



# Watershed Protection Development Review

## A Study of Diel Dissolved Oxygen on Onion Creek, Austin Texas, 2004

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### Abstract

*During the summer of 2004, diel measurements of dissolved oxygen and other field parameters were collected from six sites on Onion Creek in Austin, Texas. The two sampling periods were June (index period) and August (critical period) per Texas Commission on Environmental Quality guidance for diel sampling. Of the six sites, only one showed substantial diel depression of dissolved oxygen, with an index period mean approaching the state standard for Onion Creek of 5.0 mg/L. This site is just downstream of the recharge zone for the Edwards Aquifer. The depressed dissolved oxygen may be caused by groundwater influences, dense riparian shading, increased oxygen demand from heavy detritus, and/or aquatic vegetation.*

### Introduction

Onion Creek is approximately 75 miles in length with a drainage area of approximately 211 square miles, originating from springs in Blanco County, and flowing eastward across the limestone bedrock of the Edwards Plateau ecoregion. The creek crosses a major recharge area of the Edwards Aquifer, and enters the Blackland Prairie ecoregion before its confluence with the Colorado River. As the creek flows from west to east, and particularly, east of IH 35, land use becomes increasingly urbanized, with the western upstream areas most recently shifting from rural and sparsely populated land use to suburban residential development.

Previous City of Austin monitoring on Onion Creek involved only instantaneous field measurements of dissolved oxygen (DO) during each routine site visit. Because DO levels are influenced by biological activity (along with diffusion and aeration) on a diurnal basis, these instantaneous day-time measurements limited the ability to accurately characterize DO in the stream.

The monitoring objectives for this special study were to better characterize diel DO patterns throughout the watershed and to evaluate potential differences between sites. This characterization will help assess conditions impacting biological function in Onion Creek.

### Methods

A logging multi-probe Hydrolab <sup>TM</sup> instrument was calibrated and programmed in the lab to collect four field parameters (dissolved oxygen, conductivity, pH and temperature) at 15 minute intervals for 48 hours at five sites.

The instrument was deployed in the central channel of the flowing stream. If total depth was less than 1.5 ft, it was deployed at depth equal to one-third of the water depth; if total depth was between 1.5 and 5 ft, it was deployed at one foot below the surface. None of the Onion Creek sites in this study had depths greater than 5 ft.

Field notes included date and time of deployment, and the instrument was retrieved no sooner than 26 hours after deployment. Time of retrieval was noted along with field observations such as debris or algae entrainment on the instrument. The instrument was returned to the lab for post calibration, and the data file was downloaded. Data from each site (Table 1) was then truncated to include only the first 24 hours of measurements, beginning with the second interval after retrieval (to allow for equilibration on site).

**Table 1**  
**Sondes were deployed at the following sites**

Site #	Site Name
1365	Onion @ Pfulman
612	Onion @ Driftwood
236	Onion @ Twin Creeks
255	Onion @ McKinney Falls
1366	Onion @ SAR

## Results

Minimum, maximum, mean and range of values were calculated for all four parameters. In addition, diel graphs were made for dissolved oxygen vs time of sampling, including the range of values as well as the state standard of 5 mg/L for dissolved oxygen. Results were summarized by site.

### Onion @ Pfulman

This site was closest to the headwaters, with a relatively small drainage. All parameters were well within expected ranges, but there was a slight increase in diel swing or range for most parameters over what was found in the next downstream site (Tables 2 and 3). Dissolved oxygen varied more in June than in August, while temperature varied much less. For both sampling periods, DO dipped below 6 mg/L after midnight and approached the state standard of 5 mg/L early the next morning, then began rising with the sun after about 7 am (Figures 1 and 2).

