

The technical project description is contained within Evaluation Criterion A-E and the Performance Measures below.

Evaluation Criterion A – Project Benefits

The proposed project seeks to combine five elements to improve drought resiliency and water management within the URNRD: Real time monitoring of groundwater levels; real time monitoring of water usage; weather and evapotranspiration data; modeling tools to analyze groundwater availability under different irrigation scenarios; and the URNRD's existing authorities to limit water groundwater usage on approximately 435,000 acres in the three counties the URNRD encompasses.

The nature of the URNRD's predominant water supply, groundwater, provides two primary means of improving drought resiliency. One is importing water originating outside the URNRD, such as flood or excess flow waters from streams, into the underlying aquifer via recharge facilities or direct well injection. The second is to better manage and preserve water so it is available during drought periods by identifying how the application of groundwater by irrigators corresponds with actual crop water needs and impacts water availability. The URNRD's regulatory authorities provide a unique ability to use the resulting information of how much

irrigation applications can be reduced and still meet crop water demands to not just encourage actions that improve drought resiliency, but to require such actions. The URNRD is pursuing opportunities to import excess flows into the URNRD, but the effort is in the planning phase and may take significant time to complete. The project proposed in this application will accomplish the second manner of improving drought resiliency and has the potential to provide a water management template for much of Nebraska and even the rest of the eight-state region overlying the High Plains Aquifer.

The remote monitoring equipment that will be deployed for this project will include weather stations, pressure transducers for groundwater level monitoring, and transmitters installed to existing flow meters. Each of these sensors will be connected to remote telemetry units to remotely and automatically collect water use data for improved water management. The remote monitoring technology employed will be either UHF radio, cellular or satellite communications. The type of equipment and data communications costs will be evaluated to provide the most economical remote monitoring system to the water users in the URNRD.

At least one weather station will be deployed per county in the URNRD for a minimum of three weather stations. Each weather station will be equipped with the necessary instrumentation to collect weather data for reference evapotranspiration (ET_o) calculations. The weather stations may be co-located at the monitoring well locations where pressure transducers will be installed in existing monitoring wells for real-time groundwater level monitoring. Remote telemetry units (RTUs) will be installed on existing flow meters at irrigation wells to accurately report in near real-time the water applied to farm fields by irrigation. Additional rain gauges will be installed at well locations for accurate localized rainfall data. All of these sensors will automatically report data to a web-based server where the URNRD and irrigators alike will have access to real-time water use data.

Fifteen monitoring wells utilized to monitor groundwater levels within the URNRD and approximately five additional irrigation wells will be modified to provide near real-time information on groundwater levels that will be remotely transmitted to the URNRD. The 15 existing monitoring wells are dispersed throughout the URNRD as illustrated in the map below in green (two wells are located at the northern-most location):

Upper Republican NRD Recorder Wells

Approximately 200 groundwater irrigation wells in the vicinity of the monitoring wells will be equipped with remote telemetry devices added to flowmeters that will, in near real time, record and transmit water usage data to the URNRD during the irrigation season which generally lasts from approximately mid-to-late June through early September. The combination of equipment will allow the URNRD to monitor and better understand the relationship between volumes of water pumped for irrigation and groundwater levels in proximity to irrigation wells. As illustrated on the map, the wells are spread relatively evenly throughout the URNRD, providing broad geographical representation. Additionally, the wells are located in areas with different hydrogeological properties and varying thickness of the groundwater aquifer. For instance, some of the wells are located in regions where the movement of groundwater is

approximately 50 feet annually; other areas where groundwater moves 100-200 feet annually. Additionally, the density of irrigation wells near the monitoring wells varies significantly. In the central to west-central portion of the map, for example, you can see that the monitoring wells are in the midst of many irrigated crop fields that can be observed by their circular shape (almost all irrigated fields in the URNRD are irrigated by center-pivot systems that rotate in a circular motion) and dark green color. In the northeast and northwest portions of the map, for example, you will note that some of the monitoring wells are located in areas with a lower density of irrigation. And the southernmost well is located next to the Republican River, providing valuable information about aquifer levels in a localized area where there is a substantial connection between ground and surface water.

Importantly, most of the wells are located in areas where the saturated thickness of the aquifer is thinner, relatively speaking, than other areas of the URNRD and where there have been significant declines in groundwater levels over time. The southeasterly most monitoring well, for instance, is in an area with a relatively high density of groundwater irrigation wells and low saturated thickness where some irrigation wells have begun to show signs of declining output and under current usage rates may soon produce insufficient amounts of water to meet crop water demands during drought years.

To reduce water usage in such areas as the project proposes to make sufficient water available during drought periods, we must first answer the question: How much can water applications be reduced and still meet crop water needs? Answering this question will require, as part of the proposed project, installation of fully automated weather stations throughout the URNRD that calculate rates of evapotranspiration, or water use, for varying growth stages of crops predominant in the URNRD, namely corn. Evapotranspiration and weather related data will be electronically communicated to the URNRD. This will allow comparisons between rates of actual water applications by irrigators and what evapotranspiration data determines is actually needed to adequately sustain crops.

The comparisons of water applications from irrigators made available by real time flow meter information relayed with installation of equipment installed under the proposed project with crop water needs suggested by evapotranspiration data will guide URNRD decisions on adjustments to water use regulations with the intent of tightening regulations to ensure water availability during droughts. In addition, the URNRD will make the comparisons of actual, average water usage with crop water needs as determined by the evapotranspiration data available on its website, www.urnrd.org, and encourage irrigators to use the data to assess whether they are over-irrigating.

