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Memorandum

Cumberland County Drought Identification

Standardized Precipitation Index Analysis of monthly rainfall

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Date: September 08, 2008

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1. Introduction – Drought Identification

As Cumberland County continues to grow, it gets closer to a situation where existing water supplies may be exhausted in dry years. In 2007, Cumberland County endured a particularly harsh drought, severe enough to force the utility districts to enact a broad range of water use restrictions. The extremely low reservoir levels in the county were likely a result of both increased water demand and one of the lowest rainfall periods on record. While the severe drought tested the water supplies of Cumberland County, it did not result in reservoir failure. It has not been determined, however, just how close the reservoirs came to failure.

Instead of determining the chance of failure for the 2007 case, it is perhaps better to reexamine the firm yields of the reservoirs. The first step in re-evaluating the yield is to determine the critical drought period over which the firm yield of the reservoir will be computed. The critical drought is the sequence of hydrologic conditions (rainfall, evaporation, other losses) affecting reservoir inflow that results in the maximum storage deficit at a particular reservoir with defined storage and watershed conditions. Given a constant reservoir capacity, the critical drought sequence results in a condition in which the reservoir experiences maximum drawdown.

Since streamflow gage records are not available at the Cumberland County reservoirs, the starting point for critical drought analysis must be from other meteorological conditions. There are several widely used indices of drought severity, notably the Palmer Drought Severity Index, Crop Moisture Index, Standardized Precipitation Index and Decile Method, among others.

The characteristics of Cumberland County's location, climate, and water sources make some drought indices more applicable than others. Cumberland County sits on a high plateau in East Central Tennessee, and as result, the great majority of its water comes directly from rainfall within the county. As a headwater region, there are no very large lakes or reservoirs no major rivers, and rarely any snowpack, so drought indices that rely on large scale surface water conditions such as the Surface Water Supply Index and Reclamation Drought Index can't even be calculated in Cumberland County. Though there is certainly agriculture in the county, the general indices that track soil moisture conditions such as the Crop Moisture Index and various Palmer drought indices (PDSI, modified PDSI, PHDI) are not particularly well suited to small mountainous regions, and are difficult to analyze on multiple time scales. Furthermore, this study is concerned with Cumberland County's water supplies, and not with agricultural production. Thus, considering Cumberland County's hydrology, a flexible precipitation based index such as the Standardized Precipitation is best suited for identifying meteorological drought conditions.

The Standardized Precipitation Index (SPI) method is selected for drought identification in this study. The following sections describe the SPI methodology, application of the SPI to precipitation data from Cumberland County and the SPI results for Cumberland County.

2. Standardized Precipitation Index

The Standardized Precipitation Index (SPI) is a flexible, multi-timescale approach for drought identification based on precipitation conditions only. Though the general methodology can be applied to any rainfall duration, the SPI is usually computed with monthly data for identifying droughts.

Given a long monthly rainfall record, the SPI calculates a normalized index reflecting probability of occurrence for rainfall totals of the selected duration (e.g 1, 3, 12, 48 months, etc.). The ***duration*** for the SPI analysis is reflective of the number of months of precipitation that are summed together. The index value indicates where that sum falls compared to all the other precipitation sums (for the same duration) in the record. For a 3-month duration SPI, the index value for each month in the time series is reflective of the probability of occurrence of the total precipitation for the current month and the two previous months. For the remainder of this study, duration refers only to the analysis duration.

The SPI index value reflects the probability of certain rainfall totals occurring for the given analysis duration. Instead of reporting this probability as a percentile, the SPI index uses a standard normal variate (or Z-score). The rainfall totals are fitted to a normal distribution, and the score is roughly analogous to the number of standard deviations the rainfall total falls from the median. Below average precipitation, therefore, has a negative index value. The SPI has practical limits of -4 to 4, limits beyond which the probability of occurrence is too low to detect within standard periods of record.

Table 1 presents a range of SPI values and the degree of wetness or dryness to which they correspond. The table is adapted from a white paper on drought indices by Hayes (2006).

