CENTER FOR ReSource CONSERVATION
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September 27, 2013

Kevin Reidy and Ben Wade
Office of Water Conservation and Drought Planning Section
Colorado Water Conservation Board
1313 Sherman St, Room 721
Denver, CO 80203

Dear Mr. Reidy and Mr. Wade,

Status report for Center for ReSource Conservation grant: Water Conservation Impact Assessment

PO# OE PDA 13000000102

As of September 27, 2013, the CRC's Water Conservation Impact Assessment has reached its 50% of completion benchmark. The attached report contains a synopsis of our work to date, including a status update as well as a summary of preliminary findings.

As noted in the report, our work on this grant is progressing exactly on schedule, and we have completed 100% of tasks 1 and 2. We have also started work on tasks 3 and 4. At this time, the project is fully within its budget.

This grant funding is allowing us to gain an extensive understanding of the impacts of various water conservation programs, and we believe that the findings will be beneficial to the entire water conservation community in Colorado. As per our proposal, during the next several months we will continue to work to publicize these results, and we are confident that through this work we are making an important contribution to the water conservation field. We are grateful for CWCB's support and sponsorship, and we believe that our work funded by the grant continues to meet the Board's objectives. In particular, we feel that the work under this grant will fulfill the Board's desire to improve the nature and breadth of conservation efforts at the local level, as well as provide tools and analysis that can be used to Increase the amount of technical assistance that the CWCB can provide to local entities.

Thank you again for your support.

Respectfully Submitted,

Dan Stellar
Senior Director of Sustainability Programs
Center for ReSource Conservation

50% Progress Summary

Task	Deliverables	Timeline	Percent Complete, 9/27/2013
Task 1: Additional Data Retrieval and Literature Review	Letters to partner water providers requesting more data Updated climate data Literature Review, format of sources, pertinent findings	4/25/2013 – 7/13/2013	100%
Task 2. Expand and Enhance STF Data Analysis	Updated results of STF impact analysis using new climate data Results of control group(s) study of STF impact analysis Results of longitudinal study of STF impact analysis 50% Progress Report to CWCB	7/14/2013 – 9/27/2013	100%
Task 3. Methodology Adaptation to Other Programs	Development of methodology for assessing additional programs. Preliminary results from assessment of additional programs 75% Progress Report	9/28/2013 – 12/1/2013	10%
Task 4. Reporting and Dissemination of Results	Final Reports to All Partner Water Providers Final Report CWCB Presentation at one conference[1] Abstract submission to journal	12/2/2013-1/20/2014	25%

The CRC plans to provide the CWCB with all other progress reports as planned according to the above timeline.

Detailed Narrative

Below is a detailed narrative describing the project progress to date. The non-italicized text is the project narrative from the original grant; the italicized text under each task describes the task progress.

Task 1. Additional Data Collection and Literature Review - *Complete*

[1] Staff time and travel costs, not conference registration or abstract submission fees will be charged to this project.

For this task we will focus on retrieving data, both to add to the data sets used for our pilot analysis of Slow the Flow, and to obtain data for other programs including Slow the Flow Indoors, and Garden-In-A-Box. The main goals of this task are: 1) to expand our database to allow for a more comprehensive analysis of our programs, and 2) to become more informed on current best practices and recent developments in assessment of water conservation programs. We will also gather and update climate data.

Sub-tasks:

- Extract program identification information (e.g. Water Account Number, Water Provider Name) from CRCs master customer database and prepare for request to water providers.
- Draft and send letters to partner water providers to request water usage data for participants as well as for overall water district water usage data. The letters will specify to our partners the description of our project and goals of the project in order to educate them of the broader impact of their support.
- Receive data from partner water providers and compile the water usage data with the CRC data to create comprehensive spreadsheets that contain all pertinent customer information to water usage.
- Conduct a literature review of past and current assessments of water conservation, using academic publications (e.g. AWWA Journal), online resources, and contact with various local, regional and national water entities (e.g. Northern Water, Alliance for Water Efficiency).
- Obtain additional and more accurate climate data.

