NEBRASKA NATURAL RESOURCES COMMISSION

Water Sustainability Fund

Application for Funding

Section A.

ADMINISTRATIVE

PROJECT NAME: Characterization of Groundwater Recharge and Nitrate Transport Dynamics in the Unsaturated Zone Using Hydrologic Models

PRIMARY CONTACT INFORMATION

Entity Name: Central Platte Natural Resources District

Contact Name: Brandi Flyr

Address: 215 Kaufman Ave

Phone: 308-385-6282

Email: flyr@cpnrd.org

Partners / Co-sponsors, if any: Click here to enter text.

1. Dollar amounts requested: (Grant, Loan, or Combination)

   Grant amount requested. $ 87,540

   Loan amount requested. $ Click here to enter text.

   If Loan, how many years repayment period? Click here to enter text.

   If Loan, supply a complete year-by-year repayment schedule.
   Click here to enter text.

2. Permits Needed - Attach copy for each obtained (N/A = not applicable)

Nebraska Game & Parks Commission (G&P) consultation on Threatened and Endangered Species and their Habitat	N/A☒	Obtained: YES☐ NO☐

Surface Water Right	N/A☒	Obtained: YES☐	NO☐
USACE (e.g., 404 Permit)	N/A☒	Obtained: YES☐	NO☐
Cultural Resources Evaluation	N/A☒	Obtained: YES☐	NO☐
Other (provide explanation below)	N/A☒	Obtained: YES☐	NO☐

Click here to enter text.

3. Are you applying for funding for a combined sewer over-flow project?

   YES☐ NO☒

   If yes, do you have a Long Term Control Plan that is currently approved by the Nebraska Department of Environmental Quality?

   YES☐ NO☒

   If yes attach a copy to your application. Click here to enter text.

   If yes what is the population served by your project? Click here to enter text.

   If yes provide a demonstration of need. Click here to enter text.

   If yes and you were approved for funding in the most recent funding cycle, then resubmit the above information updated annually but you need not complete the remainder of the application.

4. If you are or are representing an NRD, do you have an Integrated Management Plan in place, or have you initiated one?

   N/A☐ YES☒ NO☐

5. Has this application previously been submitted for funding assistance from the Water Sustainability Fund and not been funded?

   YES☒ NO☐

   If yes, have any changes been made to the application in comparison to the previously submitted application? Yes

   If yes, describe the changes that have been made since the last application.
   The model being developed would also address the water quality aspects of movement of Nitrates in the vadose zone.

No, I certify the application is a true and exact copy of the previously submitted and scored application. (Signature required) Click here to enter text.

6. Complete the following if your project has or will commence prior to next July 1st.

As of the date of submittal of this application, what is the Total Net Local Share of Expenses incurred for which you are asking cost share assistance from this fund? $ *0.00*

Attach all substantiating documentation such as invoices, cancelled checks etc. along with an itemized statement for these expenses. Click here to enter text.

Estimate the Total Net Local Share of Expenses and a description of each you will incur between the date of submittal of this application and next July 1st for which you are asking cost share assistance from this fund.
$ 87,540.00

Section B.

DNR DIRECTOR'S FINDINGS

Does your project include physical construction (defined as moving dirt, directing water, physically constructing something, or installing equipment)?

YES☐ NO☒

1(a). If yes (structural), submit a feasibility report (to comply with Title 261, CH 2) including engineering and technical data and the following information:

A discussion of the plan of development (004.01 A);
Click here to enter text.

A description of all field investigations made to substantiate the feasibility report (004.01 B); Click here to enter text.

Maps, drawings, charts, tables, etc., used as a basis for the feasibility report (004.01 C); Click here to enter text.

A description of any necessary water and land rights and pertinent water supply and water quality information, if appropriate (004.01 D);
Click here to enter text.

A discussion of each component of the final plan including, when applicable (004.01 E);

Required geologic investigation (004.01 E 1); Click here to enter text.

Required hydrologic data (004.01 E 2); Click here to enter text.

Design criteria for final design including, but not limited to, soil mechanics, hydraulic, hydrologic, structural, embankments and foundation criteria (004.01 E 3). Click here to enter text.

1(b). If no (non-structural), submit data necessary to establish technical feasibility including, but not limited to the following (004.02):

A discussion of the plan of development (004.02 A);

The purposes of this project are twofold: (a) developing an integrated hydrologic model that accounts for nitrate transport and its associated recharge process in the unsaturated zone, (b) providing a scientifically defensible estimation of groundwater nitrate leaching and recharge flux at high spatial resolution and different time scales. Groundwater recharge is a hydrologic process where water moves downward from land surface to aquifer. Groundwater recharge, affected by

