1. **Title of Proposal:** Evaluating the Efficacy of a Long-Term Residential Water Conservation Program in College Station, TX.

2. **Focus Category:** Conservation, Education, Economics

3. **Keywords:** Residential Water Conservation, Water Conservation Policy, Demand Management

4. **Duration:** March 1, 2015 through February 28, 2016.

5. **Federal Funds Requested:** $5,000

6. **Non-Federal matching Funds Pledge:** $15,962

7. **Principle Investigator: Graduate Student**
Adam C. Landon, Ph.D. Student in Water Management and Hydrological Science, Texas A&M University, 2261 TAMU College Station, TX 77843, email: aclandon@tamu.edu, phone: 585-314-5454.

8. **Co-PIs: Faculty Texas A&M University**
Ronald A. Kaiser, Professor of Water Law and Policy, Water Management and Hydrological Science, Texas A&M University. 2261 TAMU College Station, TX 77843, email: rkaiser@tamu.edu, phone: 979-845-5303.

Gerard T. Kyle, Professor Department of Recreation Park and Tourism Sciences, Texas A&M University, 2261 TAMU College Station TX, 77843, email: gkyle@tamu.edu, phone: 979-862-3794.

9. **Congressional District Where Work Will Occur:** TX US District 17

Abstract: In this investigation the authors evaluate the efficacy of a large scale residential water conservation program in the city of College Station TX. Evaluation of residential conservation policy is critical in order to take adaptive management actions and meet the anticipated water savings from conservation projected in the state water plan. Specifically the authors determine the price elasticity of demand, impacts of residential irrigation system audits, rebates for technology upgrades, and a unique persuasive educational program on water use among residents of college station. The authors draw on 10 years of monthly metered household water use data from over 20,000 households to develop several models of residential demand. Results inform policy formation and effectiveness and are directly relevant to the implementation of the state water plan.

Title: Evaluating the Efficacy of a Long-Term Residential Water Conservation Program in College Station, TX.

Statement of Critical Regional or State Water Problem: Conservation has been identified as a critical component of ensuring adequate future water supplies in the state of Texas (Water for Texas, 2012). However, beyond stressing the potential contributions of conservation in closing anticipated gaps in supply and demand, the exact mechanisms through which to achieve these needed reductions in water use remain poorly defined. The residential sector is one area where significant reductions in water use stand to made. The Environmental Protection Agency (2013), for instance, estimates that as much as half of all the water used outdoors is wasted as a function of leaking infrastructure, over watering, and miss-direction in lawn and landscaping irrigation. Improving efficiency in this area, therefore, can result in significant water savings.

Achieving these potential reductions in water use requires upgrades in technology, but more importantly, significant changes in the behaviors of water users (Schultz et al., 2014; Schultz, 2011). In an attempt to manage demands for water and leverage behavior change among water customers, utility mangers have designed and implemented a host of policy interventions (for reviews see Olmstead and Stavins, 2009; Kenney et al., 2008; Campbell et al. 2004). These interventions range from progressive block rate price structures and financial incentives for technical retrofits, to persuasive educational messages and public information campaigns that stress the merits of conservation. Evaluating the ability of these various policy instruments to reduce water use and change the behaviors of residential water users is key to meeting long-term goals for water use, water supply, and conservation in the residential sector. This is particularly the case in communities where market based mechanisms are infeasible owing to the political climate, concerns over equity, and the social acceptability of rate increases.

Over the last several years, water managers in the city of College Station Texas have undertaken an ambitious residential conservation campaign featuring a number of the policy instruments mentioned above namely; block rate pricing structures, rebates for technological upgrades, audits of irrigation systems, and persuasive educational messages. ***In this investigation we will determine the water savings associated with each of these policy instruments.*** It is our intent to provide managers with the information needed to take adaptive action in managing residential demands. Not all conservation actions will result in the desired impacts on water user behavior, therefore evaluation of their performance is essential. ***We will draw on close to 10 years of monthly water meter readings from over 20,000 households (over 2,000,000 observations), climate data, and detailed information concerning the implementation of conservation policies to estimate several models of residential demand.***

Statement of Results or Benefits: The results of this work will inform local and regional planning efforts as to the efficacy of their conservation efforts and identify avenues for adaptation. The unique level of detail that we possess in regards to water use overtime and implementation of conservation measures will allow us to make a contribution to the literature regarding the ability of price, persuasive conservation messages, water audits, and technology rebates, to achieve (or not) a change water user behavior. These results will provide a more concrete foundation on which to base the projected savings anticipated from municipal and residential conservation cited in state water planning documents (Water for Texas, 2012).