Table 1 - SPI values and associated descriptions

SPI Values	
2.0+	extremely wet
1.5 to 1.99	very wet
1.0 to 1.49	moderately wet
-.99 to .99	near normal
-1.0 to -1.49	moderately dry
-1.5 to -1.99	severely dry
-2 and less	extremely dry

According to McKee et al. (1993), a drought can be identified by a stretch of at least two months for which the SPI value is continuously negative and reaches a value of -1 or less at some point in that period. The drought concludes when the SPI value becomes positive once again. The ***drought length*** is the total number of months the SPI value remained negative. *Drought length is not to be confused with duration (i.e. analysis duration).* Duration is simply the number months (x) that are totaled to compute the SPI value. Drought length is the number of consecutive months for which the totals of the previous 'x' months had below average precipitation (and therefore, a negative SPI value).

3. Computing the SPI in Cumberland County

It is not known at which duration the critical drought for Cumberland County occurs. Therefore, the SPI will be computed at multiple durations. For the purposes of this analysis, the SPI is computed for the 1, 3, 6, 9, 12, 15, 18, 24, 30, 36, 42, and 48 month durations. It is believed the critical drought will be in the 6 – 18 month range. Especially when computing the SPI at long durations, it is important to have a long, complete monthly precipitation record.

Due to Cumberland County's location on a plateau in a mountainous region with moderate orographic influence, the precipitation records should be from stations located within or in very close proximity to Cumberland County. Three stations with sufficient record lengths, identified in Table 2, are considered for using in an SPI analysis. The *Crossville* station is considered as an earlier extension to the Crossville Mem Ap station's record. Their locations are identified in Figure 1. Stations can be identified on the map by their COOP ID number.

Table 2 - Precipitations considered for SPI analysis

Station	COOP ID	County	Lat/Long	Period of Record	Elevation
CROSSVILLE Ed & Research (also, CROSSVILLE EXP STN)	402202	Cumberland	36°01'N / 85°08'W	1913-2008	1810'
Crossville Mem AP	402197	Cumberland	35°57'N / 85°05'W	1954-2008	1867'
Monterey	406170	Putnam	36°09'N / 85°16'W	1948-2008	1860'
Crossville	*402207*	*Cumberland*	*35°57'N / 85°02'W*	*1949-1954*	*1850'*

Upon reviewing the data inventories for each of the stations, it was determined that the Monterey station was not suitable for SPI analysis due to unacceptable gaps throughout the period of record. The Crossville and Crossville Mem Ap stations have temporally adjacent records and are in close enough physical proximity to combine into a single record. Thus, the combined record covers the period from 1949 to 2008.

