

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

SECTION 4

2007 STUDY SEASON RESULTS

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SECTION 4 2007 STUDY SEASON RESULTS

A total of 48,803 validated continuous DO measurements were collected in AERDOR streams between July 18, 2007 and November 9, 2007. Dissolved oxygen concentrations below both 5.0 mg/L and 3.0 mg/L were measured at all sites. In general, AERDOR reference streams exceeded applicable draft nutrient benchmarks for total phosphorus, total nitrogen, suspended chlorophyll-a, and benthic chlorophyll-a. Median photosynthesis (P) and respiration (R) rates (in units of mg O₂ L⁻¹ day⁻¹) calculated from diel DO measurements ranged from 1.3 to 5.0 (P) and 3 to 10.3 (R) at the sites. Average daily discharge was significantly correlated to DO levels at the study sites.

4.1. Quality Assurance Summary

Overall project documentation, training, and data quality objectives were met. Quality control parameters are described and documented in Appendix A. Data collected as part of 2007 sampling activities are available in a Microsoft Access database available on request to ERC.

4.2. Reference Stream Continuous Data

Nearly 300,000 continuous water quality related measurements (e.g. DO, temperature, conductivity, light, etc.) were collected between July 18, 2007 to November 9, 2007 (Table 7). Continuous data results are discussed by parameter in the following sections.

TABLE 7. Number of Validated Continuous Measurements Collected in AERDOR Reference Streams During the 2007 Study Season.

Site (#)	Period of Record (Range)	DO	DO Sat	Temp	SC	Level	Baro	Light
		(number of continuous measurements)						
LDC1	7/18/07 - 9/4/07	4587	4587	4587	4587	---	---	4601
LDC2	7/18/07 - 9/4/07	4594	4594	4594	4594	4605*	4605	4607
LDC3	7/18/07 - 8/8/07	2019	2019	2019	2019	---	---	2008
LDC4	8/8/07 - 8/23/07	1428	1428	1428	1428	---	---	1426
LDC5	8/23/07 - 9/4/07	1153	1153	1153	1153	---	---	1157
EFC1	7/17/07 - 9/5/07	4785	4785	4785	4785	---	---	4781
EFC2**	7/17/07 - 11/9/07	11008	11008	11008	11008	17898*	17898	4766
HC1	7/18/07 - 9/5/07	4674	4674	4674	4674	---	---	4678
HC2**	7/18/07 - 11/9/07	9948	9948	9948	9948	10909*	10909	4675
HC3	7/19/07 - 9/5/07	4607	4607	4607	4607	---	---	4689
PARAMETER TOTALS		48803	48803	48803	48803	33112	33112	37388

*Level Corrected for Barometric Pressure

**Extended Deployment Sites.

DO = Dissolved Oxygen (mg/L)
DO Sat = DO Percent Saturation (%)
Temp = Temperature (°C)
SC = Specific Conductivity (uS/cm)
Level = Stream level above instrument (ft.)
Baro = Barometric Station Pressure (mm Hg)
Light = Light Intensity (lumens / ft²)

4.2.1. Dissolved Oxygen

4.2.1.1. Dissolved Oxygen at Stationary Monitoring Sites

Median DO concentrations at the stationary monitoring sites ranged from 2.96 mg/L at site EFCR1 to 7.10 mg/L at site HC3 (Figure 5, Appendix F). Although site EFCR2 had the highest coefficient of variation (CV=0.42) among stationary sites, site HC3 exhibited the greatest range (17.2 mg/L) and single day maximum value (19.65 mg/L). Overall, DO concentrations in Heaths Creek were greater than at East Fork Crooked River or Little Drywood Creek (Figure 5). Dissolved oxygen concentrations were significantly greater at site HC3 (One-sided Mann-Whitney, $p < 0.001$) than at any other site. Furthermore, DO concentrations between sites on each stream were different from each other (2-sided Mann-Whitney, $p < 0.001$ for all tests).