Task 1 was completed on time, by July 13, 2013. Letters to explain the project and request participation from our partner water providers went out in late May. By mid- to late-June the research associate had met with 11 different partners who showed interest in supporting the CRCs efforts on this project. Data was requested and then collected from these groups[2] and was compiled by mid-July.

The literature review was successful in expanding the breadth and scope of background knowledge on water conservation theory, local programs, and the state of the science. The list of new bibliographic sources are included at the end, in ***Attachment 1*** *of this report.*

While an extensive and thorough investigation was undertaken in order to expand and improve the climate dataset, very few additional sources with adequate hydrologic/climatologic data were found. The greatest expansion of the dataset was made with the contribution of ET and P data from the Town of Castle Rock. They own and have operated four climate stations within their service area since 2008. The Castle Rock weather data added a key southern data point

[2] Two water providers out of the 11 that showed interest, Willows Water and Broomfield, have only participated in STF since 2012, and therefore did not have sufficient data to participate in the analysis of their programs. However, they both expressed interest in being part of the analysis in future years.

into the overall climate dataset. Another update to the dataset was made by changing our consideration of the watering months from only including May-September, as was used in the pilot impact analysis, to now including April-October. This change aligns our methods with the standard methods that are used across the Front Range and improves the dataset by more accurately representing the time frame during which Front Range Colorado residents use their sprinkler systems.

Task 2. Expand and Enhance STF Data Analysis - *Complete*

In this task, we will expand upon the pilot work already performed to further measure the impact of Slow the Flow. The main goals of this task will be the completion of two additional analyses of the STF program: 1) inclusion of control groups to further evaluate to what degree factors outside of the STF program may be impacting the data results; and 2) assessment of the longitudinal water savings of the program. We will also update our climate and weather data and use these to further improve the accuracy of the study.

Sub-tasks:

- Review of existing CRC methodology, comparing and contrasting to other methodologies discovered in the literature review (Task 1).
- Make any and all necessary updates to the climate dataset being used in the analysis. Recalculate water savings as necessary.
- Using statistical methodologies, use (a) control group(s) (i.e. water usage data from customers in the same district as STF participants of STF, who did not participate in STF) to calculate and clarify the amount of influence outside factors may be influencing the water savings calculations.
- Longitudinal impact assessment of STF. Evaluate the number of years water savings exist and rate of change in measurable water savings after the program has been administered.
- Run a variety of statistical analyses on the water savings results (e.g. simple linear regression to identify correlations that exist between various data parameters and water savings, Analysis of Variance to evaluate if the calculated water savings are significant).
- Create charts and graphs capturing the results of the analyses in clear and transparent formats.
- 50% Progress Report to the CWCB

Task 2 is 100% complete with respect to the goals listed above, however certain details of some of the individual tasks did not come through as planned. For example, the original plan was to use the updated weather data to re-calculate water savings from the pilot study dataset as well as with new data received for this larger and more thorough impact analysis. About half of the

pilot study data was not able to be updated due to lost/misplaced datasets. The functional consequences of this change are that the current analysis does not include the ~700 accounts from the pilot analysis, which reduces the sample size of the current analysis by about that much. The final sample size for the current analysis is approximately 2,200.

Time spent on this task was comprised mostly of data-managing, cleaning, and analyzing. An evaluation of the sample size requirements for a statistically valid sample was performed. Summary statistics, graphs and charts were created in order to describe and display findings. Water savings and change in water usage was tested for statistical significance. The longitudinal impact assessment of the STF program was performed for up to 5 years post-audit. A correlation analysis was run using variables collected by the CRC during the audits in order to evaluate the most important factors for predicting water use and water savings. A sampling of these results are included in ***Attachment 2****.*

One challenge of this task was comparing the methodology that the CRC has developed to other methodologies used for measuring or calculating the water savings from conservation programs. This was a challenge because there are few analytical assessments of audit-based conservation programs. Many of the analyses that have been done to assess water conservation have evaluated the water savings from replacing and updating various fixtures or by simply comparing percentage changes in weather/ET to percentage changes in GPCD or outdoor use. Our methodology goes further by quantifying water savings in gallons, using measured landscape size and annual net ET demand of the landscape. These methods follow the approach recommended in the Colorado WaterWise Guidebook of BMPs for Municipal Water Conservation in Colorado (2010).