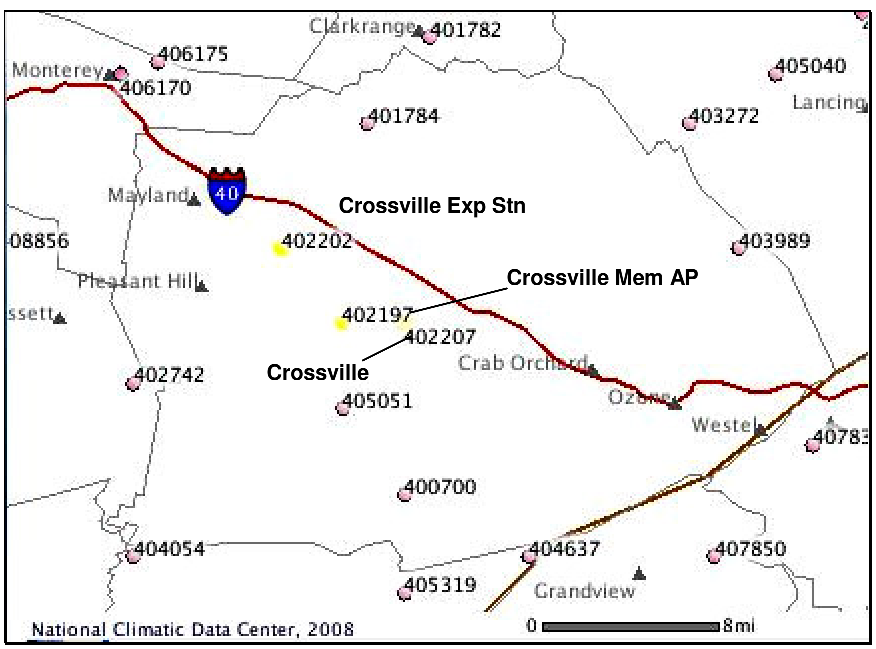

Figure 1 - Map of Selected Stations in Cumberland County

Thus, SPI analyses are to be completed for two stations: CROSSVILLE EXP STN, and CROSSVILLE MEM AP (with 5 years from CROSSVILLE 402207). The CROSSVILLE EXP STN will be the more valuable station as the record is nearly twice as long.

The precipitation records are of good quality for both stations, but there are a few missing days and months for both stations. Since the SPI requires completely continuous data, gaps in the record were addressed by using an inverse distance-squared weighted average of surrounding stations. Stations used for analysis are listed in Table 3. In general, at least three stations were used to compute the average. The inverse distance squared weighting greatly reduces the influence of stations more than 20 or so miles away.

Table 3 - Auxiliary stations used for record completion

Station	COOP_ID	County	Lat/Long	Period of Record	Elevation	Dist. From Crossville
CROSSVILLE EXP STN	402202	Cumberland	36°01'N / 85°08'W	1913-2008	1810'	0
CROSSVILLE MEM AP	402197	Cumberland	35°57'N / 85°05'W	1949-2008	1867'	5.39
ALLARDT	400081	Fentress	36°23'N / 84°52'W	1928-2008	1645'	29.37
COOKEVILLE	402009	Putnam	36°06'N / 85°30'W	1896-2008	1090'	21.18
LANTANA	405051	Cumberland	35°53'N / 85°05'W	1948-1962	1915'	9.63
McMINVILLE	405885	Warren	35°40'N / 85°47'W	1948-2008	940'	43.71
MONTEREY	406170	Putnam	36°09'N / 85°16'W	1904-2008	1860'	11.84
ROCK ISLAND 2NW	407811	Warren	35°48'N / 85°38'W	1904-1962	870'	31.73
ROCKWOOD 2	407834	Roane	35°51'N / 84°42'W	1884-2008	860'	26.84
SPARTA TVA	408527	White	35°54'N / 85°29'W	1905-1962	961'	21.17

The total record of the Crossville Exp Stn spans from September 1913 to May 2008. Precipitation for nineteen months out of a total of 1108 was computed based on other stations. The Crossville Mem AP period of record stretches from January 1949 to June 2008. A single month of data was missing (out of 714), and its value was simply assumed equivalent to that of the Crossville Exp Stn. Table 4 contains summary statistics for the two Crossville stations used in the analysis. At both stations, March is the month with the highest average precipitation, while October has the lowest average.

The *SPI_SL_6* program, made available by the National Drought Mitigation Center (NDMC) was used for calculation of the SPI at all the desired drought durations. The program download and documentation are available at the NDMC website : http://drought.unl.edu/monitor/spi/program/spi_program.htm.

Table 4 - Summary Statistics for Cumberland County Precipitation Stations (Monthly, in inches unless otherwise noted)

Station:	CROSSVILLE EXP STN	CROSSVILLE MEM AP
Yearly Average (in)	57.11	55.19
Mean	4.76	4.60
Median	4.36	4.30
Standard Deviation	2.50	2.40
Coefficient of Variation	0.53	0.52
Minimum	0.00	0.00
Maximum	16.73	15.34
March Mean	5.60	5.93
October Mean	3.14	3.11
Record Length (mo.)	1108	714

4. Results

The SPI analysis effectively identifies dry periods and wet periods based on the historical probability of rainfall totals of the given duration. Because the index reports drought periods as a normalized Z-score, the dry periods can be easily identified. The results for the Crossville Exp Stn are presented first, followed by the Crossville Mem Ap.

