Assessment of Ecoregional Dissolved Oxygen Regimes
Data Report for 2007 Study Season

SECTION 5

COMPARISON OF 2006 AND 2007 RESULTS AND DATA TRENDS

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As part of the AERDOR project, data were collected from a total of four reference streams over the course of two sampling seasons. Cedar Creek, Little Drywood Creek, and Heaths Creek were monitored in 2006. In 2007, East Fork Crooked River was monitored in place of Cedar Creek. Data from all sites and both seasons were compiled and analyzed to compare results and identify overall data patterns. Analyses were primarily limited to stationary monitoring sites where continuous and discrete data were collected. Because they were the only streams monitored during both years of the project, seasonal comparisons were limited to data collected from Little Drywood Creek and Heaths Creek.

5.1. Comparison of 2006 and 2007 Study Conditions

Precipitation and streamflow conditions varied between sampling seasons. In 2006, annual precipitation was at or below the 19th percentile of historical data at all sites (MEC 2007). During 2006, total summer (July-September) precipitation was 7.2 and 6.0 inches at Little Drywood Creek and Heaths Creek, respectively (MRCC 2008a, MRCC 2008c). Because of the persistent drought conditions, AERDOR streams were stagnant for the duration of the 2006 sampling season. In 2006, streamflows averaged less than 0.1 cfs at each of the streams. The 2007 sampling season was not as dry as in 2006. Total summer precipitation at Little Drywood Creek and Heaths Creek was 10.7 and 6.7 (MRCC 2008a, MRCC 2008b), respectively, and daily average streamflow was approximately 0.5 cfs at each stream.

5.2. Trophic State Differences and Stream Metabolism Trends

Nutrient and chlorophyll-a levels were generally higher in 2006 than 2007 (Table 18) although individual samples exceeded EPA benchmarks during both seasons. On a median basis, nitrate was the only constituent that was consistently below EPA's target concentrations (Table 18).

TABLE 18. Comparison of Median Nutrient and Chlorphyll-a Concentrations Observed at Sites LDC2 and HC2 During the 2006 and 2007 Sampling Seasons.

Parameter	Site LDC2		Site HC2		EPA
	2006	2007	2006	2007	Benchmark*
TP (ug/L)	82	57	172	151	92.5
TN (mg/L)	1.160	0.670	1.400	0.598	0.712
NO2+NO3-N (mg/L)	0.05	0.06	0.08	0.08	0.23
S-Chla (ug/L)	15.6	8.2	20.5	15	2.75
P-Chla (mg/m^2)	54	5	40	61	40

*All benchmarks except P-Chla based on Nutrient Ecoregion IX Subregion 40 thresholds.P-Chla benchmark based on Region 7 RTAG suggested levels.

Calculated community photosynthesis, respiration, and oxygen reaeration rates were pooled across all sites (CC1, EFCR2, LDC2, and HC2) and years to evaluate trends and relationships. Correlation analyses indicate that community photosynthesis is negatively related to streamflow while reaeration is positively related (Spearman Rank Correlation, $p < 0.05$, $n=38$ for both). Although community respiration appears to decrease with increasing streamflow (Figure 22), the relationship was not significant.

