

**Texas Water Resources Institute  
Annual Technical Report  
FY 2013**

# Introduction

The Texas Water Resources Institute (TWRI), a unit of Texas A&M AgriLife Research, Texas A&M AgriLife Extension Service and the College of Agriculture and Life Sciences at Texas A&M University, and a member of the National Institutes for Water Resources, provides leadership in working to stimulate priority research and Extension educational programs in water resources. Texas A&M AgriLife Research and the Texas A&M AgriLife Extension Service provide administrative support for TWRI, and the Institute is housed on the campus of Texas A&M University.

TWRI thrives on collaborations and partnerships and in fiscal year 2013 managed 41 active projects with \$12,705,219 in funds. Those projects involved more than 100 Texas A&M University System faculty members and graduate students as well as faculty from other universities across the state. The Institute maintained joint projects with both Texas universities and out-of-state universities; federal, state and local governmental organizations; consulting engineering firms, commodity groups and environmental organizations; and numerous others. In 2013 the Institute was awarded 15 new TWRI-lead projects with direct funding of \$4,394,616.

TWRI works closely with agencies and stakeholders to provide research-derived, science-based information to help answer diverse water questions and also to produce communications to convey critical information and to gain visibility for its cooperative programs. Looking to the future, TWRI awards water scholarships to graduate students at Texas A&M University through funding provided by the W.G. Mills Endowment and the U.S. Geological Survey.

## **Research Program Introduction**

Through the funds provided by the U.S. Geological Survey in combination with funding from the W.G. Mills Endowment, TWRI funded two Water Assistantship research projects in 2013-2014 conducted by two graduate students at Texas A&M University.

Elizabeth Edgerton, of Texas A&M University's Department of Wildlife and Fisheries Sciences, studied invasive aquatic species in Texas.

Benjamin Blumenthal, of Texas A&M University's Department of Geology and Geophysics, studied increasing water security through horizontal wells.

# Evaluation of invasive aquatic species in Texas

## Basic Information

<b>Title:</b>	Evaluation of invasive aquatic species in Texas
<b>Project Number:</b>	2013TX461B
<b>Start Date:</b>	3/1/2013
<b>End Date:</b>	2/28/2014
<b>Funding Source:</b>	104B
<b>Congressional District:</b>	17
<b>Research Category:</b>	Biological Sciences
<b>Focus Category:</b>	Invasive Species, Management and Planning, Ecology
<b>Descriptors:</b>	None
<b>Principal Investigators:</b>	Michael Masser, Elizabeth Edgerton, Lucas Gregory, Allen E. Knutson

## Publications

1. Edgerton, Elizabeth A. 2014. USGS Annual Report: Evaluation of invasive aquatic species in Texas. Texas Water Resources Institute, Texas A&M University. College Station, TX. 1-5.
2. Edgerton, Elizabeth; Lucas Gregory; Michael Masser; William Grant; Allen Knutson. 2013. Developing a Risk Assessment Tool for Identifying Potential Aquatic Invasive Plants in Texas in Aquatic Plant Management Society's Abstract's Review.
3. Edgerton, Elizabeth; Lucas Gregory; Michael Masser; William Grant; Allen Knutson. 2014. Aquatic Invasive Plant Management: Using modeling to Predict Existing Infestations and Prioritize Existing Infestations in Texas in Texas Invasive Plant & Pest Council's Abstract's Review.

# **REPORT**

**Title:** Evaluation of invasive aquatic species in Texas

**Project Number:** 2013TX461B

**Primary PI:** Elizabeth A. Edgerton

**Other PIs:** Lucas Gregory, Michael Masser, William Grant, Allen Knutson

## **Abstract**

Research on invasive aquatic species in Texas, funded through the USGS and the W.G. Mills Memorial Endowment, began June of 2012 and concluded May of 2014. The time frame for this report is March 1, 2013 through February 28, 2014. The focus of this research was to evaluate aquatic invasive species in the state of Texas. Upon speaking with representatives from the Texas Parks and Wildlife Department and the Lady Bird Johnson Wildflower Center, it was determined that a risk assessment tool for aquatic invasive plants, tailored to the state of Texas would be beneficial as inhibiting the introduction of new, potentially invasive species is the most successful method for preventing serious infestations. An invasion model was also developed to simulate the invasion and management of invasive species within a reservoir in Texas. The risk assessment serves as a useful predictor of future potential invasive plant species, as well as prioritizing existing invasive aquatic plants for management purposes, and is applicable to policy makers in determining which species to prohibit, as well as for managers deciding which species deserve the highest priority in management and control efforts. The invasion model is a case study model, simulating the infestation and management of hydrilla at Lake Conroe, and serves as an example of future modeling work that could be done to model the spread of an invasive species after introduction, and a tool to model potential management techniques.

## **Problem and Research Objectives**

Determining which non-native aquatic plants have the greatest potential to invade a new area, and prohibiting those species prior to their introduction, is the key to preventing future serious infestations. The vast majority of non-native plants, either aquatic or terrestrial, are intentionally introduced to an area for purposes such as food crops, ornamental gardening, or as novelties. Once established in captivity, many plants are accidentally or intentionally released into the environment. The majority do not pose a serious threat of infestation, however a select number can quickly become well established and cause severe damage to both the ecosystem and the economy. Each year, millions of dollars are spent in an attempt to control these invaders in the United States. Additionally, invasive plants cause a multitude of negative impacts, such as reduced biodiversity, increased transportation costs, changes water chemistry, and decreased land values. Weed Risk Assessments, tools for determining the invasive potential of a plant species, have been developed and are currently being used around the world to screen non-native plant species and identify those which are likely to be invasive and should be excluded. Most notably, a risk assessment was developed for Australia in 1999 as a biosecurity tool, which is referred to as the Weed Risk Assessment or WRA. The Australian system is regarded as a highly

accurate tool for screening non-native terrestrial plants prior to their introduction. This model has been widely adapted to screen for both terrestrial and aquatic plants in a number of other countries including New Zealand, Chile, and the United States, as well as individual states in the US such as California and Hawaii.

