Further Evidence for the Need to Change the Approach to Water Planning in the Colorado Basin

Prepared for:

CENTRAL TEXAS WATER COALITION

Prepared by:

INTERA
GEOSCIENCE & ENGINEERING SOLUTIONS

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EXECUTIVE SUMMARY

The State of Texas and the Lower Colorado River Authority (LCRA) base their water planning and management on historical flow records, under the assumption of homogeneity – namely that future hydrology will mimic that observed in the past. Yet inflows to the Highland Lakes have been significantly lower in recent years, causing many to wonder if the use of historical hydrology is justified for decision-making. The Central Texas Water Coalition (CTWC) has commissioned numerous rigorous studies of historical Highland Lake inflows to determine if past hydrology is a good surrogate for future hydrology in the Lower Colorado River Basin. This summary document highlights the findings from these previously published studies.

This document demonstrates that the average annual naturalized AND measured inflows to the Highland Lakes in recent years are, statistically, significantly lower than the annual averages in historical records, indicating that there has been a downward shift in the natural flow regime. Furthermore, the firm yield of the Highland Lakes, which is the starting point for water availability studies and the Lower Colorado River Basin Water Management Plan (WMP), is likely lower than the number currently being used. This is corroborated by the fact that if dry conditions persist for just a few more months, the Lower Colorado Basin will be experiencing a new drought of record. These findings lead us to conclude that past hydrology is not a good proxy for future hydrology. As such, the recently revised WMP, while a step in the right direction from the previous plan, is not appropriate for planning and allocation of flows in the basin and must be revised as soon as possible. The following sections describe the various analyses that lead to CTWC's assertions.

1.0 STREAMGAGE RECORDS SUGGEST A DRYING TREND

Recent low lake levels in Texas have caused many to speculate that we are experiencing a measurable trend in decreasing flows, not only into the Highland Lakes, but in many other parts of the state. Scientists often use the Mann-Kendall test to determine if there is a statistically significant trend in discrete hydrologic data. An analysis of active stream gages across the entire state with period of record greater than 50 years indicates that there is in fact a trend in decreasing flows across much of central, north and west Texas (see Figure 1). Furthermore, there may be a progression of these drier conditions from the northwest to the southeast of the state, as evidenced by lake levels across the region. For example in Lake Meredith, north of Amarillo, contents have been diminishing since 2000 and it no longer has any usable water. Other lakes closer to Central Texas have been shrinking since 2008. The areas in Figure 1 showing clusters of blue dots are expanding urban areas where impermeable surfaces can increase the amount of runoff and where wastewater discharge and water imported from other basins may result in more water for local streams and rivers.

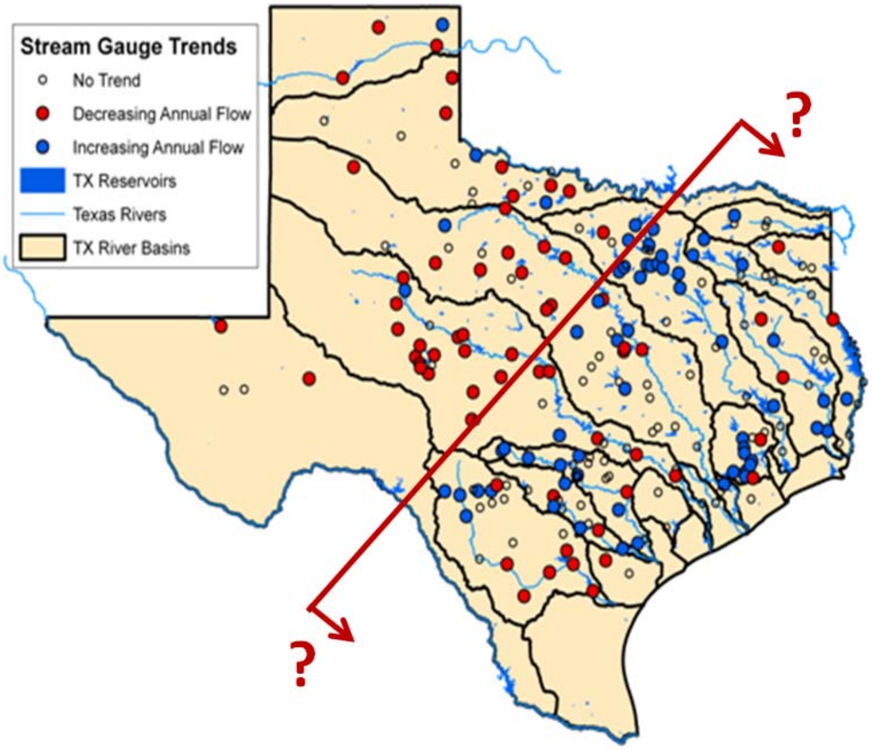

Figure 1. Trend in measured flow from active stream gages with period of record greater than 50 years

2.0 RECENT INFLOWS COMPARED WITH DOR INFLOWS

Of the three indicators used by LCRA to assess the severity of the current drought, the comparison of inflows is perhaps the most illustrative. Specifically LCRA compares the cumulative inflows to the Highland Lakes with an LCRA-defined “envelope curve,” which is a representation of what the inflows in the 1947-1956 drought of record would have been if all current basin water rights and reservoirs had existed at that time. As shown in Figure 2, measured inflows during this current drought (2008-present) have resulted in a 1.6 Million acre-ft DEFICIT compared to the envelope curve, and a 3.2 Million acre-ft DEFICIT compare with the actual inflows that occurred during the drought of record over an identical period from drought onset.