Task 3. Methodology Adaption to Other Programs (September 28, 2013 – December 1, 2013)

In this task we will make the necessary adaptions of our methodology (Appendix C) to calculate water savings for Slow the Flow Indoors, Garden-In-A-Box and any other programs that we are able to collect data for. This task will include developing a reporting format and template, so that the results of the analyses can be shared with each participating water provider.

Sub-tasks:

- Develop a methodology for calculating water savings of STF Indoors
- Develop a methodology for calculation water savings of Garden-In-A-Box
- Produce results using these methodologies
- 75% Progress Report to the CWCB

This task is approximately 10% complete. The completed portion of the task is that the data for this task is available and is ready to be incorporated into the analysis. This task will be completed by December 1, as planned.

Task 4. Reporting and Dissemination of Results (December 2, 2013 – January 20, 2014)

This task incorporates several efforts directed toward public education and outreach of our project's results. We will seek to demonstrate web application's ability, present conservation and economic case studies, and present conservation impact results, for the water community.

Sub-tasks:

- Create reports and provide partners with clear summary of the impact of STF on their customers
- Develop and present reports at various water conservation organizations including the Water Conservation Technical Advisory Group, Colorado WaterWise, and the Inter-Basin Compact Commission
- Create abstracts for conferences that have opportunities to present on water conservation, such as AWWA[3]
- Make presentations at in-state conferences for the water conservation community (e.g. Upper Colorado River Basin Water Conference (Grand Junction, November, 2012), Rocky Mountain Land-Use Institute Annual Conference (Denver, March, 2013), American Water Works Association Annual Conference (Denver, June, 2013), and WaterSmart Innovations Conference (Las Vegas, October, 2013))[4]
- Final Report to the CWCB

This task has been started and is approximately 25% complete. A short preliminary email report has been sent to all water providers with a description of the progress that has been made with the analysis using the data that they provided to us. A full-length report will be submitted to them in January.

The CRC has attended several conferences and submitted several other abstracts for future conferences. We have attended and presented Impact Analysis work at the Upper Colorado River Basin Water Conference (Grand Junction, November, 2012), Rocky Mountain Land-Use Institute Annual Conference (Denver, March, 2013), and the American Water Works Association Annual Conference (Denver, June, 2013). We will be in attendance and presenting this new work at the WaterSmart Innovations Conference from Oct 1-Oct 4, 2013 in Las Vegas. We have an abstract submitted to this year's Upper Colorado River Basin Water Conference.

The rest of this task is on track to be completed by January 20 of 2014.

[3] Staff time and travel costs, not conference registration or abstract submission fees will be charged to this project.

[4] See 2

Attachment 1. Literature Review Bibliography

Aquacraft, Inc. (1997). *Performance of Soil Moisture Sensors During Field Testing Operations Update* (p. 93).

Aquacraft, Inc. (2010). Guidebook of Best Practices for Municipal Water Conservation in Colorado. Colorado WaterWise.

Aranada, F. (2012). Conservation Measures: How the city of Santa Fe acheived water conservation while maintaining sound financial performance. Presented at the WaterSmart Innovations 2012 Annual Meeting, Las Vegas, NV: WSI.

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IA. (2005). Turf and Landscape irrigation Best Management Practices. Irrigation Association.

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Management and Adaptation (p. 52). Colorado Water Conservation Board.

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Thompson, R., Coe, A., Klaver, I., & Dickson, K. (2011). Design and implementation of a research-informed water conservatoin education program. *Applied Environmental Education and Communication*, (10), 91–104. doi:10.1080/1533015X.2011.575728

Winter, S. (2012). What Savings, Where? Presented at the WaterSmart Innovations 2012 Annual Meeting.

Zamora, J. (2012). Fact or Fiction: Are water savings real or fabricated? Presented at the WaterSmart Innovations 2012 Annual Meeting, Las Vegas, NV.

