WATER QUALITY STATUS AND TREND IN ORANGE CREEK BASIN LAKES AND TRIBUTAIRES FROM 2000 THROUGH 2014

Jian Di

Environmental Scientist IV
St. Johns River Water Management District
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This report describes water quality status and trends of the three large lakes, Lake Lochloosa, Newnans Lake, and Orange Lake, and their tributaries in the Orange Creek basin (OCB). The total phosphorus (TP), total nitrogen (TN), and color status and trends in 20 water quality stations including three in-lake stations, three outflow stations, and 14 stations in the tributaries (Figure 1) were evaluated. Table 1 lists water quality stations by sub-basin and their period of record.

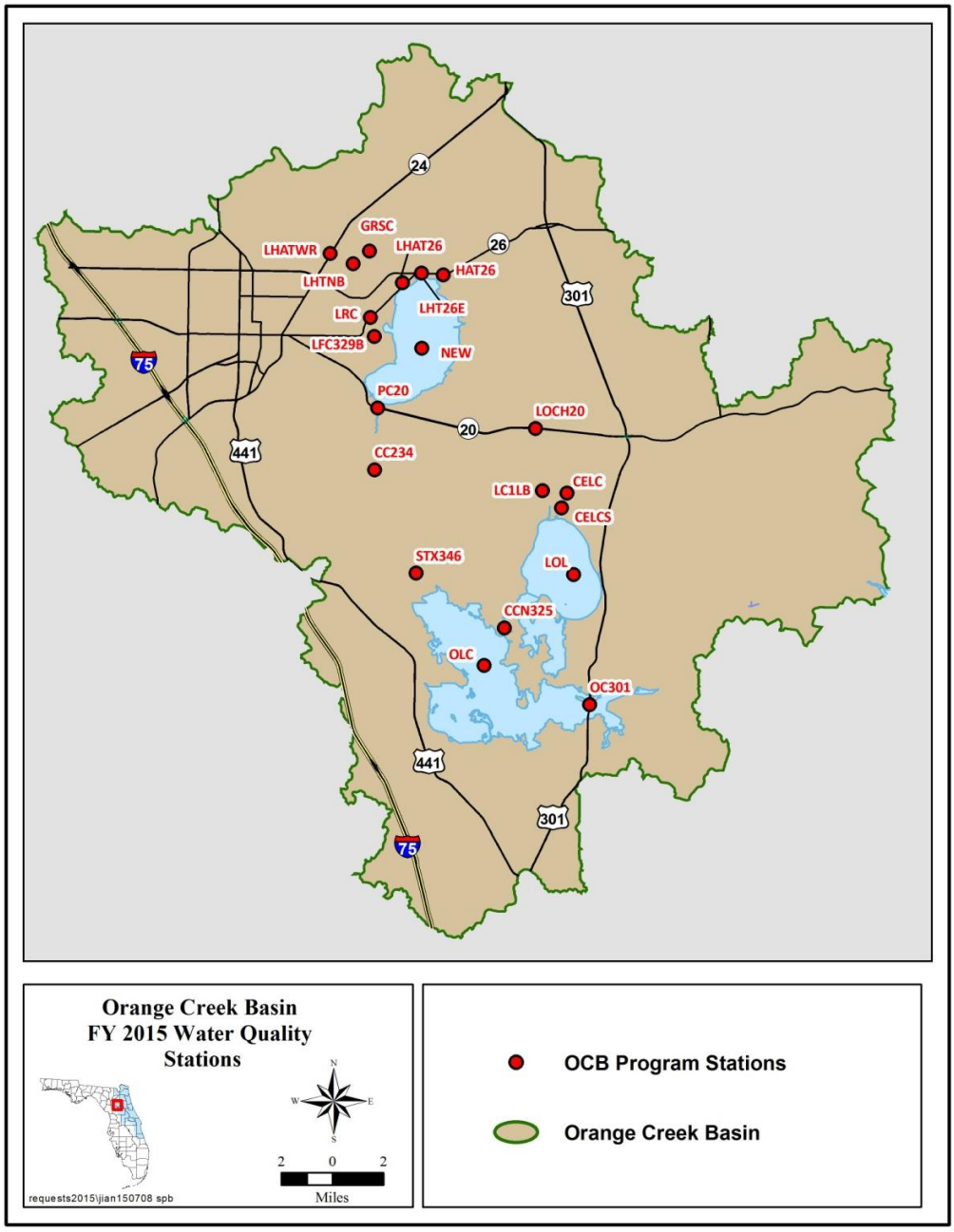

FIGURE 1: ST. JOHNS RIVER WATER MANAGEMENT DISTRICT WATER QUALITY MONITORING STATIONS IN ORANGE CREEK BASIN

TABLE 1: WATER QUALITY STATION AND PERIOD OF RECORD

Sub-basin	Station	Start	Recent
Lochloosa	CELC	10/6/2003	5/6/2015
Lochloosa	CELCS	1/3/2007	3/9/2015
Lochloosa	LC1LB	10/6/2003	3/9/2015