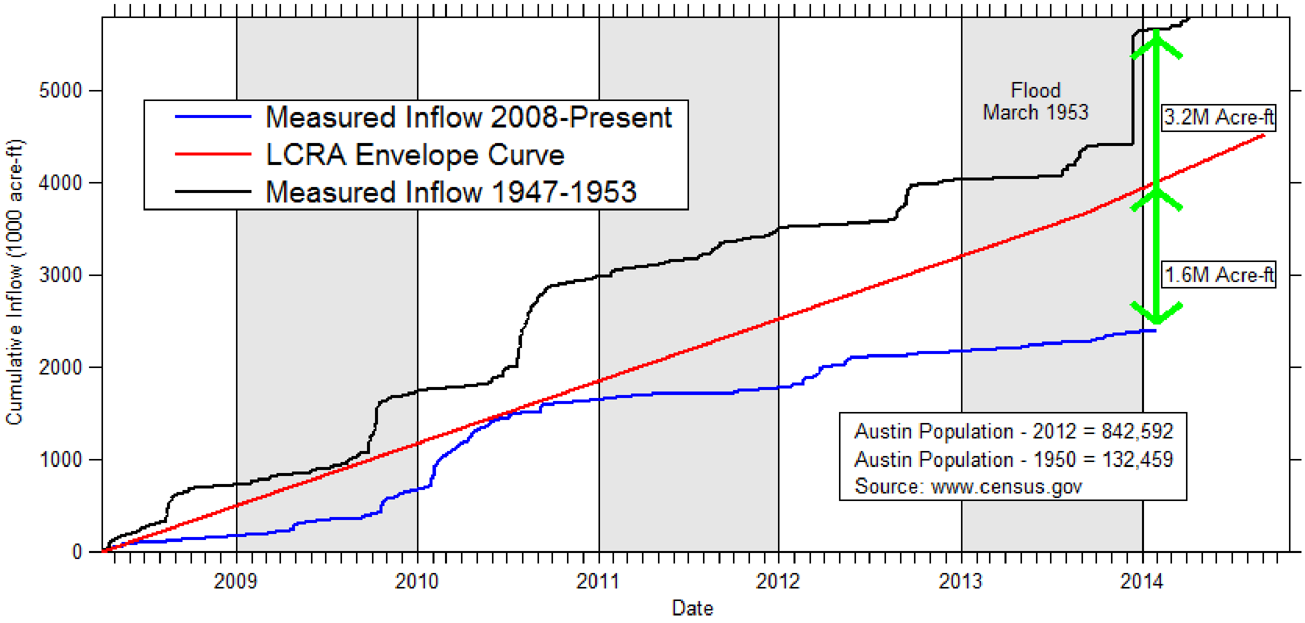

Figure 2. Cumulative inflows for the current drought compared with the LCRA envelop curve and drought of record period.

2.0 ASSESSING THE LIKELIHOOD OF THE RECENT LOW ANNUAL INFLOWS

Under the principles of water planning in Texas, future annual inflows are expected to be representative of the annual inflows observed over the historical period of record. This principle, called “homogeneity” is useful for water planning efforts, yet it does not consider the possibility that future flows could be outside the bounds of flows previously observed. One method for assessing homogeneity is to perform standard statistical analyses on the annual inflows to the Highland Lakes. The data used in the following analysis is provided in Appendix A. Figure 3 shows a histogram of the annual inflows to the Highland Lakes from 1942-2013. As shown, the distribution is skewed towards the left, which is typical of inflow datasets

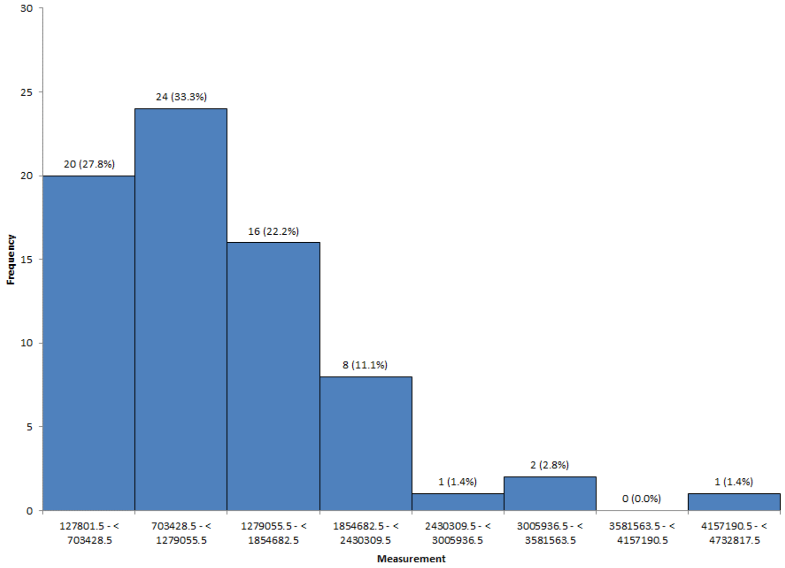

Figure 3. Histogram for Raw Inflow Data

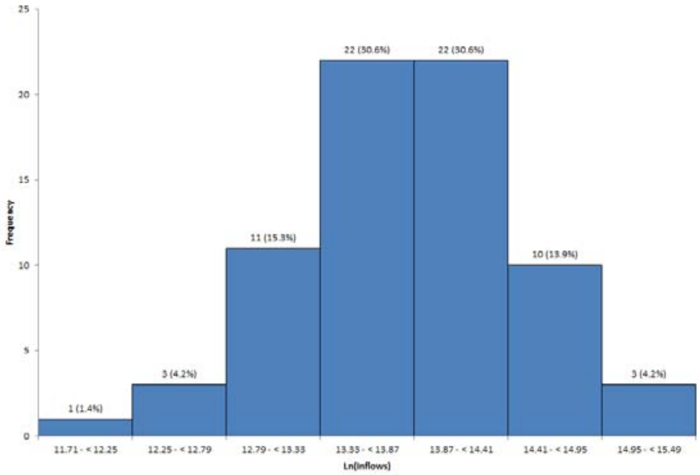

Figure 4. Histogram of Transformed Inflow Data

To better represent inflow data as being normally distributed, the standard practice is to transform the data using the natural logarithm. As shown in Figure 4, the transformed inflow data for the Highland Lakes follows a pattern more typical of a normally distributed random variable. Figure 5 is a normal probability plot of the transformed data, and it confirms that the transformed data are normally distributed. The p value for the normal probability plot is 0.467.

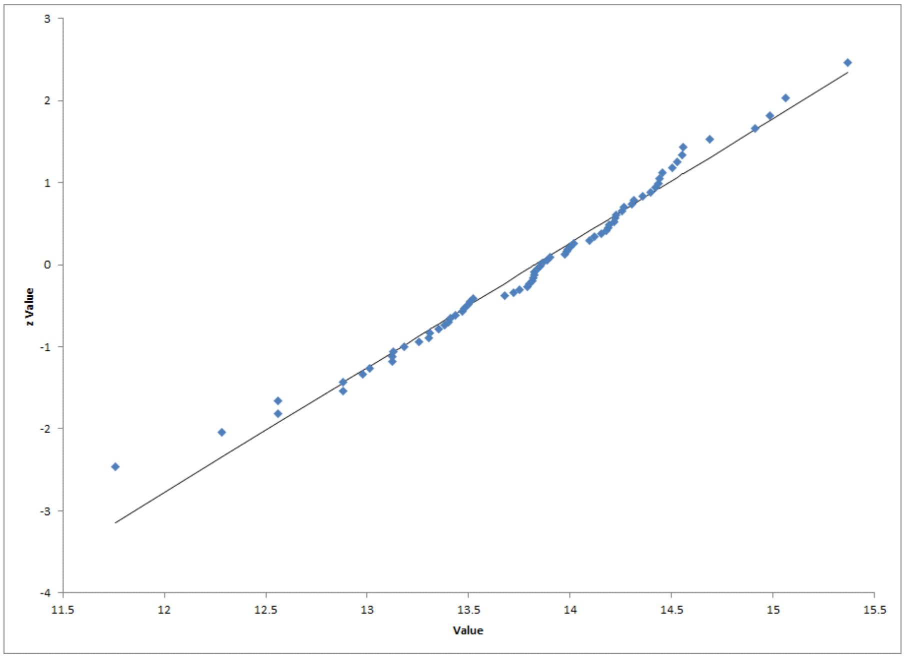

Figure 5. Normal Probability Plot of Transformed Inflow Data

One final statistical test is then needed to determine if the inflows from one year have any statistically definable impact on the inflows for any following years. Such a test is called “auto-correlation,” and the results shown in Figure 6 demonstrate a lack of correlation – namely that based on the recorded inflows data, the inflows in any given year are statistically independent upon inflows in any previous year.