Water modeling tools paid for solely by the URNRD under the proposed project will combine groundwater level and water usage information so that analysis of water availability during

drought periods under different usage scenarios can be analyzed. For example, the model inputs may include groundwater level changes that occur under current usage rates as observed using the automated flow meters proposed under the project. This will help produce projections of whether under such conditions sufficient groundwater will be available to allow wells to yield water at rates adequate to meet high crop water demands during droughts. Levels of irrigation water applications less than current usages, but that analysis of evapotranspiration data determines is still adequate to meet crop water needs, may also be inserted into the model. The resulting information will refine our understanding of how much more water may be available during drought periods under varying regulatory schemes the URNRD has the authority to implement. Management of water supplies within the URNRD has the potential to improve significantly under the proposed project and will allow a more focused approach to water management. For instance, regulations to improve drought resiliency produced by the new information available to us could vary across the URNRD, customized to improve localized water availability during droughts based on analysis of information collected as described above.

As mentioned in the background section of this grant application, the saturated thickness of the aquifer in the URNRD ranges from approximately 50-400 feet. The variability will extend indefinitely the project's ability to create drought resiliency: Areas of low saturated thickness in the URNRD where water supplies are close to being insufficient during drought periods will benefit almost immediately from the project; for other areas that may experience continually declining water supplies, the project has the potential to over many years prolong the capability of wells to yield sufficient water during drought periods. It is also the hope and desire of the URNRD that the project will help achieve the goal of stabilizing, district-wide, groundwater levels to ensure water availability for crop production. While it's unreasonable to estimate the number of years the project will continue to provide benefits, it is reasonable to estimate that it will provide benefits for the foreseeable future, so long as irrigated agriculture is viable in the URNRD.

The URNRD has the authority to regulate all agricultural groundwater use within its boundaries and that use accounts for approximately 98-99 percent of all water use in the URNRD. The high percentage is largely due to the fact that human consumption of water by residents of the URNRD is only an estimated 800-1,000 acre feet annually and there is limited industry in the URNRD aside from an ethanol plant with an allocation of approximately 1,500 acre feet annually. Groundwater applied to irrigate crops, on the other hand, accounts for an annual average of approximately 430,000 acre feet. Relative, then, to the purposes for which water are used within the URNRD, the percentage of the total accessed water supply that could potentially be better managed within the URNRD is also 98-99 percent. There are no current estimates of the total quantity of groundwater within the URNRD. However, a USGS study in

1995 determined that the High Plains Aquifer underlying an area predominated by the URNRD contained approximately 168 million acre feet. It may seem unreasonable to claim that this is the total quantity of water that could be better managed under the project, but it does in fact represent our best estimate to date of the water available in the URNRD and, as stated above, approximately 98-99 percent of all water uses within the district are overseen by the URNRD. Another way to view total quantity of water that has the potential to be better managed by the project is to count only that portion of the aquifer that that can produce enough water volume with which to irrigate. The general rule is that approximately half of the saturated thickness of an aquifer can yield sufficient water to irrigate, reducing the total amount of water that could be better managed to roughly 80 million acre feet.

Another consideration for the purpose of quantifying water that can be better managed is that approximately 25 percent of the total land mass within the URNRD is irrigated. Since there is a moratorium on new irrigation wells, one could also conclude that the volume of water subject to potential improved management within the URNRD is roughly 25 percent of the 168 million acre feet estimated to be present, or about 40 million acre feet.

The project does have the potential to benefit fish, wildlife and the environment to the extent that additional restrictions on groundwater pumping to improve availability during droughts are imposed in areas where groundwater pumping has relatively significant and immediate impacts on stream flows. In some areas immediately adjacent to the Republican River, which is the main stream in the URNRD, modeling indicates that up to 90 percent of groundwater pumped to irrigate crops would otherwise result in stream flow over a two-year period if not for irrigation. In tributaries of the Republican River throughout the URNRD the high end of the percentage impact on stream flow is generally lower than 90 percent but still significant – upwards of 70 percent to 80 percent adjacent to some tributaries. To the extent that water-saving regulations to make more water available during drought will be established where impacts to stream flow from groundwater pumping are significant, the proposed project could help increase stream flow, aiding fish and wildlife in the region.

The significance of the proposed project can be best described as a new realm of water management for the URNRD where increased understanding and analysis of the relationship between actual water usage, crop water needs and groundwater availability for drought periods will inform management decisions that to date have been based primarily on a general desire to reduce water usage. It has the potential to be one of the most, if not the most substantial change to the URNRD's approach to water management since the URNRD began regulating water use 37 years ago. As described in the section below, the proposed project meets goals and objectives of the State of Nebraska's Drought Mitigation and Response Plan and has the ability to help prevent economic instability in a region that relies heavily on

irrigated agriculture, domestic water supply problems for rural residents, and societal decay caused by economic and other disruptions induced by drought.

