AGENDA ITEM D6

TAMPA BAY WATER
Supplying Water To The Region

DATE: October 1, 2015

TO: Matt Jordan, General Manager

FROM: Alison Adams, Chief Technical Officer

SUBJECT: Fifth Amendment to Agreement 2007-014 with the University of Florida for evaluating water availability under future climate scenarios – *Approve*

SUMMARY: Research continues by Tampa Bay Water staff and University of Florida researchers to develop methods for incorporating climate variability and change information into the Agency's hydrologic and demand forecast models. Results aim to improve water management decisions and supply system reliability within Tampa Bay Water's jurisdiction.

RECOMMENDATION: Approve Fifth Amendment to Agreement 2007-014 with the University of Florida for a two-year extension plus $75,000 increase in funding for additional scope of services as Phase IV of this research project.

COST/FUNDING SOURCE: Approved FY 2016 Budget

DISCUSSION: Tampa Bay Water and University of Florida Water Institute researchers have been evaluating the use of seasonal and annual climate forecasts as well as future scenarios in Tampa Bay Water's hydrologic models. Results of Phases I and II of this collaborative research were presented to the Board of Directors during the October 2013 meeting by Dr. Wendy Graham, Director of University of Florida's Water Institute. These results highlighted that the region's surface water supplies are highly sensitive to climate variable and climate change and that continued research is warranted.

The Tampa Bay Water Board of Directors approved Agreement 2007-014 in February 2007. The first and second contract amendments extended the project duration to December 2011. The duration of the first phase spanned four fiscal years (FY 2007, FY 2008, FY 2009, and FY 2010). The total project contribution approved by the Board was $175,000. The third contract amendment increased funding by $50,000 for Phase II and extended the contract period to December 2013. The fourth amendment provided funding of $74,832 for the Phase III scope of services and extended the contract duration to December 2015.

The Fifth Amendment to Agreement 2007-014 (attached) has been reviewed and approved as to form by the Tampa Bay Water General Counsel's Office. This amendment will provide $75,000 of contribution in funding to the University of Florida. The Phase IV project completion date is December 2017. Staff recommends Board approval.

Phase IV of this project will focus on the following tasks:

a) Downloading, bias-correcting and spatially downscaling CMIP5 Precipitation and Potential/Reference Evapotranspiration (P and P/RET) retrospective predictions and future projections over the Tampa Bay Region for use in the INTB model using the procedures developed in previous phases of this effort.

b) Estimating daily retrospective and future agricultural and urban water demand that are consistent with bias-corrected downscaled daily retrospective and future climate (P and P/RET) for the Tampa Bay Region (i.e. develop climate-driven water demand estimates).

c) Developing future population and land use scenarios for the Tampa Bay Region and estimating the water demand associated with these scenarios.

d) Using future projections of P, P/RET, and water demand in the INTB to evaluate future water availability (groundwater levels, streamflows, wetland hydroperiod) in the Tampa Bay Region for a variety of future climate-population-land use scenarios.

e) Determining the relative impact and relative uncertainty associated with climate versus anthropogenic factors in predicting future water availability in the Tampa Bay Region.

f) Evaluating what types of water management strategies reduce risks and increase resilience in water supply for the Tampa Bay region across the range of possible futures and their associated uncertainties.

Collaborative Partnerships

Tampa Bay Water in collaboration with University of Florida Water Institute, Florida State University Center for Ocean-Atmospheric Studies (COAPS) and the Southeast Climate Consortium formed a multi-agency coalition in 2010 referred to as the Florida Water and Climate Alliance (www.Floridawca.com) focused on increasing the relevance of climate science data and tools for water resources planning and supply operations in Florida. Collaborative research with Florida Water and Climate Alliance partners has resulted in two two-year grants from the National Oceanic and Atmospheric Administration (NOAA). The first grant for $300,000 has funded efforts which focus on increasing the relevance of climate variability, climate change and sea level rise data for Florida Water Utilities. The second grant for $149,717 focuses on research to improve the regional relevance of seasonal climate forecasts and increase their usability to minimize short-term operational risks for water supply and ecosystems. Some of these applied research results have been highlighted by NOAA climate magazine and recently have been used an example of what communities across the nation should do to reduce their risk and build resiliency as part of the Whitehouse initiative (https://toolkit.climate.gov/).