Nature, Scope and Objectives of the Research, Timeline of Activities: The objective of the proposed research is to determine the water savings associated with the policy instruments implemented in the College Station residential water conservation program. Specifically we will estimate 1) the price elasticity of demand, 2) the impacts of voluntary household irrigation system audits, 3) the impacts of rebates for outdoor infrastructure improvements, and 3) the impacts of a unique persuasive information and education campaign that has targeted the largest water users in the city in reducing water use. This educational program has consisted of providing personalized feedback on water use to customers in the form of a "water budget". The "water budget" is composed of two key pieces of information, 1) a comparison of the customers water use to an "efficient" standard determined as a function of their lawn's water needs and climatic conditions, and 2) a comparison of their water use to the water use of their neighbors. These comparisons, along with accompanying information on how to reduce water use, are designed to give customers a benchmark against which to judge their behavior, and when appropriate conform to societal expectations of their water use (Shultz et al., 2014; McKenzie – Mohr, 2000; Cialdini et al. 1990; Festinger, 1954). Although the impacts of general conservation education programs have been reported with mixed success in the literature (Schultz et al., 2002; Michelsen et al. 2000), social norms and social marketing approaches (McKenzie-Mohr, 2000) like the one implemented here have shown promise in achieving behavior change among resource users (Schultz et al., 2014). We will complete this research in the following timeline.

Timeline of Proposed Research:

May 1, 2015: Purchase computer and software to conduct analysis (see budget justification). Develop a database spanning the period January 2006 to December 2014 containing monthly climate measurements for precipitation and temperature, monthly water meter readings, and details concerning the implementation of conservation policies.

July 1, 2015: Estimation of models and compilation of results. Craft abstract for submission to American Geophysical Union meeting (see budget justification).

August 1, 2015: Complete technical report for dissemination of findings to College Station water utility and final report of findings for TWRI/USGS.

November/December 2015: Draft of manuscript to be submitted to the Journal of Hydrology or Journal of the American Water Resources Association. Attend AGU meeting, present results and revise manuscript draft based on feedback. Manuscript submission thereafter.

Methods, Procedures, Facilities: We will use an instrumental variable – fixed effects panel data approach to estimate our models of residential demand (Kenney et al. 2008). This will allow us to account for unobserved household characteristics and obtain unbiased parameter estimates while addressing issues of endogeneity associated with the price variable and the dependent variable accounting for water use. Our models will be estimated using the statistical software STATA version 13. The parameters to be estimated and functional form are presented in Figure 1. Where "ave_price$_{t-1}$" is the average price paid for water in the previous month (Arbúes et al., 2004; Kenney et al. 2008), "month$_t$" is a time delimiting variable, "total_precip$_t$" is precipitation in month$_t$ in inches, "ave_maxtemp$_t$" is the average maximum temperature in month$_t$ in degrees Fahrenheit. The variables "audit", "rebate", and "w_budget" are dummy variables that account for households that have received an audit of their irrigation system, a rebate for infrastructure improvements, and have been a member of the water budget conservation program, respectively. The variable "w_budget_period$_t$" accounts for the study period before and after the water budget program was initiated. Accounting for households in an out of the water budget program before and after it was initiated allows us to use a difference-in-difference approach to determining the effects of the water budget program as a whole. We will explore the utility of additional segmenting variables including seasonality, home value, lot size, and total volume of water consumed as they have all been shown to impact demand, and have managerial relevance.