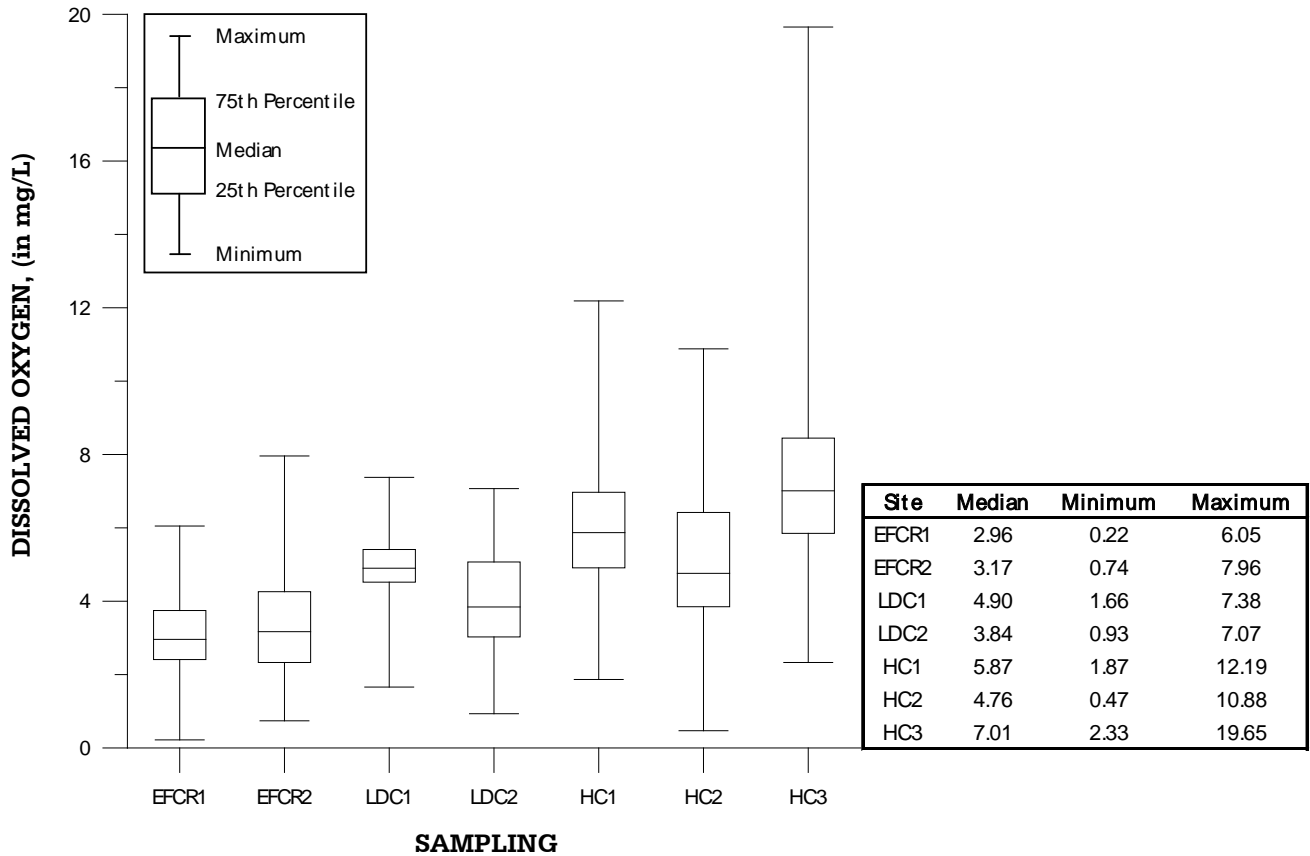


FIGURE 6. Boxplot Comparison of Continuous, Complete-Day ($n \geq 90$ per day) Dissolved Oxygen Concentration Data at Stationary Monitoring Sites (7/18/2007 – 9/4/2007).

Dissolved oxygen measurements were below 5.0 mg/L most often in East Fork Crooked River (Figure 7, 95% of all measurements at site EFCR1) and least often in Heaths Creek (13% at site HC3). Concentrations were below 3.0 mg/L at all sites during the survey period; most often occurring in East Fork Crooked River (approximately 50% of measurements below 3.0 mg/L at EFCR1 and EFCR2) and least often in Heaths Creek (< 5% at all sites). In addition to the sites on Heaths Creek, a high percentage of measurements (98%) at site LDC1 were above 3.0 mg/L (Figure 7).

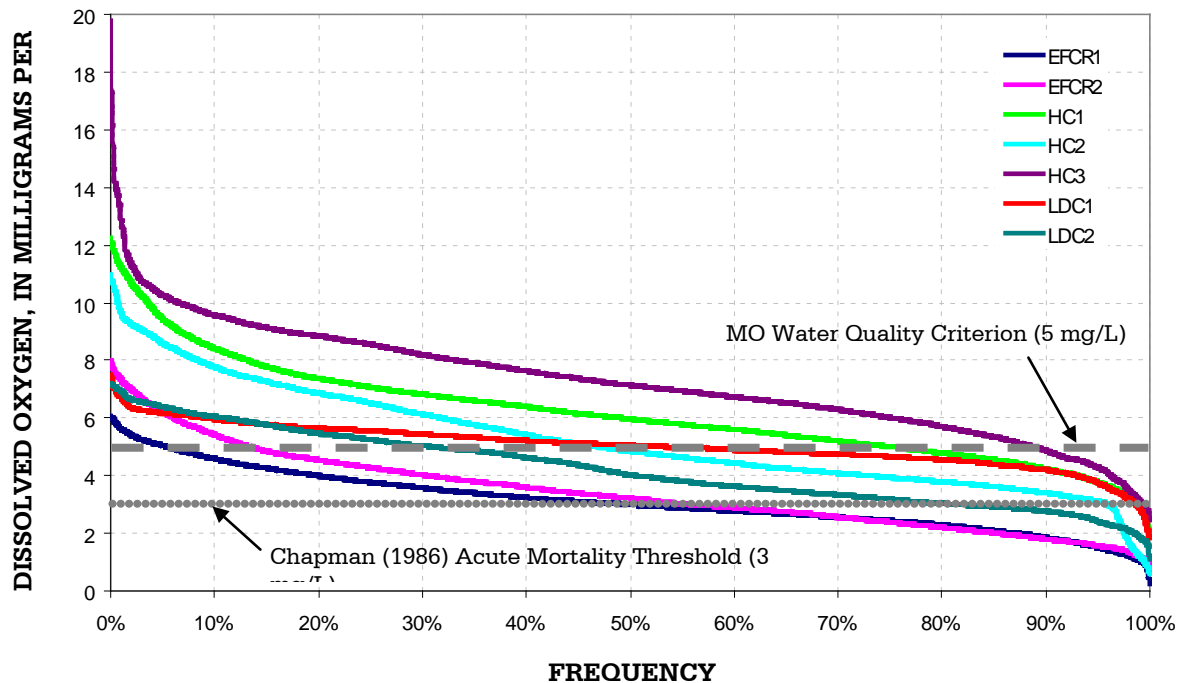


FIGURE 7. Frequency Comparison of Continuous, Complete-Day ($n \geq 90$ per day) Dissolved Oxygen Concentration Data at Stationary Monitoring Sites (7/18/2007 – 9/4/2007).