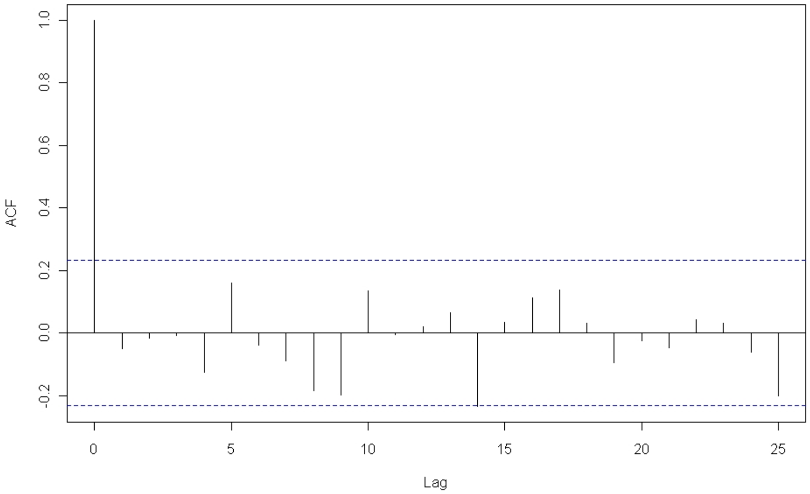

Figure 6. Auto-correlation of log-normal annual inflows to the Highland Lakes, showing statistically insignificant year-to-year correlations.

Now assuming the data shown in Figure 4 and Figure 5 are normally distributed, it becomes possible to fit the log-normal inflow values (x) to a normal distribution equation:

$$y = \left(\frac{1}{\sigma\sqrt{2\pi}}\right)\exp\left(\frac{(x - x_{mean})^2}{2\sigma^2}\right) \qquad \text{Eq. 1}$$

Where y is the likelihood of occurrence, σ is the standard deviation of the distribution, and x_{mean} is the mean value of the distribution. Integrating Eq. 1 for all possible values of x (i.e. log-normal inflows) allows for the computation of the probability that flows would be greater than a given value. Results of this computation are shown in Figure 7.

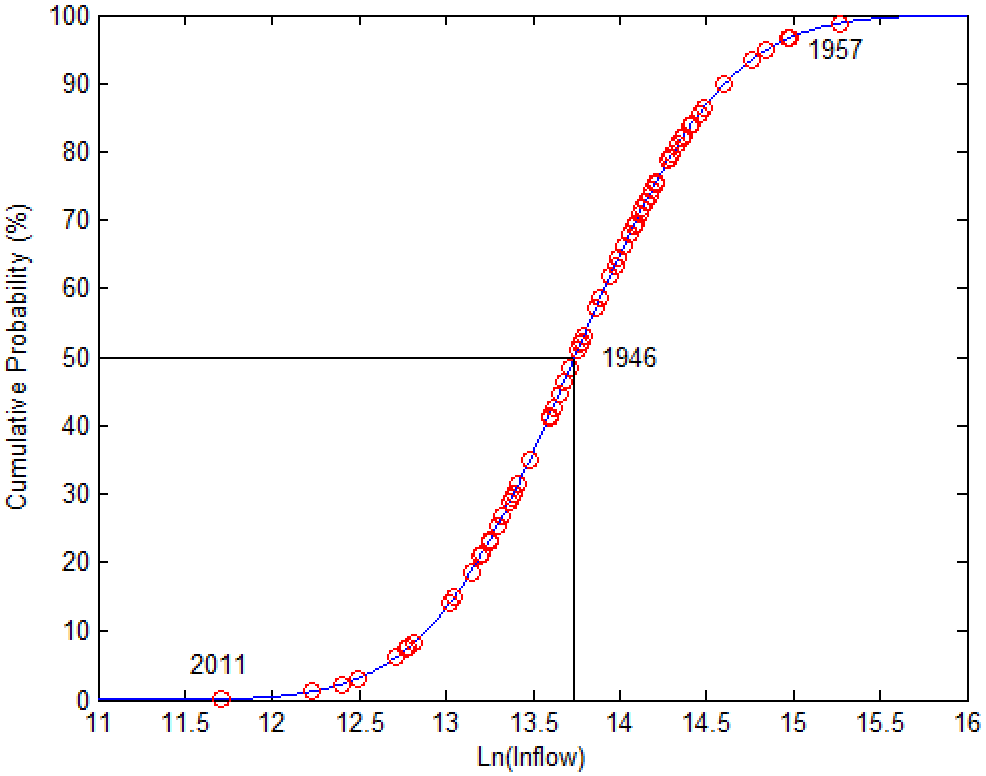

Figure 7. Cumulative Probability that inflows will be less than the amount shown.

As indicated in Figure 7, there is a near 100% chance that inflows will be less than they were in 1957, and a near 100% chance that inflows will be greater than they were in 2011. Inflows from 1946 are to be exceeded in nearly 50% of all years. Using the data in Figure 7, it is possible to determine the percent likelihood that flows will be lower than experienced in any given year. This information for the years 2008-2013 is provided in Table 1. As shown, assuming the principle of homogeneity applies to the entire period of record (1942-2013), then the probability of flows observed from 2008 to 2013 ranges from 0.13% (for 2011) to 41.17% (for 2010). The cumulative probability of flows occurring as they did from year to year from 2008-2013 is shown in the right-most column of Table 1. As calculated there is an approximate **1 in 1 BILLION** chance that the observed inflows for the past 6 years would have occurred, assuming the principle of homogeneity applies. The fact that this extremely unlikely pattern of low-flow years has occurred strongly suggests that homogeneity no longer applies in the Colorado River basin.