A tool specifically tailored to the unique ecosystems of Texas has not yet been developed, however. Texas is a major hub in the aquatic plants trade and has conditions, like a temperate climate, which are favorable for plant invasions. In fact, one of the most common sources of aquatic ornamental plants is internet sale, and Texas is home to some of the largest retailers in the country. So, developing and implementing an effective risk assessment tool is imperative to reducing future invasions. This study reviewed the models that are currently available, the New Zealand and United States models in particular, and adapted them to develop a tool that accurately identifies those aquatic species which should be prohibited from entering the state of Texas, while recognizing those which should be safe to import. The new tool will be comprised of two models: a questionnaire-style risk assessment which will give each plant an invasiveness score, and an invasion model which simulates aquatic invasive plant growth and potential management techniques.

## **Materials/Methodology**

The research began with assessing existing risk assessments models that have been developed and are currently in use, specifically the New Zealand Weed Risk Model (AWRA) and the United States Weed Risk Assessment (USAqWRA). The models are questionnaire-style assessments with a number of weighted questions which address various aspects of plant ecology, reproductive abilities, potential environmental and economic impacts, and history of invasion in other areas, among others. Questions include temperature tolerance, resistance to management, and aesthetic value. Upon completion of the questionnaire, each plant is given a score of invasiveness potential; the higher the score, the more likely the plant is to become invasive.

The risk assessment developed for Texas, the Texas Aquatic Plant Risk Assessment or TX APRA, is similar to these previous models, however minor changes were made so that the parameters accurately reflect conditions in Texas. To test for model accuracy, 100 plants which are known to have been previously introduced into Texas ranging from major invaders, to minor invaders, to non-invaders were scored to ensure that the model can correctly distinguish between the three categories.

Part two of the tool is an invasion model which shows predicted rates of growth and spread of non-native plants over time. The invasion model developed for this research is a case study model, simulating the invasion and subsequent management of hydrilla within Lake Conroe, a man-made reservoir in East Texas. Lake Conroe was chosen as because the hydrilla infestation at Lake Conroe is a very well documented event with a multitude of readily available data. Annual average temperatures, day length, water depth, and hydrilla growth and senescence rates were all used in the model. Management techniques like manual removal, herbicide application, bio-control, were also incorporated, and the control technique's effectiveness can be predicted.

## **Principal Findings**

Results from analysis of the risk assessment test data show that the risk assessment can correctly distinguish between major invaders, minor invaders, and non-invaders with an extremely high level of accuracy. Preliminary staticall analysis using multivariate analysis of variance (MANOVA) results in a 100% correct prediction rate. The invasion model accurately simulates the invasion of hydrilla in Lake Conroe and subsequent management efforts, according to data collected from the actual hydrilla invasion at Lake Conroe (Klussmann et al. 1988, Chilton et al. 2008).

## **Significance**

Implementing an accurate risk assessment tool in the state of Texas will be highly useful to policy makers, and could serve as a useful aid in determining which aquatic plant species to exclude from entry into the state. Prevention through prohibition is the most effective way of ensuring that new, potentially devastating invasive species do not enter our state's waters. With this tool, policy makers will be able to accurately determine those species which have a potential to be highly invasive and should be prohibited, while still allowing entrance of species which likely do not pose a serious threat of invasion.

The TX APRA will also benefit managers and those working to control and manage existing invasive species. The invasion model will allow managers to model various control techniques and determine what the most effective course of action will be. An invasion model to predict growth and spread of aquatic plants has not been developed with any of the previous risk assessments and could be highly useful in aiding managers when deciding the best plan of action for controlling existing aquatic invasive plants, or as an educational tool to demonstrate the consequences of aquatic invasive species. Modeling control efforts prior to testing them in the field could prove very cost effective, as time spent in the field and money spent on control efforts could be saved by narrowing down the best plan of action.

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Clayton, J.S., Champion, P.D. 2006. Risk Assessment Method for Submerged Weeds In New Zealand Hydroelectric Lakes. *Hydrobiologia* 570: 103–188.

Klussmann, W.G., Noble, R.L., Martyn, R.D., Clark, W.J., Betsill, R.K., Bettoli, P.W., Cichra, M.F. and Campbell, J.M., 1983. Control of aquatic macrophytes by grass carp in Lake Conroe, Texas, and the effects on the reservoir ecosystem.

Padilla, D.K., Williams, S.L. 2004. Beyond ballast water: aquarium and ornamental trades and sources of invasive species in aquatic ecosystems. *Frontiers in Ecology and the Environment*. 2, 131-138.

Pimentel, D., Lach, L., Zuniga, R. Morrison, D. 2000. Environmental and Economic Costs of Nonindigenous Species in the United States. *BioScience* 50, 53-65.

# **PUBLICATION**

## **Water Resources Research Institute Reports**

Edgerton, Elizabeth A. 2014. USGS Annual Report: Evaluation of invasive aquatic species in Texas. Texas Water Resources Institute, Texas A&M University. College Station, TX. 1-5.

## **Conference Proceedings**

Edgerton, Elizabeth; Lucas Gregory; Michael Masser; William Grant; Allen Knutson. 2013. *Developing a Risk Assessment Tool for Identifying Potential Aquatic Invasive Plants in Texas* in Aquatic Plant Management Society's Abstract's Review.

Edgerton, Elizabeth; Lucas Gregory; Michael Masser; William Grant; Allen Knutson. 2014. *Aquatic Invasive Plant Management: Using modeling to Predict Existing Infestations and Prioritize Existing Infestations in Texas* in Texas Invasive Plant & Pest Council's Abstract's Review.