Daily minimum DO concentrations below 5.0 mg/L were measured at all sites during the deployment period (Figure 8, Appendix F). With the exception of site HC3, minimum DO steadily decreased at all sites until mid-August, at which point concentrations gradually rebounded (Figure 8). The highest mean minimum DO concentrations were measured in Heaths Creek (5.32 and 4.08 mg/L at sites HC3 and HC1, respectively) and the lowest in East Fork Crooked River (1.77 and 2.15 at sites EFCR1 and EFCR2, respectively) (Figure 8). Daily minimum DO levels below 3.0 mg/L were measured at all sites during the study period.

A series of one-sided Mann-Whitney tests indicated that daily minimum DO concentrations were highest (One-sided Mann-Whitney test, $p < 0.001$) at site HC3 and lowest at the East Fork Crooked River sites ($p < 0.001$). Dissolved oxygen daily minima were observed between 9:33 AM to 1:54 PM while times corresponding to maximum values ranged from 1:17 PM to 4:52 PM (Table 8).

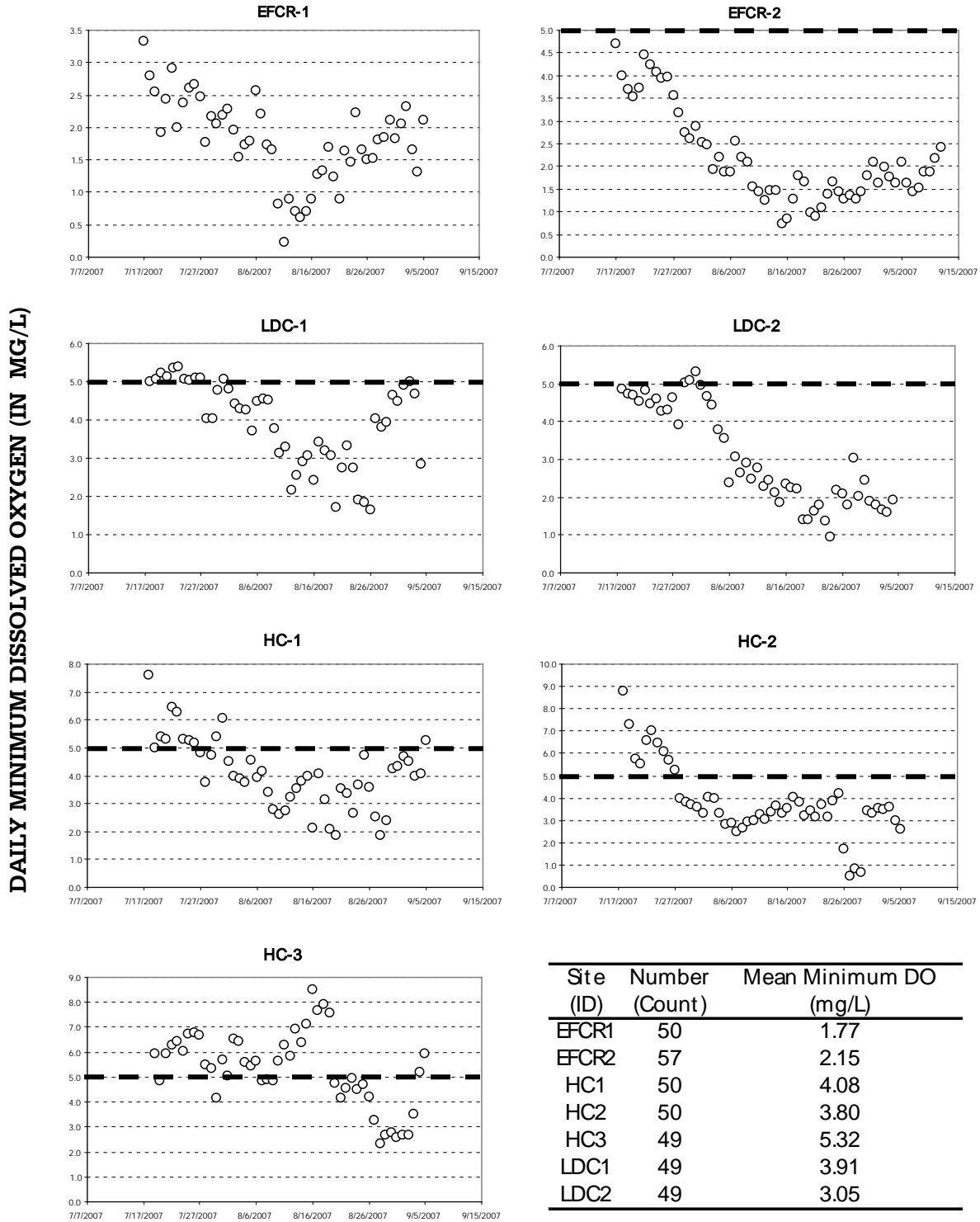


FIGURE 8. Daily Minimum Dissolved Oxygen Concentration Trends at Stationary Monitoring Sites (7/18/2007 – 9/04/2007). The Dashed Line Indicates the Missouri 5.0 mg/L Warm-Water Fishery Dissolved Oxygen Criterion.