both natural and human factors, is the primary source replenishing the groundwater storage as well as the carrier of contaminants. Accurate account of groundwater recharge process is a critical step to implement programs of water resources planning and management (Scanlon et al., 2007). However, the estimation of groundwater recharge has been regarded as a technically challenging task due to various key physical and hydrogeologic processes and their complex interplay associated with the unsaturated zone (i.e., vadose zone). Unsaturated zone, defined as the part of earth between land surface and groundwater table, serves as the intermedia for surface water, groundwater and the atmosphere (Romano et al., 2012). Water contents in the unsaturated zone is of high spatiotemporal variability due to the combined effects induced by factors such as precipitation, soil properties, drainage, irrigation, flooding and groundwater depth (Overgaard et al., 2006). Rossman et al. (2014) pointed out that high spatial variability of unsaturated zone thickness and spatio-temporal variability of climatic conditions both influence the distribution and magnitude of groundwater recharge at the water table. Ling and El-Kadi (1998) found that the complex processes dominating the fate of nitrate in soils affect accurate prediction of nitrate leaching. These studies have identified limited vadose zone information as critical problems for modeling and assessment. Thus, comprehensive and accurate representation of unsaturated zone fluxes is beneficial to better understanding of the recharge and nitrate leaching process. However, the recharge flux in the unsaturated zone is strongly simplified in both groundwater and surface hydrologic models due to challenges, such as extensive data requirement, computational expense and lack of efficient and accurate numerical solutions (Partington et al., 2013). Such simplification often leads to inaccuracy and lack of spatial-temporal variability in estimated recharge and contaminant flux at the basin or regional scales. As one of the most important models developed for the Platte River Basin, the Cooperative Hydrology Study (COHYST) model has been used with exceptional frequency to understand the hydrogeologic conditions and make water resource decisions by the CPNRD. However, water movement in the unsaturated zone was generally neglected in its recharge estimation using the soil-water balance model (i.e., the CROPSIM model). In the COHYST modeling project, water passing through the root zone was assumed to arrive at the groundwater table immediately. Thus, the impacts of unsaturated soil profile between the root zone and groundwater table on the recharge process were not considered. However, the effects of unsaturated zone can be substantial to the timing, amount and spatial variability of groundwater recharge (Rossman et al., 2014). The unsaturated zone water movement study conducted by the U.S. Geological Survey (Steele et al., 2014) in the CPNRD also indicated high variability of groundwater recharge across CPNRD. More research is much needed to understand the recharge dynamics and accompanied loading and transport of nitrate in the unsaturated zone profile. This project is expected to provide new means to examine the missing link between the recharge and nitrate fluxes at the bottom of root zones and the water table spatially and temporally.

A description of field or research investigations utilized to substantiate the project conception (004.02 B);

This project will develop and couple the Richards Equation and the advection-dispersion equation with the Soil and Water Assessment Tool (SWAT) model to simulate the soil water and contaminant transport in the unsaturated zone. SWAT is a river basin or watershed scale model developed by the USDA Agricultural Research Service (Arnold et al., 1998; Neitsch et al., 2005). SWAT is capable of predicting the impact of land management practices on water, sediment and agricultural chemical yields in large complex watersheds with varying soils, land uses and management conditions over long periods of time. The Richards equation, incorporating Darcy's law and the continuity equation, is currently the most accurate and reliable approach to simulate soil water movement in variably saturated conditions. On the other hand, the advection-dispersion equation combines the Fick's Law and the continuity equation to provide description of the movement and spread of contaminants. In recent years, we have witnessed rapid development of sophisticated variably unsaturated-saturated models based on the Richards equation (Šimůnek et al., 2009; van Dam et al., 2008; Ross, 2003). However, these equations are generally solved numerically to model the soil water and solute transport. Its instability (non-convergence), substantial computational time and mass balance errors obstructed its use in hydrologic models. To avoid these obstacles, we will implement a highly efficient soil water module originally developed by Ross (2003), and develop a new model Unsaturated-SWAT (UnSWAT) to simulate the unsaturated zone flow. The proposed UnSWAT model has been successfully applied to the Johnson Creek Watershed in the Eastern Nebraska (Ou, 2015). The parameters were calibrated to match the simulated streamflow with the measured values and groundwater levels. The simulated and measured streamflow have been found as good fit. The analysis results shows spatially detailed distribution of mean monthly net recharge in the watershed, where recharge rate is high between May and July overall due to irrigation. The spatial difference in recharge is mainly caused by the heterogeneity in the regional soil water balance. The outputs of the UnSWAT can be directly integrated with other groundwater models, such as the COHYST, for improved model calibration and scenario development. UnSWAT is suitable to estimate groundwater recharge and nitrogen loadings to groundwater in the Central Platte River Basin, because data sources for the model inputs and calibration are available. Table 1 lists the data required in the UnSWAT model. For model inputs, it needs daily climate data, topography, land use and soil information. The climate data are the driving forces of the hydrologic cycle. The topographic data are used to delineate the watershed. The land use determines the crop types. The soil data will be used for the unsaturated zone model. The total nitrogen inputs are provided by CPNRD for the model. The model will be calibrated to the streamflow in the Platte River (main reach and tributaries), the soil moisture at eight unsaturated zone study sites conducted by the USGS (Steele et al., 2014) and the Vadose Zone Nitrate Study conducted by Shields and Snow (2017). The automatic calibration tool PEST will be used to implement automatic calibration.

A description of the necessary water and/or land rights, if applicable (004.02 C); *Not Applicable for this project.*

A discussion of the anticipated effects, if any, of the project upon the development and/or operation of existing or envisioned structural measures including a brief description of any such measure (004.02 D).

The expected benefits of implementing this project include, but not limited to: (1) improving the understanding of the groundwater quality and groundwater flow budget in the CPNRD at refined spatial and temporal scales; (2) identifying geographic areas vulnerable to nitrate contamination for better-informed decision makings on water resource management and integrated management plan (IMP) compliance; (3) assisting in further calibration of the COHYST integrated water resources model; and (4) potential opportunities to facilitate other model development efforts.

2. Provide evidence that there are no known means of accomplishing the same purpose or purposes more economically, by describing the next best alternative.

As aforementioned, the nitrate leaching and recharge flux in the unsaturated zone is commonly simplified in both groundwater and surface hydrologic models due to challenges, such as extensive data requirement, computational expense and lack of efficient and accurate numerical solutions (Partington et al., 2013). Such simplification often leads to inaccuracy and lack of spatial-temporal variability in estimated contaminant and recharge fluxes at the basin or regional scales. We are currently conducting a study of recharge thru the vadose zone at 8 sites within the CPNRD. The 8 years of field measurements from these sites provide scientific basis to develop tools that can estimate recharge movement thru the un-saturated zoned across CPNRD. This type of project has not been developed or tried across much of Nebraska so this development of a new tool could benefit the water managers in Nebraska as we explore the best approaches to water management. Therefore, there are no known better means of accomplishing the same purpose.