Water measurement tools and methods to be utilized under the project are proven, including the Water Balance or Checkbook Method that is a well-known tool for irrigation scheduling. The premise of the tool is to balance water being extracted from the soil (via evaporation and plant transpiration) with water being added to the soil (via irrigation and rainfall). Typically, automated weather stations are used to measure specific environmental conditions and then specific formulas are used calculate reference evapotranspiration (ET_o) and/or estimate effective rainfall. In addition, crop specific coefficients (K_c) can be applied to ET_o values to fine tune water use based upon ET_c. When used consistently with reliable field data, the water balance index can show growers how closely their irrigation practices are meeting the current plant water use demand.

Historically, automated weather stations or weather services have collected regional weather data and produce reasonable reference ET_o indexes. However, regional rainfall measurements may not reflect field precipitation events, and in many cases growers use estimates of irrigation rather than true measurements from flow meters. The effectiveness of the water balance equation is reduced with less accurate inputs.

This project will implement a unique digital tool that increases the accuracy and simplifies the data collection and water balance calculations for growers. All three major inputs into the Water Balance Equation – crop water use from weather stations or ET gauges, rainfall from rain gauges and irrigation depth from flow meters – are automatically collected for the grower every day. User-entered information; crop coefficients, irrigated acres, and application efficiency, is required to start the process each season, allowing irrigators to calibrate the information to their specific field and irrigation system. The regular measurement and collection of the data is taken care of by flow meters and wireless systems. A real time water balance index and other information will be easily accessed via the web through a cloud-based system or via the new Connect TrendView app for either iPhone or Android.

This project will demonstrate how farmers can improve upon or maintain current yields while using less water. This will be achieved by the implementation of near real-time monitoring of irrigation water applied and the correlation with locally measured ET data as described in this proposal. Past studies have shown water savings ranging from 1% - 50% using similar technology (Buchleiter, 1996) (Kranz, 1992) (Varble, 2011). ADD DROUGHT

Evaluation Criterion B – Drought Planning and Preparedness

The State of Nebraska's Drought Mitigation and Response Plan (Appendix A) was developed in response to severe droughts that highlighted the need to improve the effectiveness of previous plans and create continuity between administrations by establishing a Climate Response and Assessment Committee (CARC).

Among other duties, CARC provides timely and systematic data collection, analysis and dissemination of information about drought and other severe climate occurrences to the Nebraska Governor and others. The current drought plan places greater emphasis on mitigating drought impacts and was developed by multiple stakeholders including: The Nebraska Department of Agriculture; the Nebraska Department of Natural Resources; the Nebraska Health and Human Services System; the Nebraska Emergency Management Agency; University of Nebraska Cooperative Extension Service; University of Nebraska Conservation and Survey Division; livestock producers, crop producers; and the Governor's Policy Research Office.

Among the entities that the plan specifically mentions as having a role in aiding with drought mitigation are Natural Resources Districts such as the URNRD.

Two of the eight prioritized drought impacts cited in the drought plan are specifically related to the URNRD's proposed project: water quantity problems at private wells; and aquifer overdrafts affecting rural and municipal water supplies. Regarding the first impact, the plan prioritizes and encourages NRDs such as URNRD to evaluate water quantity and quality and emphasizes indoor and outdoor conservation measures. The proposed project includes these actions through implementation of real-time groundwater monitoring that will aid in assessment of whether adjacent, private wells are at risk of having water quantity problems. Additionally, through development of an online tool that will encourage irrigators to apply no more water than what is necessary to meet crop water needs, the project will meet the plan's goal of emphasizing water conservation measures.

As for aquifer overdraft impacts prioritized in the drought plan affecting rural and municipal water supplies, the plan recommends that NRDs and others promote groundwater metering efforts and establish an emergency allocation program. The plan also recommends NRDs and others encourage statewide water level measurement programs to effectively monitor aquifer levels. The proposed project meets the first objective by not just encouraging groundwater metering efforts, but actually implementing meters that can help produce management actions, such as emergency allocations (limits on water use) during drought periods. The main intent of the proposed project is to prevent drought impacts by taking and encouraging management actions that make more water available than what otherwise would have been, informed by data collection and modeling described in the previous section. However, the

groundwater level information will also create the potential for establishing an emergency allocation program during a drought if need be to protect domestic water supplies. Modeling developed as part of the project will help determine how much decline in water levels can occur in proximity to domestic supplies without jeopardizing access to water.

Another drought impact the plan seeks to mitigate and that the proposed project addresses is increased irrigation pumping from aquifers that may lower water levels and decrease pumping rates, resulting in less capacity to meet crop needs and decreasing the profitability of irrigated crops during droughts. The project seeks to prevent aquifer levels from lowering to the point that pumping rates, i.e. well production, during droughts decrease enough that irrigation applications cannot keep up with crop water needs. This will primarily be achieved, as described in the previous section, by developing regulations and encouraging irrigation decisions by farmers that help ensure irrigation use does not exceed crop water needs in all periods – namely non-drought periods – so that sufficient water vis available during droughts. This proposed action is more extensive than the drought plan's proposal that NRDs maintain water-level measurement programs to monitor declining water levels.

The Nebraska Drought Mitigation and Response Plan also includes a classification of drought-related impacts that do not include recommended mitigation actions but which the proposed project addresses. Among them: Loss of farmers through bankruptcy; general income loss; losses to agricultural-related businesses; disruption of water supplies; unemployment from drought-related production declines; strain on financial institutions; conflicts between water users; decreased quality of life in rural areas; increased poverty; and population migration from rural to urban areas.

The impacts listed above all have the potential to be mitigated by the proposed project because it will reduce occurrences of water shortages during droughts.