TABLE 8. Times Corresponding to Daily Minimums and Maximums at Stationary Monitoring Sites Between 7/18/2006 to 9/4/2006.

Site	Mean Time of Minimum Dissolved Oxygen	Mean Time of Maximum Dissolved Oxygen
EFCR1	09:47	16:05
EFCR2	10:16	15:55
HC1	11:30	15:42
HC2	10:45	16:52
HC3	09:33	15:07
LDC1	13:54	13:17
LDC2	11:52	15:33

4.2.1.2. Dissolved Oxygen at Roving Monitoring Sites

Roving monitoring sites on Little Drywood Creek located outside (LDC 4, LDC5) Bushwacker Conservation Area boundaries had lower DO levels than either of the stationary sites. However, median DO (5.20 mg/L) at site LDC3 was greater than at either stationary site (Figure 9) and was above 5.0 mg/L. All measurements at sites LDC4 and LDC5 were well below 5.0 mg/L (Figure 9). Concentrations below 3.0 mg/L were measured at all roving sites but low DO was most prevalent at sites LDC4 and LDC5. More than 95% of all measurements collected at sites LDC4 and LDC5 (total n = 2,581) were less than 3.0 mg/L.

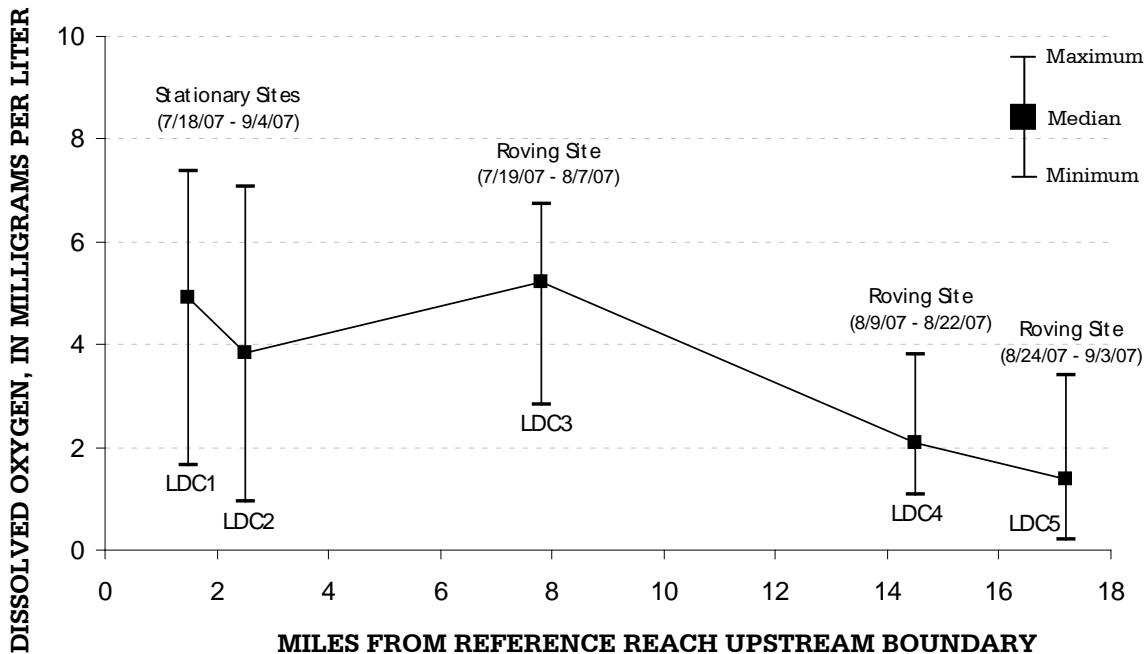


FIGURE 9. Longitudinal Dissolved Oxygen Comparison in Little Drywood

4.2.1.3. Dissolved Oxygen at Extended Deployment Sites

Elevated baseflow conditions following a rainfall event caused DO concentrations to increase during the extended deployment period (Figure 10) at site EFCR2 but concentrations were not significantly higher than summer levels (t-test, $p = 0.13$). Extended deployment DO concentrations at site HC2 were not affected by elevated flow conditions. Summer DO concentrations were not different from extended deployment DO at site HC2 (t-test, $p = 0.16$). Daily average DO concentrations followed similar patterns at both sites during extended deployment.