Lochloosa	LOCH20	2/24/1994	2/9/2011
Lochloosa	LOL	10/10/1986	5/6/2015
Newnans	GRSC	3/3/2009	3/9/2015
Newnans	HAT26	5/24/1993	3/9/2015
Newnans	LFC329B	3/9/1998	1/12/2015
Newnans	LHAT26	2/23/1994	1/12/2015
Newnans	LHATWR	3/3/2009	3/9/2015
Newnans	LHT26ER	3/21/1994	5/6/2015
Newnans	LHTNB	2/9/1998	5/6/2015
Newnans	LRC	3/3/2009	5/18/2011
Newnans	NEW	12/20/1988	5/6/2015
Newnans	PC20	2/24/1994	5/6/2015
Orange	C325	2/28/1994	5/6/2015
Orange	CC234	2/24/1994	5/6/2015
Orange	OC301	2/21/1994	9/10/2014
Orange	OLC	10/4/1985	5/6/2015
Orange	STX346	2/24/1994	5/6/2015

Water quality status

Water quality status evaluation is based on data collected between January 2010 and January 2015.

TN concentration statistics for the 20 stations are presented in figure 2 grouped by sub-basins. Median TN concentrations in tributaries stations in both Lochloosa and Newnans lakes sub-basins are close to the TMDL targets. The TN TMDL targets are 1.09 and 0.97 mg/L for Lochloosa and Newnans lakes respectively. There is no TN TMDL for Orange Lake.