3. Document all sources and report all costs and benefit data using current data, (commodity prices, recreation benefit prices, and wildlife prices as prescribed by the Director) using both dollar values and other units of measurement when appropriate (environmental, social, cultural, data improvement, etc.). The period of analysis for economic feasibility studies shall be fifty (50) years or with prior approval of the Director, up to one hundred (100) years [T261 CH 2 (005)].

- Describe any relevant cost information including, but not limited to the engineering and inspection costs, capital construction costs, annual operation and maintenance costs, and replacement costs. Cost

information shall also include the estimated construction period as well as the estimated project life (005.01).

The relevant cost for this project is the salary and expenses for conducting the work to develop a modeling tool. The project period is expected to start in March of 2018 and end in October of 2019.

- Only primary tangible benefits may be counted in providing the monetary benefit information and shall be displayed by year for the project life. In a multi-purpose project, estimate benefits for each purpose, by year, for the life of the project. Describe any intangible or secondary benefits separately. In a case where there is no generally accepted method for calculation of primary tangible benefits describe how the project will increase water sustainability, such that the economic feasibility of the project can be approved by the Director and the Commission (005.02).

There is not a dollar amount of tangible benefit that can be computed for this project at this time. The primary tangible benefit comes for better estimation of groundwater recharge and nitrate loading to the aquifer, and associated improved decision making on water quality management.

- All benefit and cost data shall be presented in a table form to indicate the annual cash flow for the life of the proposal, not to exceed 100 years (005.03).
  Not applicable for this project.

- In the case of projects for which there is no generally accepted method for calculation of primary tangible benefits and if the project will increase water sustainability, the economic feasibility of such proposal shall be demonstrated by such method as the Director and the Commission deem appropriate (005.04).

Research has found that nitrate concentration in many places in the CPNRD above the USEPA safe drinking water standard and this trend is likely to continue due to irrigation agriculture (Exner et al., 2004). The cost associated with treating and maintaining water supplies are estimated to be $400 per capita in Nebraska based on an early report (US Bureau of Reclamation, 1999). A conservative estimation, based on the population in CPNRD, translates to over 5 million investments to address current problem. The proposed project for improved estimation of groundwater recharge and nitrate loading to the aquifer would help develop precise management measures to curb the water quality problems on the vulnerable land to nitrate leaching. Compared with our requested amount of $87,540, the cost reduction in water quality treatment is expected to well surpass the requested WSF budget.

4. Provide evidence that sufficient funds are available to complete the proposal.

The CPNRD has $200,000 budgeted for FY 2017-2018 for professional water resources services and will continue to budget additional funds in FY2018 -2019 to provide 40% cost share on this project.

5. Provide evidence that sufficient annual revenue is available to repay the reimbursable costs and to cover OM&R (operate, maintain, and replace).

The CPNRD's annual budget adopted this year is $23.6 million and this project will not have any OM&R expenses.

6. If a loan is involved, provide sufficient documentation to prove that the loan can be repaid during the repayment life of the proposal.
Not applicable for this project.

7. Describe how the plan of development minimizes impacts on the natural environment.
Not applicable for this project.

8. Explain how you are qualified, responsible and legally capable of carrying out the project for which you are seeking funds.

The States 88th Nebraska Legislature change the State's Groundwater Management and Protection Act through LB 1106 to require Natural Resources Districts to prepare a Groundwater Management Plan. This was completed for the CPNRD in December 1985. That Plan has been in place and revised several times since 1985. The latest being the addition of the Integrated Management Plan (IMP) in July 2009. One focus of the IMP is continued groundwater data collection and creating partnerships with outside organizations to address current data gaps.

9. Explain how your project considers plans and programs of the state and resources development plans of the political subdivisions of the state.

The project provides supporting data for the Integrated Management Annual Report and Plan of Work for the Nebraska State Water Planning and Review Process document (dated September 2014). This project seeks to fill an analysis gap in understanding the effects of various land cover and land use on spatial and temporal patterns of groundwater nitrate levels and will provide a means to study the effectiveness of precise land management strategies to address the issue. Additionally, this project will provide a new tool to the COHYST 2010 integrated models, which is the primary decision-making tool for

GW quantity and integrated management in the CPNRD for the Platte River Recovery and Implementation Program (PPRIP).

10. Are land rights necessary to complete your project?

YES☐ NO☒

If yes, provide a complete listing of all lands involved in the project.
Not applicable for this project

If yes, attach proof of ownership for each easements, rights-of-way and fee title currently held.
Not applicable for this project

If yes, provide assurance that you can hold or can acquire title to all lands not currently held.
Not applicable for this project

11. Identify how you possess all necessary authority to undertake or participate in the project.

The CPNRD also has the authority under Nebraska State Statute Chapter 2 Article 32 to carry out this project under its authorized purposes relating to the development, management, utilization, and conservation of groundwater and surface water. This includes the CPNRD's authorities to enter into contracts or agreements, budget and expend levied property taxes, and own and operate property or equipment

12. Identify the probable environmental and ecological consequences that may result as the result of the project.

Sound integrated management of groundwater and surface water is critical to maintaining flows of the Platte River needed by endangered and threatened species as well as appropriate groundwater quality for rural citizens. Integrated management relies on decision making tools such as the COHYST model and supporting data sets. This project seeks to fill a critical analysis gap in understanding the effects of land cover and irrigation on groundwater recharge and nitrate loading, and will also provide a means to study the effectiveness of managed recharge which could enhance and retime flows needed by endangered and threatened species.