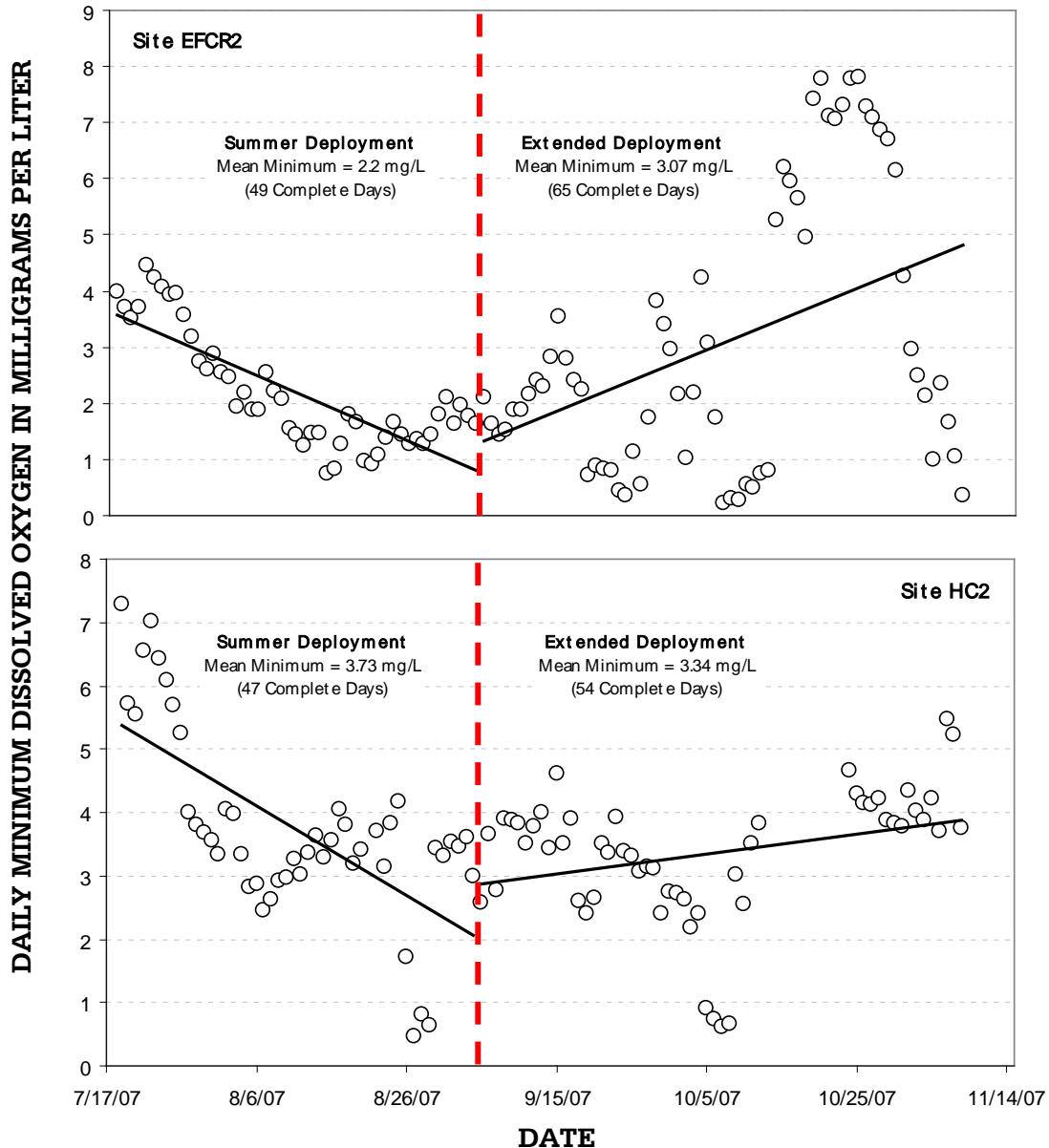


FIGURE 10. Daily Minimum Dissolved Oxygen Concentration Trends at Extended Deployment Sites. Complete-Day ($n \geq 90$ per day) Data Collected From 07/18/2007 to 11/8/2007.

4.2.2. Dissolved Oxygen Percent Saturation

4.2.2.1. Percent Saturation at Stationary Monitoring Sites

Saturation patterns at the stationary sites were similar to those described for DO concentrations in Section 4.2.1. Site HC3 had exhibited the greatest range (> 200%) and single day maximum value (255%) during the deployment period. Median DO saturation levels (Figure 11) were lowest at East Fork Crooked River (< 40% at EFCR1 and EFCR2) and generally highest in Heaths Creek (74 and 87 % at HC1 and HC3, respectively). Dissolved oxygen saturations were higher at site HC3 (One-sided Mann-Whitney, $p < 0.001$) than at any other site. Median saturation levels were different between sites on each stream (2-sided Mann-Whitney, $p < 0.001$ for all tests).