Figure 1. Residential Demand Model

$$\ln(\text{water\_use}_{i,t}) = \begin{aligned} &\beta_0 + \beta_1 \ln(\text{ave\_price}_{i,t-1}) + \\ &\beta_2(\text{month}_t) + \\ &\beta_3 \ln(\text{total\_precip}_t) + \\ &\beta_4 \ln(\text{ave\_maxtemp}_t) + \\ &\beta_6(\text{audit}_{i,t}) + \\ &\beta_7(\text{rebate}_{i,t}) + \\ &\beta_8(\text{w\_budget}_i) + \\ &\beta_9(\text{w\_budget\_period}_t) + \\ &\beta_{10}(\text{w\_budget\_period}_t) * (\text{w\_budget}_i) + \\ &\varepsilon_{it}(\eta_i + \mu_{it}) \end{aligned}$$

Related Research: Previous work in residential demand management provides a solid foundation from which to conduct the research proposed herein. Our approach is primarily informed by the work of Kenney et al. (2008) in their investigation of demand management policy, as well as the work of Schultz et al. (2014; 2002), and McKenzie-Mohr et al. (2012; 2000) in their work on behavior change, social marketing, and normative feedback. Previous work suggests that price elasticity for residential water is small and inelastic (Arbúes, 2004), and that audits and rebates will have a small but lasting impact on water use. Experimental work using feedback information like the water budget program discussed here have been shown to have significant impacts on behavior in a number of contexts (Schultz et al., 2014). We anticipate that our results will mirror these previous findings, yet extend the literature by demonstrating the utility of a large scale personalized feedback program in managing residential demand.

Training Potential: The training potential for this work is extensive. Aside from the obvious benefits to the PI and Co-PIs in the form of academic publications and conference presentations, we will be collaborating with representatives of the College Station water utility throughout the project. This will create a bridge between academia and management that will result in a greater understating of the science and impacts of the policy that is being implemented for all parties involved, with positive outcomes for the community and the environment. Additionally the PI will have the opportunity to apply and further refine analytical skills in water resource

management and conservation in a novel context including Geographic Information Systems, data management, and statistical modeling techniques, as well as engage in the communication of scientific results.

References:

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Syme, J., Nancarrow, B.E., and Seligman, C. 2000. The evaluation of information campaigns to promote voluntary household water conservation. *Evaluation Review*. 24(6): 539-578.

Schultz, P.W., Messina, A., Tronu, G., Limas, E.F., Gupta, R. and Estrada, M. 2014. Personalized normative feedback and the moderating role of personal norms: A fields experiment to reduce residential water consumption. *Environment and Behavior*. DOI: 10.1177/0013916514553835.

Schultz, P.W. 2011. Conservation means behavior. *Conservation Biology*. 25(6): 1080-1083.

Water for Texas, (2012). Texas Water Development Board.

Adam Landon

Academic Preparation

Ph.D. (Water Management and Hydrological Science) Texas A&M University, December 2015
M.S.ed (Education) Nazareth College of Rochester, December 2009
B.S. (Wildlife Science) SUNY College of Environmental Science and Forestry, December 2007

Current Position

Graduate Research Assistant - Texas A&M University (2011 to Present)

Awards

National Science Foundation IGERT Fellow in Applied Biodiversity Science (2012 – Present)
Robert Ditton Endowed Scholarship in Human Dimensions of Natural Resources (2012)
SUNY ESF Foundation Scholarship (2004-2007)

Peer-Reviewed Publications (In Review):

- **Landon, A.C**., van Riper, C.J., Fitzgerald, D.B., Angeli, N.F. & Neam, K. (2014). *Growing transdisciplinary roots in the Peruvian Amazon.* Journal of Transdisciplinary Environmental Studies.
- Wallen, K.W., **Landon, A.C.,** Kyle, G.T. & Schuett, M.A. (2014). *Bias in mode of response in survey based research: Implications for recreational fisheries management.* North American Journal of Fisheries Management.

Non-Peer Reviewed Publications:

- **Landon, A.C.**, Kaiser, R.A., Coleman, D. (2014). *Water conservation attitudes, behaviors, and management preferences of College Station water users*. Human Dimension of Natural Resources Lab Technical Document.
- Wallen, K.W., **Landon, A.C.,** Kyle, G.T. & Schuett, M.A. (2014). *The human dimension of fisheries survey research: An exploration of varied collection modes.* Proceedings of the Gulf and Caribbean Fisheries Institute.
- **Landon, A.C**., van Riper, C.J., Kyle, G.T & van Riper, C. III. (2014). *Effective biodiversity conservation: Incorporating the Human element*. Science. (Electronic Comment)
- **Landon, A.C**. 2013. *Amazon gold: Local impacts from a global market*. The Drop Newsletter 5(1): 5.
- **Landon, A.C**., Jun, J., Kyle, G.T., Yoon, J.I., Schuett, M. (2011). *Demographics, participation, attitudes, and management preferences of Texas anglers*. Texas A&M University, Human Dimensions of Natural Resources Lab Technical Document.