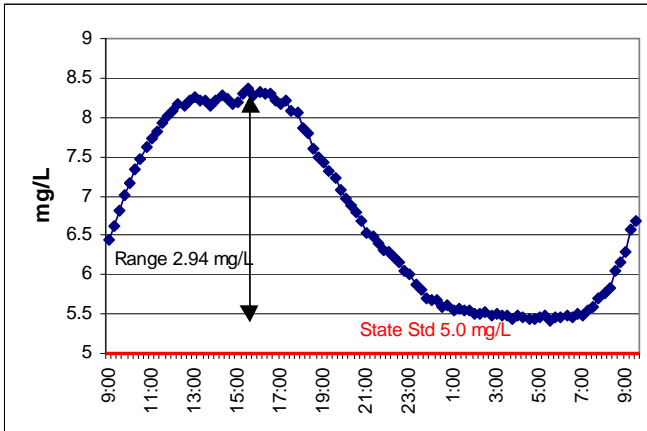
**Table 2 June 2004 Onion @ Pfulman**

	Temp	pH	Cond	DO mg/L	DO Std Dev= 1.11
MIN	25.65	7.91	425	5.42	
MAX	28.67	8.13	447	8.36	
MEAN	27.23	8.02	437	6.73	
RANGE	1.44	0.11	10	2.94	

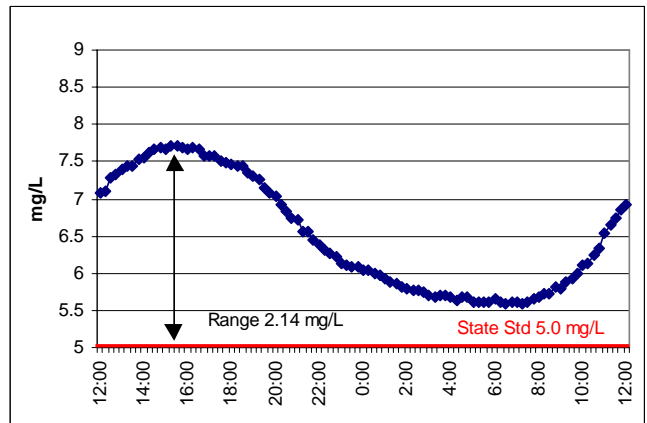
**Table 3 August 2004 Onion @ Pfulman**

	Temp	pH	Cond	DO mg/L	DO Std Dev=0.77
MIN	26.61	7.86	437	5.58	
MAX	29.31	7.97	446	7.72	
MEAN	27.80	7.91	441	6.50	
RANGE	2.70	0.11	9	2.14	

**Figure 1 Onion @ Pfulman 6/23/04 Dissolved Oxygen**



**Figure 2 Onion @ Pfulman 8/23/04 Dissolved**



**Onion @ Driftwood 06/04**

This site was also in the upper end of the watershed, but had a larger drainage area and more flow than Pfulman. For both sampling periods, this site showed the least amount of variation in all parameters for all sites, except August conductivity, when Pfulman had a narrower range (Tables 4 and 5). DO varied slightly more than other parameters but stayed well above the state standard for the 24 hour period, with maximum and minimum being reached later in the day in August than June (Figures 3 and 4).

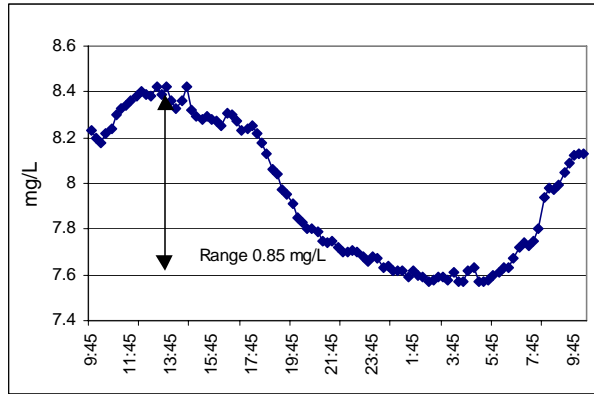
**Table 4 June 2004 Onion @ Driftwood**

	Temp	pH	Cond	DO mg/L	DO Std Dev= 0.31
MIN	24.59	7.73	516	7.57	
MAX	25.57	7.79	519	8.42	
MEAN	25.14	7.76	518	7.94	
RANGE	0.98	0.06	3	0.85	