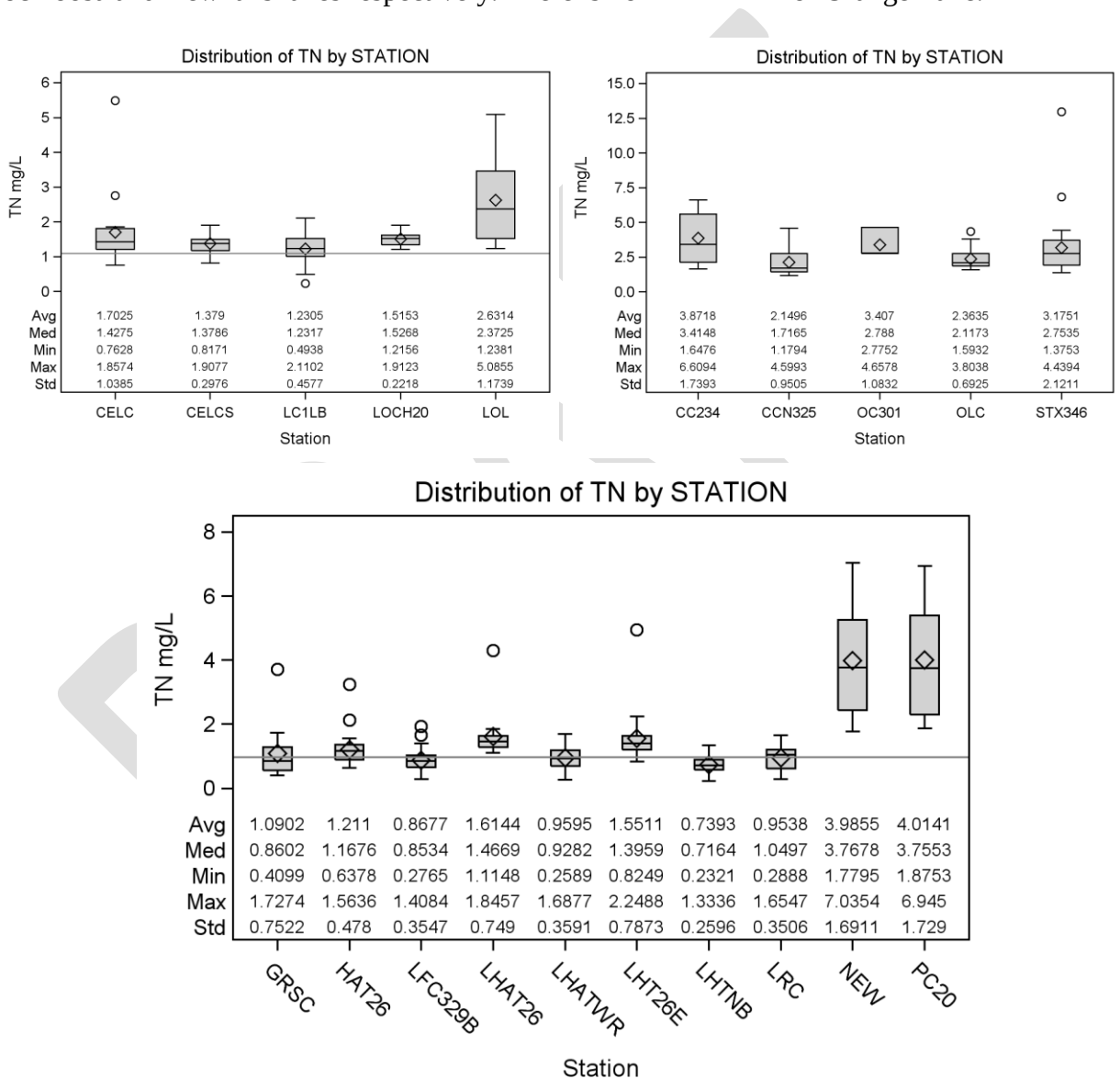

FIGURE 2. TN CONCENTRATION STATISTICS AT THE 20 WATER QUALITY MONITORING STATIONS DURING 2010 AND 2015. TOP LEFT PANEL - LOCHLOOSA LAKE SUB-BASIN STATIONS, TOP RIGHT PANEL - ORANGE LAKE SUB-BASIN STATIONS, AND BOTTOM PANEL – NEWNANS LAKE SUB-BASIN. THE HORIZONTAL LINE IS THE TMDL VALUE.

TN concentrations for both Lochloosa and Newnans lakes are much higher than in their tributaries. This strongly suggests that N-fixation is a dominate nitrogen source to these lakes.

TP concentration statistics for the 20 stations are presented in figure 3 and grouped by sub-basins. Median TP concentration in Lochloosa Lake is 0.0587 mg/L which is similar to its TMDL target of 0.052 mg/L. Median TP concentrations in Orange and Newnans lakes are about three times greater than their TMDL targets which are 0.031 and 0.062 mg/L respectively.

