APPLICATION OF THE LOWER COLORADO RIVER AUTHORITY FOR EMERGENCY AUTHORIZATION	§ § § §	**BEFORE THE TEXAS COMMISSION ON ENVIRONMENTAL QUALITY**

AFFIDAVIT OF RON ANDERSON

THE STATE OF TEXAS	§	
	§	
COUNTY OF TRAVIS	§	

Before me, the undersigned authority, personally appeared Ron Anderson, a person known by me to be competent and qualified in all respects to make this affidavit, who being by me first duly sworn, deposed as follows:

1. I am over 21 years of age, of sound mind, and have never been convicted of a felony or crime of moral turpitude. I am fully competent and qualified in all respects to make this affidavit.

2. The facts stated in this affidavit are within my personal knowledge and are true and correct. The tabs attached to this affidavit and referred to herein are incorporated by reference.

3. I, Ron Anderson, am an individual residing in Austin, Texas.

4. I have a Bachelor of Science in Engineering and a Master of Business Administration from the University of Texas at Austin. I am a Registered Professional Engineer in the State of Texas with specialization in Civil and Software Engineering. I am recognized as a Diplomate in Water Resources Engineering by the American Academy of Water Resource Engineers. A true and correct copy of resume, detailing my prior work history and education, is included as Tab 1.

5. I have worked for the Lower Colorado River Authority (LCRA) for thirteen years where I have worked on water supply planning issues for Central Texas. My current title is Chief Engineer.

6. As part of my duties at the LCRA, I track current issues affecting water supply, manage studies and modeling projects related to water supply quality and availability, enhance water supply forecasting capabilities, and evaluate water management procedures.

7. My opinions stated herein are based on my familiarity with LCRA's water supply operations and my evaluation of potential future inflows to the Highland Lakes. I have also relied upon a variety of information provided to me by LCRA staff, which

is of a nature typically relied upon in my profession, as described below and for which true and correct copies are either attached or referenced to other portions of LCRA's emergency request and incorporated by reference herein:

a. Affidavit of Bob Rose, including attachments;

b. Affidavit of Ryan Rowney, including attachments;

c. Affidavit of David Wheelock, including attachments;

d. Affidavit of Nora Mullarkey Miller, including attachments.

8. The 2010 Water Management Plan includes three criteria, all of which must be met at the same time for the LCRA Board to make a declaration of Drought Worse than Drought of Record (DWDR). (*See* 2010 WMP at p.4-34.) These criteria are indicators that can be evaluated in real-time. The three criteria are:

i. Duration of drought is more than 24 months, which is determined by counting the number of consecutive months since both lakes Buchanan and Travis were last full (i.e. "duration" criterion);

ii. Inflows to the lakes are less than inflows during the Drought of Record (i.e. "intensity" criterion); and

iii. Lakes Buchanan and Travis combined storage is less than 600,000 acre-feet of water.

9. One of the three criteria for the LCRA Board to make a DWDR declaration is the drought intensity as compared to the Drought of Record. Specifically, the inflow deficit must be at least five percent worse than the average inflow deficit over a similar period of time during the Drought of Record for at least six months. As part of my job responsibilities at LCRA, I track this criterion, which is depicted in the graphic under Tab 2. Based on this analysis, the current inflow deficit has exceeded the inflow deficit of the Drought of Record by at least five percent for more than six months. In fact, at times during the current drought, the inflow deficit has been as much as 90 percent more than the standard from the Drought of Record. (*See* Tab 2.) The intensity of the current drought can also be seen by a more simplified comparison of the cumulative inflows since 2008 which are significantly lower than those from the Drought of Record. (*See* Tab 3.)

10. As shown in the Affidavit of Ryan Rowney, additional inflow statistics demonstrate the severity of the ongoing drought over the past seven years as compared to any period of up to seven years in the Drought of Record. (*See* Affidavit of Ryan Rowney.)

11. The inflow deficit and the inflow statistics for the past seven years reveal a hydrologic condition that, for the past seven years, is more severe than any hydrologic condition evaluated as part of the 2010 WMP.

12. I have evaluated the likelihoods of lake contents dropping to 600,000 acre-feet and the drought intensity criteria continuing to qualify for a DWDR declaration using multiple hydrologic scenarios representing potential future inflows. (*See* Tab 4 for a description of the modeling tool.) Modeling methods are generally consistent within +/- 2 percent.