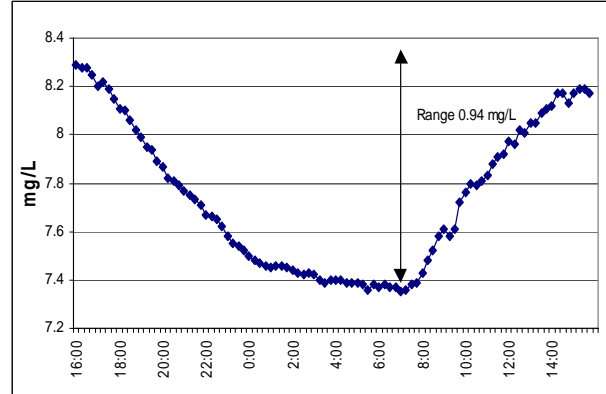
**Table 5 August 2004 Onion @ Driftwood**

	Temp	pH	Cond	DO mg/L	DO Std Dev= 0.305
MIN	26.42	7.94	485	7.35	
MAX	27.72	7.99	500	8.29	
MEAN	26.78	7.96	494	7.74	
RANGE	1.30	0.05	15	0.94	

**Figure 3 Onion @ Driftwood 6/23/04 Dissolved Oxygen**



**Figure 4 Onion @ Driftwood 8/23/04 Dissolved Oxygen**



**Onion @ Twin Creeks**

Onion @ Twin Creeks showed substantially greater swings in dissolved oxygen during both sampling periods than all other Onion Creek sites. In June, DO dipped to the lowest value recorded in the study (2.89 mg/L), with a range of 6.20 mg/L over the 24 hour period. The minimum value was higher in August (4.09 mg/L), but the range of 6.31 was slightly greater. Although the mean of June DO values (5.40 mg/L) was above the state standard of 5.0 mg/L, 53% of the measurements were below that standard. In August, DO values were below the state standard only about 30% of the time.

Unlike other Onion Creek sites, where minimum DO occurred in the early morning and then rose as the sun came up, at this site, June DO values below 5.0 mg/L began at midnight and continued through noon the next day. In August, these low values occurred between the hours of 4 and 11 am (Figures 5 and 6).

The much reduced oxygen values in June could be due in part to temperature, as the temperature range was over 3 degrees greater in June than in August, and the maximum June temperature was almost 2 degrees higher. Other sites always showed a decrease (or at SAR, no change) in both range and maximum temperature from June to August. Maximum temperature in June at Twin Creeks was higher than at all other sites; only two sites had higher maximum temperatures in August.

This site was just downstream of the Edwards Aquifer recharge zone, and flow was influenced by springs both upstream of and adjacent to the site. Ground water is often low in dissolved oxygen. The riffle where deployment occurred was well shaded, with canopy cover (primarily box elder, *Acer negundo*) extending well across the narrow stream bed. There was a significant amount of leaf pack in the riffle as well as large stands of aquatic vegetation (Coontail, *Ceratophyllum demersum*) in a long, limestone-bedded shallow pool just upstream of the site. The oxygen demand from both the vegetation and the leaf pack could have contributed to the swings in DO. The depressed values lasting past noon could be a result of the highly shaded nature of the narrow riffle portion of the stream (Tables 6 and 7).

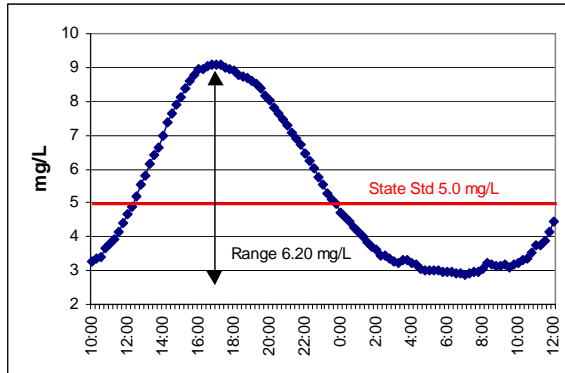
**Table 6 June 2004 Onion @ Twin Creeks**