Evaluation Criterion C – Severity of Actual or Potential Drought Impacts to be Addressed by the Project

Sectors at risk of being impacted by drought within the region include agriculture, industry, and business. It is difficult to overstate the importance of irrigated agriculture to the region; it touches nearly all economic and societal aspects of the region. A prolonged drought period(s), made more likely by climate change and not mitigated by preventative actions could severely threaten the viability of the region. A history of major depopulation following droughts provides some examples of this. During a severe drought in the 1890's, for example, the population of the three counties within the URNRD dropped by nearly half, from approximately 18,000 residents to 9,000. That is roughly the current population of the three-county region.

The development of groundwater irrigation in the area of course created some resiliency to drought that has successfully sustained the region for more than 40 years. But as described earlier, preservation of water in areas where groundwater levels have declined significantly and/or where little remaining aquifer saturated thickness exists, is becoming increasingly important to ensure such resiliency remains. The semi-arid climate of the area – rainfall averages 17-20 inches annually, with often severe year-to-year fluctuations – creates marginal conditions for non-irrigated crop production. This is evident in average crop yields, where irrigated corn yields in the URNRD, for example, average approximately 100 bushels more per acre than on non-irrigated land. There are approximately 50,000 more acres of irrigated cropland in the URNRD than non-irrigated cropland.

A 2007 study by the University of Nebraska-Lincoln Bureau of Business Research provides indications of how significant reductions in water usage would impact the economy of the area. According to the report, a 15 percent reduction in irrigation in upland areas of the URNRD (comprising approximately 400,000 irrigated acres) and 40 percent reduction in irrigation in areas adjacent to streams (approximately 40,000 acres) would annually reduce crop sales by more than $23 million due to reduced crop production. Annual economic output, measured in business receipts, would decline by an estimated $27 million under the same scenario. Labor income would decline by an estimated $15 million. The latter figure represents loss of income to farmers and employment and labor income at businesses.

Loss of revenue to government entities including schools would also decline due to a projected decline in property values. Total lost property value in the URNRD estimated in the report would be about $102 million, with a resulting loss of approximately $1.3 million in tax revenue.

The irrigation reductions used to estimate economic impacts in the report were based on potential regulations considered at the time to ensure compliance with an interstate compact during dry periods. Modeling that will be conducted as part of the study will help determine what level of irrigation reductions due to water shortages would occur during droughts lacking mitigation actions as proposed to be developed as part of the project, but the 15 percent and 40 percent reductions assumed in the study may well be in the realm of what could be expected lacking mitigation action.

Of the approximately 9,000 residents within the URNRD, approximately 45 percent of them live outside a city or village and rely upon private domestic wells for their water supplies. To date, significant water shortages at these residences have not occurred during drought periods but they are at the most risk of facing shortages during future droughts. The risk, similar to that posed to irrigators, varies significantly depending on the saturated thickness of the aquifer where they are located. Risk variability also exists due to the different depths at which wells are drilled. The proposed project presents the opportunity to assess domestic well depths relative

to aquifer saturated thickness, groundwater level changes and adjacent irrigation usage monitored under the project to help determine the risk of water shortages to residents during droughts. In many cases, such an assessment may conclude that drilling a domestic well to a deeper depth will help prevent water shortages once drought occurs. But in other cases it may indicate that development of special restrictions on irrigation usage near domestic wells is justified to protect domestic water supplies during drought. Besides preventing shortages during drought, such an approach would reduce conflicts between irrigators and residents during dry periods.

As for potential conflicts between irrigators, well-spacing regulations implemented by the URNRD in the 1980's have thus far helped prevent them. But emerging conflicts between groundwater irrigators in other heavily irrigated areas facing declining water supplies, such as southwest Kansas, present a cautionary tale. A better understanding of groundwater availability under different pumping scenarios achieved by the project will help us assess what types of regulatory measures or management actions are needed to mitigate impacts one neighbor's pumping has on another, therefore preventing conflicts during droughts.

The proposed project comes on the heels of one of the most severe droughts in the URNRD and Nebraska since precipitation and other weather-related data began being collected in the state. The onset of the drought was 2012, which was the driest, on average, ever recorded in Nebraska. As the maps below illustrate, the URNRD and adjoining areas of southwest and south-central Nebraska, along with part of the panhandle of the state, were impacted for a longer duration than any other region of the state. In August 2012, almost the entire state was classified as being in an extreme or exceptional drought (exceptional being the most severe of all classifications). The northernmost county in the URNRD, Perkins County, was among those in the state classified as being in exceptional drought at that time. The rest of the URNRD was in extreme drought.

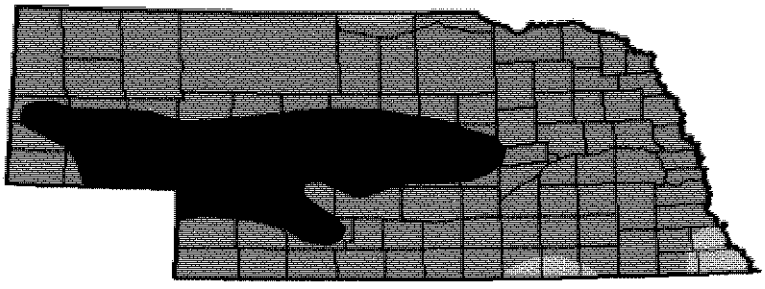
By August 2013, the drought had eased enough across most of the state for it to be considered in a moderate drought. Most of the URNRD, however, was still in an extreme drought. In 2014, most of the state had emerged from drought conditions completely. Dryness persisted in the URNRD at that time; most of the district was still classified as abnormally dry. The URNRD was out of drought conditions in 2015 and at this time still is. There are concerns that the current El Nino-induced weather system will transition into a La Nina system later this year and cause drought conditions again.