13. Based on my analysis and the foregoing review, it is my expert opinion that:

a. As of December 1, 2014, if severe drought conditions continue, the criteria for a DWDR declaration (including combined storage in lakes Buchanan and Travis falling below 600,000 acre-feet) may be met as early as March 2015. (*See* Tab 5.)

b. As of December 1, 2014, if LCRA were to follow the 2010 WMP in 2015, there is about a 33 percent chance of triggering a DWDR declaration by the end of 2015. (*See* Tab 5.)

c. As of December 1, 2014, if LCRA obtains emergency relief that suspends the supply of interruptible stored water to the Gulf Coast and Lakeside agricultural operations and Pierce Ranch and LCRA obtains emergency relief that reduces the instream flow requirement for the Blue Sucker from 500 cubic feet per second (cfs) to 300 cfs, the chance of triggering a DWDR declaration by the end of 2015 is reduced to about 8 percent.

d. As of December 1, 2014, for the ongoing drought, actual inflows into the Highland Lakes and the combined storage in Lakes Buchanan and Travis have trended close to the 99th percentile exceedance trace for extended periods.

e. As of December 1, 2014, the likelihoods of combined storage increasing to certain levels by March 1, 2015 are as presented in the table below. For example, as of December 1, 2014, there is only a 12 percent change that combined storage would be at or above 1.0 million acre-feet on March 1, 2015.

Combined storage level	Likelihood of being at or above the specified storage level on March 1, 2015
1.0 million acre-feet	12%
1.1 million acre-feet	7%
1.2 million acre-feet	5%
1.3 million acre-feet	4%
1.4 million acre-feet	3%
1.5 million acre-feet	3%

f. If combined storage on March 1, 2015 was at certain levels and LCRA were to operate under the 2010 WMP, the likelihoods of combined storage falling to 600,000 acre-feet by the end of 2015 are presented in the table below. The table also presents the date at which storage could fall to 600,000 acre-feet if conditions follow the 99% exceedance trace. For example, if combined storage was 1.0 million acre-feet on March 1, 2015 and LCRA were to operate under the 2010 WMP, the likelihood of DWDR by the end of 2015 is 6 percent and DWDR could be declared as soon as September 2015.

Combined storage level on March 1, 2015	Likelihood of storage falling to 600,000 AF by the end of 2015	Date of reaching 600,000 AF following 99% exceedance trace
1.0 million acre-feet	4%	Sept 2015
1.1 million acre-feet	>1%	Nov 2015
1.2 million acre-feet	<1%	May 2016
1.3 million acre-feet	0%	June 2016
1.4 million acre-feet	0%	July 2016
1.5 million acre-feet	0%	August 2016

14. If conditions similar to 2011 were to occur over the next 12 months, total evaporation from lakes Buchanan, Inks, LBJ, Marble Falls, Travis, Austin and Lady Bird Lake over the next 12 months would be between 150,000 and 160,000 acre-feet.

Further affiant sayeth not.

Ron Anderson

RON ANDERSON, AFFIANT

SWORN TO AND SUBSCRIBED before me on the 19th day of December, 2014.

TABETHA JASKE
Notary Public, State of Texas
My Commission Expires
January 11, 2018

Tabetha Jaske

Notary Public in and for the State of Texas

My Commission Expires: 1-11-2018

Ronald E. Anderson, PE, MBA, D.WRE

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EXPERIENCE
2001-present

Lower Colorado River Authority
Chief Engineer/Water Resources Managment

Water Supply Forecasting

- Develops stochastic model to forecast water supply availability.
- Communicates water supply forecasts online through custom reports.
- Collaborates with academic researchers to enhance forecast methods.

Lower Basin Reservoir Project, Project Sponsor

- Maintain project direction and benefits of developing 90,000 AF/yr of new supply
- Communicate project needs and obtain timely decisions to maintain schedule
- Communicate project benefits
- Support the Project Manager and the project team.

New Supply Development, Modeling Lead

- Overseeing consultant evaluation of lower basin balancing reservoirs reliability.
- Developing models to optimally size off channel storage reservoirs in irrigation divisions.
- Providing technical expertise in facility planning, siting and preliminary design for balancing reservoir projects.

2010-2014 Drought Response

- Develop scenario responses for drought response consideration.
- Provide stakeholders with updated reservoir level projections and risk assessment.
- Communicate with stakeholders about potential impacts.