	Temp	pH	Cond	DO mg/L	DO Std Dev= 2.21
MIN	24.95	7.38	468	2.89	
MAX	31.28	7.84	496	9.09	
MEAN	28.44	7.56	481	5.40	
RANGE	6.33	0.46	28	6.20	

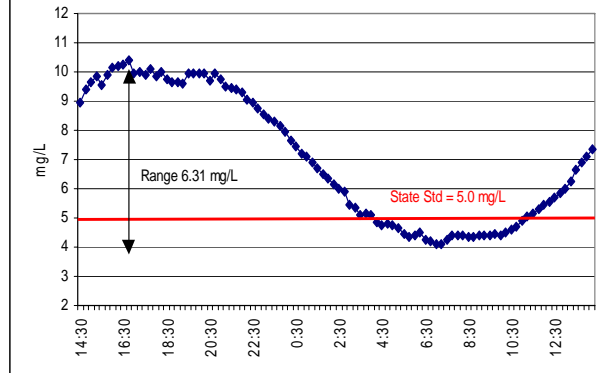
**Table 7 August 2004 Onion @ Twin Creeks**

	Temp	pH	Cond	DO mg/L	DO St Dev= 2.25
MIN	26.25	7.54	450	4.09	
MAX	29.29	7.94	476	10.4	
MEAN	27.49	7.73	464	7.03	
RANGE	3.04	0.40	26	6.31	

**Figure 5 Onion @ Twin Creeks 6/2/04 Dissolved Oxygen**



**Figure 6 Onion @ Twin Creeks 8/18/04 Dissolved Oxygen**



**Onion @ McKinney Falls**

Onion @ McKinney Falls is located within the boundaries of McKinney Falls State Park, with a significant amount of undeveloped land surrounding the creek. The earlier sample (May 2004) showed an increase in mean conductivity as well as a larger range of conductivity values compared to the August sample (Tables 8 and 9). DO mean and range were also both higher in May, with the minimum only 0.6 mg/L above the state standard while the August minimum was 1.1 mg/L above the standard. Also, the minimum was reached much earlier in the morning in August than in May (0245 and 0630 respectively) as shown in Figures 7 and 8. The range and mean for August were most similar to the upstream Pfulman site, but still more variable than the upstream Driftwood site.

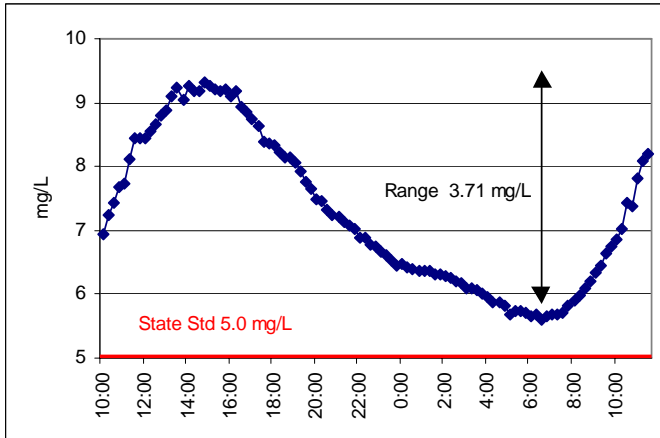
**Table 8 May 2004 Onion @ McKinney Falls**

	Temp	pH	Cond	DO mg/L	DO Std Dev = 1.20
MIN	25.33	7.64	601	5.61	
MAX	28.77	8.08	642	9.32	
MEAN	27.12	7.85	617	7.24	
RANGE	3.44	0.44	41	3.71	

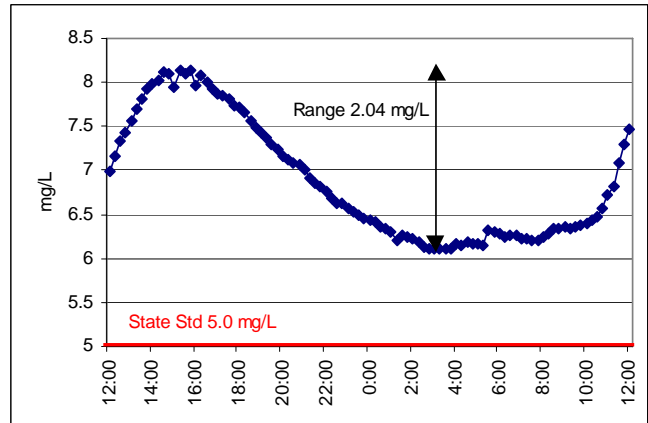
**Table 9 August 2004 Onion @ McKinney Falls**