## **NOTABLE AWARDS AND ACHIEVEMENTS**

2<sup>nd</sup> Place; Student Poster Competition at the Aquatic Plant Management Society Annual Conference, San Antonio, TX, July 16, 2013. \$200.

1<sup>st</sup> Place; Oral Student Presentation at the Texas Invasive Plant & Pest Conference, Port Aransas, TX, February 27, 2014. \$500.

Won \$150 travel grant to attend the Texas Invasive Plant & Pest Council's Conference, February 2014.

Received assistance from the Aquatic Plant Management Society in January; serve as student director on the society's board of directors and they paid flight, hotel and meals for planning the meeting held in January 2014.

# Increasing Water Security through Horizontal Wells

## Basic Information

<b>Title:</b>	Increasing Water Security through Horizontal Wells
<b>Project Number:</b>	2013TX462B
<b>Start Date:</b>	3/1/2013
<b>End Date:</b>	2/28/2014
<b>Funding Source:</b>	104B
<b>Congressional District:</b>	17
<b>Research Category:</b>	Ground-water Flow and Transport
<b>Focus Category:</b>	Groundwater, Water Quantity, Water Supply
<b>Descriptors:</b>	None
<b>Principal Investigators:</b>	Hongbin Zhan, Ben Blumenthal, Kristine Ann Uhlman

## Publications

There are no publications.

# **PROGRESS REPORT**

**Title** Increasing Water Security through Horizontal Wells

**Project Number** 2013TX462B

**Primary PI** Dr. Hongbin Zhan

**Other PIs** Benjamin Blumenthal

## **Abstract**

The use of non-vertical wells for groundwater production will allow greater production rates per well (and thus less wells) compared to traditional vertical wells. The number of vertical wells replaced by one horizontal well will be greatest in low permeability, thin aquifers. Therefore, locations with low aquifer quality will have greater access to groundwater upon the use of angle/horizontal wells. Furthermore, non-vertical wells may be advantageous for aquifer storage and recovery operations by minimizing buoyancy stratification.

While angle/horizontal well models have been developed, they typically ignore head (energy) loss within the wellbore which may be a limiting factor to angle/horizontal well use. Upon application of petroleum industry methodology, we have developed an easy to use model for common groundwater boundary conditions which incorporates intra-wellbore energy loss. Water resource managers will now be able to rigorously quantify the possible benefits of non-vertical wells and thus improve water availability in areas of low quality aquifers.

## **Problem and Research Objectives**

The use of angle/horizontal wells for groundwater supply production increases production rate for a given drawdown (i.e. less drawdown for a given pumping rate) as there is greater contact with the aquifer (Joshi, 1988; Ozkan et al., 1989). The use of angle/horizontal well technology will thus facilitate greater groundwater production per well compared to similar vertical wells in the same aquifer. The utility of horizontal/angle wells compared to vertical wells will be greatest in thin aquifers and/or lower permeability aquifers. Two such projects have completed with this goal in mind (Jehn-Dellaport, 2004; Rash, 2001).

Furthermore, the use of horizontal wells for aquifer storage and recovery (ASR) would increase the productivity/injectivity of ASR wells (Pyne, 2005; Pyne and Howard, 2004; Zuurbier et al., 2013). In addition, recovery of injected water will likely increase when using angle/horizontal wells by allowing the wells to target thin, lower permeability aquifers which would minimize buoyancy stratification effects (Esmail and Kimbler, 1967; Kimbler, 1970; Kumar and Kimbler, 1970). The ability to extract more water from these thin, lower permeability formations would improve the utility ASR especially in brackish aquifers.

To date, several analytical models have been developed for groundwater flow to a horizontal well (Hantush and Papadopoulos, 1962; Park and Zhan, 2002; Zhan et al., 2001; Zhan and Zlotnik, 2002). However, these models ignore head (energy) loss within the wellbore and assume uniform flux or uniform head along the length of the well. The investigation of head loss within the wellbore has only received limited study by the groundwater community (Chen et al.,

2003). Numerical finite-difference models (MODFLOW-CFP) can be used to study head loss in the wellbore, but are difficult to implement due to stability and grid issues (Shoemaker et al., 2007).

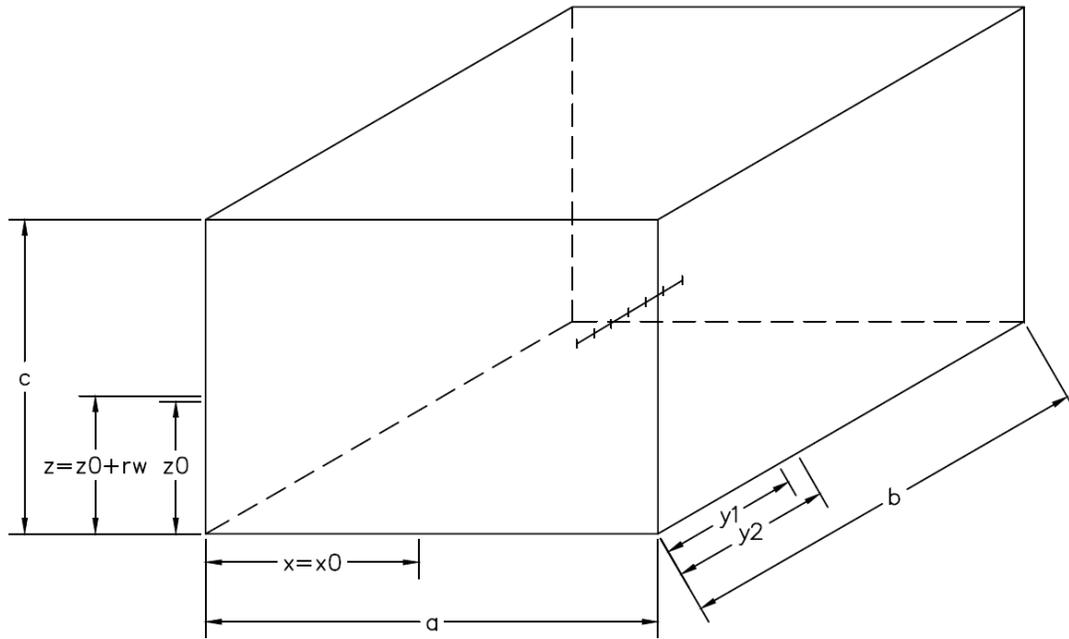
Quantification of head loss within the angle/horizontal wellbore is important as it will affect the drawdown to production ratio and hence competitiveness when compared to vertical wells. With current models, a horizontal wellbore should increase in length towards infinity to achieve the least drawdown for a give production rate. However in reality, given an extremely high pumping rate, the length of the wellbore would become inconsequential as the head loss would be very high. In this latter case, a vertical well would be essentially the same as the angle/horizontal well given high enough pumping rates. In regards to ASR, head loss along the wellbore (and hence uniform flux assumptions) will impact recoverability of injected water and thus has been cited as a research need (Maliva and Missimer, 2010).