Highland Lakes Water Management Plan Update. Technical Lead

- Procured and managed professionals to review drought of record monitoring methods
- Procured and managed professionals to develop simulation models
- Developed quality assurance procedures for project team
- Review water supply simulations and provide technical documentation.

Emerging Issues

- Responsible for scanning the political and scientific developments that might impact the future operations of the Colorado River and development of power generation.

Water Supply Model Development Project. Project Manager

- Coordinated development of the new innovative water rights solver feature to support daily river operations and allocation simulation.
- Chartered and developed project controls for the $1 million water supply planning mode development using the RiverWare platform.
- Procured engineering professionals to conduct the work.
- Conducted workshops for internal and external training.

Water Supply Reliability Team Lead

- Lead a team of internal and external professionals to review and evaluate existing and proposed plans for water supply management.
- Developed a stochastic forecasting model of the water supply for medium range planning of response to drought conditions.
- Evaluated procedures for management and operations under a drought conditions worse than the drought of record.

LCRA-SAWS Water Project

- Project Manager during pre-planning period. Responsible for project costs estimation, project controls, project consultant procurement, and project communications coordination.
- Project Controls Manager during project planning period. Responsible for setting up project financial, document, and communication controls for over $1 million in planning activities.
- Project Engineer and Technical Studies Coordinator for project study period. Responsible for quality assurance of key study scopes and products. Responsible for coordination and integration of related LCRA Projects with technical studies as well as assisting with public, stakeholder, and agency communications.
- Responsible for review and evaluation of technical studies' consultant performance.
- Studies activities include: surface water modeling, groundwater modeling, agricultural conservation, facilities engineering, environmental assessment, water quality assessment, bay health, socio-economic, waterfowl, climate change, uncertainty, and permitting.

Brazos River Authority

1998-2001 *Senior Planning Manager*
1997-1998 *Senior Water Resources Planner*

HDR Engineering, Inc.

1995-1997 *Project Manager*
1986-1995 *Engineer/Computer Modeler*

EDUCATION

Master of Business Administration, University of Texas at Austin, 1993
Post Graduate Studies, Free Surface Flow, 1987, Operations Research, 1988, University of Texas
Bachelor of Science in Engineering, University of Texas at Austin, 1986

PROFESSIONAL CREDENTIALS & ASSOCIATIONS

- Registered Software Engineer, State of Texas
- Registered Civil Engineer, State of Texas
- Member, American Society of Civil Engineers, Environmental and Water Resources Institute
- Diplomate, American Academy of Water Resources Engineers

SELECTED PUBLICATIONS & PRESENTATIONS

Anderson, R.E. and Rose, B. *Searching for Predictive Climate Signals for River Flows in the Lower Colorado River Basin,* USCID Water Resources World Congress 2012.

Anderson, R.E. and Gooch, T. *Review of Drought Worse Than Drought of Record Monitoring Methods for the Lower Colorado River in Texas*, ASCE/EWRI Water Resources World Congress 2011.

Anderson, R.E. and Walker, D. *Use of Stochastic Modeling during the 2008 and 2009 Drought on the Lower Colorado River in Texas*, ASCE/EWRI Water Resources World Congress 2011.

Water Resource Implications of Climate Change in Central Texas, Austin Climate Protection Conference & Expo 2010

Beyond the Drought of Record: Supply Forecasting for Difficult Times, Texas Water Conservation Association Fall Meeting, 2009.