	Temp	pH	COND	DO mg/L	DO Std Dev= 0.69
MIN	25.96	7.84	586	6.1	
MAX	30.01	7.98	592	8.14	
MEAN	27.76	7.90	589	6.87	
RANGE	4.05	0.14	6	2.04	

**Figure 7 Onion@ McKinney Falls 5/27/04 Dissolved Oxygen**



**Figure 8 Onion @ McKinney Falls 8/13/04 Dissolved Oxygen**



**Onion @ SAR**

Onion @ South Austin Regional (SAR) was the most downstream site in the study, located in the transitional zone between the Edwards Plateau and Blackland Prairie ecoregions, in an area of deep clayey soils and often dense riparian vegetation. Tall eroded cutbanks and large transitional deposits of cobble and boulders typified this stream channel, along with higher values for turbidity and TSS.

Like McKinney Falls, the mean and range for DO were higher in May than August, but unlike that site, minimum DO was reached well after sunrise in August when compared to May (0800 and 0600 respectively) as shown in Figures 9 and 10. This may be a function of seasonality, as the angle of the sun is somewhat lower in the sky in May than August, and the dense riparian zone at this site could shade the creek until later in the morning. pH was higher overall in May, possibly a function of increased photosynthesis shown with the increase in DO, but temperatures showed very little change between June and August (Tables 10 and 11).

**Table 10 May 2004 Onion@ SAR**

	Temp	pH	COND	DO mg/L	DO Std Dev = 1.64
MIN	25.64	7.71	561	5.86	
MAX	27.89	8	603	10.7	
MEAN	26.55	7.81	595	7.61	
RANGE	2.25	0.29	42	4.84	

**Table 11 August 2004 Onion@ SAR**

	Temp	pH	COND	DO mg/L	DO Std Dev= 0.68
MIN	25.69	7.55	586	6.27	
MAX	27.8	7.68	608	8.84	
MEAN	26.21	7.59	603	7.20	
RANGE	2.11	0.13	22	2.57	

Figure 9 Onion @ SAR 5/27/04 Dissolved Oxygen

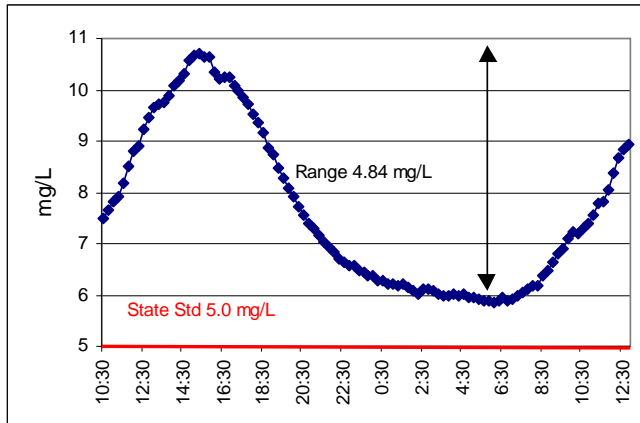
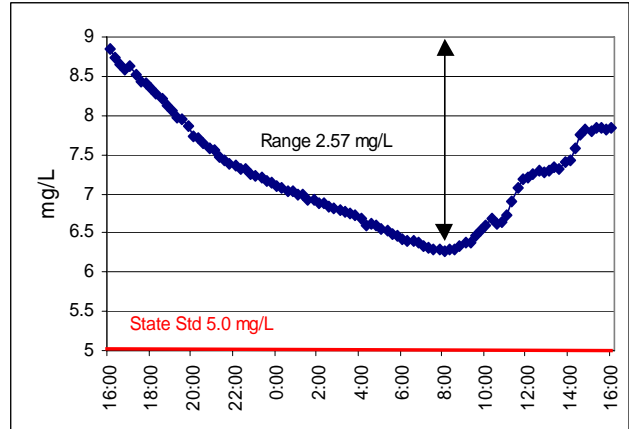