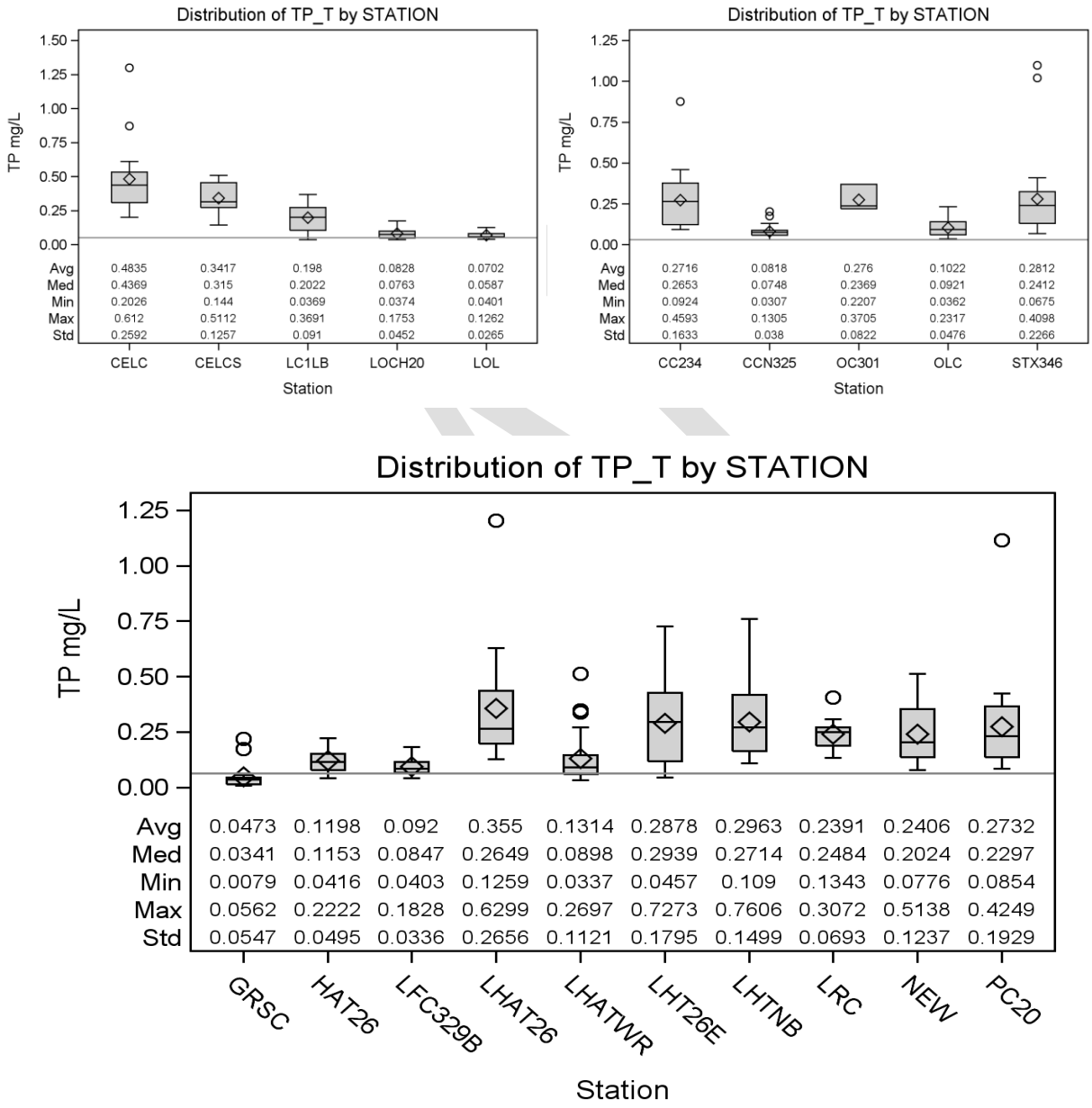

FIGURE 3. TP CONCENTRATION STATISTICS AT THE 20 WATER QUALITY MONITORING STATIONS DURING 2010 AND 2015. TOP LEFT PANEL - LOCHLOOSA LAKE SUB-BASIN STATIONS, TOP RIGHT PANEL - ORANGE LAKE SUB-BASIN STATIONS, AND BOTTOM PANEL – NEWNANS LAKE SUB-BASIN. THE HORIZONTAL LINE IS THE TMDL VALUE.