Table 1 – Highland Lakes Annual Inflows & Probability Statistics

Year	Inflow (acre-ft)	Ln(Inflow)	Probability	Cumulative Probability
2008	284462.3	12.55836	3.14%	1 in 33
2009	499731.7	13.12183	8.26%	1 in 385
2010	975321.8	13.79052	41.17%	1 in 936
2011	127802	11.75824	0.13%	1 in 720,387
2012	393426	12.88265	6.22%	1 in 11,581,790
2013	216253	12.2842	1.23%	1 in 941,608,974

3.0 USING STATISTICAL CONTROL CHARTS TO ANALYZE INFLOW SHIFTS

Control charts were used to analyze the data. One purpose of control charts is to monitor a variable over time to see if anything has significantly changed. This type of chart focuses on two different types of variation: common causes and special causes. The following everyday example helps explain how control charts work.

3.1 Control Chart Analysis Methodology

Think about how long it takes you to get to work each day. Does it take the same time each day? No, of course not. But there is a certain average time it takes. Assume that this average time is 20 minutes. It does not take exactly 20 minutes each day. There is a range of time that you consider “normal” to your process of getting to work. Maybe one day it takes 18 minutes; another day it takes 23 minutes. But as long as the time is within a “normal” range, it does not concern you. Suppose this normal range is 15 to 25 minutes. You don’t how long it will take you to get work tomorrow, but as long as things are “normal”, the time will be from 15 to 25 minutes. The differences from day to day are simply due to the amount of traffic, the speed you drive, etc. This is called common causes of variation – it is the normal variation in the process. You might call it the baseline data to judge the future against.

Figure 8 is an example of a control chart for your process of getting to work. The data are plotted over time. The top dotted line is called the upper control limit. It is the largest value you would expect from the process with just common causes (normal variation) present. The lower dotted line is called the lower control limit. It is the smallest value you would expect form the process with just common causes of variation present. As long as there are no points beyond the control limits and no patterns present, the process is said to be in “statistical control”. Only common causes of variation are present and you can predict what will happen in the near future. This prediction is the key. You don’t know how long it will take you to get to work tomorrow, but you know it will be between 15 and 25 minutes, with an average of 20 minutes.

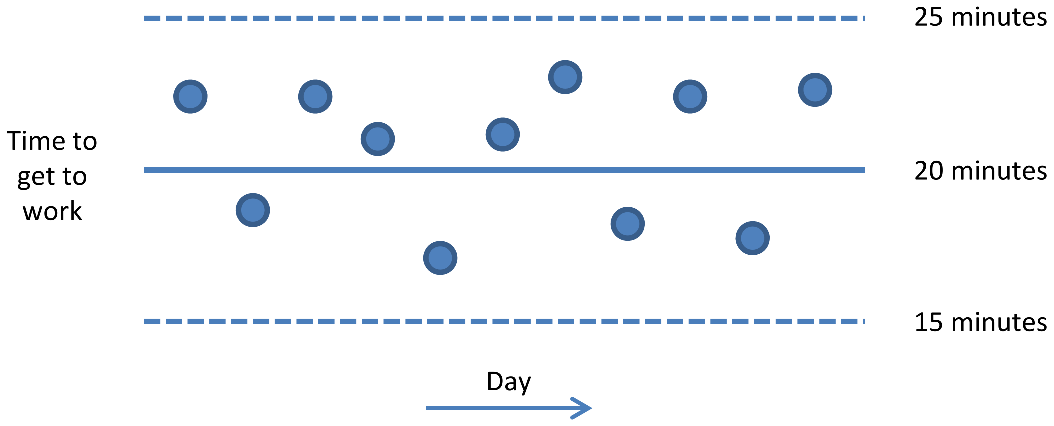

Figure 8. Control Chart for the Time to Get to Work

Now, suppose you have a flat tire when driving to work. How long will it take you to get to work? Definitely longer than the 15 to 25 minutes in your "normal" variation. Maybe it takes you 50 minutes to get to work. This is a special cause of variation. Something happened that has caused a change. It is not part of the normal process. These types of special causes are not predictable and are sporadic in nature. Figure 9 is an example of the impact of a “flat tire” on getting to work.

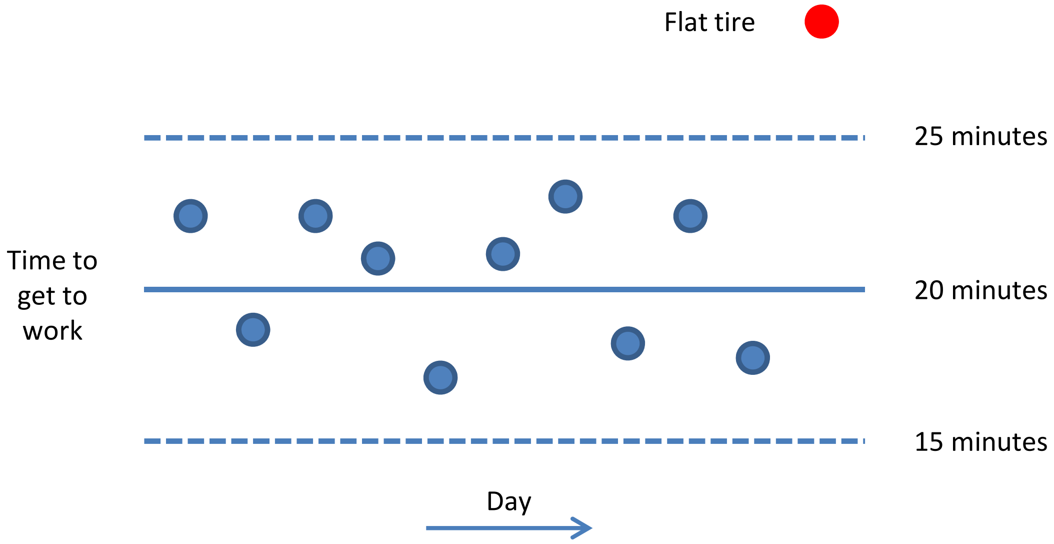

Figure 9. Control Chart with Special Cause (Flat Tire)

Once you fix the flat tire, the process will come back into statistical control. But there are special causes that represent significant shifts in the process average. For example, suppose you wanted to decrease the amount of time you get to work. So, you change your process. You get up earlier and drive a different route. This represents a fundamental change in the process. The control chart will show the impact of that change. Figure 10 shows such a process.