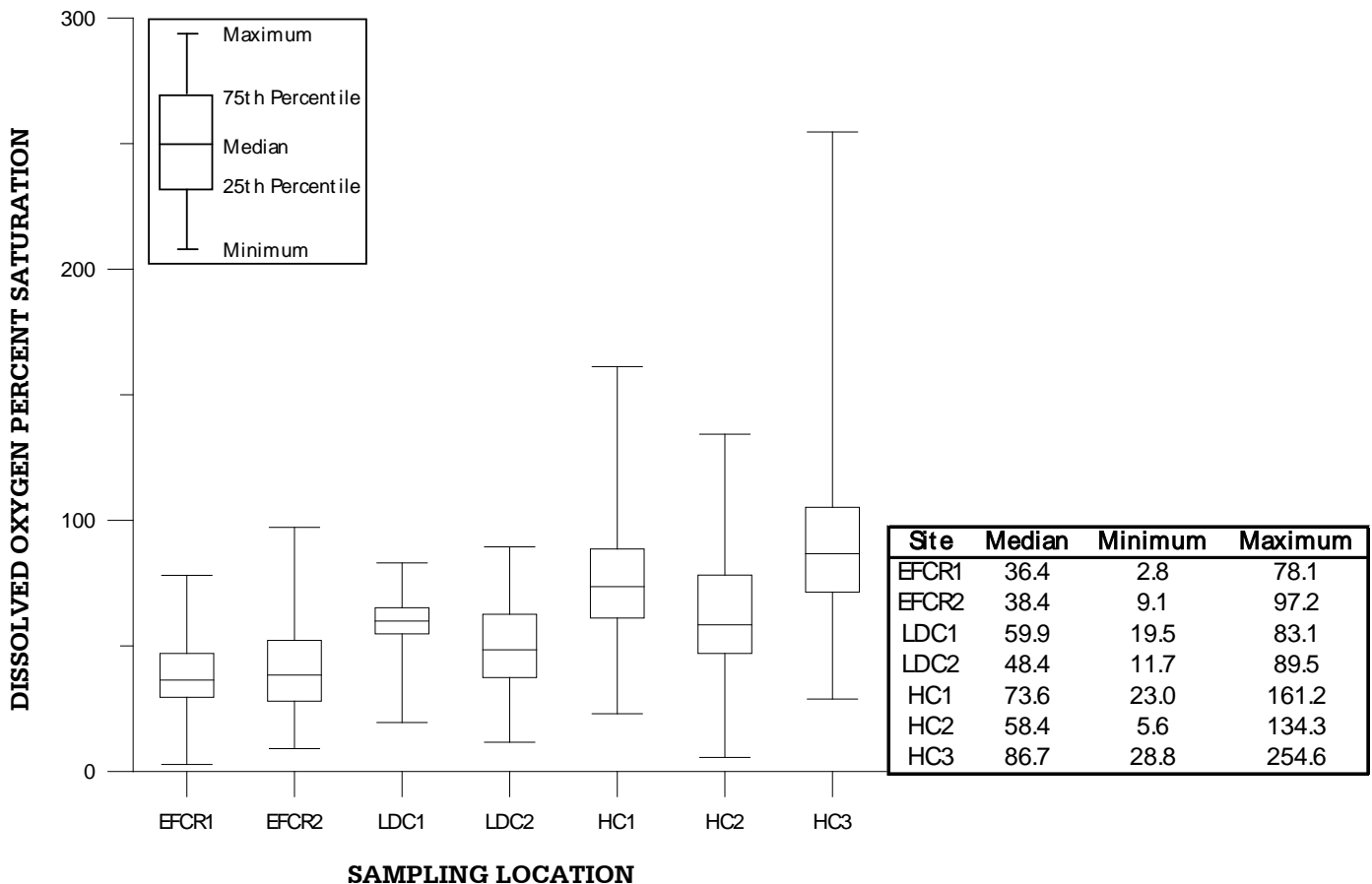


FIGURE 11. Boxplot Comparison of Continuous, Complete-Day ($n \geq 90$ per day) Dissolved Oxygen Percent Saturation Data at Stationary Monitoring Sites (7/18/2007 – 9/4/2007).

4.2.2.2. Percent Saturation at Roving Monitoring Sites

Percent saturation data at roving sites expressed similar longitudinal trends as DO concentration records. Median saturation levels at site LDC3 (65.2%) were higher than the stationary sites but sites LDC4 and LDC5 were lower (26.9 and 16.1%, respectively). The minimum saturation level was recorded at site LDC5 (2.4%) and the maximum at site LDC3 (83.4%).

4.2.2.3. Percent Saturation at Extended Deployment Sites

Daily average and minimum saturation levels during extended deployment at site EFCR2 were not significantly different (t-test, $p = 0.38$) from summer levels (Table 9). At HC2 however, saturation levels decreased during the extended deployment period and were significantly less than during summer (t-test, $p < 0.001$).

TABLE 9. Daily Average Dissolved Oxygen Percent Saturation Statistics for Extended Deployment Sites During 2007 Season (Summer Deployment Data Collected 7/18/2007 - 9/3/2007, Extended Deployment Data Collected 9/4/2007 – 11/8/2007).

Statistic	EFCR2		HC2	
	Summer	Extended	Summer	Extended
Average Daily Mean (%)	41.7	39.4	63.4	45.0
Average Daily Minimum (%)	26.1	30.1	45.2	34.1
Complete Days (n)	49	65	47	54

4.2.3. Water Temperature

4.2.3.1 Water Temperature at Stationary Monitoring Sites

Instantaneous water temperature readings ranged from 17.8 °C (HC3) to 30.9 °C (HC1) with median temperatures near 26 °C (Figure 12). Although temperature distributions were significantly different among all stationary sites (Kruskal-Wallis, $p < 0.001$) and between stationary sites on a given stream (Two-Sided Mann-Whitney, $p < 0.05$), the differences are not ecologically meaningful. The range in median temperatures between the sites was small (1.0 °C, Figure 12) so large continuous sample sizes are likely the source of significant differences.

4.2.3.2. Water Temperature at Roving Monitoring Sites

Among roving monitoring sites, median water temperature was higher at LDC4 (27.4°C) than at either LDC3 (25.7°C) or LDC5 (24.9°C) and had a smaller range (3.3°C v. 6.9°C and 5.5°C, respectively). Median temperatures at site LDC5 were cooler than other monitoring sites even though monitoring occurred during the late summer period (8/27/07-9/3/07). Maximum water temperatures were measured at LDC3 and the minimums at LDC5 (Figure 13).