Attachment 2. Results and Findings From Task 2

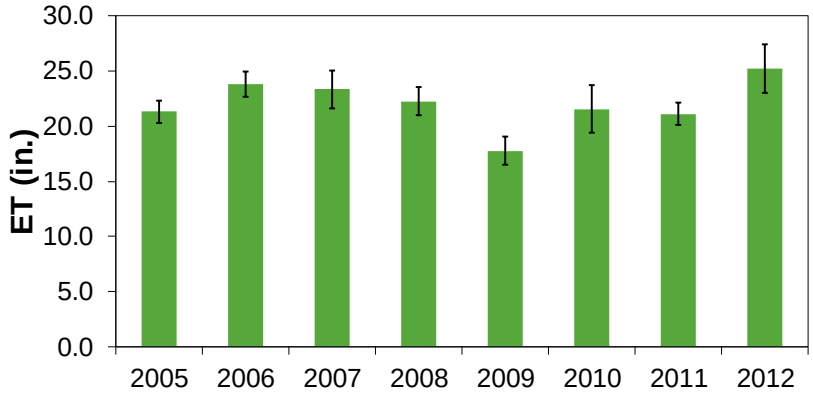

Figure 1. Updated climate dataset. Evapotranspiration (ET) from 2005-2012 for the Front Range of Colorado. The error bars represent the standard deviation from the averaging of between 4-8 regionally located weather stations. This dataset is updated from the ET data used for the pilot analysis.

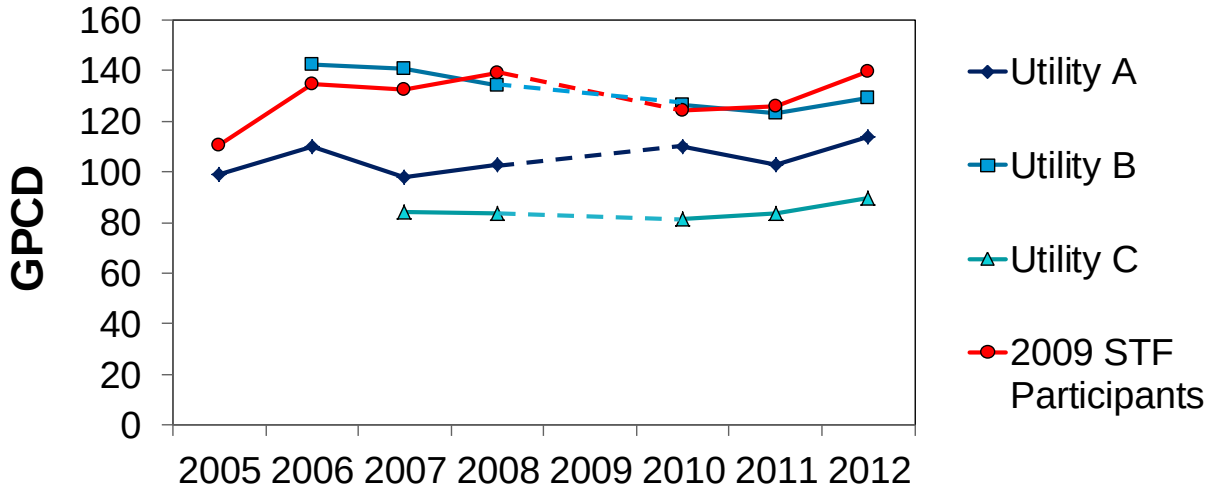

Figure 2. Control group study. Time series plot of GPCD data from 3 utilities compared to average GPCD data from the 2009 STF participant sample from these same utilities. The slope of the dotted line is greatest for the STF participants suggesting that the audit affected their overall water use relative to other factors that were affecting the total population. Statistical tests for significant differences in populations means were also performed.

