

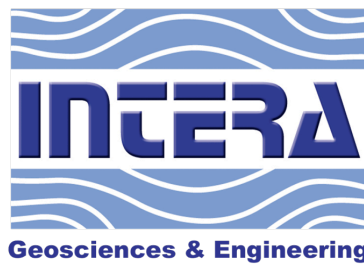
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# Evidence for the Need to Change the Approach to Water Planning in the Lower Colorado Basin Part III: Drought of Record Analysis

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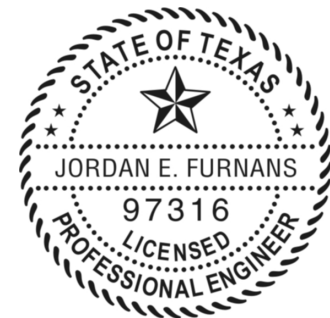


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## EXECUTIVE SUMMARY

The Lower Colorado River Authority (LCRA) has published three criteria it uses to assess whether drought conditions are worse than those experienced during the Drought of Record (DoR), which is typically defined as the period from May 1947 – June 1957. These criteria involve assessing the length of the current drought, the amount of Highland Lake inflow during the current drought, and the combined storage levels for Lake Buchanan and Lake Travis.

The Central Texas Water Coalition (CTWC) commissioned a rigorous study of the current Colorado River basin drought, specifically to assess whether the drought meets LCRA's criteria for being a drought worse than the drought of record (DWDOR). Findings of the study demonstrate that the current drought meets LCRA's criteria based upon the drought duration and Highland Lake Inflows. The current drought would also meet the DWDOR combined storage criterion had LCRA not been granted emergency orders in 2012 and 2013 allowing LCRA to retain water in the Highland Lakes. Had LCRA been required to manage the Highland Lakes according to its approved or pending water management plan, current combined storage levels would be well below the threshold for defining a new drought of record.

These findings lead us to conclude that:

- The current drought is worse than the recognized drought of record for the Colorado River basin
- Neither the current or pending WMP provide sufficient protection for firm water supplies during drought conditions

As such, the pending 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. In addition, the Firm Yield for the Highland Lakes should be revised, and should be based on the extreme drought conditions now being experienced in the Colorado River basin.

The following sections provide the technical evidence that lead to CTWC's assertions, as included in this document and in CTWC's June 8<sup>th</sup>, 2013 report entitled "Evidence for the Need to Change the Approach to Water Planning in the Lower Colorado Basin – Part II WAM & WMP Analyses."

## 1.0 IS THE CURRENT DROUGHT WORSE THAN THE DROUGHT OF RECORD?

Within its proposed water management plan (WMP) submitted to the Texas Commission on Environmental Quality (TCEQ) in March 2012, the Lower Colorado River Authority (LCRA) stated conditions for determining when a drought would be considered “worse than the drought of record” for the Highland Lakes system. These criteria were stated on page 4-26 of the document entitled “Lakes Buchanan and Travis Water Management Plan and Drought Contingency Plans,” and were approved by the LCRA Board of Directors in February, 2012. The criteria are:

1. Drought duration of at least 24 consecutive months
2. Drought intensity greater than that of the Drought of Record as measured by inflows into the Highland Lakes
3. The combined storage in lakes Buchanan and Travis is less than 600,000 acre-feet.

To be declared a new drought of record, all three of these conditions are to be met simultaneously. LCRA further clarifies the criteria as follows:

“For purposes of measuring drought duration, the beginning of the drought is based on the last time lakes Buchanan and Travis were both full. For purposes of this declaration, full is defined when either of the following criteria is met:

- Combined storage is at or above 98 percent of the combined managed conservation storage. This managed conservation storage may vary based on seasonal operational guidelines or other constraints on storage; or
- Lakes Buchanan and Travis have each been at their respective managed conservation storage capacity within 30 days of each other.

For purposes of measuring drought intensity relative to the Drought of Record, the cumulative inflows since the beginning of the drought will be compared to a Drought of Record inflow envelope curve that reflects the cumulative inflows in the critical periods of the Drought of Record. The envelope curve consists of a uniform slope of 56,141 acre-feet per month for the first 64 months of the drought and a slope of 73,241 acre-feet per month for the remainder of the drought.”