The maps provided below and on the following page are U.S. Drought Monitor maps jointly produced by the National Drought Mitigation Center at the University of Nebraska-Lincoln, the

United States Department of Agriculture, and the National Oceanic and Atmospheric Administration. Maps are courtesy of NDMC-UNL.

U.S. Drought Monitor

Nebraska



August 28, 2012

(Released Thursday, Aug. 30, 2012)

Valid 7 a.m. EST

Drought Conditions (Percent Area)

	None	D0-D4	D1-D4	D2-D4	D3-D4	D4
Current	0.00	100.00	100.00	100.00	97.21	23.33
Last Week 8/21/2012	0.00	100.00	100.00	100.00	98.30	22.53
3 Months Ago 5/29/2012	56.19	43.81	18.79	0.00	0.00	0.00
Start of Calendar Year 1/3/2012	71.68	28.32	13.81	0.66	0.00	0.00
Start of Water Year 9/27/2011	75.70	24.30	0.00	0.00	0.00	0.00
One Year Ago 8/30/2011	94.21	5.79	0.00	0.00	0.00	0.00

Intensity:

- D0 Abnormally Dry
- D1 Moderate Drought
- D2 Severe Drought
- D3 Extreme Drought
- D4 Exceptional Drought

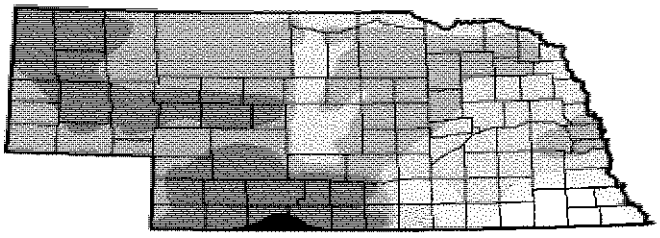
The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. See accompanying text summary for forecast statements.

Author:
Brian Fuchs
National Drought Mitigation Center

http://droughtmonitor.unl.edu/

U.S. Drought Monitor

Nebraska



August 27, 2013

(Released Thursday, Aug. 29, 2013)

Valid 7 a.m. EST

Drought Conditions (Percent Area)

	None	D0-D4	D1-D4	D2-D4	D3-D4	D4
Current	3.38	96.62	90.58	67.73	26.39	0.78
Last Week 8/20/2013	3.38	96.62	90.72	65.78	26.38	0.78
3 Months Ago 5/28/2013	2.61	97.49	93.34	76.75	39.34	4.02
Start of Calendar Year 1/1/2013	0.00	100.00	100.00	100.00	96.20	77.46
Start of Water Year 9/25/2012	0.00	100.00	100.00	100.00	97.94	73.25
One Year Ago 8/28/2012	0.00	100.00	100.00	100.00	97.21	23.33

Intensity:

D0 Abnormally Dry
D1 Moderate Drought
D2 Severe Drought
D3 Extreme Drought
D4 Exceptional Drought

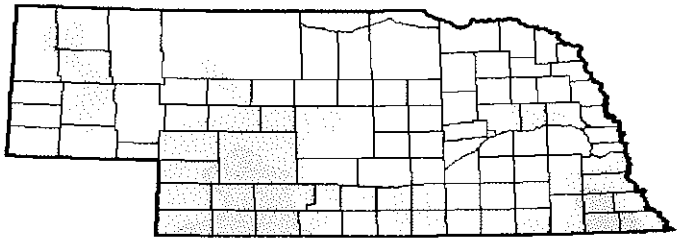
The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. See accompanying text summary for forecast statements.

Author:
Anthony Artusa
NOAA/NWS/NCEP/CPC

http://droughtmonitor.unl.edu/

U.S. Drought Monitor

Nebraska



August 26, 2014

(Released Thursday, Aug. 28, 2014)

Valid 8 a.m. EDT

Drought Conditions (Percent Area)

	None	D0-D4	D1-D4	D2-D4	D3-D4	D4
Current	68.30	31.70	7.13	0.01	0.00	0.00
Last Week 8/19/2014	63.58	36.42	5.73	0.01	0.00	0.00
3 Months Ago 5/27/2014	23.09	76.91	62.39	30.87	7.07	0.00
Start of Calendar Year 1/30/2013	13.69	86.32	47.63	26.68	4.76	0.00
Start of Water Year 10/1/2013	3.22	96.78	95.48	49.34	6.80	0.00
One Year Ago 8/27/2013	3.38	96.62	90.58	67.73	26.39	0.78

Intensity:

D0 Abnormally Dry
D1 Moderate Drought
D2 Severe Drought
D3 Extreme Drought
D4 Exceptional Drought

The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. See accompanying text summary for forecast statements.

Author:
David Simeral
Western Regional Climate Center

http://droughtmonitor.unl.edu/

Evaluation Criterion D – Project Implementation

Upon the successful award of this project, URNRD will contract with a telemetry provider to supply the telemetry equipment for monitoring ET, groundwater levels, and groundwater pumping.

