Environment and Natural Resources Trust Fund
2014 Request for Proposals (RFP)

Project Title: **ENRTF ID:** **038-B**

Rain Water Reuse and Valuation Investigation

Category: B. Water Resources

Total Project Budget: $ 310,000

Proposed Project Time Period for the Funding Requested: 2 Years, July 2014 - June 2016

Summary:

Reusing rainwater can significantly reduce demands on Minnesotas groundwater resources while reducing stormwater runoff. Evaporative chillers can efficiently utilize naturally distilled rainwater creating value from a current waste product.

Name: Scott Alexander

Sponsoring Organization: U of MN

Address: Dept of Earth Sciences, 310 Pillsbury Dr SE
Minneapolis MN 55455

Telephone Number: (612) 626-4164

Email alexa017@umn.edu

Web Address

Location

Region: Statewide

County Name: Statewide

City / Township:

_____ Funding Priorities	_____ Multiple Benefits	_____ Outcomes	_____ Knowledge Base
_____ Extent of Impact	_____ Innovation	_____ Scientific/Tech Basis	_____ Urgency
_____ Capacity Readiness	_____ Leverage	_____ Employment	_____ TOTAL _____%

PROJECT TITLE: Rain Water Reuse and Valuation Investigation

I. PROJECT STATEMENT

This project aims to convert a liability, in the form of excess storm water runoff in urban environments, into a valued resource for chilled water production. Rain water reuse for evaporative chiller feed directly replaces potable drinking water typically supplied by ground water wells. Rain water has the advantage very low dissolved solids as it is naturally distilled by atmospheric processes.

Currently, most urban areas, and particularly commercial districts, produce large amounts of rainfall runoff creating localized flooding while washing nutrients and contaminants downstream. Conventional storm water systems to mitigate these problems are difficult to implement in densely urban areas with many pre-existing structures and dense underground utilities. Additionally, most urban properties, especially shopping centers, put a premium on maximizing parking area.

Coincidentally, evaporative chiller systems are widely used in commercial, retail, and educational settings. On the U of M Twin Cities campuses about 1/3 of the summer-time potable water usage goes to evaporative chiller systems (100 million gallons/year). Chilled water systems fed by ground water can only cycle water 3 to 4 times before it has to be replaced to prevent mineral build up. By its very dilute, naturally distilled character, rain water can by cycled many more times before disposal. Additionally, this distilled water should reduce chemicals and acids used in "blow-down" cycles where accumulated minerals are removed reducing waste discharge and extending equipment life.

The discharge from roofs is nearly pure distilled water, relatively free of contaminants, and requires only modest cleanup for reuse. In Minnesota, the annual average rainfall on a typical building can easily supply feed water to evaporative chillers cooling the same building and perhaps several surrounding buildings.

Calculations of storage volumes and treatment requirements, based on rainfall rates, urban roof water quality, and seasonal chiller demand, are needed to estimate project costs and space requirements. Once these baseline parameters and engineering/operational issues are defined, design and implementation of rain water reuse in an operational chiller system can commence. The cost of cistern systems compared to traditional storm water management can be offset by savings on potable water supply.

Supplemental work would include evaluation of rain water reuse compared to applications that have been traditionally supplied by treated, municipal potable water supplies. Current reuse programs are focused on lawn and turf grass irrigation where low cost treated city water is difficult to displace. New areas of reuse include water supply for toilet flushing, laundry, industrial process water, and anywhere the naturally dilute nature of rain water would be an advantage. Additionally, this study would investigate scaling up from individual chillers to district areas, identify policy issues, and analyze cost benefits associated with a high quality, non-potable water supply distinct from gray water and treated waste water.

II. DESCRIPTION OF PROJECT ACTIVITIES

Activity 1: Rain water quality and evaporative concentration **Budget: $ 150,000**

Collect representative samples of rain water from typical roof types representing seasonal, storm-to-storm, and single-storm variation. Analyze samples for constituents susceptible to concentration and mineralization in evaporative chiller systems. Conduct laboratory-scale evaporative concentration studies using rain water.