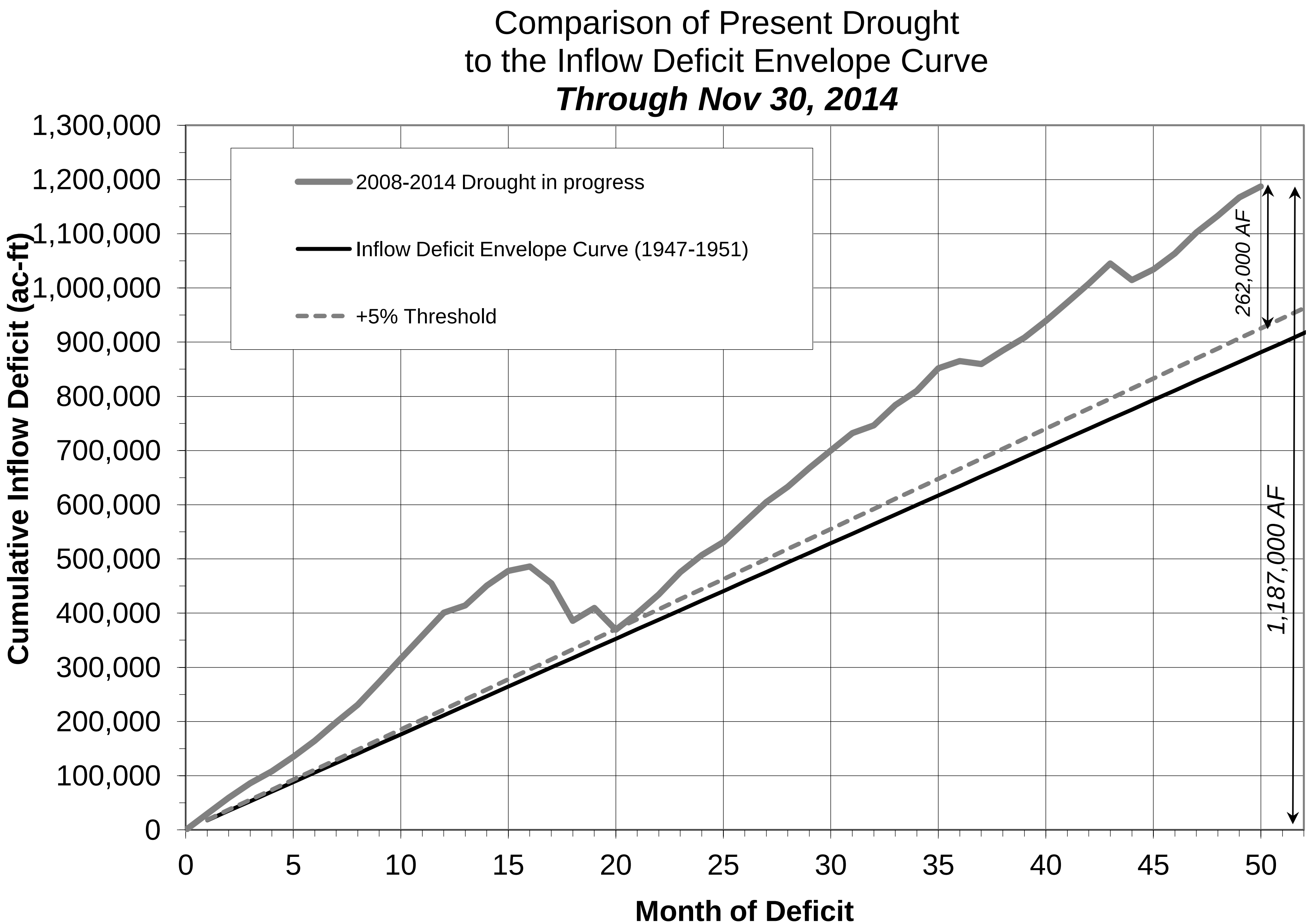
Anderson, R.E. and Walker, D. *Stochastic Forecasting of Conservation Storage on the Lower Colorado River in Texas,* Texas Water 2009.

Co-Author, *Assessing Potential Implications of Climate Change for Long-Term Water Resources Planning in the Colorado River Basin, Texas*, American Geophysical Union Annual Conference Poster, 2008.