Section C.

NRC SCORING

In the NRC's scoring process, points will be given to each project in ranking the projects, with the total number of points determining the final project ranking list.

The following 15 criteria constitute the items for which points will be assigned. Point assignments will be 0, 2, 4, or 6 for items 1 through 8; and 0, 1, 2, or 3 for items 9 through 15. Two additional points will be awarded to projects which address issues determined by the NRC to be the result of a federal mandate.

Notes:

- The responses to one criterion *will not* be considered in the scoring of other criteria. Repeat references as needed to support documentation in each criterion as appropriate. The 15 categories are specified by statute and will be used to create scoring matrixes which will ultimately determine which projects receive funding.

- There is a total of 69 possible points, plus two bonus points. The potential number of points awarded for each criteria are noted in parenthesis. Once points are assigned, they will be added to determine a final score. The scores will determine ranking.

- The Commission recommends providing the requested information and the requests are not intended to limit the information an applicant may provide. An applicant should include additional information that is believed will assist the Commission in understanding a proposal so that it can be awarded the points to which it is entitled.

Complete any of the following (15) criteria which apply to your project. Your response will be reviewed and scored by the NRC. Place an N/A (not applicable) in any that do not apply, an N/A will automatically be placed in any response fields left blank.

1. Remediates or mitigates threats to drinking water;

    - Describe the specific threats to drinking water the project will address.
    - Identify whose drinking water, how many people are affected, how will project remediate or mitigate.
    - Provide a history of issues and tried solutions.
    - Provide detail regarding long range impacts if issues are not resolved.

Groundwater is the principal source of drinking water for approximately 97% of those persons residing in rural areas nationwide according to National Research Council. In Nebraska, 85% of the population relies on groundwater for their potable water.

Increasing evidence of groundwater contamination in recent years, coupled with concerns about human health and ecological effects of contaminants such as nitrates and pesticides, has heightened pressure on public agencies to better manage groundwater. The application of fertilizer and pesticides on croplands, for example, has often been shown to result in deterioration of the quality of drinking water. In the Central Platte Natural Resources District (CPNRD), a dominant portion of wells along the Platte River Valley shows the level of nitrate-N concentration exceeding 10 mg/L, the federal maximum contaminant level (MCL) for nitrate according to 2016 Nebraska Groundwater Quality Monitoring Report. The degraded water quality poses health threat to about 140,000 people residing in the CPNRD. Historically, CPNRD developed Nebraska's first groundwater quality management plan (GWQMP) that divides the NRD into three management areas allowing variable fertilizer application rates and irrigation regulation. Although these management actions have reversed the long-term trend of increasing average nitrate-N concentrations in the primary aquifer, reaching the goal of a mean nitrate-N level below 10 mg/L is still expected to take decades (Spalding et al., 2010). Therefore, it is essential to fully understand the complex dynamics of contamination and groundwater hydrology in subsurface, especially in the unsaturated zone (a.k.a., vadose zone). The determination of groundwater recharge, a factor critical to the transport of ground contaminants and numerical groundwater model development, can help prioritize the deployment of management actions.

The objective of this project is to ***determine groundwater recharge and nitrate leaching dynamics in the unsaturated zone using hydrologic models at different spatial and temporal scales****. We anticipate that the recharge information generated as a result of this research can then be used by water resource managers to reassess the groundwater contamination potential and preserve the quality of the drinking water. Without accurate estimation of spatial and temporal dynamics of groundwater recharge process, limited resources may not target at the most vulnerable areas and the negative health effects of low groundwater quality will persist. Although this project will focus on the CPNRD area, the research outcome will be transferrable to other areas experiencing groundwater contamination in Nebraska. Thus, not only 140,000 people residing in CPNRD but also the entire Nebraska citizens will benefit from the project.*

Reference: Spalding, M., H. Perea-Estrada, R. Spalding. 2010. Long-Term Response of Groundwater Nitrate Concentrations to Management Regulations in Nebraska's Central Plate Valley. The Scientific World Journal,10: 286–297.

2. Meets the goals and objectives of an approved integrated management plan or ground water management plan;

    - Identify the specific plan that is being referenced including date, who issued it and whether it is an IMP or GW management plan.
    - Provide the history of work completed to achieve the goals of this plan.
    - List which goals and objectives of the management plan the project provides benefits for and how the project provides those benefits.

The proposed project ***meets the goals and requirements of the Integrated Management Plan (IMP) and Groundwater Management Plan*** *existed in the CPNRD. For the IMP, it was initially issued by the CPNRD and Nebraska Department of Natural Resources (DNR) in 2009, and a revised IMP was adopted in 2012. Historically, CPNRD has been working with the DNR to implement programs that help meet the goals of the IMP, such as promoting water use efficiency, metering wells, retiring marginal land from irrigation, enhancing educational programs. In particular, CPNRD has been working with the DNR and other stakeholders in the Cooperative Hydrologic Study (COHYST) to advance the understanding of the hydrologic system in the basin. This project can provide benefits to meet the goals "to maintain for present and future generations the District's water resources while promoting programs that allow economic growth" and "to provide, for present and future generations, an adequate supply of quality water for feasible and beneficial uses". Since the recharge is the main source of groundwater storage, accurate estimation of recharge rate and its dynamics with the unsaturated zone are vital to sustainable supply of water resources for agricultural, residential and recreational uses. This project also provides a unique opportunity of improving the calibration of the COHYST model, the current pivotal hydrologic model in this area, with more accurate recharge estimation in the unsaturated zone.*

In addition, this project is critical to support groundwater supply management area designation by "following evaluation of relevant data and projection of effects of current and new developments, that a management area is necessary in order to achieve the groundwater reservoir life goal" in the CPNRD Groundwater Management Plan. This outcome of this project (i.e., recharge patterns) can be directly used by water resource managers to assess the balance of groundwater budget.