Crossville Education and Research Station (CROSSVILLE EXP STN)

As a preliminary tool for rapid evaluation of the most critical droughts, a plot of the SPI over time at all durations in the analysis was created. Figure 2 (end of document) displays a surface plot with time (months) along the vertical axis, the duration of analysis on the horizontal axis and the SPI value indicated on the legend.

Figure 2 clearly identifies the dry periods in the redder colors. Interestingly, while the droughts are relatively easy to identify, their severity varies according to the duration of interest. Some droughts are short and intense, while others do not become severe until the longer durations. For instance, the drought of 1952 was very intense, but was fairly quickly ameliorated by higher rainfall, whereas a series of smaller droughts in the late 1980s contributed to a rather serious drought at the 42 month duration.

Using the multiple duration SPI chart, seven potentially critical drought periods can be identified. Table 5 displays the most critical SPI values at various durations for the seven droughts. The approximate time periods of the most critical droughts are in the left column, while the duration of the SPI calculation is in the first row. The SPI values reported in the table are the most critical (i.e. most negative) within each drought period. The most negative SPI value for each duration is highlighted in bold, and the most critical duration for each individual drought (i.e. each row) is indicated in italics.

Table 5 - Critical 3 to 48 months duration SPI values for droughts at Crossville Exp Stn

Drought	3	6	9	12	15	18	24	30	36	42	48
1924-1926	-2.49	-2.71	-2.73	**-2.83**	***-2.86***	-2.53	-2.69	-2.49	-2.41	-2.22	-2.01
1930-1934	-2.18	-2.25	-2.38	-2.55	***-2.86***	**-2.81**	**-2.77**	-2.45	-2.39	-2.28	**-2.59**
1940-1942	**-2.66**	***-2.92***	-2.53	-2.48	-2.37	-2.57	-2.48	**-2.59**	**-2.62**	-2.16	-2.14
1952-1953	-2.54	-2.89	***-2.95***	-2.21	-1.78	-2.14	-1.93	-1.94	-	-	-
1980-1982	-2.1	-2.44	*-2.82*	-2.51	-2.03	-1.83	-	-	-	-	-
1986-1988	-1.8	-1.99	*-2.35*	-2.11	-2.18	-2.25	-1.74	-2.03	-1.94	**-2.33**	-2
2006-2008	-2	-2.17	-2.55	*-2.56*	-2.18	-2.18	-1.91	-1.83	-1.9	-	-

Table 5 indicates the difficulty in identifying a true most critical drought. By SPI value alone, the 1952-1953 drought at the nine month duration appears to be the most severe drought. SPI values, however, are not entirely comparable across durations because the sample size for a 3 month SPI is greater than a nine month SPI (by six), so more critical droughts at longer periods may not show as impressive SPI values as shorter duration droughts. Nonetheless, it is potentially significant that all seven droughts report their most critical SPI values at durations between 6 and 15 months. Additionally, no less than five drought periods can claim to have the most severe drought at some duration. The two remaining droughts have the second most critical SPI value for at least one duration.

Notably, the drought of 2007, though indeed severe, is not the most severe drought at any duration as measured by SPI value. Of course, the longer duration SPI values could become more critical if the remainder of 2008 and future years are dry.

The SPI can easily be used to determine meteorological drought length. The drought length is simply the number of consecutive months the SPI, computed at any duration, is continuously negative. Additionally, at least one month in the period must have an SPI value of -1 or less.

Table 6 illustrates how the drought length is calculated. The 1952-1953 drought is selected as a sample case. The computed SPI values for the 3 and 6 month SPI durations for each month are displayed. Yellow indicates negative SPI values. The drought begins when the SPI values become negative. So the drought begins in April 1952 at the 3 month duration, and June 1952 at the 6 month duration. Orange shading highlights the first month the drought has an SPI below -1. This is the qualification for being a true drought instead of simply a mild dry spell. The number of consecutive months the SPI values remain negative (are still yellow) is the drought length. In Table 6, the 3-month duration has a drought length of 10 months, while the 6-month duration has a length of 11 months.