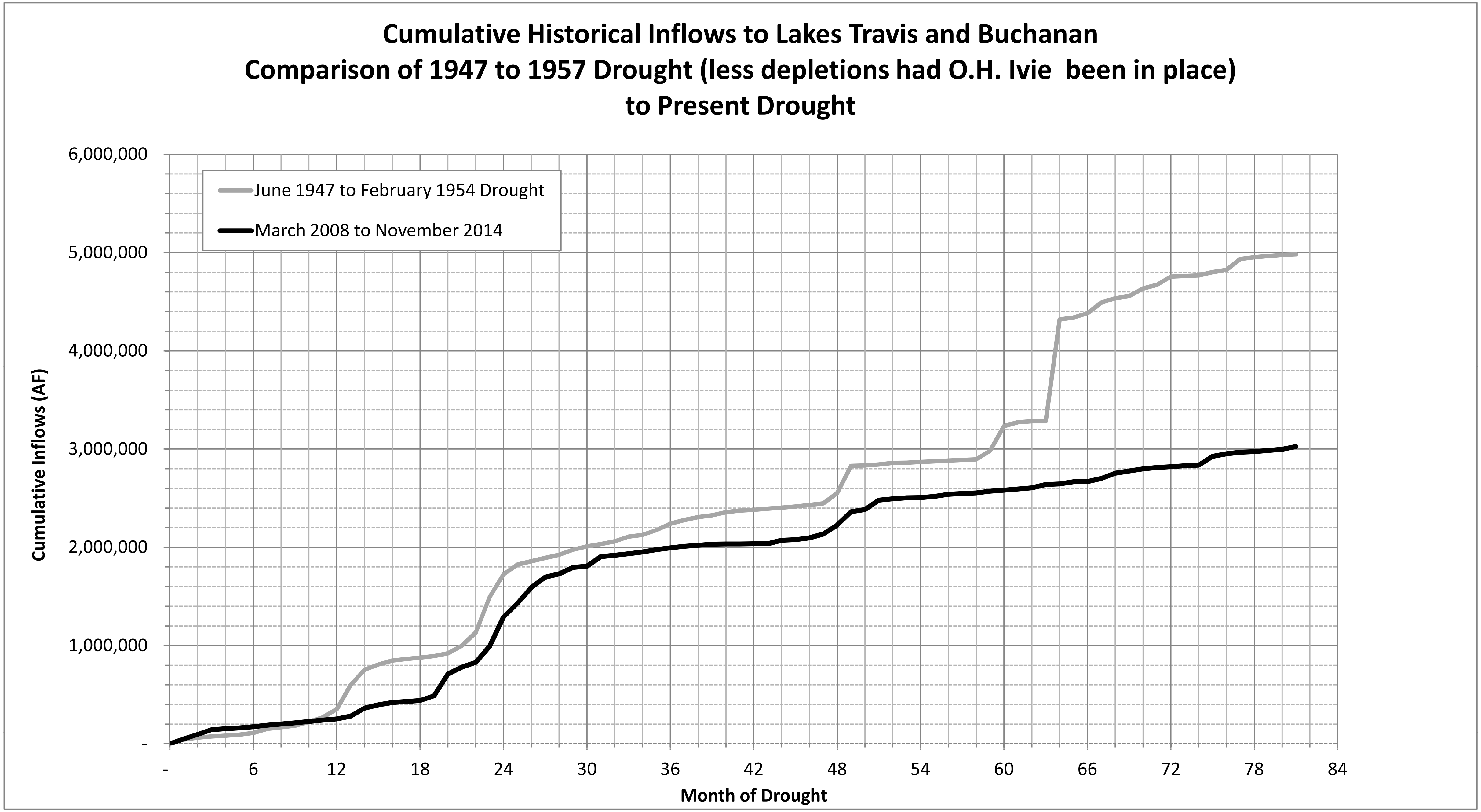
Current and Future Drought Assessment Activities, Drought Benchmarking Conference, 2007.

Co-Author, *Matagorda Bay Freshwater Inflow Needs Study*, LCRA, TCEQ, TPWD, and TWDB, August 2006.

Tab 2



12/1/2014
Subject to Revision


Cumulative Historical Inflows to Lakes Travis and Buchanan
Comparison of 1947 to 1957 Drought (less depletions had O.H. Ivie been in place)
to Present Drought
6,000,000
5,000,000
4,000,000
3,000,000
2,000,000
1,000,000
-
Cumulative Inflows (AF)
June 1947 to February 1954 Drought
March 2008 to November 2014
-
6
12
18
24
30
36
42
48
54
60
66
72
78
84
Month of Drought

Tab 4

LCRA's Use of Stochastic Modeling to Forecast Future Combined Storage
December 18, 2014

Introduction

No one can predict the future, but decision makers in all walks of life have to make judgments based on their best analysis of likely future conditions. This can be particularly difficult in situations where multiple factors and their interplay can influence the outcome of important events.

Because of the complications involved in this type of decision making, many industries rely on computer models called stochastic models to evaluate the likelihood of future conditions. This type of model is able to take a number of factors and data into account to generate a large number of potential future outcomes. Each individual outcome is as statistically likely as any other. Therefore, when all outcomes are plotted on a graph, areas where potential outcomes are denser depict a range of future results that is more likely. Conversely, areas on the graph where potential outcomes are less dense depict a range of future results that is less likely. The number of outcomes in a range can be expressed as a statistical probability for the future.

The insurance and financial industries are among those that use this type of computer model to help make their decisions. LCRA has been using and refining its stochastic modeling for six years to help inform water management decisions. LCRA's model has been reviewed internally by staff and externally by Dr. John Carron of Hydros Consulting and Dr. David Watkins of the Michigan Technological University. The methods have also been peer reviewed and published at multiple professional conferences of the American Society of Civil Engineering, American Water Works Association, and U.S. Committee on Irrigation and Drainage.