URNRD staff will supply necessary information on wells, meters, and weather station locations. Telemetry professionals will supervise the installation of equipment to ensure proper installation, reporting and performance of all telemetry equipment.

Field installation of telemetry equipment for this project will begin immediately after the cooperative agreement is signed in summer, 2016. The first equipment installed will be the weather stations and the groundwater level monitoring equipment and approximately 10% of the automated meter reading equipment. The remaining telemetry equipment will be installed irrigation flow meters in the fall and winter of 2016 and throughout 2017.

Work to develop a groundwater model for the URNRD utilizing inputs from the monitoring equipment described in this proposal will likely begin in fall or winter 2016. This groundwater model will assist in integrating the ET, groundwater level monitoring, precipitation, and groundwater pumping data to develop forward-looking strategies that can inform regulation changes.

The final report will be completed by June, 2018.

Evaluation Criterion E – Nexus to Reclamation

The proposed project is in the same basin – the Republican Basin – as some Reclamation projects:

Enders Reservoir, which has historically served Frenchman Valley Irrigation District.

Swanson Reservoir, serving Frenchman-Cambridge Irrigation District

Hugh Butler Lake, serving Frenchman-Cambridge Irrigation District

Harry Strunk Lake, serving Frenchman-Cambridge Irrigation District

Harlan County Lake, serving Nebraska Bostwick and Kansas Bostwick Irrigation Districts

The URNRD does not receive Reclamation water and is not on Reclamation lands. To the extent that reduced groundwater under the project will increase stream base flow, it will contribute water to Reclamation projects.

The URNRD has previously received a WaterSMART grant and entered into an agreement with Reclamation in 2012 to conduct a program that implemented soil moisture probes within the URNRD. The project was successfully completed in 2014.

Performance Measures

The URNRD will be able to quantify additional volumes of water that can be made available during drought periods from additional regulations and/or management actions that would be an outcome of analysis of groundwater level, groundwater use, evapotranspiration and modeling tools described in this proposal.

Groundwater level changes caused by pumping under status quo regulatory conditions will be analyzed, with aid from modeling developed under the project, in comparison to groundwater level changes and availability caused by lower pumping levels that evapotranspiration data collected as part of the project suggests are reasonable without causing significant crop yield reductions. Special focus will be given to the impact different regulatory scenarios have on regions of the District where low saturated aquifer thickness exists, significant groundwater declines have occurred and there is a high density of groundwater wells, especially in proximity to domestic wells with a higher risk of experiencing water shortages during drought periods.

The project will permit an ongoing analysis and quantification well beyond the two-year project period and into the foreseeable future of additional water supplies that can be made available during drought periods by regulations and/or management actions that the project will allow to be developed for consideration by the URNRD.

Additionally, the URNRD has annual water usage data for every irrigation well in the URNRD since 1979, allowing quantification of additional water made available during drought periods compared to what would have been available assuming average, previous usage.

The number of irrigators in the URNRD is a known quantity. The URNRD will be able to gauge the adoption of the practice of implementing the Real-Time Water Balance Method by the issuance of log-in IDs and passwords to the water management database, monitoring attendance at URNRD meetings and other public events.

Environmental and Cultural Resources Compliance

- Will the project impact the existing environment? No, no earth-disturbing work affecting water, animals or water will be done.
- Are there any species listed as Federal threatened or endangered, or designated critical habitat in the project area? The Red Knot is a federally listed threatened species within Dundy County and the Whooping Crane is a federally listed endangered species within

Perkins and Chase Counties. Would they be affected by any activities associated with the project? No

- Are there any wetlands or other surface waters inside the project area that potentially fall under CWA jurisdiction as Waters of the United States? Yes, but none will be impacted as no project equipment will be installed on such lands.
- When was the water delivery system constructed? The water delivery system consists of privately owned groundwater wells constructed from the 1950's through the mid 1990's.
- Will the proposed project result in any modification of or effects to features of an irrigation system? Existing flowmeters on irrigation wells will be modified with transmitters and telemetry equipment for remote monitoring of water use. Irrigation systems will not be modified, just the meter for improved water management. Are any buildings, structures, or features in the irrigation district listed or eligible for listing on the National Register of Historic Places? No
- Are there any known archeological sites in the proposed project area? No
- Will the proposed project have a disproportionally high and adverse effect on low income or minority populations? No, the project may help them by sustaining the economy of the region.
- Will the proposed project limit access to and ceremonial use of Indian sacred sites or result in other impacts on tribal lands? No
- Will the proposed project contribute to the introduction, continued existence, or spread of noxious weeds or non-native invasive species known to occur in the area? No

Drought Plan

The drought plan is included in the application materials as **Appendix A.**

Required Permits or Approvals

The only permit or approval required by the URNRD would be an FCC license, at minimal cost, to obtain a radio frequency in the event that a radio network was pursued for its mode of communications instead of cellular. At this time, it is expected that cellular communications will be used.

Letters of Support

Letters of support for the project from the following organizations are included in **Appendix B** of the application materials: National Drought Mitigation Center; University of Nebraska-Lincoln Institute of Agriculture and Natural Resources; State of Nebraska Department of Agriculture; Republican River Restoration Partners; and the Nebraska Water Balance Alliance.