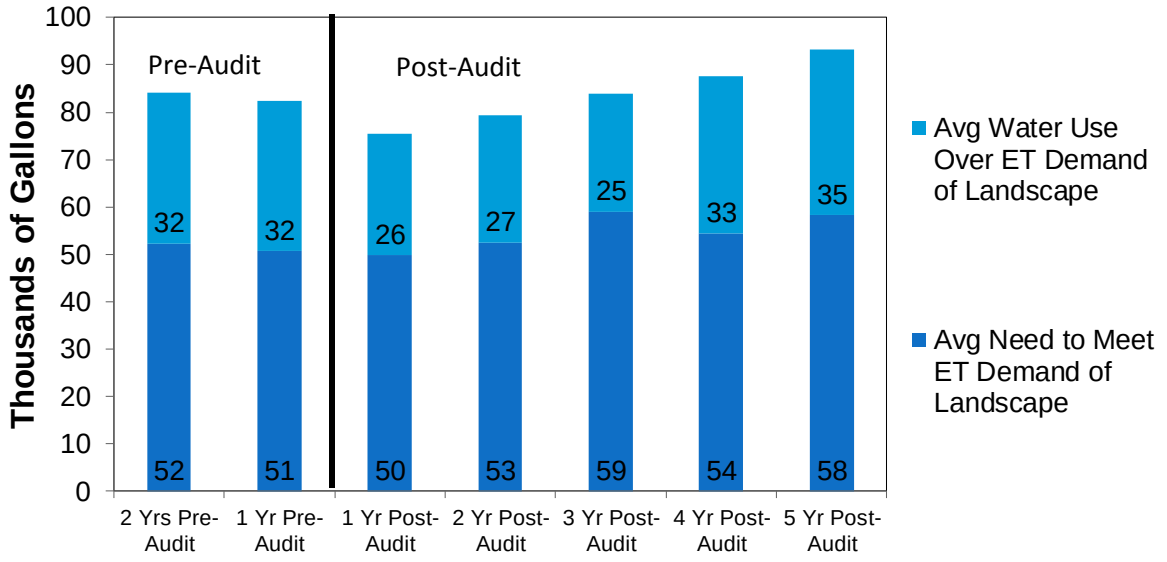

Figure 3. Longitudinal impact assessment. Stacked bar graph showing the difference in pre- and post-audit numbers for the average water use over ET demand of the landscape and the average need to meet ET demand of the landscape. The height of the total bar equals the average amount of water applied to the landscape. This graph indicates that 4 yrs post-audit, the average STF participant returned to overwatering at pre-audit levels.

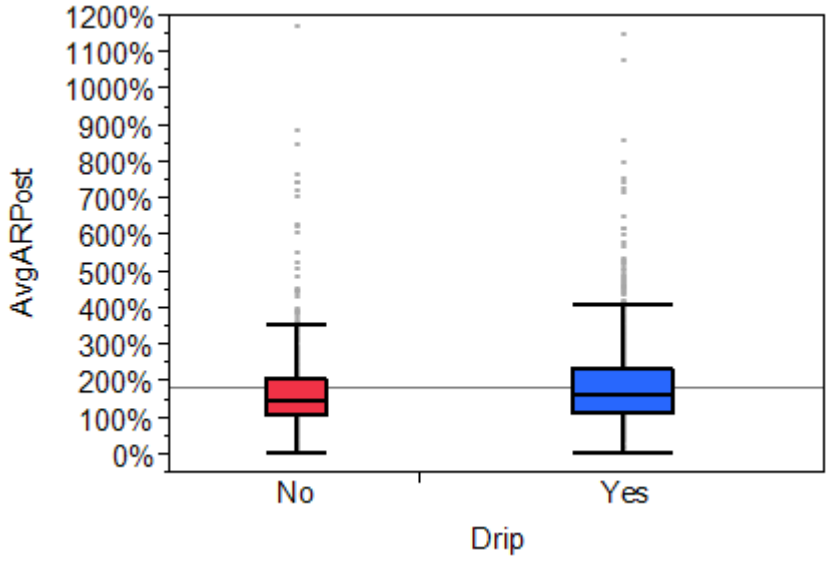

Figure 4. One example of statistical analysis of water savings results . Box-and-whisker plots of the presence of a drip system (No or Yes) verses the Average Application Ratio (AR) post-audit. The ANOVA results from this test showed that the mean AR post-audit is significantly different between those participants who answered “Yes” to having a drip system and those who answered “No” to having a drip system. Surprisingly, those who answered “Yes” to having a drip system had a mean AR post-audit of 193%, whereas those who answered “No” to having a drip system had a mean AR post-audit of 174%. Many other tests were performed with a variety of X and Y variables. Non-parametric tests were used when necessary. Interpretation of these results will occur in future reports.