LCRA uses the model to show possible future combined storage levels of lakes Travis and Buchanan. LCRA also uses the results of the model to calculate potential future lake elevations. During drought, this is a popular tool for many of our firm water customers with intakes on the lakes. These customers use future lake level probabilities in their decision making process when evaluating whether or not to extend or move their intake structures.

What goes into LCRA's model?
LCRA uses the following sets of data in its stochastic model:

Current conditions: Each month when the projections are updated, the current levels of Travis and Buchanan serve as the starting point for the model.

Historical hydrology: LCRA currently uses the hydrological record from 1940 to 2014. Upstream inflows, downstream run-of-river flows and evaporation records for every month of that period are incorporated into the model. This includes the 10-year drought of the 1950s known as the state's Drought of Record and the drought of 2011, which is the most severe single-year drought on record. This data set is updated as each year of data becomes available.

Drought year firm customer demands: LCRA uses firm customer base demands in its model that are similar to demands experienced in 2008 and 2012 (no major new firm customers have entered into agreements since then). Drought year demands are appropriate when evaluating the impacts of drought on the water supply because drought conditions increase the demand for stored water that would otherwise be met through rainfall.

Interruptible customer requests: LCRA uses the 2011 planted acreage in the four irrigation operations to determine how much water downstream interruptible customers would require if all agricultural irrigation demands are met. This acreage is used to determine demands under an open supply scenario as well as to evaluate the level of curtailment under conditions that do not allow open supply.

2010 Water Management Plan: When determining how much interruptible stored water will be provided to the downstream irrigation operations, LCRA uses the assumptions of the current Water Management Plan. If a new Water Management Plan is approved or TCEQ approves an amendment to the current plan such as emergency relief, LCRA would use the new management assumptions in the model.

A measurement of El Niño/Southern Oscillation index: The El Niño/Southern Oscillation is a cyclic warming and cooling of the sea surface temperatures in the Pacific Ocean near the equator that can affect the weather in Texas. If the Pacific warms enough, it can produce an El Niño weather pattern that increases the chances of wetter than normal weather in Central Texas, particularly during the fall and winter. If the Pacific is cool enough, it can produce a La Niña weather pattern that increases chances of dry weather in central Texas. The El Niño/Southern Oscillation index (ONI) is a measurement of this cycle. LCRA uses the measurement in its model to help predict whether future conditions should be weighted toward a wet, dry or neutral scenario. Current conditions and future ensembles of the index are provided by the Climate Prediction Center and updated monthly.

Last two months of inflows: As explained above, LCRA's model uses historical inflow data for the last 75 years to help evaluate the likelihood of possible future conditions. The model specifically uses inflow data from the last two months to help determine one very important factor: the chances that the region's weather pattern could change significantly from one month to the next.

Historical data shows the tendency for the weather to stay the same from one month to the next in Texas, particularly during the winter months and to a lesser extent in May and October. If the weather is wet one month, it tends to stay wet the next month. Conversely, if it is dry one month, it tends to stay dry the next. This is the norm, but of course, it doesn't always hold true. As we all know, the weather does eventually change.

Through years of improving the model, LCRA staff has found that the best way to evaluate the likelihood of a significant change in the weather is to (1) use the most recent two months of inflows to determine if there is a wet, dry or neutral weather pattern and (2) look at the historical record to determine how often the weather pattern has changed from one month to the next. The model is able to use this data to determine the probability that the local weather will change significantly from one month to the next (from wet to dry, dry to wet, neutral to dry, etc.).