## **Materials/Methodology**

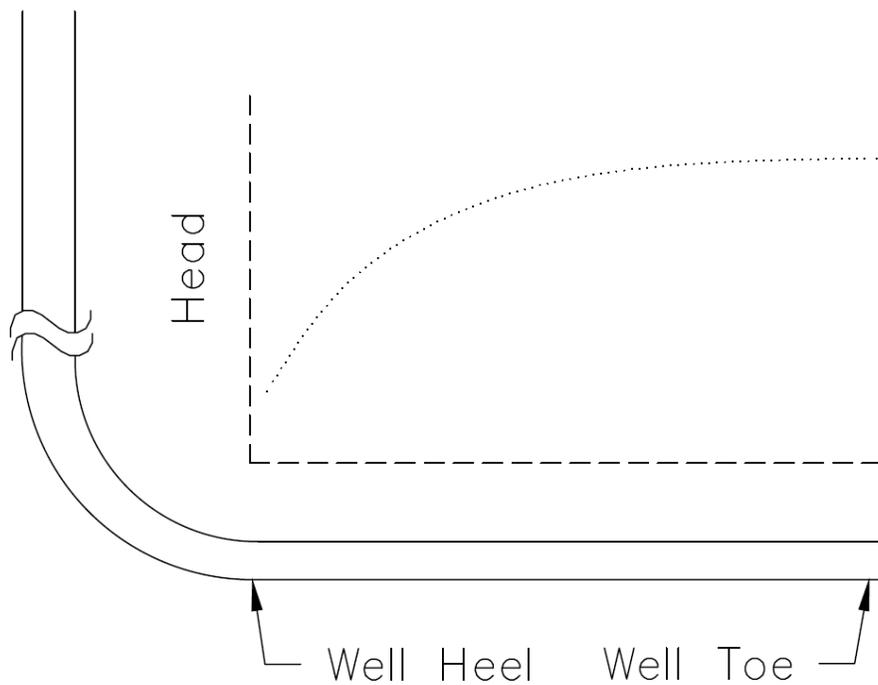
As a result of the stability issues of MODFLOW-CFP and the requirement of user intervention to achieve accurate results, we chose to implement an automatable, analytical method. The petroleum industry has derived analytical angle/horizontal well solutions with incorporation of wellbore head loss (Dikken, 1990; Landman, 1994; Novy, 1995). However, these solutions used many unrealistic assumptions such as an fully penetrating well, 2-dimensional reduction of space, etc.

More recently, however, a solution methodology has been developed for a three-dimensional well in an anisotropic aquifer within a box shaped aquifer/reservoir (Ouyang and Aziz, 1998; Penmatcha and Aziz, 1999). Solutions to date have included a confined reservoir of infinite extent and a reservoir with all closed (no-flux) boundaries. In addition, the wellbore has a limited extent in the box to roughly the middle fifty percent and is bound along one principal axis (Babu and Odeh, 1988; Babu and Odeh, 1989).

Our work expands on that of the petroleum industry by allowing the wellbore to be at any location in the reservoir along any angle from point  $X_1, Y_1, Z_1$  to  $X_2, Y_2, Z_2$ . In addition, we expand the boundary conditions to those found in groundwater systems, namely constant head (river/lake) and a leaky-aquifer. A conceptual diagram of our model may be seen in Figures 1 & 2.



**Figure 1.** Conceptual diagram of the box-shaped reservoir/aquifer.



**Figure 2.** Conceptual diagram of the head (energy) along a horizontal wellbore.

Derivation of our model begins with the differential equation governing groundwater flow and a point sink represented by a delta function. We then compute the time Laplace transform and solve the boundary conditions using Fourier series. Upon solution of the boundary conditions, we take the inverse Laplace transform and now have the time derivative for a point sink. We then focus on the very slowly convergent Fourier series at time zero and find closed

form solutions/approximations. Upon derivation of closed forms, we take the numerical time integral and numerical line integral from point  $X_1, Y_1, Z_1$  to  $X_2, Y_2, Z_2$  to represent the angle/horizontal/vertical wellbore. We now have a uniform flux line sink in an aquifer with one of several boundary conditions. With the analytics of the problem complete, we now move to numerics.

