Environment and Natural Resources Trust Fund
2018 Request for Proposals (RFP)

Project Title: **ENRTF ID:** **075-B**

Water Saving Subsurface Irrigation to Reduce Contamination

Category: B. Water Resources

Total Project Budget: $ 93,391

Proposed Project Time Period for the Funding Requested: 2 years, July 2018 to June 2020

Summary:

We investigate below-ground irrigation to 1) reduce water use, 2) reduce operational cost, and 3) reduce pollution of both groundwater and surface water. A construction manual will be created.

Name: Otto Strack

Sponsoring Organization: U of MN

Address: 500 Pillsbury Drive SE

Minneapolis Minn 55455

Telephone Number: (715) 673-4392

Email strac001@umn.edu

Web Address

Location

Region: Statewide

County Name: Statewide

City / Township:

Alternate Text for Visual:

The map shows both a vertical section and a plan view of the below-ground irrigation system

_____ Funding Priorities _____ Multiple Benefits _____ Outcomes _____ Knowledge Base

_____ Extent of Impact _____ Innovation _____ Scientific/Tech Basis _____ Urgency

_____ Capacity Readiness _____ Leverage _______ TOTAL ______%

I. PROJECT STATEMENT

We investigate below-ground irrigation of farmland, which has three major advantages over above-ground irrigation:

1. Reduces water use
2. Reduces operational cost
3. Reduces pollution of both groundwater and surface water.

We investigate the use of drains for irrigation, develop design criteria and methodology, and create a construction manual, the deliverable of the project. The manual helps farmers create an irrigation system that fits their needs.

Below-ground irrigation is not commonly used, and the necessary criteria and design formulas have not been developed to the point of general applicability. We propose to remedy this deficiency, which is important in view of concerns regarding groundwater depletion, groundwater and surface water pollution, and the cost of energy to operate large above-ground irrigations systems.

Crops thrive when the groundwater table is at a certain distance below surface; for grass, for example, this is about 40 cm, or a bit over a foot. Above-ground irrigation is done by spraying water into the air; part of the water is lost to evaporation. This kind of irrigation is often accompanied by discharge drains, installed in the ground to remove excess water to maintain the groundwater table at the optimal level. This excess water carries pollutants into the groundwater and, via the drains, to surface water as well. Subsurface irrigation avoids this problem, because the recharge is precisely controlled and with that, the water table.

Subsurface irrigation is particularly attractive to small farmers, as the cost of both operation and installation is less than that of above-ground irrigation. Installation of the drains can be done by the farmer, provided that the size of the drain tiles, the depth below ground, and the spacing of the drains are all known.

The overall goal of the project is to produce a design manual of an irrigation system, that reduces groundwater withdrawal, avoids excess water removal by discharge drains, and reduces the energy needs and pollution.

A number of variables are important to achieve an effective below-ground irrigation system. The main variables are the depth of the irrigation drains below ground, the spacing between them, the diameter of the drains, the depth of the base of the aquifer below ground, the hydrogeologic properties of the soil, and finally, the desired level of the groundwater table that is best for the crop. Since many variables are important, a design manual is essential; poor designs adversely affect the efficiency of the system.
Although numerous drain spacing formulas exist for discharge drains, i.e., drains that remove excess groundwater, no useful formulas exist for the opposite purpose, where the drains supply water to the soil to be used by the crop. The PI presented an approach for accurately modeling the groundwater flow from recharge drains in both his Ph.D thesis and in his textbook *Groundwater Mechanics,* Prentice-Hall, 1989. We propose to apply this approach to obtain the data that the design manual will be based on.

II. PROJECT ACTIVITIES AND OUTCOMES

Evaluating subsurface irrigation and developing design formulas **Budget: $ 46,229**

This activity consists of collecting data on existing below-ground irrigation systems used throughout the world, and the development of the necessary formulas for the design of efficient blow-ground irrigation systems. The existing systems are designed by trial and error, and are suitable only for local conditions, but will provide useful information.