3. Contributes to water sustainability goals by increasing aquifer recharge, reducing aquifer depletion, or increasing streamflow;

   List the following information that is applicable:

   - The location, area and amount of recharge;
   - The location, area and amount that aquifer depletion will be reduced;
   - The reach, amount and timing of increased streamflow. Describe how the project will meet these objectives and what the source of the water is;
   - Provide a detailed listing of cross basin benefits, if any.

The location of project implementation is in the scope of the CPNRD. The modeling project contributes to water sustainability by providing a necessary model for evaluating management actions that will increase or reduce aquifer recharge. The outcome of the project is particularly important to the assessment of recharge at local scales, because it will be calibrated based on the point recharge measurements of unsaturated zone. Furthermore, this project determines the timing and amount of recharge allowing more accurate account of the accretion in streamflow and hydrologic connection between the aquifers and streams. It would assist the selection of artificial recharge locations from the seasonable flood water, which ultimately would augment the streamflow. The model can

also assist the CPNRD in reducing aquifer depletion and enhancing streamflow by testing different management scenarios.

One of the remarkable cross-basin benefits of implementing this project is the improvement in understanding the dynamics of recharge at different depth, timing and locations. The recharge estimation, different from current soil-water balance modeling approach, may lead to the improvement of basin-wide hydrologic models, such as the COHYST and WWUM models.

4. Contributes to multiple water supply goals, including, but not limited to, flood control, agricultural use, municipal and industrial uses, recreational benefits, wildlife habitat, conservation of water resources, and preservation of water resources;

    - List the goals the project provides benefits.
    - Describe how the project will provide these benefits
    - Provide a long range forecast of the expected benefits this project could have versus continuing on current path.

The proposed modeling project contributes to multiple water supply goals and benefits, including augmentation of agricultural water use, preservation and sustainability of water quality, by providing truthful hydrologic information for informed decision making. The CPNRD plans to use the model to assess and monitor how much, when and where the nitrate and recharge fluxes occur through the unsaturated zone to the aquifer. It can be further used to predict the potential aquifer recharge and nitrate reduction benefits from various management actions, and thus make informed water resource management decisions for meeting these water supply goals. Furthermore, since this project provides more accurate account of recharge through the unsaturated zone to the aquifer, the benefits is expected to be extended to current hydrologic modeling efforts (e.g., COHYST) and advance the understanding of hydrologic system in the entire Platte River Basin. This will greatly benefits and augment the investment of other modeling projects in a synergistic manner.

5. Maximizes the beneficial use of Nebraska's water resources for the benefit of the state's residents;

    - Describe how the project will maximize the increased beneficial use of Nebraska's water resources.
    - Describe the beneficial uses that will be reduced, if any.
    - Describe how the project provides a beneficial impact to the state's residents.

The IMP for the CPNRD aims at maintaining "for present and future generation the District's water resources". The entire NRD is subject to fully appropriation status and has closed all management areas to the expansion of new irrigation acres. The CPNRD is striving to strike the appropriate balance between maximizing beneficial consumptive use and limiting impacts to the aquifer and streamflow. This project will help water resource

managers gain insight into the groundwater budget by taking more accurate account of the recharge, and help improve the current groundwater model used to assess the hydrologically connected water resources (e.g., COHYST model). As the CPNRD is one the NRDs with many productive agricultural lands, the project can benefit the state's agricultural economy and farmers by providing more accurate account of water resources available for irrigation under current water regulation and laws. In addition, the deterioration of groundwater quality due to elevated nitrate concentration has been a public health concern in many parts of the CPNRD, especially among the rural population relying on groundwater as sole drinking water source. The modeling project would improve the identification of the areas subject to heavy leaching of fertilizers and focus resources and preventative measures on these areas. If the project is implemented successfully in CPNRD, the approach would be likely applicable to other parts of the state and hence benefit the entire state residents.

6. Is cost-effective;

- List the estimated construction costs, O/M costs, land and water acquisition costs, alternative options, value of benefits gained.
- Compare these costs to other methods of achieving the same benefits.
- List the costs of the project.
- Describe how it is a cost effective project or alternative.

The total cost of the project is $145,900 with 40% cost share from the CPNRD. This project does not involve construction, O/M, land and water acquisition costs, but is used to cover the costs associated with the model development by the consulting team. There is no other technically comparable approach of achieving the same benefits according to our technical review. The model and its results can fully characterize the groundwater dynamics through the unsaturated zone at various spatial and temporal scales. Without the modeling project, there is no other cost-effective means to determine the recharge and aquifer sustainability in such details. The application of the model over the CPNRD is inherently cost-effective because it will reduce the uncertainty about the effects of land use and climate on water movement in the unsaturated zone, and allow limited fund and staff to focus on the target areas.

Regarding the cost effectiveness, research has found that nitrate concentration in many places in the CPNRD above the USEPA safe drinking water standard and this trend is likely to continue due to irrigation agriculture (Exner et al., 2004). The cost associated with treating and maintaining water supplies are estimated to be $400 per capita in Nebraska based on an early report (US Bureau of Reclamation, 1999). A conservative estimation, based on the population in CPNRD, translates to over 5 million investment to address current problems. The proposed project for improved estimation of groundwater recharge and nitrate loading to the aquifer would help develop precise management measures to curb the water quality problems on the vulnerable land to nitrate leaching. Compared with our requested amount of $87,540, the cost reduction in water quality treatment is expected to well surpass the requested WSF budget.