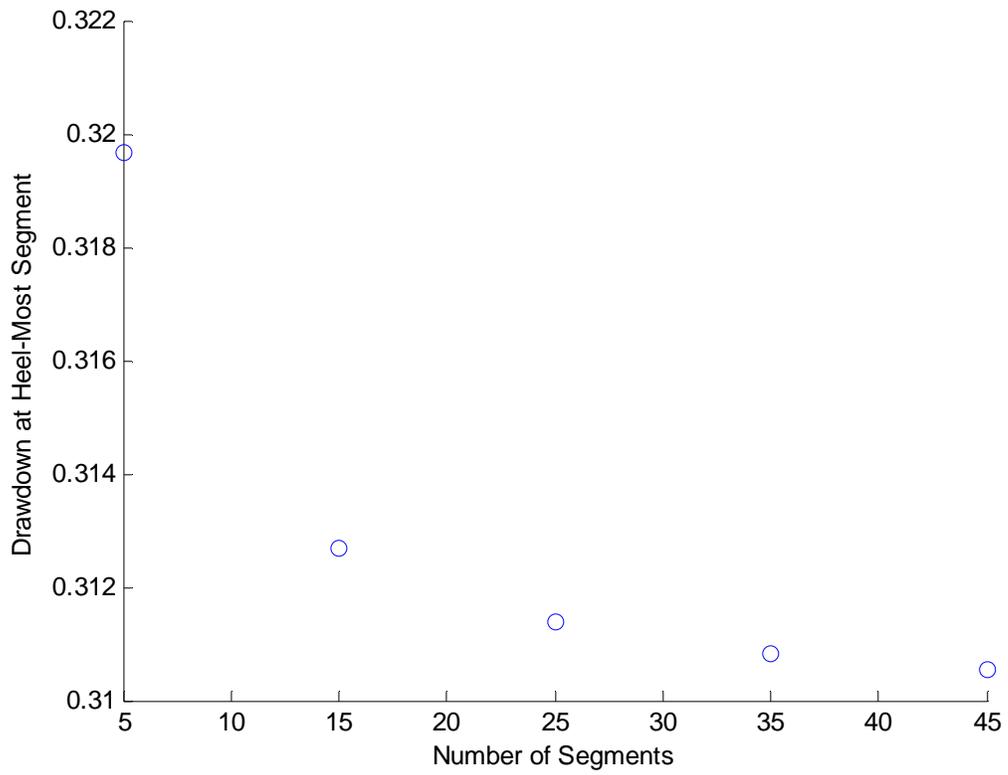
A numerical implementation of the above equations is written in Matlab. To model the head (energy) loss in the wellbore, we use the principle of superposition and subdivide one long wellbore (angle, horizontal or vertical well) into many small uniform flux line sinks. Using superposition, we define the difference in head between one segment and the next using frictional and acceleration head loss equations.

As the aquifer is dynamically connected to the wellbore (both in reality and our model), this circular connection must be numerically solved as such. We first assume a uniform flux between each of the segments to establish a direction of flow via the energy loss equations. We then solve the matrix with the coupled aquifer. This updates the flux to some non-uniform distribution. We then re-solve the energy loss terms and continue the process until convergence is reached. With a solution obtained for a given number of segments, we then add segments and repeat the entire process; continually adding segments until the heel-most segment numerically converges.

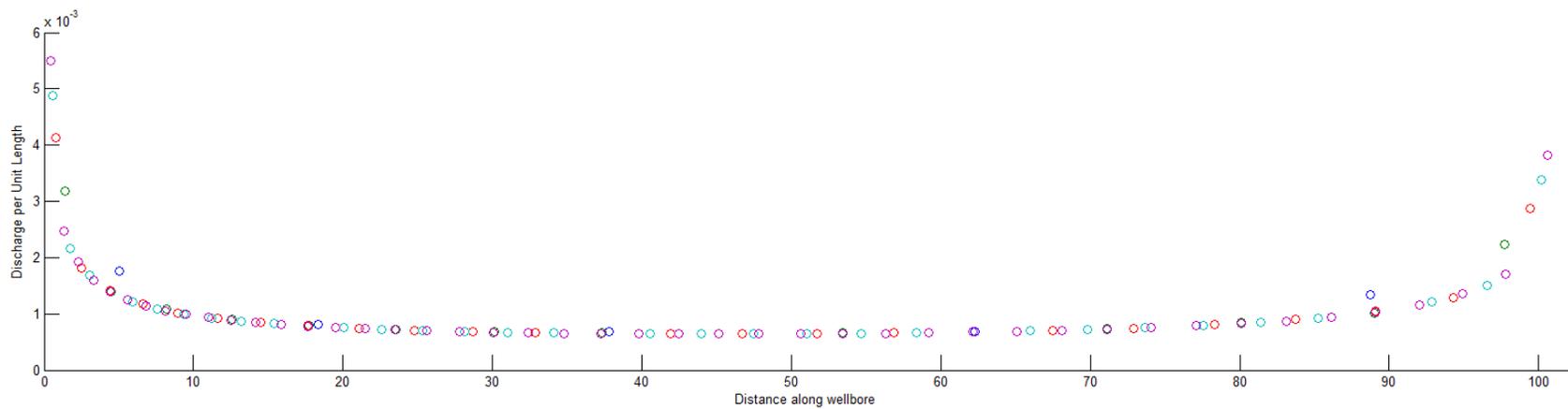
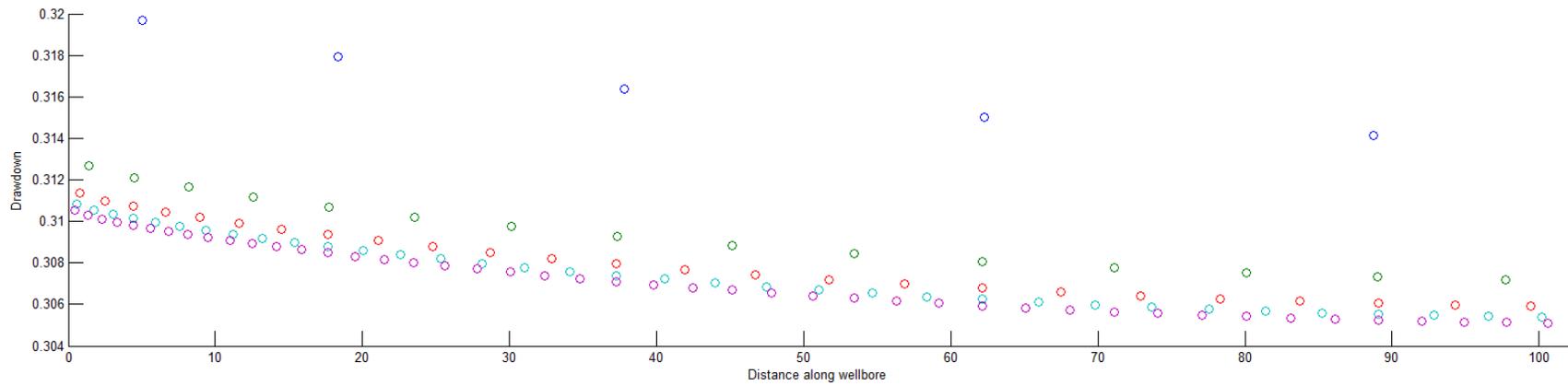
This method is typically convergent around forty segments. Due to the automatic nature of the MATLAB code, one only needs to input a well and aquifer parameters, then wait for convergence. The minimal need for user intervention allows for ease of use and the computation of many different input parameters with relative ease.

