

APPENDIX G

STATISTICAL CALCULATIONS

Project Number 2013-013-SIP-NR

Proposal
June 18, 2013

STATISTICAL CALCULATIONS

t-TEST

As discussed in Chapter 3: *Assessment of Visibility* and shown in the copy of Figure 3-4: *Annual Average Visibility at Big Bend National Park for the 20% Least Impaired Days* that follows, there is substantial year-to-year variation in these metrics. A slight positive difference between baseline and current value for the 20% least impaired days is found at Big Bend National Park. The TCEQ performed a statistical *t*-test (Moore and McCabe, 1993) comparing the baseline to the current annual average visibility values for the 20% least impaired days at Big Bend National Park and found that there was no statistically significant difference in visibility impairment between the two time periods. The following details of the test outcomes are discussed.

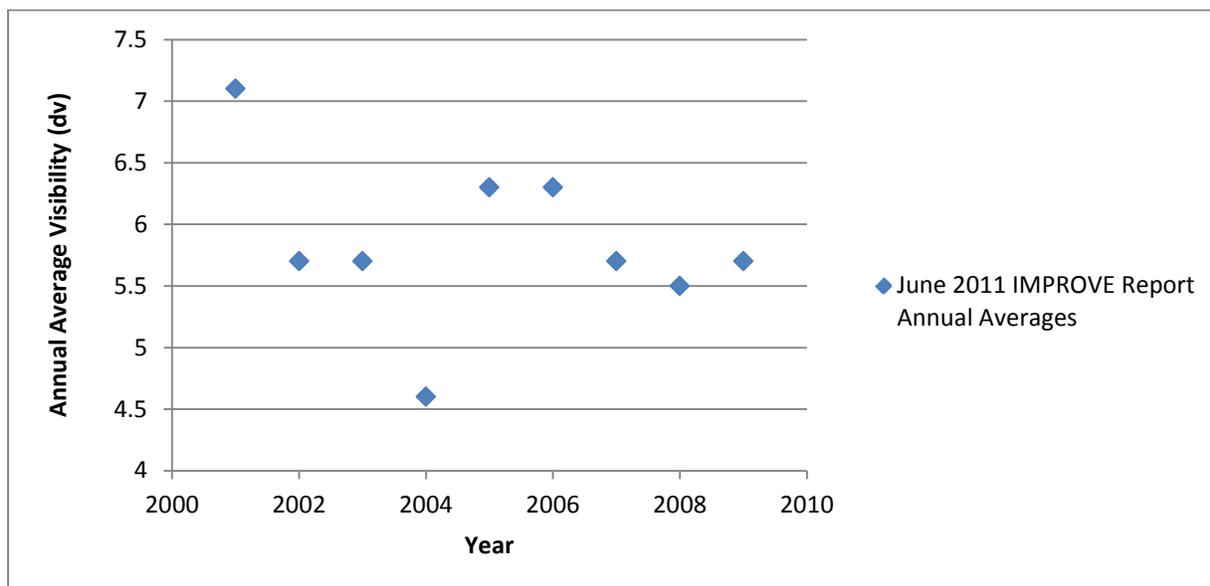


Figure 3-4: Annual Average Visibility at Big Bend National Park for the 20% Least Impaired Days

The data for years 2000 through 2004 and 2005 through 2009 were grouped and then compared. The data used in the *t*-test for Big Bend National Park is presented as follows in Table G-1: *Annual Average Values of Visibility at Big Bend National Park on the 20% Least Impaired Days*.

Table G-1: Annual Average Values of Visibility at Big Bend National Park on the 20% Least Impaired Days

Year	Annual Average Visibility (dv)
2000	Missing
2001	7.1
2002	5.7
2003	5.7
2004	4.6
2005	6.3
2006	6.3
2007	5.7
2008	5.5
2009	5.7

The values used to generate the five-year averages were compared using R statistical software (<http://www.r-project.org>) to determine if there was a significant difference between the two groups. The following is the output of the R program and the results of the test.

```
Two Sample t-test

data:  d$d2004 and d$d2009
t = -0.256, df = 7, p-value = 0.8053

alternative hypothesis: true difference in means is not equal to 0

95 percent confidence interval:
-1.27941  1.02941

sample estimates:
mean of x mean of y
  5.775     5.900
```

The p-value=0.8 is greater than the alpha=0.05, which suggests that we cannot accept the alternate hypothesis in favor of the null hypothesis. Therefore, the two groups of annual average visibility are not significantly different.

The *t*-test was also performed for Wichita Mountains Wilderness. The values tested are presented as follows in Table G-2: *Annual Average Values of Visibility at Wichita Mountains Wilderness on the 20% Least Impaired Days*. The data for years 2000 through 2004 and 2005 through 2009 were grouped and then compared.

Table G-2: Annual Average Values of Visibility at Wichita Mountains Wilderness on the 20% Least Impaired Days

Year	Annual Average Visibility (dv)
2000	Missing
2001	Missing
2002	9.8
2003	10.0
2004	9.6
2005	10.6
2006	9.7
2007	9.3
2008	9.8
2009	Missing

The values used to generate the five-year averages were compared using R statistical software (<http://www.r-project.org>) to determine if there was a significant difference between the two groups. The following is the output of R program and the results of the test.

```
Two Sample t-test

data:  d$d2004 and d$d2009
t = -0.1486, df = 5, p-value = 0.8877

alternative hypothesis: true difference in means is not equal to 0

95 percent confidence interval:
 -0.9147503  0.8147503

sample estimates:
mean of x mean of y
  9.80      9.85
```

The results of the test gave a p-value=0.9 which is greater than the alpha=0.05, which suggests that we cannot accept the alternate hypothesis in favor of the null hypothesis. Therefore, the two groups of annual average visibility are not significantly different.

Reference: Moore, D. S. and G. P. McCabe. 1993. Introduction to the Practice of Statistics, Second Edition.