BACKGROUND: Tampa Bay Water uses a variety of hydrologic and statistical models as part of its effort at risk-based management of short- and intermediate-term operations and long-range planning. The operational models include the Short Term Demand Forecast Model (STDF), surface water artificial neural network models (SW ANN), and groundwater artificial neural network models (GW ANN). The planning models include the Long Term Demand Forecasting System (LTDFS), the Flow Modeling System (FMS), and the Integrated Hydrologic Model (IHM). These models relate weather/climate inputs (e.g., rainfall and temperature) and pumping or diversions to outputs such as water levels, storage levels or river flows.

Dr. Wendy D. Graham is Director of the University of Florida Water Institute. The Water Institute was officially established in May 2006 with a mission to foster interdisciplinary research, education, and public outreach programs designed to:

- Improve understanding of the physical, chemical, and biological processes in aquatic systems (rivers, lakes, oceans, estuaries, wetlands, and ground waters)

- Enhance understanding of how human activities and attitudes affect aquatic systems

- Develop and promote the adoption of improved methodologies for water management and policy development based on a strong background in water-related sciences, engineering, management and law

In 2007, Tampa Bay Water initiated a project with the University of Florida to assess the usefulness of climate indices and climate model output as input to the Agency's hydrologic models. The project has focused on the medium-term planning interval and examined how reliability can be improved (or risk can be reduced). This work incorporated seasonal climate forecasts into the Tampa Bay Water resource planning processes of forecasting water demand and making source allocation decisions. The research also determined how to use climate model output as input into the Integrated Hydrologic Model, Northern Tampa Bay application.

Phase II of this project focused on evaluation of dynamically downscaled General Circulation Model (GCM) predictions over the Tampa Bay region using Florida State University's regional climate model which has been shown to simulate climate in the southeastern United States and Florida quite well. Results of the Phase II effort showed that dynamically downscaled reanalysis and retrospective simulations required bias correction using a cumulative distribution function mapping approach in order to accurately reproduce historic rainfall and temperature over the Tampa Bay Region. The bias-corrected reanalysis and retrospective rainfall and temperature results were found to satisfactorily simulate monthly streamflow in the region when used to drive the IHM/INTB model.

Phase III focused on evaluating the sensitivity of retrospective predictions and future projections of precipitation (P) and potential or reference evapotranspiration (P/RET) under various climate futures using modeled results for the Coupled Model Intercomparison Project–Phase Five (CMIP5) set of global climate models. Projecting P/RET under various possible future climate scenarios depends on the choices of Global Climate Model (GCM), P/RET estimation method and choice of Representative Concentration Pathway (RCP) trajectory. The relative contribution of each of these factors to differences in future P/RET projections must be evaluated in order to choose an appropriate ensemble of future scenarios for water resources planning. Variance-based global sensitivity analysis and Monte Carlo filtering were used to evaluate the relative sensitivity of projected changes in precipitation P, P/RET and water availability (defined here as P – P/RET) to choice of GCM, P/RET estimation method and RCP trajectory over the continental United States (US) for two future periods: 2030-2060 (future period 1) and 2070-2100 (future period 2). A total of nine GCMs, ten P/RET methods and three RCP trajectories were used to quantify the range of future projections and estimate the relative sensitivity of future projections to each of these factors. The results indicate that choice of evapotranspiration method needs careful consideration when predicting the effects of future climate on water resources. Results of this research have been submitted for publication.