In addition, this project will leverage the previous research investment, the measurements of transient vertical gradients in total water potential in the CPNRD conducted by the U.S. Geological Survey (Steele et al., 2014). No other modeling effort has been done to make good use of these datasets. Thus, this project itself is cost-effective in leveraging existing federal and NRD investments in research.

Reference:
Steele, G.V., J.J. Gurdak, and C.M. Hobza. 2014, Water movement through the unsaturated zone of the High Plains Aquifer in the Central Platte Natural Resources District, Nebraska, 2008–12: U.S. Geological Survey Scientific Investigations Report 2014–5008, 51 p.
Exner M.E., A.J. Hirsh, and R.F. Spalding. 2014, Nebraska's groundwater legacy: Nitrate contamination beneath irrigated cropland. Water Resources Research, 50, 4474-4489.
US Bureau of Reclamation, Department of the Interior. 1999, Nitrate and Nebraska's small community and rural domestic water supplies: An assessment of problems, needs and alternatives. December, 1999, 79 p.

7. Helps the state meet its obligations under interstate compacts, decrees, or other state contracts or agreements or federal law;

   - Identify the interstate compact, decree, state contract or agreement or federal law.
   - Describe how the project will help the state meet its obligations under compacts, decrees, state contracts or agreements or federal law.
   - Describe current deficiencies and document how the project will reduce deficiencies.

This project is essential to Nebraska's ability to meet its obligations under the Platte River Recovery Implementation Program (PRRIP), an interstate agreement. Under the PRRIP, Nebraska has made a number of commitments to Colorado, Wyoming and the U.S. Secretary of the Interior while receiving millions-dollar benefits from the program. Nebraska is obliged to provide sufficient environmental flows to and through the Central Platte River habitat area to assist in improving and maintaining habitats for the target species, Interior Least Tern, Piping Plovers and Whooping Cranes. This project can help accurately quantify the depletion of streamflow in the Platte River from land use activities by improving the recharge estimation. Currently, the COHYST model dose not fully consider the recharge dynamics occurring in the unsaturated zone, and thus the current depletion mitigation strategies may not be effectively assessed. This project will reduce this deficiency, and enhance Nebraska's abilities to meet the PRRIP obligations.

8. Reduces threats to property damage or protects critical infrastructure that consists of the physical assets, systems, and networks vital to the state or the Untied States such that their incapacitation would have a debilitating effect on public security or public health and safety;

- Identify the property that the project is intended to reduce threats to.
- Describe and quantify reductions in threats to critical infrastructure provided by the project and how the infrastructure is vital to Nebraska or the United States.
- Identify the potential value of cost savings resulting from completion of the project.
- Describe the benefits for public security, public health and safety.

This project would reduce the risks associated with sustainable and integrated groundwater management. Sustainable groundwater storage and supply is critical to the economic viability in Nebraska, especially for the CPNRD with some of the most fertile irrigated croplands. In the absence of appropriate management of this resource and hydrologically connected surface water, the property values of the irrigated land and associated household income and social security will be seriously affected, and current water supply infrastructure such as canals and wells may not be fully operational due to noncompliance with applicable state laws and interstate compacts. It would cost the CPNRD and the state tens of millions of dollar with mismanagement of hydrologically connected water supplies. The accurate account of this resource through this modeling project is vital to ensuring the sustainable use of hydrologically connected water supplies in the long run.

9. Improves water quality;

- Describe what quality issue(s) is/are to be improved.
- Describe and quantify how the project improves water quality, what is the target area, what is the population or acreage receiving benefits, what is the usage of the water: residential, industrial, agriculture or recreational.
- Describe other possible solutions to remedy this issue.
- Describe the history of the water quality issue including previous attempts to remedy the problem and the results obtained.

In addition to water quantity, this project directly addresses the water quality issues in the CPNRD. The modeling project will produce scientifically defensible information on nitrate loading and transport in the unsaturated zone and aquifer. In the CPNRD, a large amount of wells along the Platte River Valley shows the level of nitrate-N concentration exceeding the MCL (10mg/L) for nitrate. The degraded water quality poses health threat to about 140,000 people residing in the CPNRD. Historically, CPNRD developed Nebraska's first groundwater quality management plan that divides the NRD into three management areas allowing variable fertilizer application rates and irrigation regulation. Although these management actions have reversed the long-term trend of increasing average nitrate-N concentrations in the primary aquifer, reaching the goal of below 10 mg/L mean nitrate-N is still expected to take decades. Therefore, it is essential to fully understand the complex dynamics of contamination and groundwater hydrology in subsurface specially the unsaturated zone (a.k.a., vadose zone). The determination of nitrate loading and transport via numerical groundwater model development helps prioritize the deployment of water quality management actions.

10. Has utilized all available funding resources of the local jurisdiction to support the program, project, or activity;

- Identify the local jurisdiction that supports the project.
- List current property tax levy, valuations, or other sources of revenue for the sponsoring entity.
- List other funding sources for the project.

The local jurisdictions that support the project are the CPNRD. The CPNRD has used its own tax dollars to fund previous related projects, including the measurement of transient vertical gradients in the unsaturated zone conducted by U.S. Geological Survey and the COHYST modeling project cost-shared with other agencies. Since this project will use the datasets and the COHYST model from other funded projects, the previous research investment virtually reduce the cost of this proposed project.

11. Has a local jurisdiction with plans in place that support sustainable water use;

- List the local jurisdiction and identify specific plans being referenced that are in place to support sustainable water use.
- Provide the history of work completed to achieve the goals of these plans.
- List which goals and objectives this project will provide benefits for and how this project supports or contributes to those plans.
- Describe and quantify how the project supports sustainable water use, what is the target area, what is the population or acreage receiving benefits, what is the usage of the water: residential, industrial, agriculture or recreational.
- List all stakeholders involved in project.
- Identify who benefits from this project.