Outcome	Completion Date
1. The section of the manual that describes existing techniques for installation of below-ground irrigation systems and a paper that contains the derivation of the design formulas. Research Assistant, 12 months at 50% time	6/30/2019

Activity 2: Development of the design manual for below-ground irrigation systems, including graphs and tables to facilitate the design. The main purpose of the manual is to determine the spacing between drains. **Budget: $ 47, 163**

The drain spacing depends on the following data:

1. The hydraulic conductivity of the aquifer
2. The pressure to be applied to the water in the recharge drains
3. The diameter of the drains
4. The distance between the center of the drains and the ground surface
5. The depth of the base of the aquifer below the ground surface.

Activity 2 consists of using the drain spacing formula developed under activity 1 to generate graphs and an elementary computer program that can be used for application in the field, for the most common conditions in Minnesota.

Outcome	Completion Date
2. A design manual, including graphs to determine the drain spacing, as well as a simple computer implementation of the drain spacing formula. Cost of installation of the drain tiles will be estimated, based on the assumption that the farmer will install the drains himself. Research Assistant, 12 months at 50% time	6/30/2020

III. PROJECT STRATEGY

A. Project Team/Partners

The project team consists of the Principal Investigator and a graduate research assistant. The PI is responsible for the project and will guide the graduate research assistant during the project. The PI will write the paper and the manual, together with the graduate research assistant. The PI expects to spend a minimum of two months on the proposal, at no cost to the project.

B. Project Impact and Long-Term Strategy

The deliverable of the project provides the necessary information for farmers to install subsurface irrigation systems. The information will be available through the design manual that is the main deliverable of the project. This will help to reduce water demands, reduce energy required, and reduce pollution of both groundwater and surface water.

C. Timeline Requirements

Activity 1 must be completed by june 30, 2019 prior to beginning activity 2.

2018 Detailed Project Budget

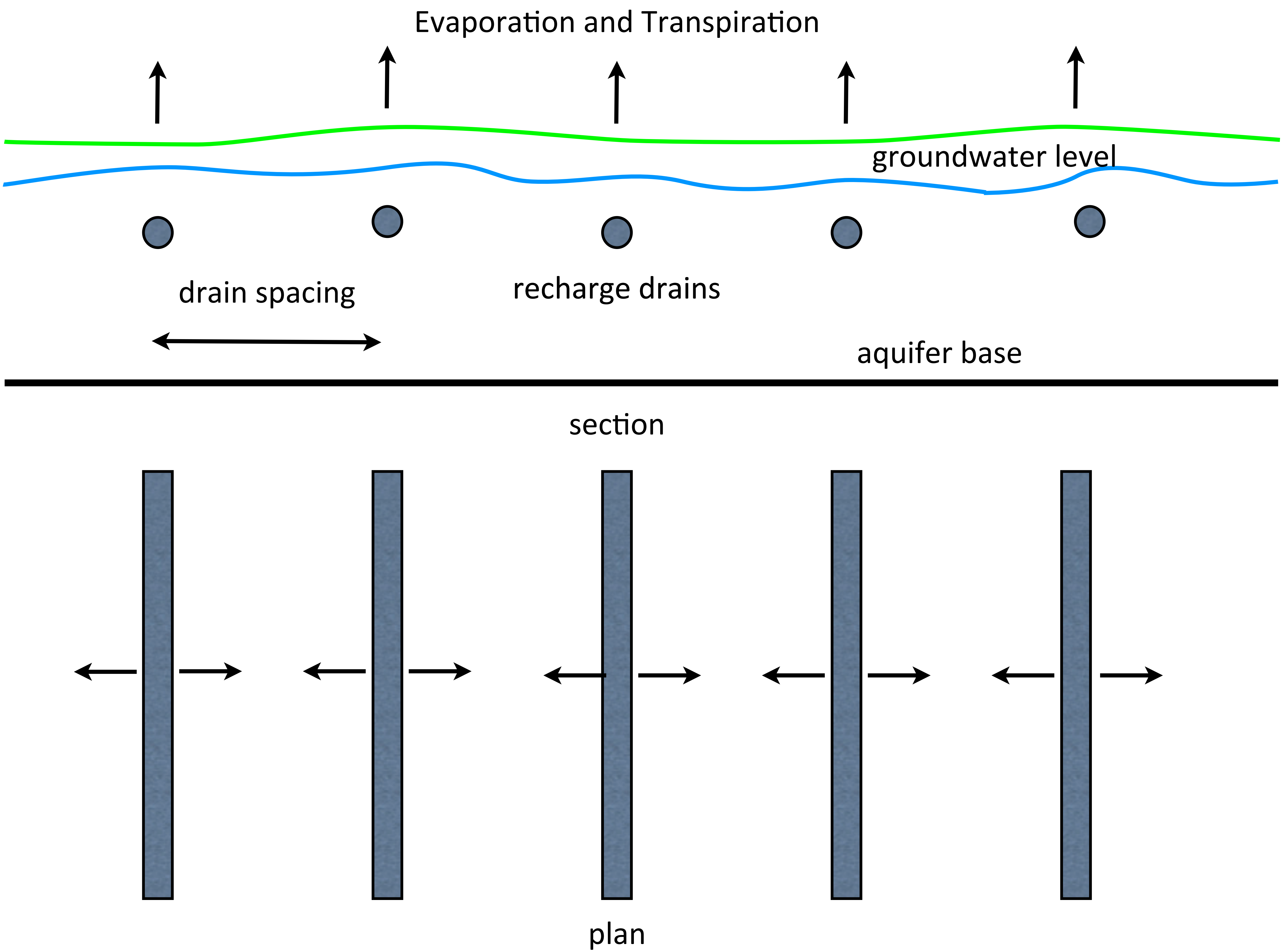
Project Title: Watersaving Subsurface Irrigation to Reduce Contamination