Attachment

Exhibit A
Scope of services
Phase IV – Estimation of streamflow, groundwater levels and wetland hydroperiods under CMIP5 future climate scenarios
September 2015

Introduction

Tampa Bay Water uses a variety of hydrologic and statistical models as part of their effort at risk-based management of short- and intermediate-term operations and long-range planning. The operational models include the Short Term Demand Forecast Model (STDF), surface water artificial neural network models (SWANN), and Groundwater ANN Models (GWANN). The planning models include the Long Term Demand Forecasting System (LTDFS), the Flow Modeling System (FMS), and the Integrated Northern Tampa Bay Model Application of the Integrated Hydrologic Model (IHM/INTB). These models relate inputs such as weather and climate and pumping or diversions to outputs such as water levels, storage levels or flows. The models in use may be broadly classified as (a) physically based, deterministic with limited uncertainty analysis and (b) statistical models (all others) where uncertainty analysis is feasible, but is not always performed. These two types of models can require substantially different types of input data in the context of the objectives of rainfall forecasts at multiple scales. While rainfall is the most important input for both types of models, it may be needed as a highly *spatially and temporally distributed* product for the *deterministic* models. On the other hand *statistical* models typically require a *minimal index set* of rainfall forecasts, either spatially or temporally aggregated, or recorded at specific locations and times.

Rainfall and temperature variability at multiple time and space scales profoundly affect both water demand fluctuations and supply availability. In support of effective water resource management and efficient groundwater/surface water source rotation that enhances system reliability Tampa Bay Water must develop more robust climate forecasts and simulation techniques. In 2007, Tampa Bay Water initiated a project with University of Florida to assess the usefulness of climate indices and climate model output as input into the agency's hydrologic models. The project has focused primarily on evaluating the utility of using Global Climate Model (GCM) reanalysis data as well as retrospective and future GCM output as input into the Integrated Northern Tampa Bay Hydrologic Model.

Phase I Efforts:

During Phase I the University of Florida developed a new statistical downscaling method that was shown to improve rainfall outputs from GCMs for the Tampa Bay Region over other existing statistical downscaling methods. Furthermore results of the phase I effort demonstrated that climate model outputs can be used as inputs in the Agency's Integrated Northern Tampa Bay Hydrologic Model (IHM/INTB) and that choice of statistical downscaling method has important implications for water supply management.

Phase II Efforts:

Phase II of this project focused on evaluation of dynamically downscaled General Circulation Model (GCM) predictions over the Tampa Bay region using Florida State University's regional climate model which has been shown to simulate climate in the southeastern United States and Florida quite well.

Results of the Phase II effort showed that dynamically downscaled reanalysis and retrospective simulations required bias correction using a cumulative distribution function mapping approach in order to accurately reproduce historic rainfall and temperature over the Tampa Bay Region. The bias-corrected reanalysis and retrospective rainfall and temperature results were found to satisfactorily simulate monthly streamflow in the region when used to drive the IHM/INTB model.

The three future CLARENCE10 temperature projections consistently estimated a 2-3^{o}C increase in mean temperature over the Tampa Bay Region for the 2039-2070 period under the CMIP3 A2 future emission scenario studied. However the three models did not produce any consensus about the precipitation change that can be expected for the 2039-2070 period. The differences in future precipitation projections propagated into significant differences in future hydrologic predictions when used to drive the IHM/INTB model. Due to this lack of agreement among the three GCM projections it was determined that future work should evaluate additional CMIP5 climate model projections and additional greenhouse gas emission scenarios using statistical downscaling methods.

Phase III efforts (January 2014-Dec 2015):