The CPNRD is the local jurisdiction with plans that support sustainable water use, including both IMP and Groundwater Management Plan. The CPNRD has completed an extensive amount of work to achieve the goals of these plans, including the implementation of rules and regulations for fully & over-appropriated areas, monitoring the status of groundwater quality and quantity, and extensive implementation of educational programs. The IMP was jointly adopted by the NRD and the DNR in May of 2009 and updated on March 22, 2012.

This project provides benefits to meet the IMP goals "to maintain for present and future generations the District's water resources while promoting programs that allow economic growth", and "to provide, for present and future generations, an adequate supply of quality water for feasible and beneficial uses". Since the recharge is the main source of groundwater storage and carrier of contaminants, accurate estimation of nitrate transport dynamics within and beyond the unsaturated zone are vital to sustainable supply of water resources for agricultural, residential and recreational uses in sufficient quality. This project also provides a unique opportunity of improving the COHYST model with more accurate recharge estimation and better model calibration. Currently, the

COHYST model is the major model used to support a variety of IMP management actions. The stakeholders involved in this project may include farmers and ranchers, the NRD and DNR staff, U.S. Fish and Wildlife Service, and environmental groups. These stakeholders will also benefit from the updated information on groundwater recharge and stream depletion based on the research outcome of this project.

12. Addresses a statewide problem or issue;

- List the issues or problems addressed by the project and why they should be considered statewide.
- Describe how the project will address each issue and/or problem.
- Describe the total number of people and/or total number of acres that would receive benefits.
- Identify the benefit, to the state, this project would provide.

This project directly addresses a critical statewide problem concerning the discrepancy in recharge estimation across the state. Recharge is a critical component of groundwater models, the essential tools used for statewide water resource planning and management. Groundwater modelers in water governing agencies and consulting firms have been relied upon recharge estimates to develop steady-state and transient groundwater models. There have been many methods developed for mapping regional groundwater recharge, including soil-water balance models, empirical models, and distributed models. In the past, multiple versions of statewide recharge datasets have been developed by researchers from the University of Nebraska-Lincoln and the Flatwater Group. However, these statewide datasets, none of which explicitly considers the water movement in the unsaturated zone, often differ from each other with high discrepancy. This problem often cost the state tens of thousands of dollars to reevaluate these datasets and reconcile the discrepancy in the phase of model development. This project, with good extensibility and adaptability to other regions, can greatly improve the accuracy of recharge estimation and reduce the costs and time spent for future groundwater model development in State of Nebraska. From this perspective, the benefits are expected to be extended to the citizens in the entire state.

In addition, this project helps the state meet its obligations under the Platte River Recovery Implementation Program (PRRIP), which is apparently a statewide issue. Nebraska is obliged to provide sufficient water to and through the Central Platte River habitat area to assist in improving and maintaining habitats for the endangered species. This project can help accurately quantify depletions to Platte River streamflow from land use activities by improving the recharge estimation used by the COHYST model.

13. Contributes to the state's ability to leverage state dollars with local or federal government partners or other partners to maximize the use of its resources;

- List other funding sources or other partners, and the amount each will contribute, in a funding matrix.

- Describe how each source of funding is made available if the project is funded.
- Provide a copy or evidence of each commitment, for each separate source, of match dollars and funding partners.
- Describe how you will proceed if other funding sources do not come through.

The CPNRD will pay 40% of the total project cost ($58,360). The CPNRD has $200,000 budgeted for FY 2017-2018 for professional water resources services and will continue to budget additional funds in FY2018 -2019 to provide 40% cost share on this project. Attached are copies of the CPNRD budget showing their commitment to the project and a letter documenting the NRD's intent to include the appropriate matching funds in their budget. The budgetary commitment authority ensures the project will be completed.

In addition, this project will leverage the existing research investment, the measurements of transient vertical gradients in total water potential, funded by the CPNRD and U.S. Geological Survey along with a NET and a former WSF fund. The project will also make use of the COHYST model, a model that has been invested over 10 million dollars by multiple state and local agencies. The proposed project will maximize the use of these existing resources (i.e., datasets and models).

14. Contributes to watershed health and function;

- Describe how the project will contribute to watershed health and function in detail and list all of the watersheds affected.

In the context of the CPNRD, a healthy watershed means sustainable supply of clean water for the people and the wildlife in the basin. The proposed project will assist the CPNRD in managing the hydrologically connected water supply for the Central Platte River Basin and maintaining its quality. The project will contribute to watershed health and functions by providing decision makers with accurate hydrologic information regarding nitrate loading and transport, the aquifer replenishment through recharge, and focused management areas. In addition, this project can help improve the COHYST model calibration in the CPNRD and its adjacent areas, and thus equips Nebraska with better decision-making tools for supplying environmental flows to habitats of endangered species, such as Least Tern, Piping Plover, and Whooping Crane in the Platte River Basin.

15. Uses objectives described in the annual report and plan of work for the state water planning and review process issued by the department.

- Identify the date of the Annual Report utilized.
- List any and all objectives of the Annual Report intended to be met by the project
- Explain how the project meets each objective.