Table 6 - Computation of drought length for the 3, 6 month duration SPI in the 1952-1953 drought

Month	Year	3m SPI	6m SPI
3	1952	0.38	1.37
4	1952	-0.66	1.17
5	1952	-0.53	0.54
6	1952	-1.51	-0.62
7	1952	-1.76	-1.64
8	1952	-2.1	-1.78
9	1952	-2.54	-2.65
10	1952	-2.35	-2.89
11	1952	-1.44	-2.85
12	1952	-1.21	-2.64
1	1953	-0.35	-1.58
2	1953	0.12	-0.83
3	1953	0.15	-0.69
4	1953	0.34	-0.07
5	1953	0.06	0.06

Using this approach, Table 7 presents the drought length of all of the major droughts as identified by their patterns SPI scores. At the bottom, the average dry spell length is presented. (Dry spells are identified when the SPI value is continuously negative, though it need not reach -1 as in a drought.)

The drought years identified in the left column are a rough indication of periods during which the driest weather occurred. At long SPI durations, the drought length may be quite long, as it may take several months (or even years) of above average precipitation to return the SPI value to being positive after a prolonged dry spell. Additionally, the longer durations allow smaller dry periods to extend the drought length after major droughts.

Table 7 is useful for assessing drought length, but it should be noted that the observed drought length is only slightly correlated with the critical SPI value for each duration. Additionally, the 2007 drought has not yet abated for durations from 6 to 48 months, so the reported lengths could lengthen depending on future rainfall. Ongoing droughts are indicated in *italics.*

Table 7 - Drought Length (months) at 3 - 48 months durations at Crossville Exp Stn

<table>
<tr><th>Drought</th><th>3</th><th>6</th><th>9</th><th>12</th><th>15</th><th>18</th><th>24</th><th>30</th><th>36</th><th>42</th><th>48</th></tr>
<tr><td>1924-1926</td><td>16</td><td>34</td><td>38</td><td>40</td><td>37</td><td>37</td><td>37</td><td>38</td><td>47</td><td>51</td><td>55</td></tr>
<tr><td>1930-1934</td><td>24</td><td>23</td><td>25</td><td>81</td><td>79</td><td>85</td><td>95</td><td>98</td><td>103</td><td rowspan="2">169</td><td rowspan="2">173</td></tr>
<tr><td>1940-1942</td><td>15</td><td>35</td><td>33</td><td>33</td><td>34</td><td>37</td><td>44</td><td>62</td><td>58</td></tr>
<tr><td>1952-1953</td><td>10</td><td>11</td><td>11</td><td>30</td><td>32</td><td>32</td><td>39</td><td>44</td><td>47</td><td>43</td><td>47</td></tr>
<tr><td>1980-1982</td><td>12</td><td>16</td><td>16</td><td>18</td><td>20</td><td>23</td><td>24</td><td>29</td><td>37</td><td>38</td><td>43</td></tr>
<tr><td>1986-1988</td><td>18</td><td>17</td><td>17</td><td>44</td><td>41</td><td>42</td><td>39</td><td>41</td><td>39</td><td>42</td><td>34</td></tr>
<tr><td>2006-2008</td><td>11</td><td>19</td><td>17</td><td>19</td><td>19</td><td>24</td><td>19</td><td>16</td><td>15</td><td>15</td><td>12</td></tr>
<tr><td>Avg. Dry Spell Length</td><td>4.1</td><td>5.8</td><td>8.0</td><td>9.0</td><td>10.3</td><td>10.0</td><td>11.8</td><td>17.0</td><td>19.2</td><td>21.2</td><td>15.3</td></tr>
</table>

The average length of the droughts has a strong relationship with the duration at which the SPI is calculated. This is unsurprising, since the SPI is calculated on the rainfall total in the duration of analysis, and therefore smaller, shorter dry and wet periods get smoothed out. At long enough durations, the drought length may include several smaller droughts. The 1930s drought is an excellent example. Based on the 42 or 48 month SPI, the drought of the early 1930s would seem to extend to 1945. (The drought length is spread across the two accordingly in Table 7.) In fact, there were several shorter droughts (e.g. the 1940 -1942 drought) in that period, and the wet periods were simply not wet enough to end the long term drought. Figure 3, which displays drought length over a series of months in the 1930s and 40s, illustrates how many shorter droughts can result in longer droughts at longer calculation durations.