IV. TOTAL ENRTF REQUEST BUDGET *2* **years**

BUDGET ITEM	AMOUNT
Personnel: 24 months research assistant at 50% time	$93,191
Professional/Technical/Service Contracts: N/A	
Equipment/Tools/Supplies: computer supplies	$ 200
Acquisition (Fee Title or Permanent Easements): N/A	$ -
Travel: N/A	$ -
Additional Budget Items: N/A	$ -
TOTAL ENVIRONMENT AND NATURAL RESOURCES TRUST FUND $ REQUEST =	$ 93,391

V. OTHER FUNDS *(This entire section must be filled out. Do not delete rows. Indicate "N/A" if row is not applicable.)*

SOURCE OF FUNDS	AMOUNT	Status
Other Non-State $ To Be Applied To Project During Project Period: N/A	$ -	
Other State $ To Be Applied To Project During Project Period: N/A	$ -	
In-kind Services To Be Applied To Project During Project Period: 1% Cost Share for Otto Strack ($1009 salary, $338 fringe per year or 1%) 54% F&A waived $34,156 savings	$ 36,851	
	$ -	
Other Funding History: N/A	$ -	



Using recharge drains to irrigate crops from below.

Project Manager Qualifications & Organization Description

Biographical sketch

Dr. Strack received his PhD from the Technical University of Delft in 1973. He joined the Department of Civil Engineering of the University of Minnesota in 1974, where he is currently a Professor. Dr. Strack is the original developer of the Analytic Element Method, which is now the second most popular method in groundwater modeling. He is the author of the textbook *Groundwater Mechanics*, Prentice-Hall, 1989 (732 pp.) and the textbook *Analytical Groundwater Mechanics,* in press, Cambridge University Press. He has authored numerous papers, is the third recipient of the Lifetime Achievement Award, granted by the Minnesota Groundwater Association, and is a Correspondent (foreign member) of the Royal Dutch Academy of Sciences. Professor Strack has taught groundwater flow for over 45 years and has over 45 years of experience as a consultant. He is the author of the computer programs MLAEM and SLAEM.

Duties and responsibilities of the project manager

The project manager will bear the full responsibility for the quality of the final products and for their suitability for the goals specified in the proposal. The project manager is responsible for the testing of the concept explained in the proposal, and for the writing of the guidelines. The project manager will meet with his student several times a week, and will schedule regular meetings to assess progress. The weekly groundwater seminars, organized at the Department of Civil, Environmental, and Geo- Engineering, University of Minnesota, will serve as a platform for discussions regarding the project; members of the professional groundwater community regularly participate in these meetings, and will be asked for their professional opinion regarding progress and quality of the work.