Appendix 15

University of Nebraska Lincoln

SCHOOL OF NATURAL RESOURCES
National Drought Mitigation Center

April 4, 2016

Nate Jenkins, Assistant Manager
Upper Republican Natural Resources District
PO Box 1140
Imperial, NE 69033

Dear Mr. Jenkins:

Please accept this letter as formal support for the Upper Republican Natural Resources District's Drought Mitigation and Groundwater Management project. The proposed project attempts to meet goals contained in Nebraska's Drought Mitigation and Response Plan and I am hopeful it can be pursued with aid from the U.S. Bureau of Reclamation's WaterSMART Drought Resiliency program.

The project has the potential to limit irrigation and domestic water shortages during droughts by identifying opportunities to reduce water usage during drought and non-drought periods alike, making more water available during dry events. The additional groundwater level and water usage monitoring the project proposes, coupled with your NRD's ability to adjust water usage regulations, could produce valuable drought mitigation tools to protect residents, the economy of the area, and sustain water resources—thereby increasing the overall drought resilience of the region.

The National Drought Mitigation Center (NDMC) has had extensive experience working with the Bureau of Reclamation, Nebraska's Climate Assessment and Response Committee (CARC) and, more recently, with the National Drought Resilience Partnership (NDRP). This project is perfectly aligned with the long-term goals of each organization and recognizes the important role groundwater use has with the agricultural, environmental, and water supply sectors within the NRD. The effective proactive planning and timely responses within these sectors require consistent, high-quality information from a monitoring system that addresses the unique climate, hydrology, and socio-economic characteristics of the Upper Republican NRD region. In addition, I am confident that the lessons learned from this project would be applicable in other locations around the country.

Again, I support the proposed project and am hopeful it is funded by the U.S. Bureau of Reclamation's Drought Resiliency program. I look forward to hearing about its progress and please let me know if you have questions or if the NDMC can provide assistance in the future.

Sincerely,

Michael J. Hayes

Michael J. Hayes, Ph.D.
Director, National Drought Mitigation Center
Professor, School of Natural Resources

3310 Holdrege Street / 819 Hardin Hall / P.O. Box 830988 / Lincoln, NE 68583-0988
(402) 472-4271 / FAX (402) 472-2946 / E-mail: mhayes2@unl.edu / http://drought.unl.edu

University of Nebraska Lincoln

INSTITUTE OF AGRICULTURE AND NATURAL RESOURCES
OFFICE OF THE NU VICE PRESIDENT AND HARLAN VICE CHANCELLOR

April 4, 2016

U.S. Bureau of Reclamation
Denver Federal Center
Building 67, Room 152
6th Avenue and Kipling Street
Denver, CO 80225

To Whom It May Concern:

Please accept this letter as a formal expression of support from the University of Nebraska-Lincoln, Institute of Agriculture and Natural Resources, for the Upper Republican Natural Resources District's proposed Drought Mitigation and Groundwater Management Project. The semi-arid climate of the region, high concentration of groundwater irrigation, and projections that droughts may become more prolonged and severe, make projects such as the one proposed essential to ensuring plentiful water is available during future drought periods.

The University of Nebraska-Lincoln is currently involved in research projects in the region, some in partnership with the Upper Republican NRD, designed to increase water availability and drought resiliency in the region. The real-time water usage, groundwater level, weather, and evapotranspiration data that will be available to the University as part of the proposed project would significantly aid these ongoing efforts and would potentially create new research and outreach opportunities focused on drought resiliency.

I urge you to fund the proposed project as applied for by the Upper Republican NRD under the Bureau of Reclamation's WaterSMART Drought Resiliency program.

Sincerely,

Ronnie D. Green
Vice President, University of Nebraska
IANR Harlan Vice Chancellor, University of Nebraska-Lincoln

Ronald E. Yoder
Associate Vice Chancellor

202 Agricultural Hall / P.O. Box 830708 / Lincoln, NE 68583-0708 / (402) 472-2871 / FAX (402) 472-5854

Pete Ricketts
Governor

STATE OF NEBRASKA

Department of Agriculture
Greg Ibach
Director
P.O. Box 94947
Lincoln, NE 68509-4947
(402) 471-2341
Fax: (402) 471-6876
www.nda.nebraska.gov

April 6, 2016

Nate Jenkins, Assistant Manager
Upper Republican Natural Resources District
PO Box 1140
Imperial, Nebraska 69033

Dear Mr. Jenkins:

The Nebraska Department of Agriculture (NDA) would like to express its support for the Upper Republican Natural Resources District's proposed Drought Mitigation and Groundwater Management Project.

NDA helps lead efforts in Nebraska to mitigate the impacts of drought and currently chairs the state's Climate Assessment and Response Committee. The committee developed Nebraska's Drought Mitigation and Response Plan and is charged under Nebraska state law with providing timely and systematic data collection, analysis and dissemination of information about drought to the Governor and interested parties, among several other duties. The committee includes representatives of government agencies, climate and drought experts, and private stakeholders.

Nebraska's agriculturally-based economy demands comprehensive efforts to increase drought resiliency, and your proposed project has the ability to significantly aid these efforts. Specifically, the additional understanding between groundwater pumping for irrigation and groundwater levels, coupled with modeling planned under the project, will aid in the development of regulations to make more water available during drought periods. This will help protect agriculture in a productive three-county region of Nebraska and water resources for generations to come.