Color statistics for the 20 stations are presented in figure 4 and grouped by sub-basins. All three lakes are classified as alkaline colored lakes. Median color contents in tributaries stations in both Lochloosa and Orange lake sub-basins are greater than in the lakes.

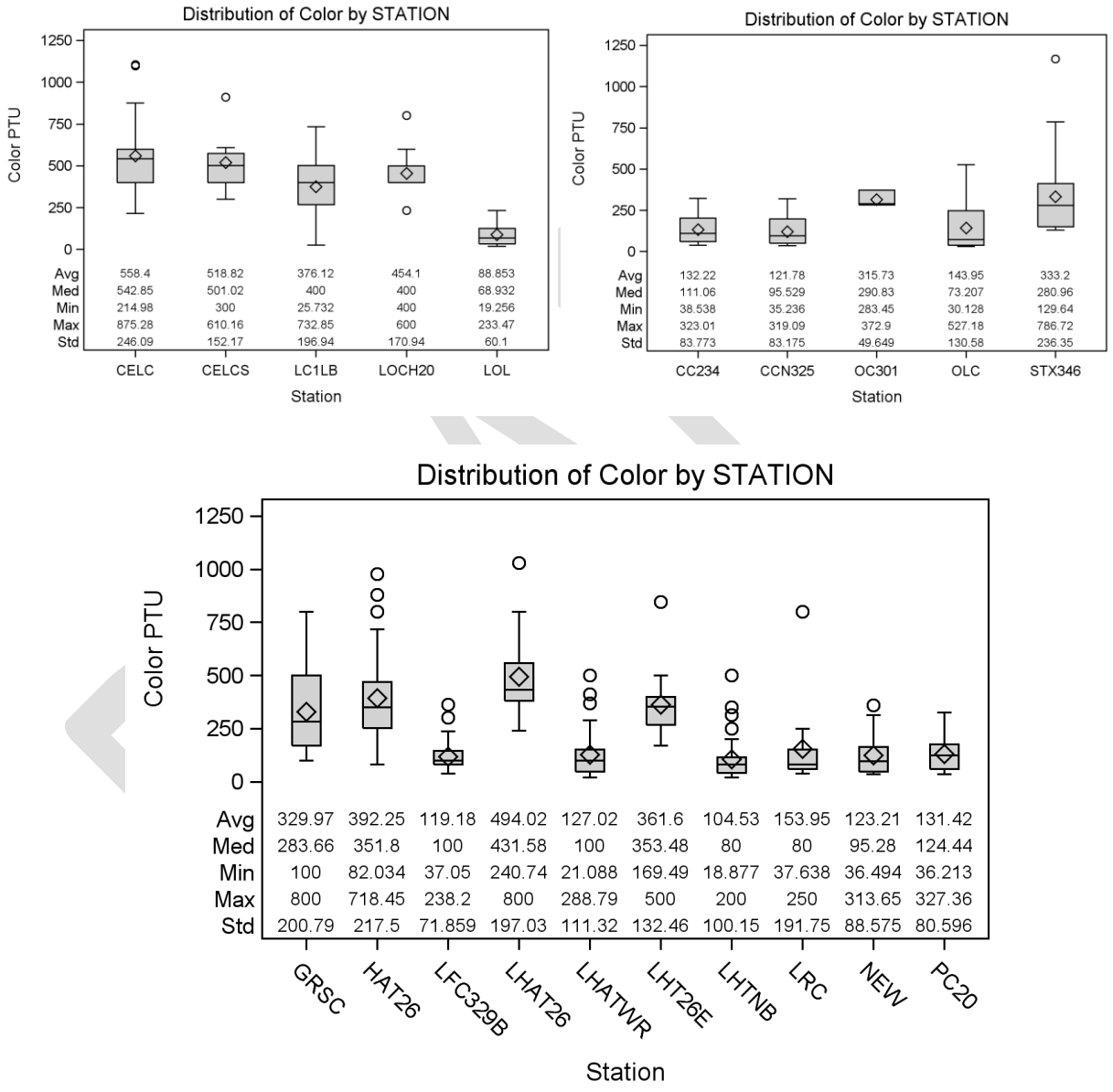

FIGURE 4. COLOR STATISTICS AT THE 20 WATER QUALITY MONITORING STATIONS DURING 2010 AND 2015. TOP LEFT PANEL - LOCHLOOSA LAKE SUB-BASIN STATIONS, TOP RIGHT PANEL - ORANGE LAKE SUB-BASIN STATIONS, AND BOTTOM PANEL – NEWNANS LAKE SUB-BASIN.

Water quality trend

The TN and TP concentration trends were evaluated over a 15 year period, from 1/1/2000 through 12/31/2014. The seasonal Kendall Test, a nonparametric statistical analysis method, was used for detecting the trends. A P value of 0.1 was used to determine whether the trend is statistically significant or not. The year was divided into four seasons:

Spring: March – May
Summer: June – August
Fall: September – November
Winter: December – February

A SAS® program (Winkler 2004) developed by the St. Johns River Water Management District was used to perform the trend analysis.

TN trend

The TN trend was insignificant in Lochloosa Lake as well as in Lochloosa Creek which is the main tributary of the lake (Table 2). It had a significant decreasing trend in Hawthorn Creek.

TN concentration in Newnans Lake as well as in Hatchet and Little Hatchet creeks had decreasing trends. Stations in other tributaries in the Newnans Lake sub-basin had no trends for TN.

In Orange Lake and its main tributary, River Styx, TN had no significant trends; but at the Cross Creek inflow station, TN had a significant increasing trend.

TP trend

Lochloosa Lake had an insignificant decreasing trend in TP. However, TP concentration had a significant decreasing trend in its main inflow tributary, Lochloosa Creek. (Table 3).

TP concentration in Newnans Lake as well as in Hatchet and Little Hatchet East creek had significant decreasing trends. The trend was insignificant in all the other inflow tributaries to Newnans Lake.

TP trend was insignificant in Orange Lake. However, TP had a significant decreasing trend in both of its inflow tributaries, River Styx and Cross Creek.

Time series plots

Time series plots of TN, TP, Color and Chlorophyll-*a* are included in the appendix (separate document).