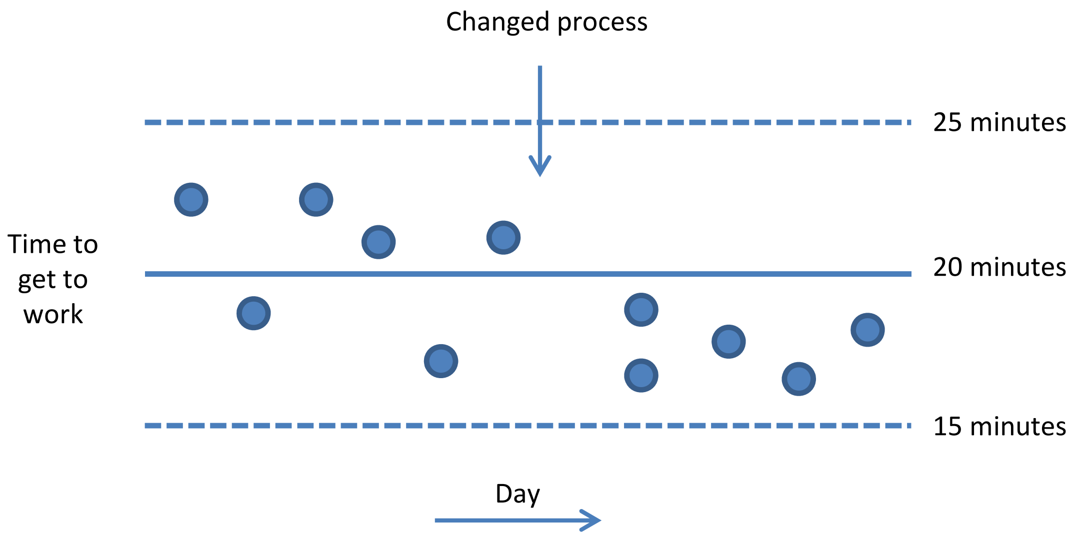

Figure 10. Control Chart with Changed Process

This type of shift will show up in a control chart as a special cause of variation. It is clear from the chart that the average has shifted downward. The new average for the process of getting to work can be estimated from the data collected after the change in process.

2.2 Control Chart Analysis with Highland Lake Inflow Data

The data used in the analysis are shown in Appendix A. The control chart (Figure 11) used in the analysis was an individual (X-mR) control chart using the log-normally transformed data shown in Figure 4. There are additional lines plotted on the chart. One line is the average, which is 13.85. This is the average of the natural logarithms of the inflow data. The top line is the upper control limit (UCL). This represents the largest value one would expect if the process has not changed.   The two lines between the average and UCL represent one and two standard deviations above the average.   The bottom line is the lower control (LCL).   This is the smallest value one would expect if the process has not changed. The two lines between the average and the LCL represent one and two standard deviations below the average. The lines between the average and the control limits are used to detect patterns that indicate a process has changed.

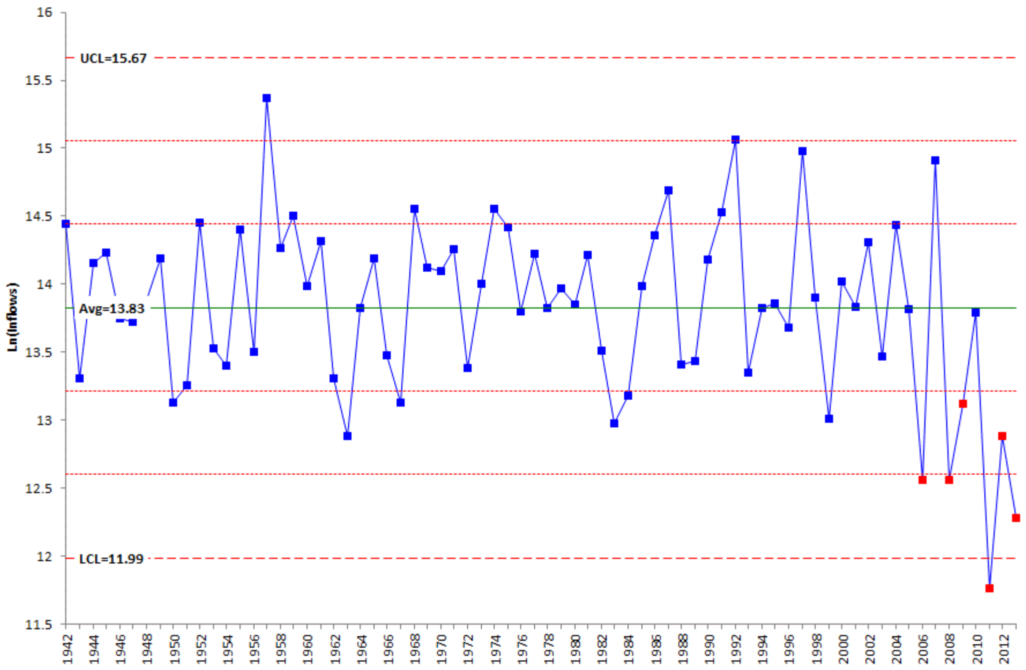

Figure 11. Control Chart for Transformed Inflow Data – Logarithmic Scale

There are six red points at the right-hand side of the control chart shown in Figure 11. These red points represent "out of control" conditions – something has happened during that time frame to change the process. There are four out of control conditions beginning in 2006:

- 2006 to 2008: two out of three consecutive points are beyond two standard deviations below the average; 2008 is the confirmation year that the process has changed.
- 2006 to 2012: four out of five consecutive points are beyond one standard deviation below the average; 2011 and 2012 are the confirmation year that the process has changed
- 2011: point is beyond the lower control limit
- 2011 to 2013: two out of three consecutive points are beyond two standard deviations below the average

These conditions indicate that the process driving Highland Lakes inflows has indeed changed. The inflow data are no longer "consistent" over the years. There is statistical evidence that the process shifted downward starting in 2006. Figure 12 shows in the X-mR control chart for the inflow data plotted on a normal (non-logarithmic) scale. Note that this chart shows that the process is out of control in the last few years as well – although it indicates the process changed in 2008.

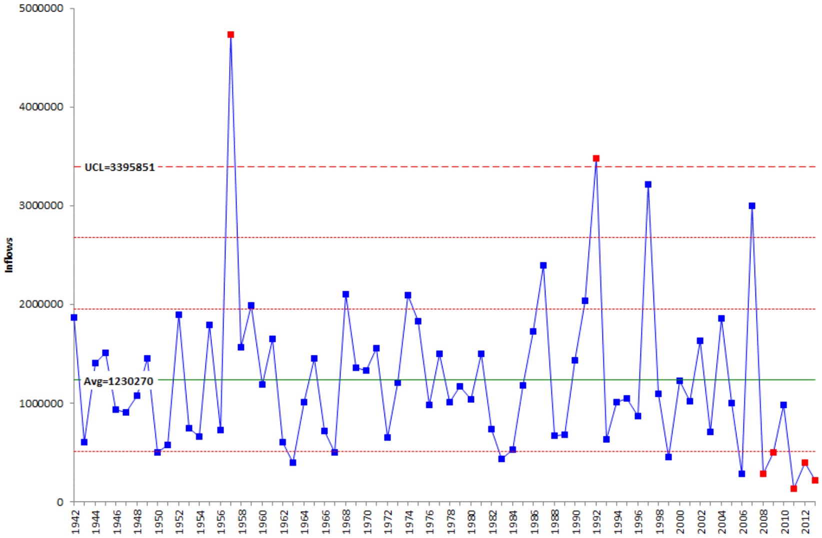

Figure 12. Control Chart Based on Raw Inflow Data – Regular Scale

In conclusion, the control chart approach shows that there has been a shift in the inflows to the lakes over the past few years. The average inflow has decreased significantly as indicated by the control charts. Yet the control chart (Figures 11, 12) shows the change – not the reason(s) for the change. Figure 13 shows the control chart from Figure 11 with the chart split in 2008, showing pre- and post- split inflow statistics. The average inflow from 1942 to 2007 was 1,304,361 acre-ft/yr. The average inflow in the more recent (2008-present) regime is 416,166 acre-ft/yr, or approximately 32% of the average flows from 1942-2007.