Natural Resources Districts have an important role in Nebraska's drought plan, and the proposed project meets goals and objectives contained in the plan including preventing both water quantity problems at private wells and aquifer overdraft that can limit irrigation potential during droughts.

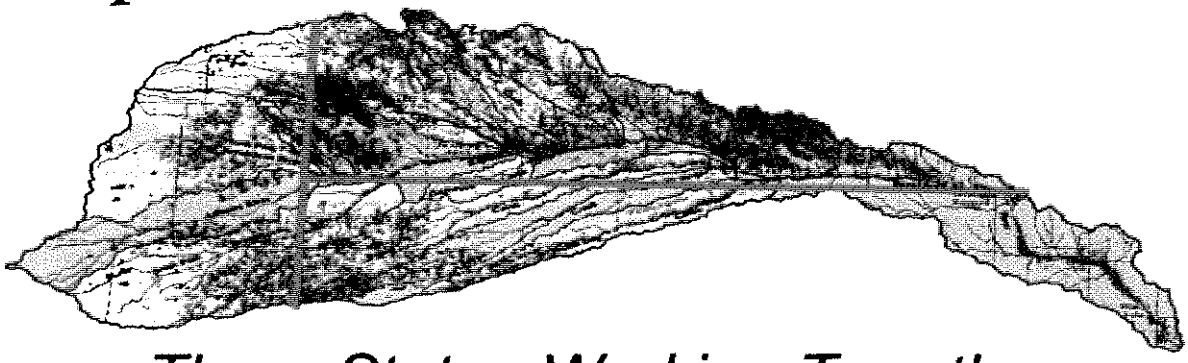
We support your efforts to obtain U.S. Bureau of Reclamation grant funding for the project.

Sincerely,

NEBRASKA DEPARTMENT OF AGRICULTURE

Greg Ibach
Director

Republican River Restoration Partners



Three States Working Together to Achieve Future Benefits

Mar 31, 2016

US Bureau of Reclamation
Denver Federal Center
Building 67, R00m 152
6th Ave & Kipling St
Denver, CO 80225

To: Whom it may concern

The Republican River Restoration Partners (RRRP) representing Colorado, Kansas and Nebraska is requesting your support for the Upper Republican Natural Resource District's (URNRD) proposed Drought Mitigation and Groundwater Management Project.

The URNRD serves an area that has a significant portion of its irrigation derived from ground water. Drought and reduced precipitation over a prolonged period would have a major impact on the economic future for the people living in the URNRD service area. Exploring and identifying options to reduce risk would be beneficial to the district.

We have observed several University of Nebraska projects conducted in the district in partnership with the URNRD designed to measure real time pumpage and evapotranspiration (ET) on a limited bases to see if the equipment functioned properly.

The proposed WaterSmart Drought Resiliency project would expand measuring in real time water table changes, real time pumpage and changes in ET to better understand what happens in a drought and what should be done to reduce risk.

Ted Tietjen

Ted Tietjen, Chairman
Republican River Restoration Partners
32726 Hwy 23
Grant, NE 69140

Nebraska Water Balance Alliance
Roric Paulman, Chairman
28042 West Power Rd
Sutherland, NE 69165

March 31, 2016

US Bureau of Reclamation
Denver Federal Center
Building 67, R00m 152
6th Ave & Kipling St
Denver, CO 80225

To: Whom it may concern

The Nebraska Water Balance Alliance (NEWBA) is supporting the Upper Republican Natural Resource District's (URNRD) proposed Drought Mitigation and Groundwater Management Project.

NEWBA has for several years worked with growers on demonstration projects in the URNRD and found that drought and reduced precipitation had a major impact on the economic viability of the URNRD service area. Utilizing some of the new technology tools developed by industry and University of NE would if applied properly reduce much of the risk associated with drought stress.

We would encourage approving the proposed WaterSmart Drought Resiliency project to expand measuring in real time water table changes, real time pumpage and changes in ET to better understand what happens under drought stress conditions. Then develop strategies based on what was learned in the project to reduce risk.

Sincerely Yours,

Roric Paulman, Chairman

Appendix C

RESOLUTION OF THE UPPER REPUBLICAN NATURAL RESOURCES DISTRICT

Resolution No. UR-2016-4-05-01

WHEREAS, the Board of Directors agrees that Jasper Fanning, General Manager of the Upper Republican Natural Resources District, and Nate Jenkins, Assistant Manager, have legal authority to enter into an agreement with the U.S. Bureau of Reclamation to execute provisions of the WaterSMART Drought Resiliency Project Grant program; and

WHEREAS, Management of the Upper Republican Natural Resources District has reviewed and supports the application for WaterSMART Grant funds; and

WHEREAS, the Upper Republican Natural Resources District is a political subdivision of the State of Nebraska and as such has taxing authorities and current budgetary capabilities sufficient to provide the amount of funding specified in the WaterSMART Grant application funding plan; and

WHEREAS, the Upper Republican Natural Resources District agrees to work with the U.S. Bureau of Reclamation to meet established deadlines for entering into a cooperative agreement.

NOW, THEREFORE, be it resolved, that the Upper Republican Natural Resources District Board of Directors authorizes Management of the District to meet legal and financial obligations required under the U.S. Bureau of Reclamation's WaterSMART Drought Resiliency Project Grant Program.

Terry L. Martin

Terry Martin, Chairman

April 5, 2016

Date Approved