The proposed project will contribute to achieving the objectives laid out in the Annual Report and Plan of Work for the Nebraska State Water Planning and Review Process, submitted to the Governor and State Legislature in September of 2015. The following objectives can be met by this project, such as "maintain data, information, and analysis capabilities for water planning, including specific programs for collecting, maintaining, and distributing information on streamflows, as well as analyzing water uses and water supplies across the state" and "support locally developed water management plans for managing hydrologically connected water supplies". This project meets the first objective by enhancing the CPNRD's and the state's abilities to estimate aquifer recharge and nitrate loading through the unsaturated zone at various spatial and temporal scales, which is essential information for state and local water planning. The project meets the second objective by improving the COHYST model, a critical tool for managing hydrologically connected water supplies in the IMP, with more accurate recharge estimation and model calibration.

16. Federal Mandate Bonus. If you believe that your project is designed to meet the requirements of a federal mandate which furthers the goals of the WSF, then:

    - Describe the federal mandate.
    - Provide documentary evidence of the federal mandate.
    - Describe how the project meets the requirements of the federal mandate.
    - Describe the relationship between the federal mandate and how the project furthers the goals of water sustainability.

The federal mandate is the Platte River Recovery Implementation Program (PRRIP) which is the means by which the states of Colorado, Wyoming, and Nebraska are collaborating to provide sufficient water supplies to the endangered species, such as Piping Plovers, Interior Least Tern and Whooping Cranes, pursuant to the U.S. Endangered Species Act. The interstate program aims at providing sufficient environmental flows to and through the Central Platte River habitat area to assist in improving and maintaining habitats for target species. This project can help accurately quantify depletion of streamflow in the Platte River from land use activities by improving the recharge estimation. Currently, the COHYST model did not fully consider the recharge dynamics occurring in the unsaturated zone, and thus may affect the assessment of depletion mitigation strategies. This project is expected to enhance Nebraska's abilities to meet the PRRIP obligation on sustaining instream water supplies in the Central Platte River, which is indisputably consistent with the state goals of water sustainability.

Section D.

PROJECT DESCRIPTION

1. Overview

In 1,000 characters *or less*, provide a brief description of your project including the nature and purpose of the project and objectives of the project.

Accurate account of groundwater recharge and nitrate transport dynamics is a critical step to implement programs of water resources planning and management. However, the estimation of groundwater recharge and nitrate leaching has been regarded as a technically challenging task due to various key physical and hydrogeologic processes and their complex interplay associated with the unsaturated zone. Water contents in the unsaturated zone is of high spatiotemporal variability due to the combined effects induced by factors such as precipitation, soil properties, drainage, irrigation and groundwater depth. The recharge and contaminant flux in the unsaturated zone is commonly simplified in both groundwater and other hydrologic models due to technical challenges. Such simplification, however, often leads to inaccuracy and lack of spatial-temporal variability in estimated recharge at the basin or regional scales. The purposes of this project are (a) developing an integrated hydrologic model that accounts for recharge process and nitrate loading and transport in the unsaturated zone, and (b) providing a scientifically defensible estimation of groundwater recharge and nitrate leaching flux at high spatial resolution and different time scales. This project will develop and couple the Richards Equation and the advection-dispersion equation with the Soil and Water Assessment Tool (SWAT) model to simulate the soil water and contaminant transport in the unsaturated zone. The parameters will be calibrated with the MODFLOW groundwater model to match with the measured streamflows and groundwater levels. This project is expected to provide new means of examining the missing links between the soil infiltration and deep percolation at the water table spatially and temporally. The expected benefits of implementing this project include, but not limited to: (1) improving the understanding of groundwater quality and groundwater flow budget in the CPNRD at refined spatial and temporal scales; (2) identifying geographic areas vulnerable to nitrate contamination for better-informed decision makings on water resource management and integrated management plan (IMP) compliance; (3) assisting in further calibration of the COHYST integrated hydrologic model; and (4) potential opportunities to facilitate other model development efforts.

2. Project Tasks and Timeline

Identify what activities will be conducted by the project. For multiyear projects please list what activities are to be completed each year.

The project will be completed within 1 year and 8 months:

Year 1*: the tasks will focus on data collection, a project development plan, and model development and calibration. The detailed activities include: a) project kickoff meeting, b) reviewing current hydrogeology and climate data for model development and calibration, c) evaluating the up-to-date COHYST model and propose a project development plan, d) developing the model grids, and compiling data inputs for the model, e) assigning model boundary conditions, and establishing model calibration targets, and f) calibrating the model along with the COHYST model.*

Year 2*: the tasks will focus on model review, application and reporting. The detailed activities include: a) review model results with the NRD technical staff, b) applying the model to develop recharge datasets for the CPNRD area over the same time period as the COHYST model, c) compiling the dataset at designated spatial and time scales for each groundwater management area (GWMA) in the CPNRD, and d) documenting the model and submitting the final report and deliverables.*

3. Partnerships

Identify the roles and responsibilities of agencies and groups involved in the proposed project regardless of whether each is an additional funding source. List any other sources of funding that have been approached for project support and that have officially turned you down. Attach the rejection letter.

The CPNRD are the sole entity involved in the project. Its general responsibilities involve hiring consultants to complete the project on time and within budget. In addition, the development of the model will be in consultation with the expert opinions from the Nebraska DNR. The project outcome will be briefed and shared with the interested NRDs and other agencies involving in the COHYST model development.

4. Other Sources of Funding

Identify the costs of the entire project, what costs each other source of funding will be applied to, and whether each of these other sources of funding is confirmed. If not, please identify those entities and list the date when confirmation is expected. Explain how you will implement the project if these sources are not obtained.

The cost of the entire project is $145,900. 60% of the project cost ($87,540) is intended to be funded by the Water Sustainability Fund, and 40% of the cost ($58,360) is committed by the CPNRD. There are no other sources of funding for the project.

5. Support/Opposition

Discuss both support and opposition to the project, including the group or interest each represents.

There is a high level of support for the project from the CPNRD. We have not identified opposition to the project.