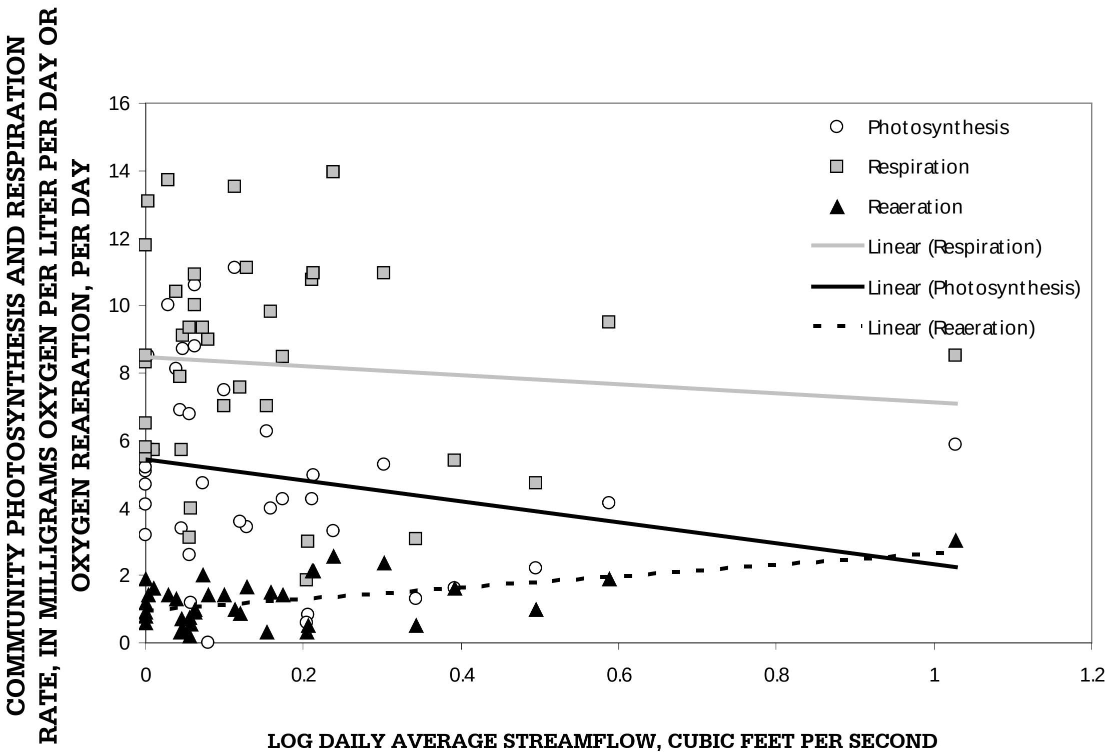

FIGURE 22. Relationships Between Calculated Community Photosynthesis, Community Respiration, Oxygen Reaeration and Daily Average Streamflow During the 2006 and 2007 Sampling Seasons. All rates adjusted to 20°C.

5.2. Comparison of 2006 and 2007 Continuous Data Results

Continuous data were collected at stationary monitoring sites on Little Drywood Creek and Heaths Creek during both study seasons. Mean daily average water temperatures were generally comparable between years. Mean temperatures ranged from 24.3 to 26.0 °C in 2006 and from 23.9 to 26.0°C in 2007 (Table 19). Water temperature at sites HC2 and HC3 were significantly cooler during 2007 (One-Sided Mann-Whitney, $p < 0.05$). Because water temperatures were generally warm during both years however, the statistical differences at sites HC2 and HC3 likely do not reflect practical differences that would impact metabolism processes that control DO.

TABLE 19. Comparison of Mean Daily Average Water Temperatures Collected at Stationary Monitoring Locations on Little Drywood Creek and Heaths Creek During the 2006 and 2007 Sampling Seasons. Significant differences based on one-sided Mann Whitney Test results ($p \leq 0.05$).

Site ID	Water Temperature (°C)			
	2006	2007	Difference	Sig. Difference?
LDC1	24.3	25.0	0.7	No
LDC2	24.8	25.5	0.7	No
HC1	25.2	26.0	0.8	No
HC2	26.0	23.9	-2.1	Yes
HC3	25.8	25.5	-0.3	Yes

Low DO was more prevalent in 2006 than in 2007 (Table 20). In 2006, between 46% and 83% of the DO measurements were less than 5.o mg/L. In 2007, those frequencies fell to between 13% and 74% of all measurements. Similarly, the frequency of measurements below 3.0 mg/L decreased from between 14% and 33% in 2006 to between 1% and 24% in 2007 (Table 20). Overall, the frequency of low DO measurements decreased in 2007 at all sites except LDC2.

TABLE 20. Frequency of Dissolved Oxygen Measurements Below Critical Thresholds at Stationary Monitoring Sites During 2006 and 2007 Sampling Seasons.

Site ID	% < 5.0 mg/L		% < 3.0 mg/L	
	2006	2007	2006	2007
LDC1	83%	56%	33%	3%
LDC2	75%	74%	24%	24%
HC1	65%	27%	29%	1%
HC2	62%	55%	27%	5%
HC3	46%	13%	14%	1%

Daily average DO concentrations were generally higher in 2007 than 2006 (Figure 23). Mean daily average DO ranged from 3.7 to 5.4 mg/L in 2006 and increased to between 4.9 and 7.1 mg/L in 2007. Mean daily minimum DO concentrations ranged from 2.4 to 2.6 mg/L in 2006 and were between 3.0 and 5.3 mg/L in 2007 (Figure 23). Mean daily average DO was similar between years at site LDC2 (4.09 vs. 4.06 mg/L) but mean daily minimum DO concentrations at the site increased in 2007 (2.6 vs. 3.0 mg/L).