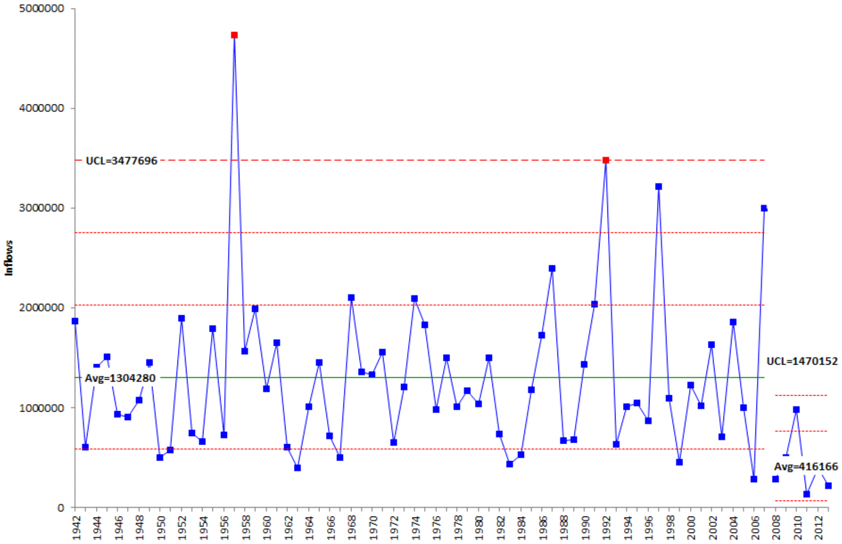

Figure 2. Split Control Chart to Estimate New Inflows

4.0 NATURALIZED FLOW DATA DEMONSTRATE A SHIFT IN HYDROLOGY

The fact that measured inflows to the Highland Lakes have decreased overtime is to be expected as reservoirs have been built and water diversions have steadily increased in the basin. For example, construction of Lake O.H. Ivie on the Colorado River above the Highland Lakes was completed in 1990, resulting in a reduction in the inflows to Lake Buchanan. To demonstrate that the hydrology has changed beyond what one would expect through increased use of water in the basin, naturalized flows (flows with anthropogenic impacts artificially removed) should be used with control charts, and in fact it is naturalized flows that form the basis for water planning and water availability modeling in the state.

A time series of naturalized flows from 1940 through 1998 was developed for the TCEQ Water Availability Model (WAM). LCRA extended these naturalized flows through 2009 for the WMP and these data were obtained. Developing naturalized flows is a lengthy and tedious process and has been simplified here. For the purposes of this report, naturalized inflows to the Highland Lakes for the period 2010 through 2012 were estimated based on the largest ratio between measured and naturalized Highland Lake annual inflows from past records. This is a very conservative approach for the point we're making as it results in naturalized flows that are likely higher (wetter) than reality. The results (Figure 14) show that three of the past seven years (2006, 2008 and 2011) have been below the 5th percentile (two standard deviations below the mean). Furthermore, the naturalized inflows for 2011 were far below any other year in the hydrologic record and in fact the 5th percentile for low flows was not exceeded prior to 2006 – not even during the drought of record (1947 through 1956) or in 1963, which was the driest year on record until 2006.

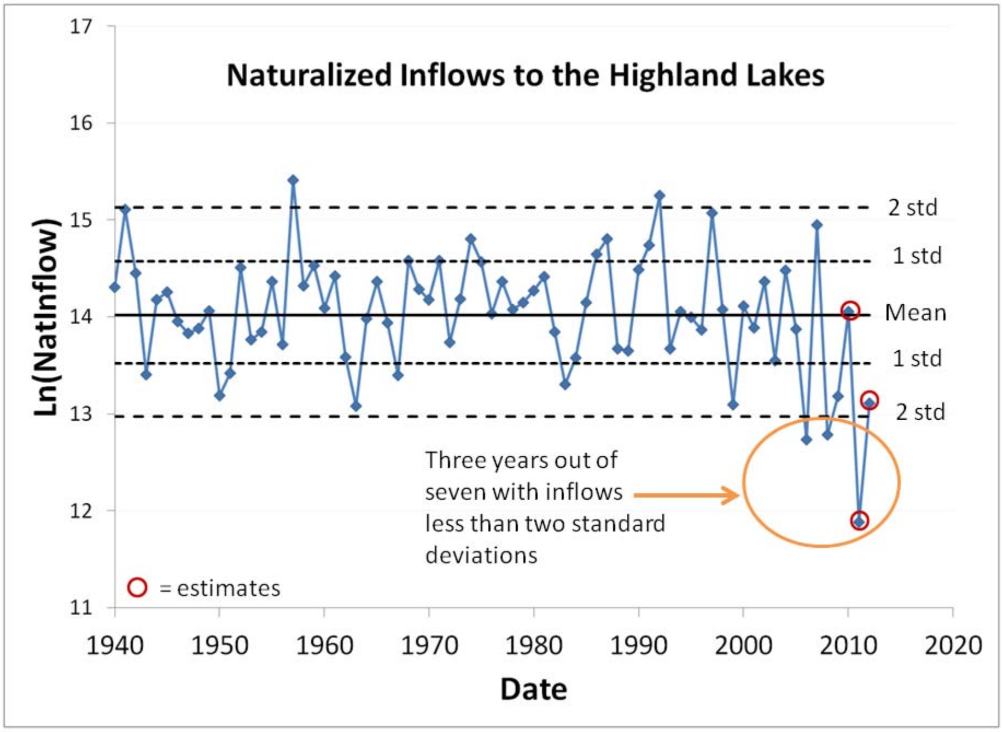

Figure 3. Demonstration of the fact that naturalized inflows to the Highland Lakes have changed.

This analysis strongly suggests that we are in a hydrologic regime with naturalized flows for which the mean has shifted significantly lower than what we have seen historically (i.e., beyond natural variability), which corroborates the control chart analysis results obtained using measured Highland Lake inflows. For the decade 2003 to 2012, naturalized inflows were on average more than 30 percent lower than the average for the period of record prior to that (1940 – 2002). For the five years from 2008 to 2012, average annual naturalized inflows are more than 55 percent lower than the average for the period of record prior (1940 – 2007).