TABLE 2: TN SEASONAL KENDAL TREND TEST FOR 20 WATER QUALITY STATIONS IN OCB DURING THE PERIOD OF 2000 THROUGH 2014

Sub-basin	Station Name	Number of Observations	Years of Data	Kendall Sum	Z Score	Z Probability	Trend	Seasonality Test	Sen Slope
Lochloosa	CELC	66	11	81	0.443	0.658	Stable	Non-seasonal	0.005
Lochloosa	CELCS	41	8	-363	-4.066	0	Decreasing	Non-seasonal	-0.094
Lochloosa	LC1LB	86	13	-235	-0.873	0.383	Stable	Non-seasonal	0.028
Lochloosa	LOCH20	61	9	-30	-0.673	0.501	Stable	Seasonal	0.038
Lochloosa	LOL	137	16	-754	-1.401	0.161	Stable	Non-seasonal	-0.018
Newnans	GRSC	30	6	14	0.866	0.386	Stable	Seasonal	0.030
Newnans	HAT26	185	16	-864	-3.998	0	Decreasing	Seasonal	-0.034
Newnans	LFC329B	153	16	1793	2.827	0.005	Increasing	Non-seasonal	0.016
Newnans	LHAT26	77	15	-246	-4.06	0	Decreasing	Seasonal	-0.018
Newnans	LHATWR	51	7	115	0.926	0.354	Stable	Non-seasonal	0.024
Newnans	LHT26E	127	16	-724	-5.891	0	Decreasing	Seasonal	-0.078
Newnans	LHTNB	160	16	1496	2.206	0.027	Increasing	Non-seasonal	0.010
Newnans	LRC	25	3	-24	-2.028	0.043	Decreasing	Seasonal	-0.207
Newnans	NEW	159	16	2373	-3.533	0	Decreasing	Non-seasonal	-0.138
Newnans	PC20	107	14	1205	3.241	0.001	Increasing	Non-seasonal	0.230
Orange	CC234	106	13	1303	3.554	0	Increasing	Non-seasonal	0.175
Orange	CCN325	106	13	833	2.271	0.023	Increasing	Non-seasonal	0.030
Orange	OC301	49	8	-418	-3.594	0	Decreasing	Non-seasonal	-0.322
Orange	OLC	120	14	176	0.397	0.691	Stable	Non-seasonal	0.006
Orange	STX346	106	13	-156	-1.644	0.1	Stable	Seasonal	-0.032

TABLE 3: TP SEASONAL KENDAL TREND TEST FOR 20 WATER QUALITY STATIONS IN OCB DURING THE PERIOD OF 2000 THROUGH 2014

Sub-basin	Station Name	Number of Observations	Years of Data	Kendall Sum	Z Score	Z Probability	Trend	Seasonality Test	Sen Slope
Lochloosa	CELC	66	11	629	3.475	0.001	Increasing	Non-seasonal	0.019
Lochloosa	CELCS	41	8	-346	-3.875	0	Decreasing	Non-seasonal	-0.031
Lochloosa	LC1LB	86	13	-1833	-6.833	0	Decreasing	Non-seasonal	-0.029
Lochloosa	LOCH20	61	9	-173	-3.994	0	Decreasing	Seasonal	-0.007
Lochloosa	LOL	137	16	-614	-1.141	0.254	Stable	Non-seasonal	-0.001
Newnans	GRSC	30	6	30	0.517	0.605	Stable	Non-seasonal	0.001
Newnans	HAT26	185	16	-2602	-3.089	0.002	Decreasing	Non-seasonal	-0.003
Newnans	LFC329B	153	16	197	1.223	0.221	Stable	Seasonal	0.001
Newnans	LHAT26	77	15	-962	04.227	0	Decreasing	Non-seasonal	-0.004
Newnans	LHATWR	51	7	-51	-0.406	0.685	Stable	Non-seasonal	-0.002
Newnans	LHT26E	127	16	182	1.455	0.146	Stable	Seasonal	-0.009
Newnans	LHTNB	160	16	-2079	-3.066	0.002	Decreasing	Non-seasonal	-0.008
Newnans	LRC	25	3	60	1.378	0.168	Stable	Non-seasonal	0.017
Newnans	NEW	159	16	-1520	-2.262	0.024	Decreasing	Non-seasonal	-0.005
Newnans	PC20	107	14	1209	3.252	0.001	Increasing	Non-seasonal	0.016
Orange	CC234	106	13	1188	3.24	0.001	Increasing	Non-seasonal	0.012
Orange	CCN325	106	13	-826	-2.252	0.024	Decreasing	Non-seasonal	-0.003
Orange	OC301	49	8	-644	-5.543	0	Decreasing	Non-seasonal	-0.098
Orange	OLC	120	14	-560	-1.268	0.205	Stable	Non-seasonal	-0.002
Orange	STX346	106	13	-380	-4.019	0	Decreasing	Seasonal	-0.015

References

Winkler, S. 2004. A User-Written SAS Program for Estimating temporal trends and Their Magnitude. Technical Publication SJ2004-4. St. Johns River Water Management District, Palatka, Florida.