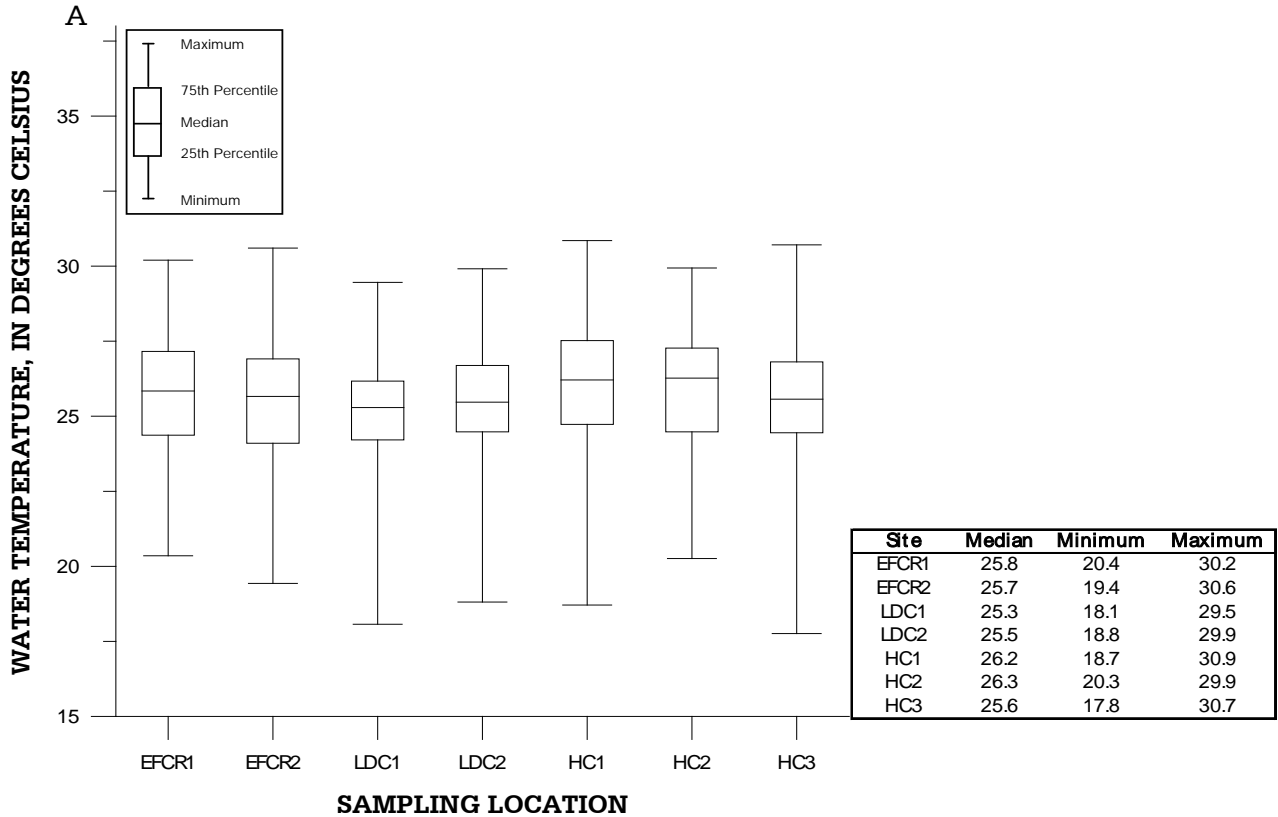


FIGURE 12. Boxplot Comparison of Continuous, Complete-Day ($n \geq 90$ per day) Water Temperature Data at Stationary Monitoring Sites (7/18/2007 – 9/4/2007).