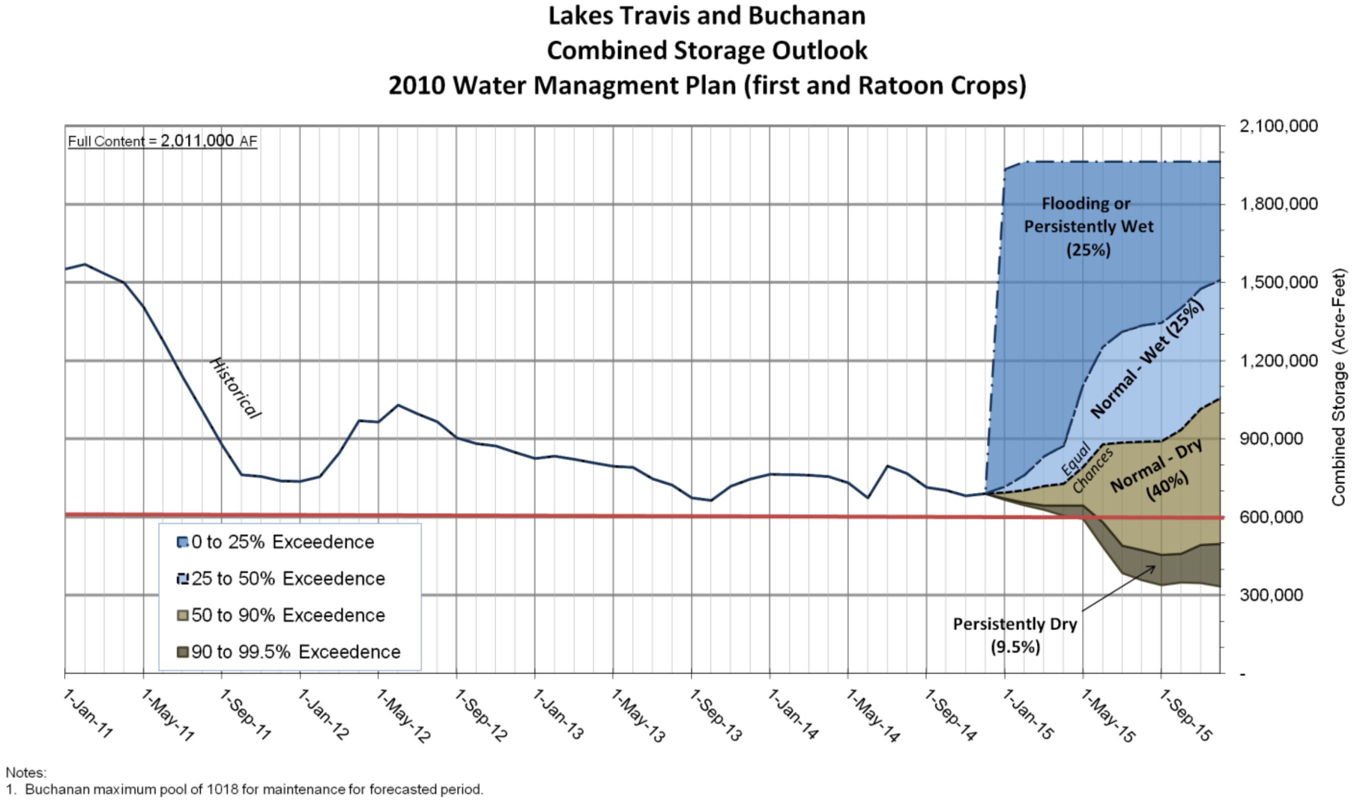
How does the model work?

The model proceeds month by month re-ordering the historical hydrology according to a rational method that preserves the historical observed switching patterns (wet, neutral, dry) and preserves the cumulative historical frequency of inflows to the highland lakes. That is the stochastic part of the model. Then it simulations operations of the system to meet demands and determines the monthly lake storage. That is the accounting part of the model. The model does this 2,000 times. These multiple scenarios are then summarized into graphical products.

What comes out of the model?

As discussed above, LCRA's stochastic model uses the factors we've described to calculate a large number (2,000) of possible future scenarios for the combined storage of lakes Travis and Buchanan. By plotting those 2,000 points on a graph, we are able to determine ranges that are more likely and less likely. LCRA uses that information to produce a graph that shows future combined storage ranges under different inflow conditions and management actions.

Consider the following graphic produced from the results of our model:



This graphic depicts potential future combined storage scenarios. It is divided into four ranges associated with the general weather conditions that would lead to the ranges of combined storage. We have titled them: Flooding or Persistently Wet; Normal-Wet; Normal-Dry; and Persistently Dry.