## **Principal Findings**

As we are still improving the model, we have yet to compute the benefits of a horizontal well for many input parameters and therefore cannot make specific statements on horizontal well production. From the model runs completed, however, we have noticed that the importance of head loss is relative to the permeability of the aquifer and the production rate. In addition, greater wellbore length in the aquifer has led to smaller drawdowns as expected. More interestingly, we have noticed that the production along the wellbore is greatest at the well ends (heel and toe). This increase appears to be of more importance than the wellbore head loss effects, but is yet to be rigorously confirmed. Preliminary output from the model for a steady state horizontal well may be seen in Figures 3 & 4.



**Figure 3.** Increasing segments leads to convergence around 40 segments.



**Figure 4.** Top: Drawdown at each segment, notice the increase in drawdown towards the well heel – left side – due to energy loss (drawdown = initial head minus current head). Bottom: Discharge per unit length of the well, notice the peaks at well tips due to greater exposure to the aquifer.

## **Significance**

Our research has led to development of an easy to use angle/horizontal/vertical well model for groundwater systems which incorporates intra-wellbore energy loss. Our model will allow water resource planners to rigorously assess the possible improvements of angle/horizontal well production against more commonly used vertical wells. Upon running the model with a variety of input parameters, general quantitative statements on angle/horizontal well production verses vertical well production will be made.

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## **NOTABLE AWARDS AND ACHIEVEMENTS**

Ben Blumenthal received a general fellowship from the Geology Department through Energy Cup in the amount of \$5,000.

## **Information Transfer Program Introduction**

In 2013, the Texas Water Resources Institute continued its outstanding communication efforts to produce university-based water resources research and education outreach programs in Texas.

The institute publishes a monthly email newsletter and an institute magazine published two times a year. The institute also publishes an online peer-reviewed journal in conjunction with a nonprofit organization. Additionally, social media is used, as appropriate, to publicize information.

TWRI works to reach the public and expand its audience by generating news releases as well as informational packets. The institute also publishes technical reports and education material publications in cooperation with research scientists and Extension education professionals.

Finally, TWRI continues to enhance its web presence by posting new project-specific websites and continually updating the information contained within the current websites.

# Information Transfer

## Basic Information

<b>Title:</b>	Information Transfer
<b>Project Number:</b>	2013TX463B
<b>Start Date:</b>	3/1/2013
<b>End Date:</b>	2/28/2014
<b>Funding Source:</b>	104B
<b>Congressional District:</b>	17
<b>Research Category:</b>	Not Applicable
<b>Focus Category:</b>	None, None, None
<b>Descriptors:</b>	None
<b>Principal Investigators:</b>	Roel R Lopez, Danielle Kalisek, Leslie H Lee, Kevin Wagner, Kathy Wythe

## Publications

1. Arnold, J.G., J.R., Kiniry, R., Srinivasan, J.R., Williams, E.B, Haney, S.L., Neitsch, 2013, SWAT 2012 Input/Output Documentation, (TR-439), Texas Water Resources Institute, Texas A&M System, College Station, Texas, 650 pages.
2. Delaune, Paul, Bridget R. Scanlon, Robert C. Reedy, Robert C. Schwartz, Louis Baumhardt, Lucas F. Gregory, 2013, Groundwater Nitrogen Source Identification and Remediation in the Texas High Plains and Rolling Plains Regions, (TR-451), Texas Water Resources Institute, Texas A&M System, College Station, Texas, 70 pages.
3. Di Giovanni, George D., Elizabeth A. Casarez, Terry J. Gentry, Emily C. Martin, Lucas Gregory, Kevin Wagner, 2013, Support Analytical Infrastructure and Further Development of a Statewide Bacterial Source Tracking Library, (TR-448), Texas Water Resources Institute, Texas A&M System, College Station, Texas, 74 pages.
4. Fuller, Sarah, Sarah Schwab, Lucas Gregory, 2013, Attoyac Bayou Recreational Use Attainability Analysis, (TR-445), Texas Water Resources Institute, Texas A&M System, College Station, Texas, 253 pages.
5. Gregory, Lucas, Elizabeth Casarez, Joy Truesdale, George Di Giovanni, Tony Owen, June Wolfe, 2013, Bacterial Source Tracking to Support the Development and Implementation of Watershed Protection Plans for the Lampasas and Leon Rivers: Leon River Watershed Final Report, (TR-441), Texas Water Resources Institute, Texas A&M System, College Station, Texas, 76 pages.
6. Gregory, Lucas, Elizabeth Casarez, Joy Truesdale, George Di Giovanni, Tony Owen, June Wolfe, 2013, Bacterial Source Tracking to Support the Development and Implementation of Watershed Protection Plans for the Lampasas and Leon Rivers: Lampasas River Watershed Final Report, (TR 442), Texas Water Resources Institute, Texas A&M System, College Station, Texas, 82 pages.
7. Gregory, Lucas, Phyllis Dyer, 2013, Water Quality Monitoring in the Buck Creek Watershed and Facilitation of Buck Creek Watershed Partnership, (TR-444), Texas Water Resources Institute, Texas A&M System, College Station, Texas, 29 pages.
8. Gregory, Lucas, Larry Hauck, Ben Blumenthal, Matthew Brown, Amy Porter, 2013, Pecos River WPP Update, (TR-447), Texas Water Resources Institute, Texas A&M System, College Station, Texas, 61 pages.
9. Gregory, Lucas, Amy Porter, Allen Knutson, Mark Muegge, 2013, Implementing the Pecos River WPP through Invasive Species Control and by Providing Technical and Financial Assistance to