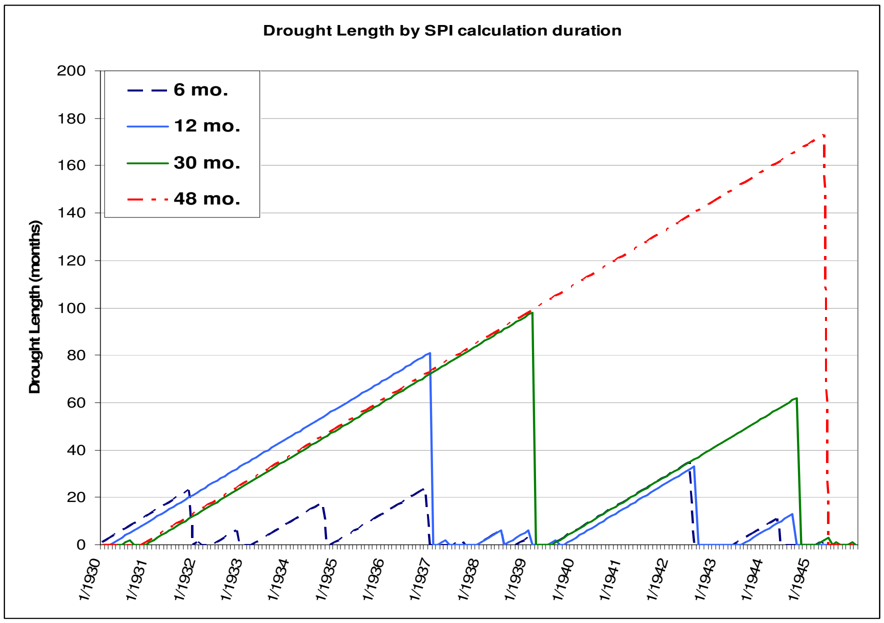

Figure 3 - Drought Length by Duration used to calculate SPI (1930s and 40s)

Figure 4 highlights the relationship between SPI duration and drought length on a multiple duration SPI plot for the same time period as Figure 3. The SPI plot is simplified from Figures 1, such that positive SPI values appear blue, and negative ones appear orange. Vertical lines trace over the SPI values over time at the 6, 12, 30, and 48 month durations (as in Figure 3). A yellow point marks the beginning of each dry spell. At longer calculation durations, it is quite evident that there are fewer shifts between wet (positive SPI) and dry (negative SPI) periods.