Outcome	Completion Date
1. Report on properties and quality of rain water from urban roof top environments.	June 30,2015
2. Report on potential impacts and improvements to chiller operation from rainwater reuse.	July 31, 2015

Activity 2: Design, installation, and monitoring of rain water reuse system. Budget: $ 125,000

Select site, design, and install cistern and treatment system. Connect to existing evaporative chiller system. Monitor and adjust/adapt operation as needed.

Outcome	Completion Date
1. Design rain water storage and reuse system.	July 31, 2015
2. Install rainwater reuse in evaporative chiller system.	March 1, 2016
3. Monitor and report on operation of rain water fed chiller system.	June 30, 2016

Activity 3: Public education and outreach. Budget: $ 35,000

Results will be presented in an addendum to the Minnesota Storm Water Manual in coordination with UM Extension Service. Develop materials covering the potential for expanded rain water reuse that take advantage of rain water properties for irrigation, non-potable supply to toilets, laundry, etc.

Outcome	Completion Date
1. Addendum for Storm Water Manual.	June 30 ,2016
2. Identify and report on policy implications for storm water reuse.	June 30 ,2016
3. Identify and report on additional reuse opportunities.	June 30 ,2016

III. PROJECT STRATEGY

A. Project Team/Partners

P.I. Scott Alexander UM Earth Sciences (1/2 time salary support from ENRTF) will oversee project, coordinating the different research partners and will lead the Activity 1 studies of rain water properties and Activity 3 Public education and outreach.

Co-P.I.s Martin Saar UM Earth Sciences and John Gulliver UM Civil Engineering with their grad students (3 - ¼ time grads supported by ENRTF) will provide support in all three Activity areas with Gulliver leading the Storm Water Manual Addendum Activity 3.1.

Co-P.Is Scott McCord, Nirml Jain, Cathy Abene of UM Energy Management will provide in-kind support for engineering, taking the lead on Activity 2 designing and installing a rain water reuse system with the support and input from the other co-P.I.s and graduate students.

B. Timeline Requirements

Project Activities 1 and 2 would start with the start of the grant (July 1, 2014) with early results of Activity 1 driving early design in Activity 2. Final design of cistern system to be completed after one year of rainfall monitoring allowing time for construction (Fall 2015) and at least 2 summer months of operation (May and June 2016). Activity 3 would run the full 2 years of the project building as data is developed.

C. Long-Term Strategy and Future Funding Needs

This project aims to reduce the demands on municipal water supplies and the aquifers that feed them while improving management storm water management. Storage cisterns would help meet MS-4 storm water rules while reducing the load on existing storm water conveyances. By realizing the value of rain water compared to potable drinking water we can reduce the need for additional wells and water treatment systems in a given municipality. A by-product is the more efficient operation of evaporative chiller systems. By demonstrating the combined improvements in storm water, municipal water supply and chiller operation the costs of cistern installation and operation can be offset allowing wide-spread adoption. Chiller systems actually mimic the natural system where evapo-transpiration of rain water dominates the hydrologic cycle in Minnesota.