## Information Transfer

- Reduce Agricultural Nonpoint Source Pollution, (TR-449), Texas Water Resources Institute, Texas A&M System, College Station, Texas, 20 pages.
10. Ed Rister, Ron Lacewell, Allen Sturdivant, 2013, Costs of Saving Water in South Texas with Irrigation District Infrastructure Rehabilitation - Using Capital Budgeting with RGIDECON, (TR-438), Texas Water Resources Institute, Texas A&M System, College Station, Texas, 3 pages.
  11. Swanson, Charles, Guy Fipps, 2013, Evaluation of Smart Irrigation Controllers: Year 2012 Results, (TR-433), Texas Water Resources Institute, Texas A&M System, College Station, Texas, 30 pages.
  12. Wagner, Kevin, Daren Harmel, Kori Higgs, 2014, Preliminary Evaluation of VTA Effectiveness to Protect Runoff Water Quality on Small Pork Production Facilities in Texas, (TR-452), Texas Water Resources Institute, Texas A&M System, College Station, Texas, 10 pages.
  13. Wagner, Kevin, Larry Redmon, Jennifer Peterson, 2013, Development of a Synergistic, Comprehensive Statewide Lone Star Healthy Streams Program, (TR-466), Texas Water Resources Institute, Texas A&M System, College Station, Texas, 17 pages.
  14. Wurbs, Ralph. A., Richard Hoffpauir, 2013, Environmental Flows in Water Availability Modeling, (TR-440), Texas Water Resources Institute, Texas A&M System, College Station, Texas, 284 pages.
  15. Cabrera, Raul, Kevin Wagner, Ben Wherley, Leslie, Lee, 2013, Urban Landscape Water Use in Texas, (EM-116), Texas Water Resources Institute, Texas A&M System, College Station, Texas, 4 pages.

**Texas Water Resources Institute**  
**Information Transfer Activities**  
**March 1, 2013 – February 28, 2014**

In 2013, the Texas Water Resources Institute continued its outstanding communication efforts to produce university-based water resources research and education outreach programs in Texas.

The Institute publishes a monthly email newsletter and an institute magazine published two times a year. The Institute also publishes an online peer-reviewed journal in conjunction with a nonprofit organization and uses social media to publicize information.

*Conservation Matters*, an email newsletter, publishes timely information about natural and water resources news, results of projects and programs, and new natural resources and water-related research projects, publications and faculty at Texas universities. As of February 28, 2014, the newsletter has a subscription of 2,390.

*txH<sub>2</sub>O*, a 30-page glossy magazine, is published two times a year and contains in-depth articles that spotlight major water resources issues in Texas, ranging from agricultural nonpoint source pollution to landscaping for water conservation. Subscribers are at 2,435 for hard copies and 964 for email copies and approximately 1,000 more magazines are distributed.

The Texas Water Journal is an online, peer-reviewed journal devoted to the timely consideration of Texas water resources management and policy issues from a multidisciplinary perspective that integrates science, engineering, law, planning and other disciplines. The journal has published four issues. It currently has 493 enrolled users, although registration is not required to view the journal.

The Institute has a Twitter and now a Facebook account to promote the institute and water resources news and education throughout the state. The Institute currently has 1,335 Twitter followers and engagement levels have steadily increased, and the Institute Facebook page has 71 likes. It also has a project-specific blog and two project-specific Facebook pages.

Working to reach the public and expand its audience, the Institute generates news releases and cooperates with Texas A&M AgriLife Communications writers for them to produce news releases about projects as well. The Institute prepared numerous informational packets for meetings. TWRI projects or participating researcher efforts had at least 100 mentions in the media.

For each of the institute's projects, TWRI published a one-page fact sheet that explains the purpose, background, objectives, and, if applicable, accomplishments of the program.

In cooperation with research scientists and Extension education professionals, the institute published 15 technical reports and one educational material publication, which provide in-depth details of water resource issues from various locations within the state.

TWRI continues to enhance its web presence by posting new project-specific websites and continually updating the information contained within the websites. The institute currently maintains 38 websites.