This report provides evidence that all three LCRA-approved criteria for declaring a drought worse than the drought of record would have been met had LCRA not been granted emergency orders by TCEQ, allowing LCRA to deviate from their approved WMP. A portion of the analysis presented in this report has been largely repeated from the analysis included in CTWC’s June 8<sup>th</sup>, 2013 report (herein referred as “June 8<sup>th</sup> Report”) entitled “Evidence for the Need to Change the Approach to Water Planning in the Lower Colorado Basin Part II – WAM & WMP Analyses.”

## 2.0 CRITERIA #1 ASSESSMENT – DROUGHT DURATION

According to LCRA’s 1<sup>st</sup> criteria for determining a drought worse than the drought of record, the drought must be at least 24 months in length, starting from the last day when Lake Buchanan and Lake Travis were full. To determine when Lake Travis and Lake Buchanan were last full, INTERA downloaded lake level data from the LCRA’s website (<http://hydromet.lcra.org/chronhist.aspx>). The data were downloaded for the gauges “Mansfield Dam” and “Buchanan Dam” with settings “Level Above the Dam” for Lake Travis and Lake Buchanan, respectively, starting from January 1, 2007 to June 18, 2013. Lake level data was converted to lake storages using the most recently updated elevation-area-capacity tables downloaded from the Texas Water Development Board (TWDB) Hydrographic Survey program website (<http://www.twdb.state.tx.us/surfacewater/surveys/completed/list/index.asp>). Elevations obtained for Lake Travis from the LCRA website were increased by 0.6 ft to correct for the difference in datum from that used in the TWDB survey. The time series of combined storage values is provided in Figure 1.

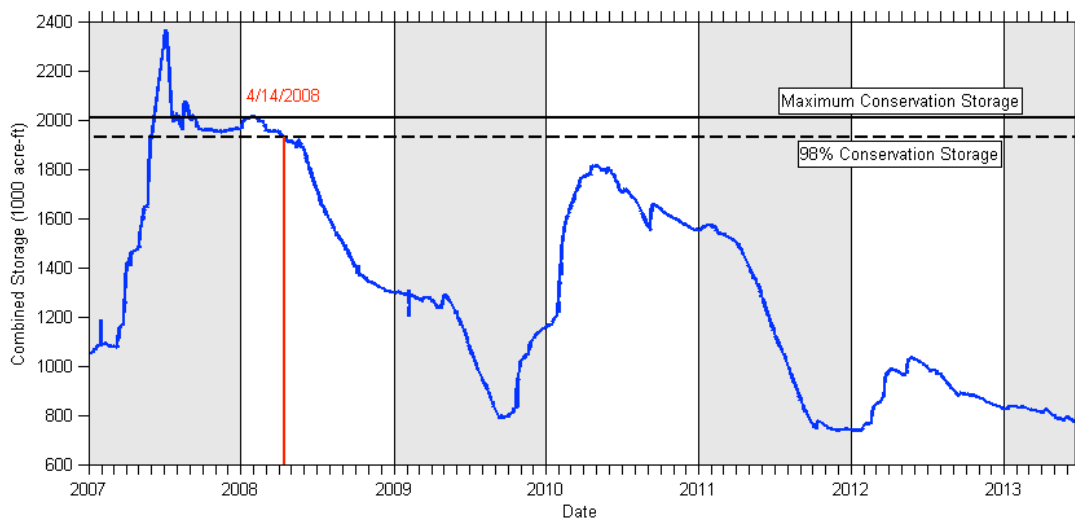


Figure 1 – Observed Combined Storage of Lakes Travis and Buchanan from January 1 2007-June 18, 2013.

Per LCRA’s definition of “Full”, the combined storage must be at 98% of the combined managed conservation storage. This storage quantity is not actually defined by LCRA within its WMP, yet was assumed to be the combined storage when Lake Travis water levels are at 681.6 ft (NAVD88) and when Lake Buchanan water levels are at 1018 ft (NGVD29). This combined storage quantity amounts to 1,927,417 acre-ft, and as shown in Figure 1 was last observed on April 4, 2008. Therefore the current drought duration is 5 years, 2 months, and 14 days (1,901 days total, 62 months total). This drought duration exceeds the 24 month duration specified in LCRA’s Criteria #1.



### 3.0 CRITERIA #2 ASSESSMENT – DROUGHT INTENSITY

According to LCRA’s 2<sup>nd</sup> criteria for determining a drought worse than the drought of record, the drought intensity must be equal to or less than that observed during the current drought of record. The drought intensity is to be measured using the cumulative inflow to the Highland Lakes. This inflow is routinely calculated by LCRA as the sum of measured inflows at four USGS gauges, weighted by drainage area ratios to account for surface runoff and ungauged catchment area affects. The gauges and drainage area ratios used by LCRA are provided in Table 1.