2014 Detailed Project Budget

Project Title: Rain Water Reuse and Valuation Investigation

IV. TOTAL ENRTF REQUEST BUDGET 2 years

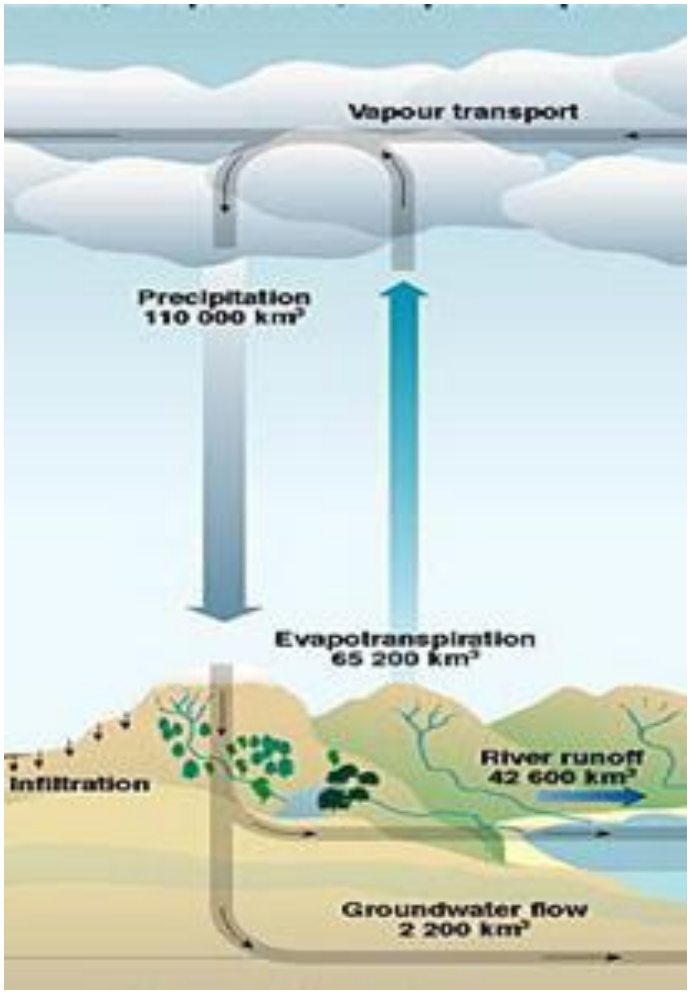
BUDGET ITEM	AMOUNT
Personnel	
Personnel: Research Scientist (S. Alexander) 72% salary, 28% benefits, 2 years, 1/2 time position	$ 72,800
Personnel: Graduate Students in Earth Sciences and Mechanical/Civil Engineering 52% salary, 48% benefits (includes tuition), 2 years, three - 1/4 time positions	$ 70,200
Contracts: N/A	$ -
Equipment/Tools/Supplies	
Equipment: Roto-Evaporator for evaporation of rain water research	$ 8,000
Equipment: Pilot scale cistern components and installation	$ 100,000
Supplies: Water chemistry and stable isotope analysis of rain water and evaporative concentrates 300 analyses at $110 per analysis.	$ 33,000
Supplies: Water treatment and monitoring supplies for pilot cistern system	$ 25,000
Acquisition (Fee Title or Permanent Easements): N/A	$ -
Travel: *Presentation of talks and/or posters at Minnesota Water Resources Conference, St. Paul, MN (registration fees for 2 faculty and 3 students).*	$ 1,000
TOTAL ENVIRONMENT AND NATURAL RESOURCES TRUST FUND $ REQUEST =	$ 310,000