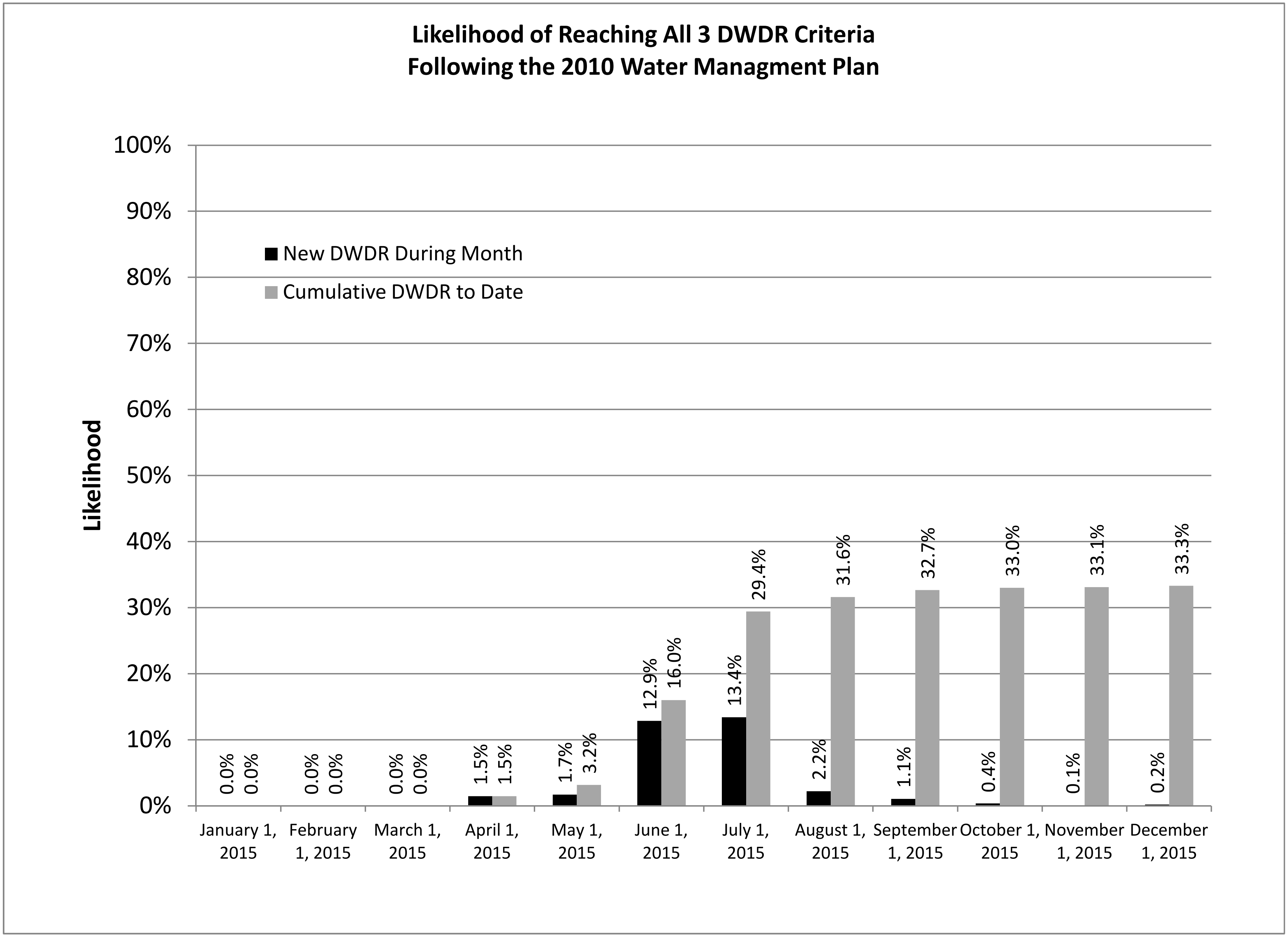
The legend with the graphic contains a percentage range associated with each category. This range corresponds with the percentage of the 2,000 future scenarios that falls into each category. Here's what it tells us:

- The Flooding or Persistently Wet range contains 25 percent, or 500, of the potential outcomes;
- The Normal-Wet range contains 25 percent, or 500, of the potential outcomes;
- The Normal-Dry range contains 40 percent, or 800, of the potential outcomes;
- The Persistently Dry range contains 9.5 percent, or 190, of the potential outcomes; and
- The Equal Chances line means that 50 percent of the potential outcomes, or 1,000, are above the line and 50 percent are below.

- A small number of outliers, 0.5 percent or 10 of the potential outcomes, are not depicted on the graphic.

As the graphic shows, the model cannot predict the future. What it does show is how likely a range of combined storage is in the future based on the historical hydrological record and other information contained in the model. This information is intended to help LCRA staff, Board members, and stakeholders make informed water management decisions.

Tab 5



12/19/2014