Figure 10 Onion @ SAR 8/18/04 Dissolved Oxygen



## Conclusions

This first year of sampling indicated that Onion @ Driftwood (upstream site) had very stable diel dissolved oxygen concentrations in both June and August. DO did not drop below the state standard at any site except for Onion @ Twin Creeks, which also showed not only significant depression of DO but considerable diel variability (Figure 11). Diel dissolved oxygen concentrations were significantly lower during both sampling periods at Onion @ Twin Creeks; and although no samples had means below the state standard of 5 mg/L, the June sample mean was within 0.6 of that standard, with over 50% of measured values below the standard (Figure 12).

Twin Creeks scored lower on more benthic macroinvertebrate metric scores from the spring sampling period than other Onion Creek sites, with 7 of the lowest scores, as well as the lowest benthic macroinvertebrate sub-index score (77) from the City's Environmental Integrity Index (Table 12). It also received an Intermediate score (25) for TCEQ's Quantitative Aquatic Life Use, while SAR received Exceptional (41) and Pfulman, Driftwood and McKinney received High (33, 37, 33). Number of Ephemeroptera taxa (2) and number of intolerant taxa (7) were lower than any other diel study site while number of EPT taxa (4) was 50 % less than the next highest value, and Percent of Total as EPT was less than half the next highest value. These metrics reflect the status of particularly sensitive aquatic insects, and can decrease with increasing impairment.

In August, benthic macroinvertebrate scores at Twin Creeks improved considerably, with 10 metrics showing improvement. This could be due in part to cooler temperatures and a slight improvement in DO; although the range was greater in August, the minimum was higher and the low values lasted for a much briefer period of time.

For both sampling periods Onion @ Driftwood had the highest ratio of intolerant to tolerant taxa, as well as the highest number of Ephemeroptera taxa, and the best HBI, reflecting the very stable dissolved oxygen values at this site. The two downstream sites (McK Falls and SAR) both had minimum DO values less than 6.0 mg/L in June, but the means were well above the state standard (Figure 12). The benthic metrics relating to intolerant taxa (# EPT, Ephemeroptera, Intolerant taxa) at these sites were lower than those at the two upper sites, but well above those for Twin Creeks.

In general, the upstream sites (Onion @ Pfulman, Onion @ Driftwood) had higher benthic metric scores than the downstream sites (Onion @ McKinney Falls, Onion @ SAR) for both sampling periods. The range of diel DO was larger at these downstream sites, but mean DO values were not different enough to account for differences in benthic communities. It is more likely that the benthic community differences between upstream and downstream are due to other factors, such as nutrient inputs and ecoregion differences.

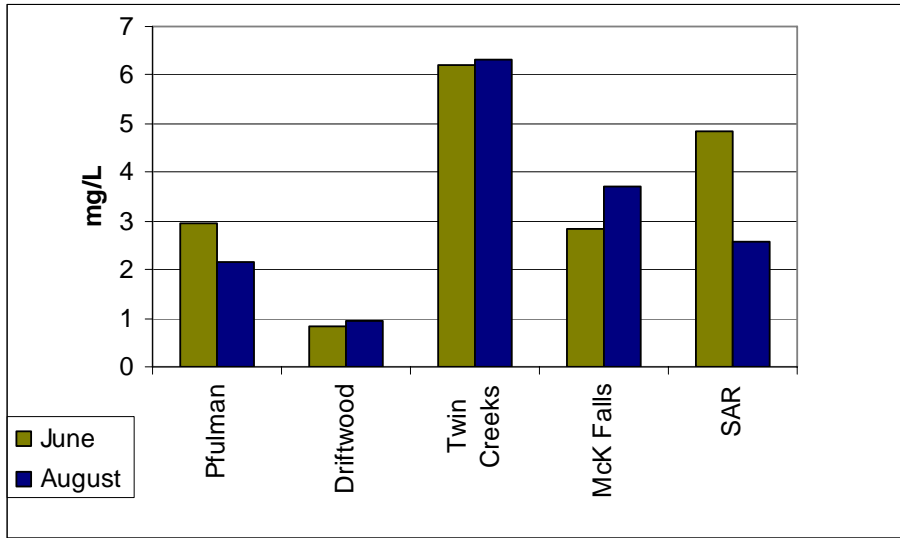
No relationship is evident between diatom metrics and dissolved oxygen, as the lowest diatom metric scores (4 of 5 metrics, both seasons) were at Onion @ McKinney Falls which did not have the lowest mean or the widest range of D.O. (Table 13). Conversely, Twin Creeks (with the most limited D.O.) had the second highest values for 3 of the 5 metric scores during May and none of its scores were the lowest of all sites in either sampling period. In particular, percent motile taxa was highest at McKinney Falls during both sampling periods, indicating a concern with sedimentation at that site, but this was not reflected in D.O. values. Also unlike the benthic scores, no consistent improvement was evident in scores in August for any site, although certain metrics did improve at particular sites between the two sampling periods.