Table 1 – USGS Gauges and Drainage Area Ratios for Calculating Inflows to the Highland Lakes

USGS Gauge	Gauge Number	Drainage Area Ratio
Colorado River Near San Saba	08147000	1.0350
Llano River at Llano	08151500	1.0000
Sandy Creek near Kingsland	08152000	2.3671
Pedernales River near Johnson City	08153500	2.0300

To compute the inflows to the Highland Lakes for the current drought (starting from 4/4/2008 as defined in the previous section), INTERA downloaded the daily averaged flow for each gauge listed in Table 1, as made available from the USGS NWIS database (<http://waterdata.usgs.gov/tx/nwis/current/>). Daily streamflows were then multiplied by the appropriate drainage area ratio (table 1), summed, and converted from ft<sup>3</sup>/s units to acre-ft/day units. Cumulative inflows were computed and compared against LCRA’s envelope curve for drought intensity, which:

“consists of a uniform slope of 56,141 acre-feet per month for the first 64 months of the drought and a slope of 73,241 acre-feet per month for the remainder of the drought.”

The resulting comparison is provided in Figure 2. As shown, the measured cumulative inflow does not, at any time, exceed LCRA’s envelope curve. Therefore the current drought satisfies criteria #2.

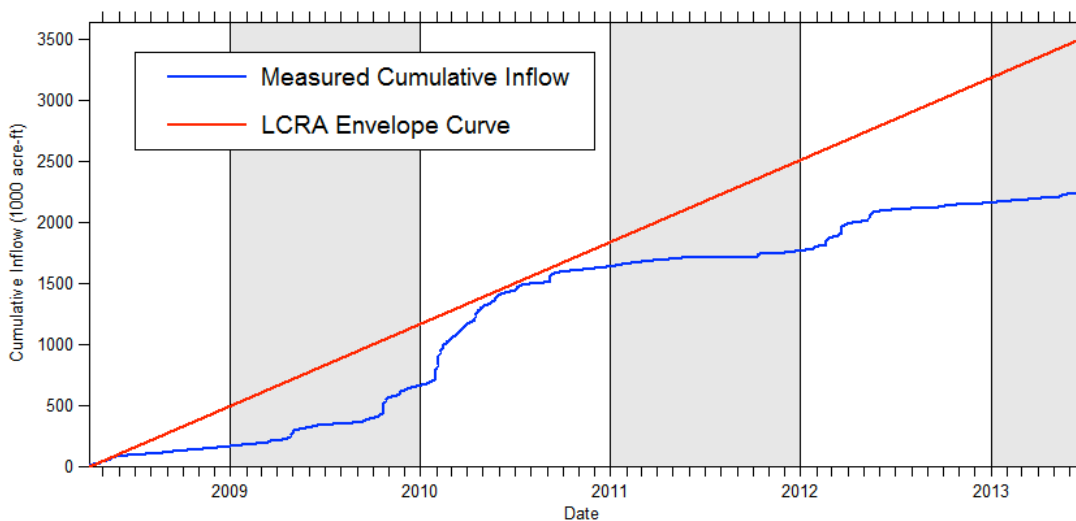


Figure 2 – Observed Cumulative Inflows to the Highland Lakes from 4/4/2008-Present, compared with the LCRA drought intensity envelope curve.

## 4.0 CRITERIA #3 ASSESSMENT – COMBINED STORAGE

According to LCRA's 3<sup>rd</sup> criteria for determining a drought worse than the drought of record, the combined storage in Lakes Buchanan and Travis must be below 600,000 acre-ft. As of June 26, 2013, the combined storage, as reported by LCRA, was 756,000 acre-ft. Therefore the storage is above the drought criteria threshold, and LCRA can therefore conclude that the current drought is not worse than the drought of record. This assertion, however, is misleading in that the current combined storage is only above the 600,000 acre-ft criteria because of emergency orders granted by TCEQ, allowing LCRA to deviate from its water management plan and not release water for irrigation in 2012 and 2013. Had such orders not been in place, the combined storage would currently be below 500,000 acre-ft, thus meeting LCRA's 3<sup>rd</sup> criteria for determining a drought worse than the drought of record. The remaining text and graphics documenting the impact of the emergency orders are repeated from the June 8<sup>th</sup> Report.