*TWRI Program Sites:*

Arroyo Colorado	<a href="http://arroyocolorado.org">arroyocolorado.org</a>
Attoyac Bayou Watershed Protection Plan Development	<a href="http://attoyac.tamu.edu">attoyac.tamu.edu</a>
Automated Metering Initiative	<a href="http://arlingtontxwater.org">arlingtontxwater.org</a>
Bacteria Fate and Transport	<a href="http://bft.tamu.edu">bft.tamu.edu</a>
Big Cypress Creek Modeling and BST	<a href="http://bcc.tamu.edu">bcc.tamu.edu</a>
Buck Creek Watershed Protection Plan Development	<a href="http://buckcreek.tamu.edu">buckcreek.tamu.edu</a>
Caddo Lake Data	<a href="http://caddolakedata.us">caddolakedata.us</a>
Carters and Burton Creeks Water Quality	<a href="http://cartersandburton.tamu.edu">cartersandburton.tamu.edu</a>
Center for Invasive Species Eradication	<a href="http://cise.tamu.edu">cise.tamu.edu</a>
Consortium for Irrigation Research and Education	<a href="http://cire.tamu.edu">cire.tamu.edu</a>
Copano Bay Water Quality Education	<a href="http://copanobay-wq.tamu.edu">copanobay-wq.tamu.edu</a>
Efficient Nitrogen Fertilization	<a href="http://n-fertilization.tamu.edu">n-fertilization.tamu.edu</a>
Environmental Effects of In-House Windrow Composting of Poultry Litter	<a href="http://windrowlitter.tamu.edu">windrowlitter.tamu.edu</a>
Evaluating BMPs to Reduce Poultry Odors	<a href="http://poultrybmps.tamu.edu">poultrybmps.tamu.edu</a>
Fort Hood Range Revegetation	<a href="http://forthoodreveg.tamu.edu">forthoodreveg.tamu.edu</a>
Groundwater / Surface Water Interactions	<a href="http://waterinteractions.tamu.edu">waterinteractions.tamu.edu</a>
Groundwater Nitrogen Source Identification and Remediation	<a href="http://groundwatern.tamu.edu">groundwatern.tamu.edu</a>
Lake Granbury Water Quality	<a href="http://lakegranbury.tamu.edu">lakegranbury.tamu.edu</a>
Leon/Lampasas BST	<a href="http://leon-lampasasBST.tamu.edu">leon-lampasasBST.tamu.edu</a>
Little Brazos River Bacteria Assessment	<a href="http://lbr.tamu.edu">lbr.tamu.edu</a>
Lone Star Healthy Streams	<a href="http://lshs.tamu.edu">lshs.tamu.edu</a>
North Central Texas Water Quality	<a href="http://nctx-water.tamu.edu">nctx-water.tamu.edu</a>
Pecos River WPP Implementation Program	<a href="http://pecosbasin.tamu.edu">pecosbasin.tamu.edu</a>
Rio Grande Basin Initiative	<a href="http://riogrande.tamu.edu">riogrande.tamu.edu</a>
Rio Grande Basin Initiative Conference	<a href="http://riogrande-conference.tamu.edu">riogrande-conference.tamu.edu</a>
State BST Infrastructure Support	<a href="http://texasbst.tamu.edu">texasbst.tamu.edu</a>
Texas Water Resources Institute	<a href="http://twri.tamu.edu">twri.tamu.edu</a>
Texas Watershed Planning	<a href="http://watershedplanning.tamu.edu">watershedplanning.tamu.edu</a>
Texas Well Owner Network	<a href="http://twon.tamu.edu">twon.tamu.edu</a>
Water Resources Training Program	<a href="http://watereducation.tamu.edu">watereducation.tamu.edu</a>

*Completed Program Sites:*

Dairy Compost Utilization	<a href="http://compost.tamu.edu">compost.tamu.edu</a>
Environmental Infrastructures	<a href="http://bosque-river.tamu.edu">bosque-river.tamu.edu</a>
Improving Water Quality of Grazing Lands	<a href="http://grazinglands-wq.tamu.edu">grazinglands-wq.tamu.edu</a>
Irrigation Training Program	<a href="http://irrigationtraining.tamu.edu">irrigationtraining.tamu.edu</a>

*Other Sites:*

Save Texas Water	<a href="http://savetexaswater.tamu.edu">savetexaswater.tamu.edu</a>
Texas Water Journal	<a href="http://journals.tdl.org/twj">journals.tdl.org/twj</a>
WATER Scholars Program	<a href="http://waterscholars.tamu.edu">waterscholars.tamu.edu</a>
SELECT	<a href="http://select.tamu.edu">select.tamu.edu</a>

# USGS Summer Intern Program

None.

<b>Student Support</b>					
<b>Category</b>	<b>Section 104 Base Grant</b>	<b>Section 104 NCGP Award</b>	<b>NIWR-USGS Internship</b>	<b>Supplemental Awards</b>	<b>Total</b>
<b>Undergraduate</b>	0	0	0	0	0
<b>Masters</b>	2	0	0	0	2
<b>Ph.D.</b>	0	0	0	0	0
<b>Post-Doc.</b>	0	0	0	0	0
<b>Total</b>	2	0	0	0	2

## **Notable Awards and Achievements**

2013TX461B (Edgerton) - 2nd Place; Student Poster Competition at the Aquatic Plant Management Society Annual Conference, San Antonio, TX, July 16, 2013. \$200.

2013TX461B (Edgerton) - 1st Place; Oral Student Presentation at the Texas Invasive Plant & Pest Conference, Port Aransas, TX, February 27, 2014. \$500.

2013TX461B (Edgerton) - Won \$150 travel grant to attend the Texas Invasive Plant & Pest Council's Conference, February 2014.

2013TX461B (Edgerton) - Received assistance from the Aquatic Plant Management Society in January; serve as student director on the society's board of directors and they paid airfare, hotel, shuttle and per diem (\$497) for planning the meeting held in January 2014.

2013TX462B (Blumenthal) - received a general fellowship from the Geology Department through Energy Cup in the amount of \$5,000.

# Publications from Prior Years