One similarity between the benthics and diatoms was that the upstream sites (Onion @ Pfulman, Onion @ Driftwood) generally had higher diatom metric scores than other sites, with Onion @ Driftwood having the highest number of top scores during both sampling periods. These sites also had the lowest number of taxon for both sampling periods, possibly because of lower nutrients often typical in Central Texas headwater streams. As with benthics, the diatom community differences between upstream and downstream sites are most probably due to other factors relating to increasing urbanization and ecoregion transition rather than dissolved oxygen.

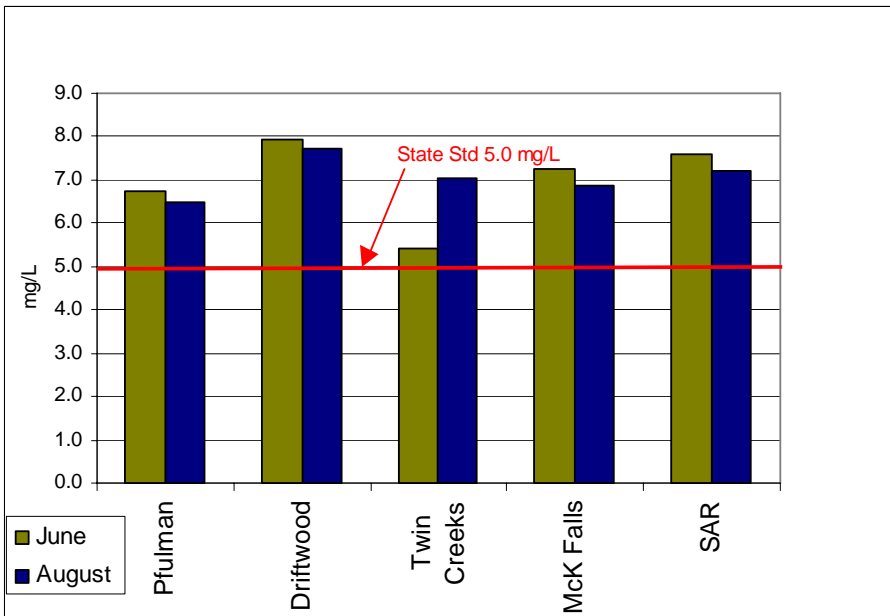
## **Recommendations**

It is recommended that diel dissolved oxygen sampling continue on all sites in this study for one more year to verify this first year of sampling and establish a baseline. After this time, if upper watershed sites (Pfulman, Driftwood) show no changes, it is possible that monitoring could be dropped at these sites, as they show little variation in diel DO. Monitoring Twin Creeks should continue, as this site had mean values close to the state standard for dissolved oxygen.