V. OTHER FUNDS

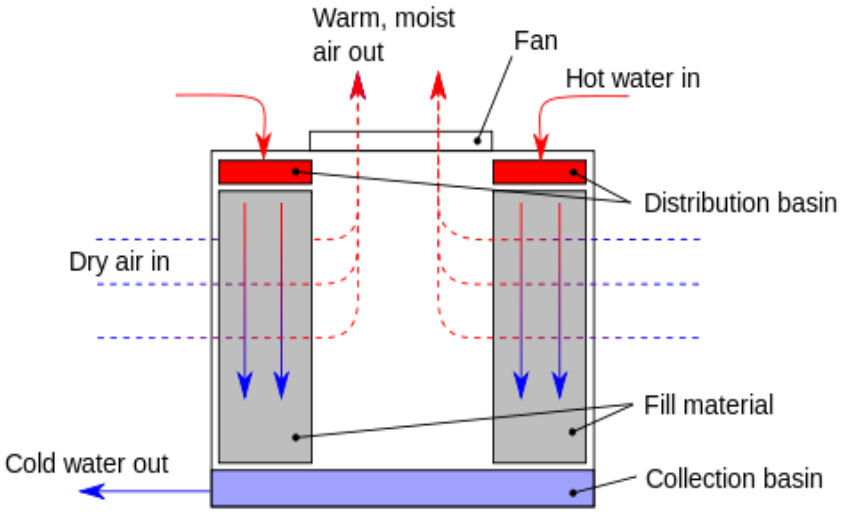
SOURCE OF FUNDS	AMOUNT	Status
Other Non-State $ Being Applied to Project During Project Period: *N/A*	$ -	
Other State $ Being Applied to Project During Project Period: *N/A*	$ -	
In-kind Services During Project Period: *N/A*	$ -	
'In-kind Services During Project Period: 2 weeks per year of 3 engineers time (12 weeks total salary and fringe from Energy Management Team: Nirml Jain, Scott Mccord, Cathy Abene)	$ 24,000	*Pending*
Remaining $ from Current ENRTF Appropriation (if applicable): N/A	$ -	
Funding History: N/A	$ -	

Rain Water Reuse and Valuation Investigation Visual

Rain water is naturally distilled from the oceans.



UNESCO 1999



Evaporative chillers that recycle rain water mimic the natural hydrologic cycle replacing plant transpiration with evaporation.

About 60% of Minnesota rain water is transpired back to the atmosphere under natural conditions.

Sanford and Selnick 2013 JAWRA 49:217-230.

Scott C. Alexander
Research Scientist and Environmental Health Specialist
Dept. of Earth Sciences and Environmental Health and Safety, University of Minnesota
Minneapolis, MN 55455
alexa017@umn.edu

Research Scientist/Project Manager 1991 to present. Dept. of Earth Sciences. Current duties include project management for Geothermal / CO_2 Sequestration studies and technical oversight and supervision of Hydrogeochemistry, Fluormetrics and Analog Fluid Hydrology Laboratories. Specific duties include collection of ground water and surface water samples for chemical and isotopic analysis, development of analytical techniques utilizing chemical and fluorescence properties of natural and synthetic materials, and development of tools to measure fluid properties. Additional duties include coordination of Hydrogeology Field Camp.

Environmental Health Specialist 2004 to present. Dept. of Environmental Health and Safety. Position requires a combination of scientific and administrative skills while interacting with students, professors, administrators, facilities staff and trades people. Specific tasks include design and review of storm water systems and management practices from individual rain garden to football stadium district scales. As part of this position I am a member of the Storm Water Linkage Committee, linking faculty and students with facilities and operations, and am a member of the Storm Water Task Force, helping to integrate campus storm water policies with facilities and operations. I was a co-author of the U of M Storm Water Policies and Procedures (the equivalent of our campus MS4 storm water ordinances). These policies and procedures were based on the State of Minnesota B3 Guidelines for storm water management, of which I was also a co-author.

Education
Michigan Technological University
University of Minnesota, B.S. Geophysics 1985

Expertise
Utilizing natural and man-made tracers in hydrogeologic systems including stable isotopes, radio-active isotopes, inorgranic chemical constituents and fluorescent organic dyes to define ground water recharge rates and travel times. Modelling of geochemical processes using computer based aqueous speciation programs. Measurement of fluorescent properties of organic dyes in aqueous solutions. Measurement of chemical, isotopic and physical properties fluids. Measurement of aquifer properties ranging from microscopic lithologic to macroscopic fractures to large scale conduits which has direct applications in the design, evaluation, and monitoring of storm water management systems.

Professional Associations
Geochemical Society, American Geophysical Union, Geological Society of America, National Ground Water Association, National Cave and Karst Research Institute, and Past President of the Minnesota Ground Water Association.