A persistence of these lower inflows would be crippling to our economy and place a real threat on water providers' ability to continue supplying water to their customers, even with strict water conservation measures in place. Preparation for that eventuality requires careful planning and a move away from a reliance on historical hydrologic data to a more realistic assessment of flows likely to occur over the next several years. We can no longer assume that the future will be like the past.

5.0 A NEW DROUGHT OF RECORD IS IMMINENT AND THE FIRM YIELD OF THE HIGHLAND LAKES NEEDS TO BE REASSESSED

In previous sections we made the case that there is a high probability that we have experienced a shift in the naturalized flows entering the Highland Lakes. This is more than an anomaly or serious drought - we have a new normal and this new normal flow condition is significantly lower than it used to be. The question we need to answer is does this new condition signify that we have a new drought of record, thus requiring a reassessment of the firm yield of the Highland Lakes and an update to the WMP? The firm yield is the amount of water that is available out of a water supply source, such as a reservoir or system of reservoirs, every year through a repeat of the drought of record and is an important planning tool in Texas and elsewhere. In fact most water availability studies use the firm yield as a starting point for permitting and planning. A new drought of record would lead to the need to reassess the firm yield of the Highland Lakes and would also raise serious questions about the WMP. LCRA uses a customized methodology for determining "Drought Worse than Drought of Record" conditions. The drought of record for the Lower Colorado River is currently the period from May 1947 through to June 1956. Water Availability Models (WAMs) were developed to address this question, and were based on LCRA's Firm Yield WAM developed during the creation of the WMP using two sets of modified naturalized flow data. The first modified dataset consisted of reduced by 30% inflows for the period 1940-1998; this reduction approximates the mean reduction identified for the period 2003-2012 relative to the period before 2003. The WAM-computed combined storage of Lakes Buchanan and Travis (Figure 15) resulting from these reduced inflows indicate would have dropped to 0 acre-ft in early 1950, and would have remained essentially empty until 1957 when the drought ended. Also shown in Figure 15 is that the combined storage values computed using the reduced naturalized flow dataset would have periodically dipped below the 600,000 acre-ft mark currently used by LCRA for signaling complete curtailment of all irrigation operations downstream from the Highland Lakes.

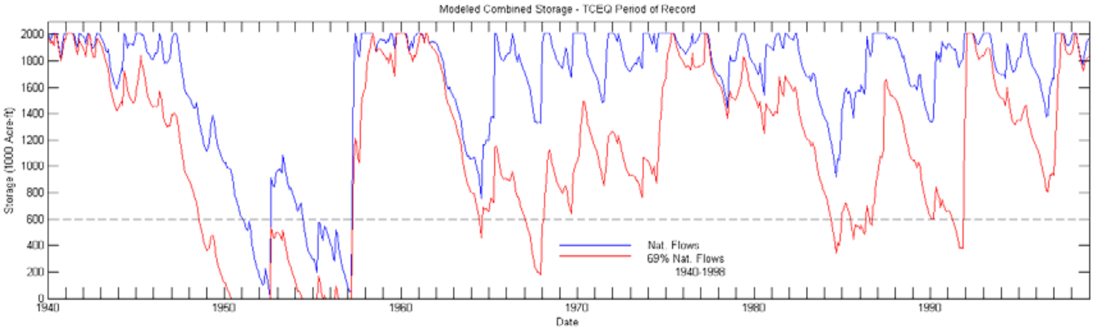

Figure 4. Modeled Combined Storage in the Highland Lakes using TCEQ Naturalized Flows (1940-1998) and flows reduced by 31% (as observed for the period 1999-2012)

Both the TCEQ and LCRA compute the "firm yield" of the Highland Lakes in assessing water availability in the Colorado River Basin. Typically, a firm yield is the minimum quantity of water able to be withdrawn from a system on an annual basis without causing complete depletion of the system reservoir storage. For the Colorado River Basin, however, TCEQ and LCRA compute the firm yield slightly differently, as:

> *"the average annual amount of water supplied during the critical period. The critical period covers a 10.2 year period from May of 1947 through June of 1957"*
> *(Memo* dated April 15, 2013 from Dr. Kathy Alexander, TCEQ, *Page 8)*

By this definition, the firm yield for the Highland Lakes is not the minimum annual amount of available water, but rather an average amount over the currently accepted basin drought of record. Table 2 presents computed firm yields for the Highland Lakes using data from Figure 15 as well as both definitions of firm yield (TCEQ/LCRA's method and the minimum annual available water definition). As indicated, the combined firm yield calculated by INTERA using the method and model adopted by LCRA (TCEQ WAM & period 5/47-6/57) is 473,684 acre-ft/yr, which is higher than the 439,155 acre-ft/yr yield reported by TCEQ (Memo, page 8). The reason for this yield difference was not investigated by INTERA, yet is likely due to INTERA's use of a model developed by LCRA, which differs from TCEQ's WAM model in that before performing their analysis, TCEQ "updated LCRA's WAMs to include more recent amendments to water rights in the Colorado River Basin" (Memo, Page 7).

As conveyed in Table 2, computing the firm yield as a minimum annually available quantity of water results in yields less than those computed as an average during the critical period. Firm yields are also reduced when modeling using the reduced flows WAM. The firm yield reduces to zero when calculated from the reduced flows WAM using the minimum annual availability approach. This signifies the fact that by reducing naturalized inflows from 1940-1998 by 31% (to match recent averaged flows), there are annual periods when the Highland Lakes would not be able to provide any water to firm or interruptible customers.

Table 2 – Highland Lake Firm Yields computed from TCEQ & Reduced Inflow WAMs (1940-1998)

	Period 5/47-6/57	Minimum Annual Availability
TCEQ WAM (1940-1998)	473,684 acre-ft/yr	127,091 acre-ft/yr
Reduced Flows WAM (1940-1998)	297,099 acre-ft/yr	0 acre-ft/yr

One problem with assessing the firm yield using a defined critical period is that the yield cannot be adjusted to reflect conditions observed in a new drought of record (were one to be declared in the future). In TCEQ's "Notice of an Application to Amend the LCRA Water Management Plan," TCEQ stated that complete curtailment of interruptible water releases for the Lakeside, Pierce Ranch, and Gulf Coast operations will be required when combined storage values drop below 600,000 acre-ft. TCEQ also stated that such curtailments will be implemented if the LCRA board declares a drought worse than the drought of record. From these statements, it is suggested that a combined storage value of 600,000 acre-ft is indicative of a new drought of record.