**Figure 11 Range of diel dissolved oxygen, June and August, all sites**



**Figure 12 Mean diel dissolved oxygen, June and August, all sites**



**Table 12. Benthic macroinvertebrate metric scores, Onion Creek, May and August 2004**

Site Number	Pfulman 1365		Drifwood 612		Twin Creeks 236		McKinney Falls 255		SAR 1366	
	May-04	Aug-04	May-04	Aug-04	May-04	Aug-04	May-04	Aug-04	May-04	Aug-04
EPT/EPT+CHIRONOMIDAE	0.983	0.967	0.986	0.973	0.929	0.922	0.862	0.912	0.975	0.954
HILSENHOFF BIOTIC INDEX	4.85	4.38	4.64	4.25	5.42	5.19	5.33	4.86	4.83	4.98
# DIPTERA TAXA	6	5	3	4	3	4	4	7	2	3
# EPHEMEROPTERA TAXA	5	5	6	8	2	6	3	7	5	9
# EPT TAXA	9	7	8	11	4	9	8	11	8	15
# INTOLERANT TAXA	14	12	10	15	7	12	10	14	12	16
# NONINSECT TAXA	3	2	6	4	7	6	8	3	5	4
# ORGANISMS	392	245	102	108	189	193	700	1226	368	915
# TAXON	25	22	20	27	22	30	31	33	24	32
% DOMINANCE (TOP 1 TAXA)	16.58	19.18	22.54	19.44	12.16	12.95	17.14	20.06	17.11	16.17
% DOMINANCE (TOP 3 TAXA)	29.59	40.81	40.19	37.96	29.1	25.9	47	41.35	30.43	34.97
% AS EPT	73.97	48.16	71.56	66.66	20.63	54.92	56.42	71.94	53.26	79.89
% AS CHIRONOMIDAE	1.27	1.63	0.98	1.85	1.58	4.66	9	6.93	1.35	3.82
% AS ELMIDAE	3.57	4.89	0.98	15.74	2.64	1.55	5.71	2.36	13.31	2.4
% TRICHOPTERA AS HYDROPSYCHIDAE	32.53	22.72	33.33	2.63	14.7	60.31	65.75	38.59	79.16	77.65
% AS DOMINANT GUILD (FFG)	70.91	40.81	50.98	45.37	50.79	36.26	40.14	87.76	41.03	79.67
% AS COLLECTOR/GATHERER	13.77	26.12	50.98	45.37	8.46	24.87	31.14	5.13	41.03	13.98
% AS FILTERERS	70.91	40.81	35.29	37.03	24.33	36.26	40.14	87.76	23.36	79.67
% AS GRAZERS (PI AND SC)	3.82	5.3	6.86	16.66	15.34	3.62	11.57	2.69	31.52	3.06
% AS PREDATOR	15.56	33.87	10.78	16.66	50.79	35.75	22.42	8.07	20.65	8.52
INTOLERANT TO TOLERANT ORGANISMS	1.68	2.88	2.4	6.13	1.25	0.95	0.98	1.48	2.01	0.96
TCEQ QUALITATIVE ALU SCORE	36	38	35	39	35	36	34	33	34	36
TCEQ QUANTITATIVE ALU SCORE	33	37	37	41	25	37	33	37	41	33
EII BENTHIC SUB-INDEX SCORE	96		100		77		88		93	

**Table 13. Diatom Metric Scores, Onion Creek, May and August 2004**

Site Number	Pfulman 1365		Driftwood 612		Twin Creeks 236		McKinney Falls 255		SAR 1366	
	May-04	Aug-04	May-04	Aug-04	May-04	Aug-04	May-04	Aug-04	May-04	Aug-04
CYMBELLA RICHNESS	3	4	4	4	3	3	2	2	2	3
NUMBER OF TAXON	15	27	21	15	25	37	36	38	27	28
% MOTILE TAXA	1	14.83	2.4	2	9.8	21.6	31.4	26.2	19.6	12.4
% SIMILARITY TO REFERENCE	27.992	61.593	49.444	36.77	40.4745	58.638	46.566	59.421	42.4759	36.072
POLLUTION TOLERANCE INDEX	2	2	4	2	2	2	2	2	2	2
EII DIATOM SUB-INDEX SCORE	3.02	2.882	3.31	3.044	3.016	2.878	2.63	2.778	2.885	2.89
	74		92		76		57		63	