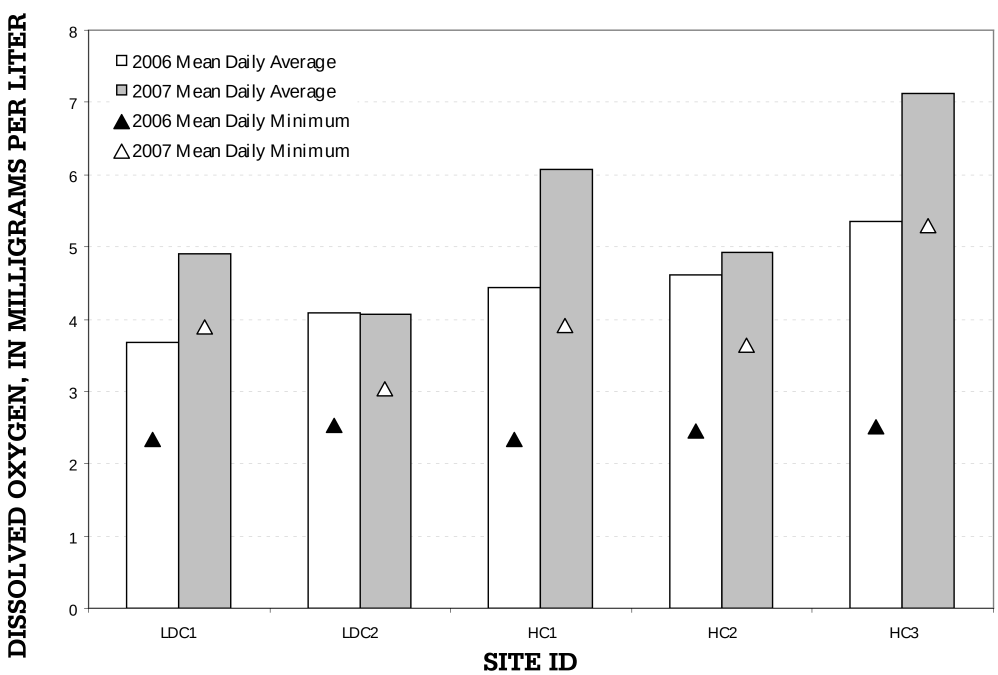

FIGURE 23. Comparison of Mean Daily Average and Minimum Dissolved Oxygen Concentrations at Stationary Monitoring Sites during 2006 and 2007 Sampling Seasons.

5.3. Comparison of 2006 and 2007 Dissolved Oxygen Correlation Results

Correlation results from the 2006 AERDOR analysis were very similar to 2007 results in that significant relationships between DO and light, watershed area, depth, and discharge were identified (MEC 2007). Correlations between DO and light intensity were unclear during both study seasons; light was positively correlated with DO at some sites and inversely related at others (MEC 2007). The 2006 data also indicated inverse relationships between DO and watershed area although, as in 2007, small sample sizes at roving sites exerted considerable leverage and may have influenced the results (MEC 2007).

Stream discharge and mean depth were positively related to DO during both study seasons. Although both variables exhibited significant correlations with DO, stream discharge is a more useful variable than mean depth for two reasons. First, since both mean depth and discharge were derived using the same rating curves (See Figure 13 for 2007 rating curves) they are correlated with each other. Because the variables are strongly correlated it is not necessary to evaluate both. Second, stream discharge is the more common of the two variables and is easily calculated and communicated. For these reasons, only the DO:discharge relationship will be evaluated from this point forward.

5.4. Influence of Streamflow on Attainment of Critical Dissolved Oxygen Concentrations in Study Streams

Data from stationary monitoring sites where continuous DO and discharge data were collected in 2006 and 2007 (CC1 on Cedar Creek, EFCR2 on East Fork Crooked River, LDC2 on Little Drywood Creek, and HC2 on Heaths Creek) were pooled and regression analyses were conducted to quantify DO:discharge relationships in the study streams. Simple regressions were attempted but resulting equations were generally not significant ($p \geq 0.20$) or had low coefficients of determination ($R^2 < 0.30$). Models were likely poor because discharge data were not robust (generally < 2.0 cfs). If data are collected under higher baseflow conditions during the 2008 study season these regressions may be re-examined.

Probabilistic regression models were investigated because acceptable linear relationships were not identified. Logistic regression models were developed to determine the probability that a stream attains both a 5.0 mg/L daily average and 3.0 mg/L daily minimum DO (5/3) on the same day at any given streamflow. Regression models were derived for each of the four streams monitored during the two AERDOR study seasons (Table 21). Because the streams were not monitored in 2007, regressions for Cedar Creek and East Fork Crooked River were based on only one season of data. Regressions for Little Drywood Creek and Heaths Creek were calculated from two seasons of data each.

TABLE 21. Major Logistic Regression Model Parameters and Fit Summary ($\alpha = 0.05$).