Manuscripts in Preparation:

- **Landon, A.C.** Kaiser, R.A. & Kyle, G.T. 2015. *Predicting voluntary compliance in a residential water conservation program using the theory of planned behavior*. Target Journal: Society and Natural Resources.
- **Landon, A.C.** Kaiser, R.A. & Kyle, G.T. 2015. *Motivations and constraints to residential water conservation*. Target Journal: Journal of Hydrology.
- Treglia, M.L & **Landon, A.C.** (2015). *A generalized framework for the study of freshwater Coupled Human and Natural Systems*. Target Journal: Frontiers in Ecology and the Environment.

Gerard T. Kyle **Texas A&M University**

Professional Preparation:

University of New South Wales	Psychology	BS 1993
The Pennsylvania State University	Leisure Studies	MS 1998
The Pennsylvania State University	Leisure Studies	PhD 2001

Appointments:

- 2012-Present, **Professor,** , Department Recreation, Park & Tourism Sciences, Texas A&M University
- 2007-2012, **Associate Professor**, Department Recreation, Park & Tourism Sciences, Texas A&M University
- 2004-2007, **Assistant Professor**, Department Recreation, Park & Tourism Sciences, Texas A&M University
- 2001-2004**, Assistant Professor**, Department Park, Recreation & Tourism Management, Clemson University
- 1996-2001, **Teaching assistant**, The Pennsylvania State University

Five Most Relevant Publications (> 60 Total):

- van Riper, C. J., & **Kyle, G. T.** (In print). Understanding the internal processes of behavioral engagement: A latent variable path analysis of the value-belief-norm theory. *Journal of Environmental Psychology.*
- Wynveen, C. J., Kyle, G. T., & Sutton, S. G. (2014). Environmental worldview, place attachment, and attitudes toward environmental impacts in a marine environment. *Environment & Behavior, 46,* 993-1017.
- Kyle, G. T., Jun, J., & Absher, J. D. (2014). Repositioning identity in conceptualizations of human-place bonding. *Environment & Behavior, 46,* 1018-1043.
- van Riper, C. J., **Kyle, G. T.,** & Sutton, S. G., Yoon, J., & Tobin, R. C. (2013). Australian residents' attitudes toward pro-environmental behavior and climate change impacts on the Great Barrier Reef. *Journal of Environmental Planning and Management, 56*(4), 494-511.
- **Kyle, G. T.,** Theodori, J. L., Absher, J. D., & Jun, J. (2010). The influence of home and community attachment of Firewise behvavior. *Society and Natural Resources*, *23*(11)*,* 1075-1092.

Five Additional Publications:

- Schuett, M. A., **Kyle, G. T.,** Leitz, J., Kurzawski, K., & Lee, K. (2014). Anglers' motivations for volunteering with fishing conservation organizations. *Fisheries, 39*(7), 305-311.
- Wynveen, C. J., Connally, W. D., & Kyle, G. T. (2013). Antecedents to pro-environmental behavior in marine protected areas: The cases of the Great Barrier Reef Marine Park and the Florida Keys National Marine Sanctuary. *Journal of Park & Recreation Administration, 31*(2), 28-49.*
- Wynveen, C. J., Kyle, G. T., & Sutton, S. G. (2012). Natural area visitors place meaning and place attachment ascribed to a marine setting. *Journal of Environmental Psychology, 32,* 287-296.*
- van Riper, C. J., **Kyle, G. T.,** Sutton, S. G., Barnes, M., & Sherrouse, B. C. (2012). Mapping outdoor recreationists' perceived social values for ecosystem services at Hinchinbrook Island National Park, Australia. *Applied Geography*, *35,* 164-173.
- Wynveen, C., Kyle, G. T., & Absher, J. D., & Theodori, G. L. (2011). Linking measures and meaning: A mixed-method approach for understanding the meaning underlying quantitative indicators of place attachment. *Journal of Leisure Research, 43*(2), 289-310.

RONALD A. KAISER
Professor of Water Law and Policy
Chair Water Management and Hydrological Science graduate degree program.

SIGNIFICANT RECENT ACHIEVEMENTS

Developed the Water Management and Hydrological Science Interdisciplinary Graduate program that currently enrolls 60 students and has graduated 75 students.
Developed a two-week field study course on Rio Grande River water management.