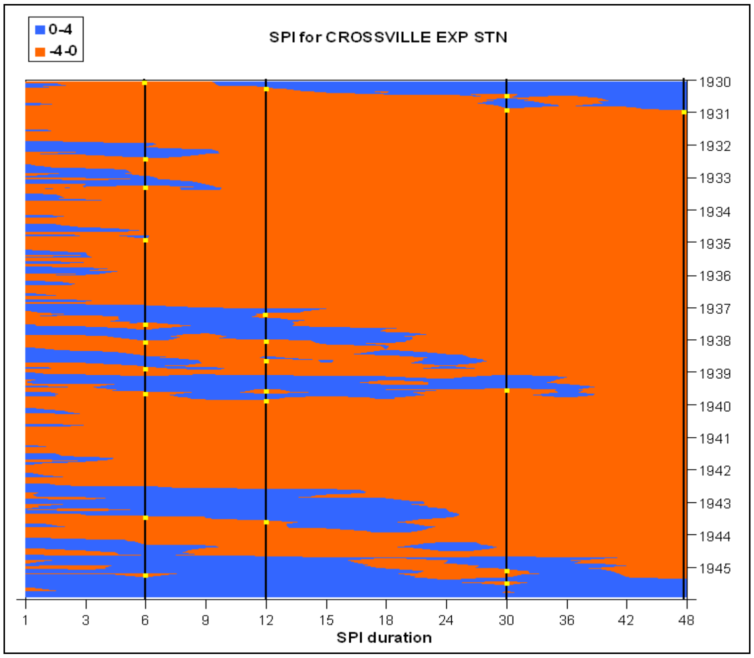

Figure 4 - Dry-Wet transitions on the SPI plot for the 1930 -1945 time period

At Crossville Exp Stn, the most severe droughts were fairly well distributed throughout the historical record. Many of the most sever droughts occurred before the historical record began at the Crossville Mem Ap. At the Crossville Mem AP station, the most severe droughts should show good agreement with the Crossville Exp Stn for the period after 1949. The Crossville Mem AP results follow.

Crossville Memorial Airport (CROSSVILLE MEM AP)

Figure 5 (end of document) displays the multiple duration SPI chart for the Crossville Mem Ap station. In general, the dry and wet periods seem to match quite well with the Crossville Exp Stn. However, the transitions between dry and wet seem better defined. Notably, the droughts of the mid 1960s appear as three short, distinct droughts in early 1964, early 1966, and early 1969 instead of two more drawn out moderate droughts in the mid 1960s. Additionally, with the removal of the droughts of the 1920s, 30s, and 40s from the record, the droughts of the early and mid 1980s, and especially the 2007 drought appear much more severe. Interestingly, the 2006-2008 drought is by far the most severe drought in the Crossville Mem Ap record at the middle range calculation durations (24 – 36 months). In fact, the 2006-2008 and 1952 – 1953 droughts are the only ones considered to be extremely dry periods (SPI less than -2) at the 24 – 36 month duration. Table 8 highlights the most severe SPI values reached for each drought.

There are some similarities and some pronounced differences between Table 5 and Table 8. The common drought periods between the tables are highlighted in dark red. As before, the most critical SPI value for each duration is in bold and for each drought is in italics. The bolded values show a similar pattern between the tables, as the most critical SPI value occurs at the 9 month duration. The italicized values (most critical value in the row) are rather different however, as they occur across the whole range of durations instead of all occurring in the 6 – 15 month durations.

Table 8 - Critical 3 to 48 months duration SPI values for droughts at Crossville Mem Ap

Drought	3	6	9	12	15	18	24	30	36	42	48
1952-1953	-2.24	-2.19	-2.26	-2.06	-1.89	***-2.45***	-2.11	-2.37	-2.13	-2.08	-1.77
1966	*-2.48*	-2.37	-2.45	-2.42	-1.94	-2.15	-1.87	-1.62	-1.79	-1.96	**-2.12**
1968	*-2.38*	-2.3	-2.09	-2.16	-2.09	-2.02	-1.76				
1978	***-2.77***	-2.02	-	-	-	-	-	-	-	-	-
1980-1982	-2.36	-2.32	***-3.16***	**-2.85**	**-2.44**	-2.08	-1.86	-	-	-	-
1986-1988	-1.92	-2.37	*-2.39*	-1.8	-1.93	-1.94	-1.88	-1.98	-1.82	-2.16	-2.03
2006-2008	-2.28	**-2.41**	-2.4	-2.25	-2.4	-2.2	**-2.46**	***-2.68***	**-2.63**	**-2.21**	-1.71

Three of the droughts in Table 8 are not included in Table 5. The 1978 drought owes its place on the chart to a very dry 3 month spell, but occurs in an otherwise wet period, so it does not even appear at longer durations. The 1966 and 1968 droughts, though distinct at first, blend together at longer durations, and in fact become the most critical drought at the 48 month duration.