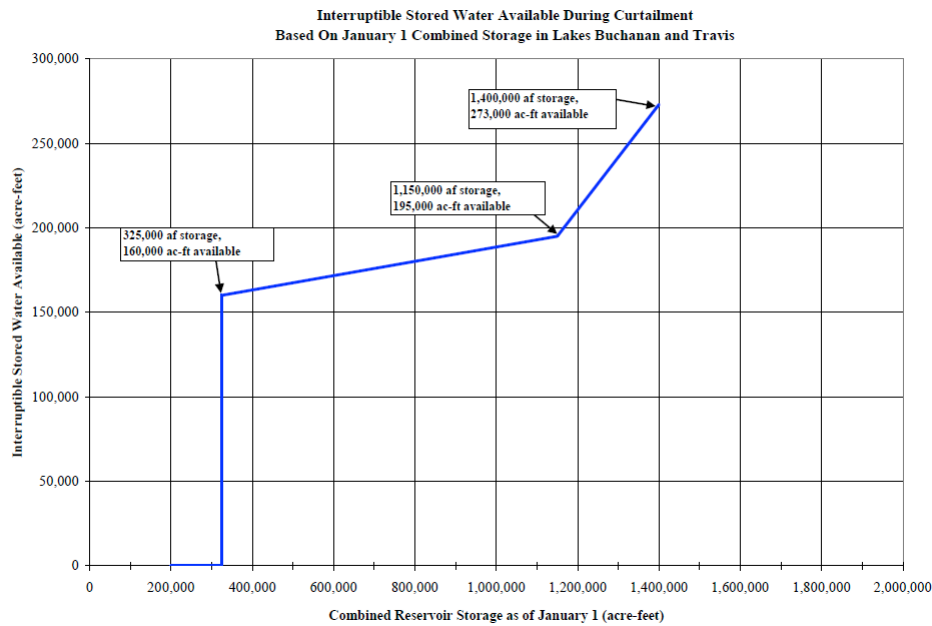
In 2012 and 2013, LCRA was granted permission by TCEQ to manage water resources outside of the requirements stipulated in the current WMP or in the WMP that is pending approval. These "emergency orders" allowed LCRA to withhold interruptible water releases and therefore retain greater quantities of water within the Highland Lakes. As such, in 2012 and in 2013, there were not and have not been any releases of interruptible water. INTERA performed a water accounting analysis to determine what the combined storage in the Highland Lakes would be "now" (as of 5/21/2013) had emergency orders not been issued. Without the emergency orders in place, LCRA would have made interruptible water releases according to published curtailment curves. This analysis shows that under either the current or pending WMP, without emergency orders the combined storage in the Highland Lakes would drop below 500,000 acre-ft, triggering the recognition of a drought worse than the drought of record.

For this analysis, INTERA started from the combined storage value observed on January 1, 2012 and "projected" forward into the future by using the observed storage changes (without interruptible water releases) and adding releases dictated by the WMP curtailment curves. INTERA performed separate analyses using the current WMP curtailment curves and using the pending WMP curtailment curves. For each analysis, INTERA assumed that storage changes observed from 2012 to the present would have occurred in the same timing and magnitude whether or not interruptible water releases were being made. INTERA did not account for reduced evaporative losses that would occur after interruptible water releases when lake surface areas would be smaller. INTERA also assumed that 1<sup>st</sup> crop releases would be completed before May 21 of each year, and that 2<sup>nd</sup> crop releases under the current WMP curtailment curves amount to 27% of the total releases for the year. This percentage is the approximate percentage of the 2<sup>nd</sup> crop release out of the total curtailment release under the proposed WMP.

The curtailment curves in the current WMP are based entirely on the combined storage on January 1. Curtailment curves for 1<sup>st</sup> crop releases in the pending WMP are based on the maximum combined storage on January 1 or March 1 of a given year. Similarly, curtailment curves for 2<sup>nd</sup> crop releases in the pending WMP are based on the maximum combined storage on June 1 or August 1 of a given year. To determine the combined storage of Lakes Buchanan and Travis at the dates needed for this assessment, INTERA obtained lake levels from the USGS NWIS system, and converted the lake levels to storage quantities through the use of TWDB volume-elevation tables published in 2006 (for Lake Buchanan) and in 2009 (for Lake Travis). USGS NWIS data was not available for January 1, 2013, yet LCRA reported a combined storage value of 825,000 acre-ft on this date. Table 2 presents the observed combined storage values used in this analysis.