Site	B_0	B_1	Dev_0	Dev_{Fit}	df
LDC2	-2.1	3.1	62.8	55.9	46
HC2	-1.1	1.0	53.4	51.7	38
EFCR2	-5.6	14.1	35.2	15.2	23
CC1	-7.4	57.9	18.3	4.2	10

Results indicate the probability that AERDOR streams will achieve 5/3 increases with additional streamflow (Figure 24). The fitted logistic models suggest the probability of achieving 5/3 is most sensitive to increased flow at Cedar Creek and least sensitive at Heaths Creek (Figure 24). Furthermore, Cedar Creek would require the lowest daily average streamflow (~0.3 cfs) to consistently achieve 5/3 (Pr=1.0) while site HC2 would require the highest streamflow (~5.8 cfs). The models indicate that site LDC2 is moderately sensitive to increased flows and would require approximately 2.5 cfs to consistently meet 5/3. Under critical flow conditions (0.0 cfs), the probability of attaining 5/3 is less than 0.25 at all of the streams and is lowest in East Fork Crooked River and Cedar Creek (0.0 at each stream) (Figure 24).

Logistic regressions were also investigated to determine the probability that a stream can attain a 5.0 mg/L daily minimum DO concentration. Preliminary analysis however, indicated that out of all the complete day, valid, baseflow data collected during the 2006 and 2007 summer monitoring periods (n=299 total data days at CC1, HC2, LDC2 and EFCR2), daily minimum DO concentrations were at or above 5.0 mg/L on only 6 days (all at site HC2). Therefore, regressions predicting the probability that each stream would attain a 5.0 mg/L daily minimum could not be developed. These results (or lack thereof) suggest that under low to moderate summer baseflow conditions, such as those observed in 2006 and 2007, it is highly unlikely that AERDOR streams can consistently attain a 5.0 mg/L daily minimum DO concentration.

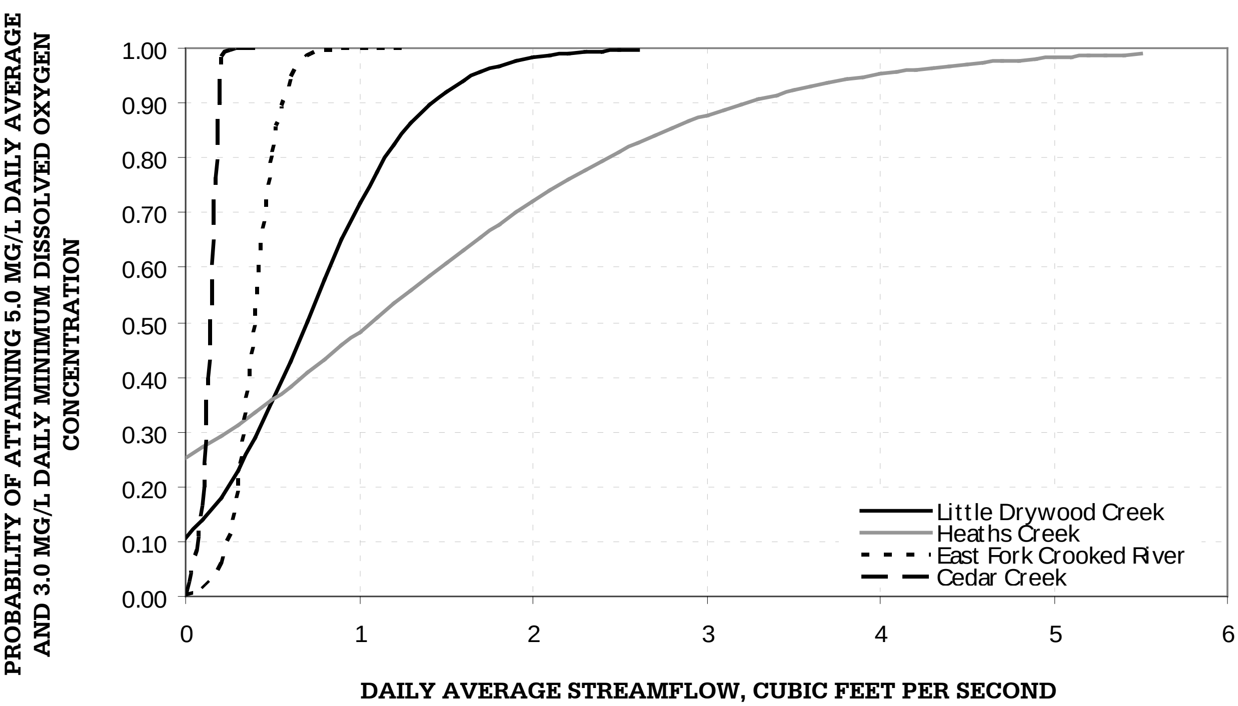

FIGURE 24. Logistic Regression Model Relating Daily Average Streamflow and Critical Dissolved Oxygen Threshold Attainment for Stationary AERDOR Monitoring Sites.