Phase III focused on evaluating Coupled Model Intercomparison Project – Phase Five (CMIP5) retrospective predictions and future projections of precipitation (P) and potential or reference evapotranspiration (P/RET). Projecting P/RET under various possible future climate scenarios depends on the choices of Global Climate Model (GCM), P/RET estimation method and Representative Concentration Pathway (RCP) trajectory. The relative contribution of each of these factors to differences in future P/RET projections must be evaluated in order to choose an appropriate ensemble of future scenarios for water resources planning. Variance-based global sensitivity analysis and Monte Carlo filtering was used to evaluate the relative sensitivity of projected changes in precipitation P, P/RET and water availability (defined here as P – P/RET) to choice of GCM, P/RET estimation method and RCP trajectory over the continental United States (US) for two future periods: 2030-2060 (future period 1) and 2070-2100 (future period 2). A total of 9 GCMs, 11 P/RET methods and 3 RCP trajectories were used to quantify the range of future projections and estimate the relative sensitivity of future projections to each of these factors. In general, for all regions of the US, changes in future precipitation are most sensitive to the choice of GCM, while changes in future P/RET are most sensitive to the choice of P/RET estimation method. For changes in future water availability, the choice of GCM is the most influential factor in the cool season (Dec – Mar) and the choice of P/RET estimation method is most important in the warm season (May – Oct) for all regions except the South East US (including the Tampa Bay

Region) where GCM and P/RET have approximately equal influence throughout most of the year. Although the choice of RCP trajectory is generally less important than the choice of GCM or P/RET method, the impact of RCP trajectory increases in future period 2 over future period 1 for all factors. Monte Carlo filtering results indicated that particular GCMs and P/RET methods drive the projection of wetter or drier future conditions much more than RCP trajectory; however the set of GCMs and P/RET methods that produce wetter or drier projections varies substantially by region. For example in the SE the CSIRO_mk3_6_0 , GFDL_CM3 and MPI_ESM_LR GCM models and the methods the Hargreaves, Dalton and Meyer P/RET methods tend to drive the projection of wetter future conditions, while the remainder of the GCMs and P/RET methods tend to drive the projection of drier future conditions. Results of this study indicate that, in addition to using an ensemble of GCMs and several RCP trajectories, a range of regionally-relevant P/RET estimation methods should be used to develop a robust range of future conditions for water resource planning under climate change in the Tampa Bay Region.

In addition during Phase III the University of Florida developed a framework to bias-correct and statistically downscale CMIP5 P and P/RET projections for the Tampa Bay Region, taking into account the possible need for joint downscaling of these variables. It was found that sequential univariate bias-correction of P and P/RET reproduced the joint P-P/RET bivariate cumulative distribution function, and reduced bias in the individual variables, better than joint bias correction. It was also determined that since the spatiotemporal variability of PET is very small compared to the spatiotemporal variability of precipitation spatial disaggregation of the P/RET using the BCSA method developed for precipitation is not necessary. Thus, for the Tampa Bay Region, UF recommends sequential bias correction of the P and P/RET fields then spatial disaggregation of only the P field using the BCSA method.

Phase IV Scope of Work (January 2016-December 2017)

Phase IV will focus on:

Downloading, bias-correcting and spatially downscaling CMIP5 P and P/RET retrospective predictions and future projections over the Tampa Bay Region for use in the INTB model using the procedures developed in previous phases of this effort.

Estimating daily retrospective and future agricultural and urban water demand that are consistent with bias-corrected downscaled daily retrospective and future climate (P and P/RET) for the Tampa Bay Region (i.e. develop climate-driven water demand estimates).

Developing future population and land use scenarios for the Tampa Bay Region and estimating the water demand associated with these scenarios.

Using future projections of P, P/RET, and water demand in the INTB to evaluate future water availability (groundwater levels, streamflows, wetland hydroperiod) in the Tampa Bay Region for a variety of future climate-population-land use scenarios.

Determining the relative impact and relative uncertainty associated with climate versus anthropogenic factors in predicting future water availability in the Tampa Bay Region.

Evaluating what types of water management strategies reduce risks and increase resilience in water supply for the Tampa Bay region across the range of possible futures and their associated uncertainties.

Project budget :

Year	**Calendar Year 2016**	**Calendar Year 2017**	**Total**
Ph. D. student stipend	$23,750	$24,460	$48,210
Fringe (14.9%)	$3,539	$3,644	$7,183
Travel and Supplies	$2,711	$1,896	$4,607
Subtotal	$30,000	$30,000	$60,000
Indirect Costs (25%)	$7,500	$7,500	$15,000
Total	$37,500	$37,500	$75,000