**Table 2 – Observed Highland Lake Combined Storage Volumes**

Date	Combined Storage (acre-ft)	Change (acre-ft) Current WMP Scenario	Change (acre-ft) Pending WMP Scenario
January 1, 2012	738,715		NA
March 1, 2012	846,359		107,644
June 1, 2012	1,028,665		182,306
August 1, 2012	964,768		-63,897
January 1, 2013	825,000	86,285	-139,768
March 1, 2013	822,782		-2,218
May 21, 2013	782,367	-42,633	-40,415



*Figure 3 – Interruptible Water Curtailment Curve in the current LCRA WMP. (Source: LCRA)*

Under the current WMP, interruptible releases are calculated based on the curtailment curve shown in Figure 3. With the January 1, 2012 combined storage of 738,715, the curtailment curve requires the release of 180,044 acre-ft from Highland Lake storage. Combined with the observed increase in storage from January 1, 2012 to January 1, 2013, the projected January 1, 2013 storage is calculated as:

Storage <sub>January 1, 2012</sub>	738,715	Acre-ft
+ Storage_Change <sub>January 1, 2012 to January 1, 2013</sub>	+ 86,285	Acre-ft
- Interruptible Release	- 180,044	Acre-ft
<b>Projected_Storage<sub>January 1, 2013</sub></b>	<b>644,956</b>	<b>Acre-ft</b>

With a projected storage on January 1, 2013 of 644,956 acre-ft, the required interruptible water release is 176,635 acre-ft. This amount is the total amount to be released for both 1<sup>st</sup> crop and 2<sup>nd</sup> crop, yet only releases for 1<sup>st</sup> crop would occur before May 21, 2013. Assuming the 1<sup>st</sup> crop release is 73% of the total release, the projected 2013 1<sup>st</sup> crop release quantity is 128,944 acre-ft. Combined with the observed

decrease in storage from January 1, 2013 to May 21, 2013, the projected May 21, 2013 storage is calculated as:

Projected_Storage <sub>January 1, 2013</sub>	644,956	Acre-ft
+ Storage_Change <sub>January 1, 2013 to May 21, 2013</sub>	+ -42,633	Acre-ft
- Interruptible 1 <sup>st</sup> Crop Release	- 128,944	Acre-ft
<b>Projected_Storage<sub>January 1, 2013</sub></b>	<b>473,379</b>	<b>Acre-ft</b>

Therefore the projected May 21, 2013 combined storage under the current WMP would be **473,379** acre-ft.

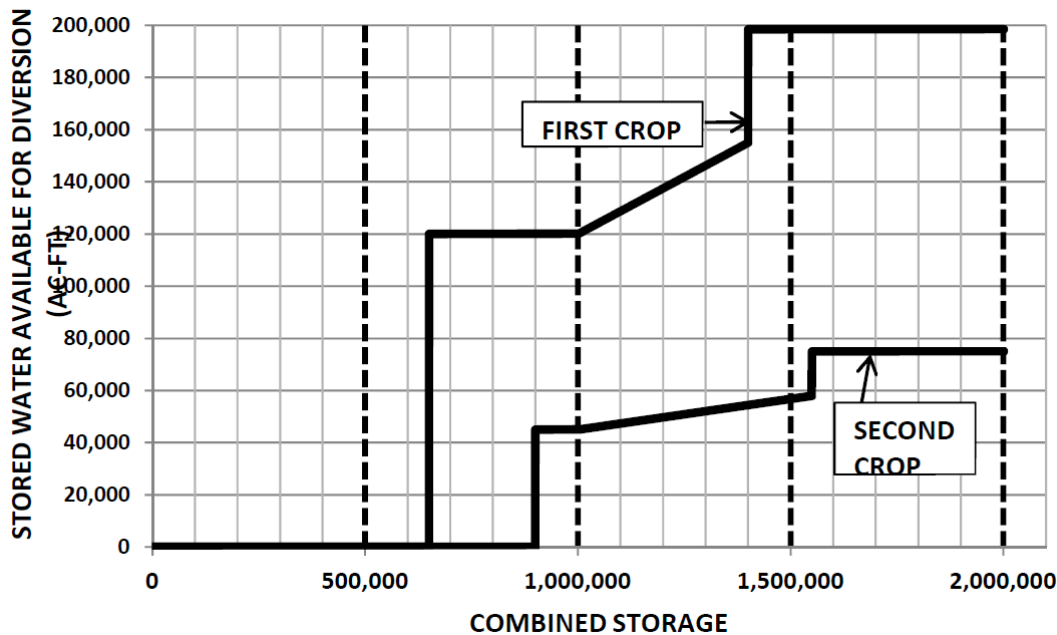


Figure 4 – Interruptible Water Curtailment Curve in the proposed LCRA WMP. (Source: LCRA)