EDUCATION

LL.M. *University of California @ Berkeley*
J.D. *Thomas M. Cooley Law School*
M.S. *Michigan State University*
B.S. *Michigan State University*

PUBLICATIONS AND PRESENTATIONS

Journal articles: 35 -- Books: 3 --Book chapters: 5 -- Technical papers: 23

SELECTED WATER PUBLICATIONS

- Khedun, C., Sanchez, R., Rughoonondun, H., and Kaiser, R. (2014). "World Water Use: Conflicts and Challenges for the Future" in Encyclopedia of Agriculture and Food Systems (N. Van Elfin Ed) Elsevier Publisher.
- Khedun, C. P., A. K. Mishra, J. Bolten, H. K. Beaudoing, R. A. Kaiser, J. Giardino, and V. P. Singh (2012). Understanding changes in water availability in the Rio Grande/Río Bravo del Norte basin under the influence of large-scale circulation indices using the Noah land surface model, J. Geophys. Res., doi:10.1029/2011JD016590.
- Sanchez, R. & R. Kaiser. (2011). "Multilateral cooperation: Water as a tool not as a goal" Journal of the International Relations and Affairs Group 1 (1) 75-91.
- Kaiser, R., (2012). "Conjunctive Water Management" in Texas Water Resources: (Mary Sahs Ed) State Bar of Texas: Austin, Tx.
- Kaiser, R.,(2011). "Texas Water Institutions and Laws" in Water Policy in Texas: Management for a Diverse Land, (R. Griffin Ed) Resources for the Future, Wash D.C.

RECENT FUNDING RELATED TO WATER

1. Bridging Hydrology, Governance, Culture and Scarcity for Effective Rio Grande Water Management: An Interdisciplinary Learning and Research Experience. Included a 2 week field trip in Colorado, New Mexico and Texas, $150,000.
2. Climate variability on Rio Grande, Funded by Sate of Coahuila, Mexico, $40,000.
3. Assessing the efficacy of selected urban water conservation strategies, $240,000.
4. Water quality assessment for the National Park Service, $570,000.
5. Risk assessment for the San Antonio desalination plant, $22,000.

Budget Breakdown			
Start Date	03/01/15		
End Date	02/28/16		
Project Number	*to be completed by TWRI*		
Project Title	Evaluating the Efficacy of a Long-Term Residential Water Conservation Program in College Station, TX.		
Principal Investigator(s)	Adam C. Landon		
Cost Category	**Federal**	**Non-Federal**	**Total**
1. Salaries and wages			
- Professional			$0
- Graduate Student(s)		$9,882	$9,882
- Undergraduate Student(s)			$0
- Other			$0
Total Salaries and Wages	$0	$9,882	$9,882
2. Fringe benefits			
- Professional			$0
- Graduate Student(s)			$0
- Undergraduate Student(s)			$0
- Other			$0
Total Fringe benefits	$0	$0	$0
3. Tuition			
- Graduate Student(s)	$1,200		$1,200
- Undergraduate Student(s)			$0
Total Tuition	$1,200	$0	$1,200
4. Supplies	$1,895		$1,895
5. Equipment			$0
6. Services/Consultants			$0
7. Travel	$1,870		$1,870
8. Other direct costs			$0
9. Total direct costs	$4,965	$9,882	$14,847
10. Indirect costs		*$5,229*	
		$851	$6,080
11. Total estimated costs	$4,965	$15,962	$20,927

Budget Justification

Travel to American Geophysical Union meeting to present results

- December 15-19, 2015
- Estimated airfare roundtrip College Station, TX to San Francisco, CA $600
- Estimated Hotel 5 days @ $150 = $750
- Registration $270
- Per Diem 5 days @ $50 = $250

  Total = $1,870

Computer and software needed to conduct analysis

- Computer = $1500
- Site license for STATA 13 SE = $395

  Total = $1,895

Tuition and Fees

- Summer fees for PI Adam Landon = $1,200

  Total = $1,200

Total Federal Direct Costs = $4,965

Total Non-Federal Direct Costs = $9,882

- **6 months of salary for PI @$1,647/month**

Total Indirect Cost = $6,080 ($5,229/$851)

Total Estimated Costs = $20,927