To assess the likelihood of meeting the 600,000 acre-ft combined storage criteria as the current Colorado Basin drought continues, INTERA modified the LCRA WMP WAM models (Firm Yield and 2010 Interim Demand Models) to include naturalized flow data for the years 2010-2016. As previously stated in this report, naturalized inflows to the Highland Lakes for the period 2010 through 2012 were estimated based on gauged inflows to the Highland Lakes, with adjustments made to account for the subordination of Colorado River water flowing into OH Ivie Reservoir. The annual total inflows to the Highland Lakes were then "naturalized" by multiplying the inflows by the largest ratio between measured and naturalized Highland Lake annual inflows from past records. This is a very conservative approach as it results in naturalized flows that are likely higher (wetter) than reality. To extend the naturalized flow dataset for WAM modeling, INTERA determined which year in the LCRA WMP period of record (1940-2009) had the total naturalized inflow to the Highland Lakes most similar to the naturalized annual inflow computed based on gauged records (for years 2010, 2011, and 2012). INTERA then modified the WAM-specified naturalized flows for each modeled control point according to the ratio of the total annual WAM inflow to the total annual naturalized gauged flows. For example, the total annual naturalized Highland Lake inflow for 2010 was computed to be 1,594,419 acre-ft/yr, which is nearly identical to the total naturalized inflows for 1969. Therefore in modeling 2010, INTERA used naturalized flows from 1969. No corrections were made for the seasonal pattern of flows occurring in any given year. In a similar manner, INTERA calculated naturalized flows for 2011 to be equal to 60% of the naturalized flows for 2006, and the naturalized flows for 2012 were 96% of the naturalized flows from 2003. INTERA approximated a continuing drought by modeling years 2013-2016 with are repeat of years 2006, 2008, 2006, and 2008 respectively.

WAM modeling results obtained with INTERA's extended naturalized flow dataset (1940-2016) are presented in Figure 16, along with a time-history of observed combined storage values for Lakes Buchanan and Travis from October 1942 – April 2013. Also shown on Figure 16 is the 600,000 acre-ft combined storage threshold for identifying a new drought of record.

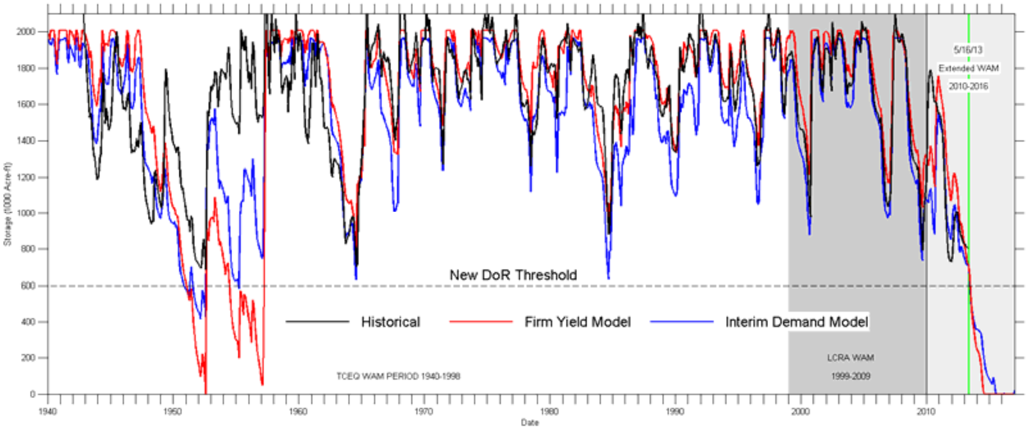

Figure 5. Historical and WAM-modeled combined storage of Lake Buchanan and Lake Travis, using INTERA's extended 1940-2016 naturalized flows dataset.

Notable aspects of the modeling results presented in Figure 13 include:

- Large differences between modeled and historical combined storages during the 1947-1957 drought of record, with historical storages exceeding modeled levels
- Excellent agreement between historical and interim demand model storages during the 1963-1965 dry period
- Historical storages typically in between modeled storages calculated using the firm yield and interim demand models for the period from 1990-2009.

It is also notable that for both the interim-demand and firm yield models, the continued dry period from 2010 onward causes modeled combined storage to drop to zero by mid-2014, passing the 600,000 acre-ft combined storage threshold in July of 2013. INTERA notes, however, that the historical combined storage in April 2013 was approximately 100,000 acre-ft higher than the modeled combined storage at this time, suggesting perhaps that the modeled date for crossing the drought of record threshold is too early.

5.0 CONCLUSIONS AND RECOMMENDATIONS

As demonstrated using statistical hydrology and control chart analyses, recent inflows to the Highland Lakes have been lower than expected based on the principle of homogeneity – namely that future inflows are to be similar to those experienced in the past. Unfortunately the State of Texas and LCRA insist upon using historical hydrology to demonstrate the impact of their proposed water management plans, rather than tailor a more flexible plan that does not assume homogeneity. Analyses conducted by and on behalf of CTWC, as summarized herein, demonstrate that old management methods combined with extremely low Highland Lake inflows will quickly lead to diminished lake levels and the declaration of a drought worse than the drought of record.

It is difficult to solve problems with the same methods used in creating the problems. Yet this is exactly the type of water management approach taken by entities in the Colorado River basin. Alternative water management methods, not based on historical hydrology, should be explored. Let's leave the past behind us and only look forward.

APPENDIX A

Annual Inflows (Acre-ft/yr) to the Highland Lakes

Year	Yearly Inflow		Year	Yearly Inflow		Year	Yearly Inflow
1942	1869518		1966	713993.3		1990	1435134
1943	602151.5		1967	503571.6		1991	2035664
1944	1404905		1968	2098909		1992	3482690
1945	1512085		1969	1357418		1993	629759.4
1946	935782.5		1970	1324530		1994	1006258
1947	908242.3		1971	1551080		1995	1047405
1948	1072715		1972	647921		1996	870509.6
1949	1455462		1973	1209395		1997	3212723
1950	501926.3		1974	2091525		1998	1088462
1951	570254.8		1975	1829737		1999	448161.5
1952	1897714		1976	983240.6		2000	1227130
1953	746945.6		1977	1502871		2001	1021712
1954	661556.9		1978	1004812		2002	1630324
1955	1789597		1979	1169847		2003	708077.3
1956	729079.9		1980	1036941		2004	1859272
1957	4732816		1981	1495960		2005	999540.7
1958	1566071		1982	734603.9		2006	285229.1
1959	1991513		1983	433312.1		2007	2996572
1960	1188341		1984	529697.5		2008	284462.3
1961	1645561		1985	1181458		2009	499731.7
1962	598867.6		1986	1723391		2010	975321.8
1963	392589.4		1987	2389690		2011	127802
1964	1007825		1988	667395		2012	393426
1965	1452809		1989	682212.6		2013	216253