The characteristics of the droughts common to both tables have changed as well. The 2006 - 2008 drought, which was never the most critical drought at any duration in Table 5, is the most critical drought at 5 different durations in Table 8. Furthermore, it reaches its most critical value at 30 months instead of 12 months in the previous table. This is likely a result of the omission of the droughts before 1949.

The changes in the 1980-1982 and 1952-1953 droughts are not easily explained. The 1952-1953 was the most severe drought at the 9 month duration at Crossville Exp Stn, but the 1980 – 1982 drought is more severe by far at the Crossville Mem AP station. This is not easily explained, especially at such a short duration, and could potentially point to a real difference in meteorological conditions between the stations for these events. The 1952 – 1953 drought, however, is the most severe for the 18 month duration at Crossville Mem Ap.

Table 9 displays the drought length at Crossville Mem AP in an identical methodology to Table 7. The two tables are not really comparable because of the much longer record for the Crossville Exp Stn gage. The 1966 and 1968 droughts clearly join at the 24 month duration. The 2006 – 2008 drought displays a much longer drought length in Table 9 than in Table 7. Similar to Table 7, the drought has not ended at any duration beyond 3 months. Based on the scale in Table 1, the drought is still classified at severely dry (SPI < -1.5) at all durations 24 months and longer. Finally, the average drought length in Table 9 appears shorter than in Table 7. This is likely a result of the shorter record length at Crossville Mem Ap gage, and that the very dry decades from the 1920s through 1940s were not included in the record.

Table 9 – Drought Length (months) at 3 - 48 month durations at Crossville Mem AP

Drought	3	6	9	12	15	18	24	30	36	42	48
1952-1953	7	21	23	33	36	34	46	45	47	50	45
1966	12	13	19	21	23	26	57	82	84	80	83
1968	8	13	20	21	20	24					
1978	5	13	8	7	9						
1980-1982	12	14	16	18	19	20	21	28	38	22	26
1986-1988	10	11	21	24	24	43	39	42	42	43	60
2006-2008	12	*38*	*37*	*34*	*31*	*31*	*29*	*29*	*25*	*20*	*17*
Avg. Dry Spell	***2.0***	***4.0***	***6.1***	***7.6***	***7.9***	***8.8***	***10.8***	***11.8***	***15.0***	***16.3***	***15.6***

5. Conclusion and Continuation

Cumberland County, TN, though generally wet compared to the nation as a whole, has experienced severe drought conditions several times over the past 100 years, and most recently in 2007. Cumberland County's location on the top of a plateau makes its water supply vulnerable during long periods of lower than normal precipitation. Determining the firm yield of the existing water supplies must start with an analysis of historic precipitation records to help identify the critical drought.

The Standardized Precipitation Index was used to identify the particularly dry periods in Cumberland County's rainfall record. The CROSSVILLE EXP STN gage, with over 90 years of monthly records, is the primary basis for analysis. The CROSSVILLE MEM AP gage was used for cross validation. The SPI was calculated at durations ranging from 3 to 48 months.

By using the SPI, seven potentially critical droughts have been identified. The most critical drought varies according to the duration at which the SPI is calculated. Based on the size of the water sources and their catchments, it is hypothesized that the critical drought duration is between 9 and 15 months. Overall, the droughts of 1925 – 1926, 1930 – 1934, 1940 – 1942, and 1952 – 1953 appear the most likely to be the critical drought. The 2007 drought closely follows, and may yet prove to be the critical drought since it has not yet fully abated according to the SPI analysis. No single drought however, was the most critical at all of these durations based on the SPI analysis alone.

Therefore, to identify the critical drought sequence for each water supply reservoir, a sequent peak analysis will have to be performed on streamflow for the entire period of record. The sequent peak analysis uses streamflow to determine the maximum cumulative storage deficit for a given water demand (yield). The critical drought is the period when the maximum storage deficit occurs. In future work, simulated streamflow will be generated in HEC-HMS using the Crossville Exp Stn daily rainfall record as the hydrologic input.

6. References

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