Under the proposed WMP, interruptible releases are calculated based on the curtailment curve shown in Figure 4. With the March 1, 2012 combined storage (846,359 acre-ft) being larger than the January 1, 2012 combined storage (738,715 acre-ft), the March storage value dictates a 1<sup>st</sup> crop release of 120,000 acre-ft. Combined with the observed increase in storage from January 1, 2012 to March 1, 2012 and the observed increase in storage from March 1, 2012 to June 1, 2012, the projected June 1, 2012 storage under the proposed WMP curtailment curve is calculated as:

Storage <sub>January 1, 2012</sub>	738,715	Acre-ft
+ Storage_Change <sub>January 1, 2012 to March 1, 2012</sub>	+ 107,644	Acre-ft
+ Storage_Change <sub>March 1, 2012 to June 1, 2012</sub>	+ 182,306	Acre-ft
- Interruptible 1 <sup>st</sup> Crop Release	- 120,000	Acre-ft
<b>Projected_Storage<sub>June 1, 2012</sub></b>	<b>908,655</b>	<b>Acre-ft</b>

As the observed storage decreased between June 1, 2012 and August 1, 2012 (See Table 2), the June 1, 2012 storage would be used to calculate 2<sup>nd</sup> crop interruptible releases. With a projected storage on June 1, 2012 of 908,655 acre-ft, the required interruptible 2<sup>nd</sup> crop release is 45,000 acre-ft. Combined with the

observed decrease in storage from June 1, 2012 to August 1, 2012 and the observed storage decrease from August 1, 2012 to January 1, 2013, the projected January 1, 2013 storage is calculated as:

Projected_Storage <sub>June 1, 2012</sub>	908,655	Acre-ft
+ Storage_Change <sub>June 1, 2012 to August 1, 2012</sub>	+ -63,897	Acre-ft
+ Storage_Change <sub>August 1, 2012 to January 1, 2013</sub>	+ -139,768	Acre-ft
- Interruptible 2 <sup>nd</sup> Crop Release	- 45,000	Acre-ft
<b>Projected_Storage<sub>January 1, 2013</sub></b>	<b>659,990</b>	<b>Acre-ft</b>

As the observed combined storage on March 1, 2013 was less than the observed combined storage on January 1, 2013, the January 1, 2013 combined storage dictates the volume of interruptible 1<sup>st</sup> crop release. With a projected storage on January 1, 2013 of 659,990 acre-ft, the required interruptible 1<sup>st</sup> crop release is 120,000 acre-ft. Combined with the observed decrease in storage from January 1, 2013 to March 1, 2013 and the observed decrease in storage from March 1, 2013 to May 21, 2013, the projected May 21, 2013 storage is calculated as:

Projected_Storage <sub>January 1, 2013</sub>	659,990	Acre-ft
+ Storage_Change <sub>January 1, 2013 to March 1, 2013</sub>	+ -2,218	Acre-ft
+ Storage_Change <sub>March 1, 2013 to May 21, 2013</sub>	+ -40,415	Acre-ft
- Interruptible 1 <sup>st</sup> Crop Release	- 120,000	Acre-ft
<b>Projected_Storage<sub>May 21, 2013</sub></b>	<b>497,357</b>	<b>Acre-ft</b>

Therefore the projected May 21, 2013 combined storage under the proposed WMP would be **497,357** acre-ft.

## 5.0 CONCLUSIONS AND RECOMMENDATIONS

As shown in this report, the Colorado River Basin is currently experiencing severe drought conditions, and had LCRA been required to manage the basin water supplies according to the approved WMP, a drought worse than the drought of record would have been declared. Neither the current nor proposed WMPs would have provided sufficient drought protection for LCRA's firm water customers during the 2012-2013 current drought. A new WMP must be developed that provides such firm water protection without the need for continual emergency orders to be issued by the TCEQ.

The current drought is severe, and has had devastating effects on Central Texas. We will not know how bad the current drought is or by how much the firm yield should be reduced until the drought has broken or we have a good understanding of the new hydrology of the basin. Until that time, policy-makers should take a conservative approach to water management to ensure that there remains sufficient water in the basin to meet the needs of firm customers under uncertain future conditions.