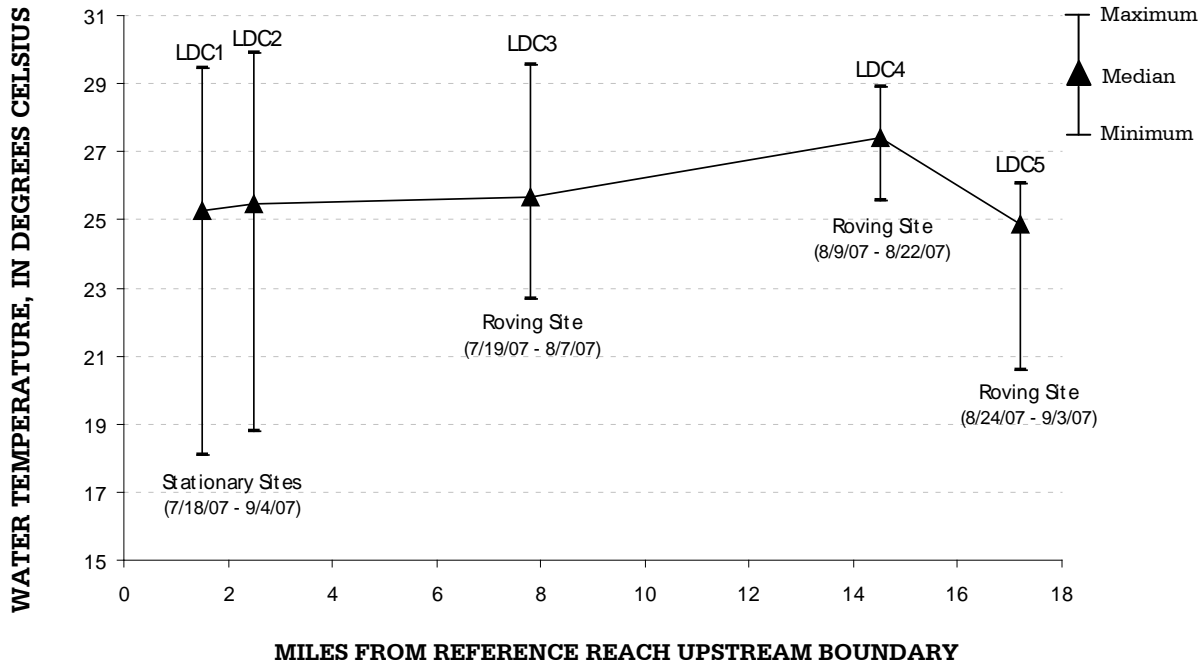


FIGURE 13. Longitudinal Water Temperature Comparison in Little Drywood Creek.

4.2.3.2. Water Temperature at Extended Deployment Sites

Daily average temperatures generally decreased from the time of initial deployment (Figure 14) although the trend was more prominent during the extended deployment period. Average daily temperatures were approximately 9°C cooler during the extended deployment period.

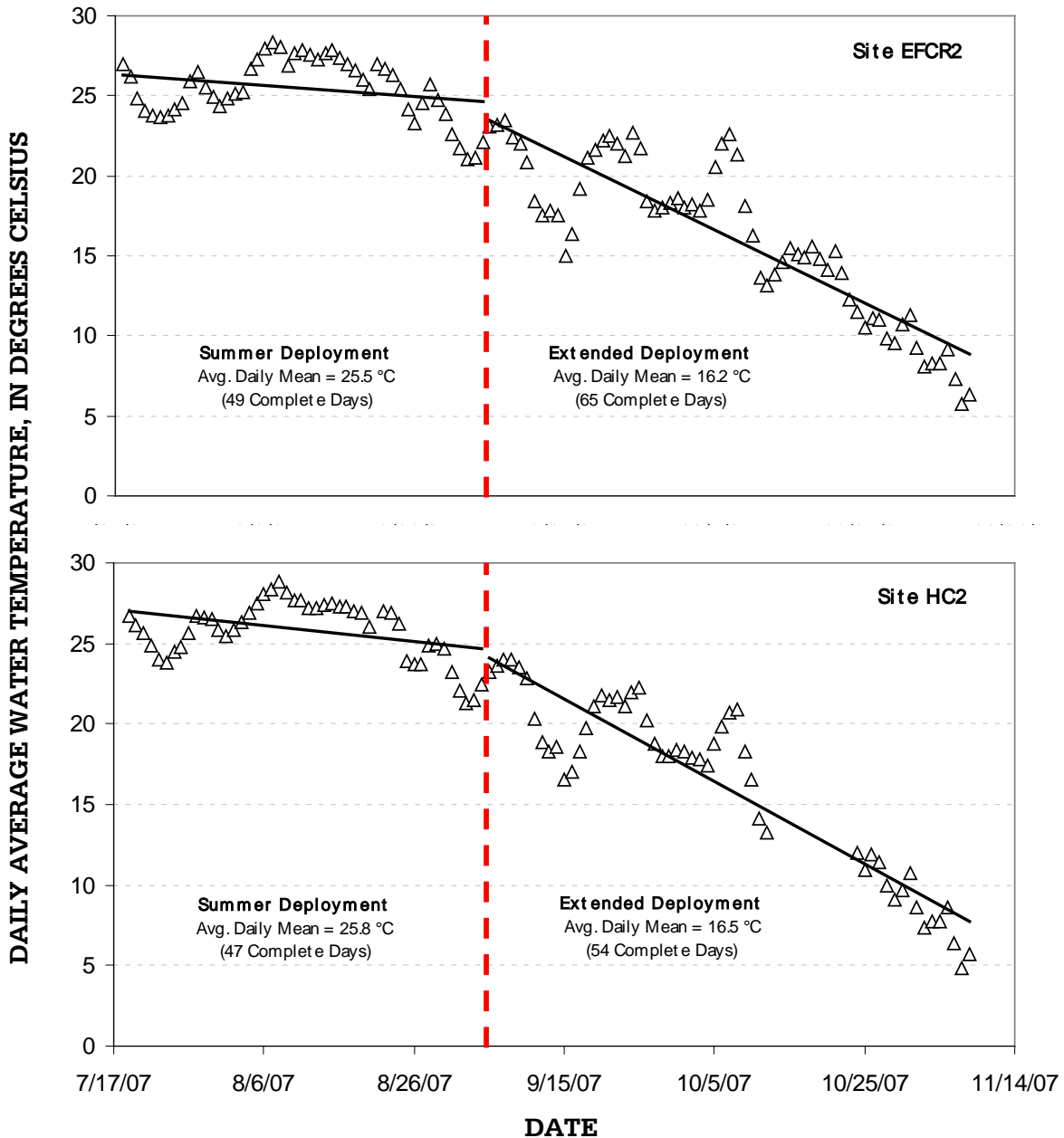


FIGURE 14. Daily Average Water Temperature Trends at Extended Deployment Sites. Complete-Day ($n \geq 90$ per day) Data Collected From 07/18/2007 to 11/8/2007.

4.2.4. Stream Level and Flow

Pressure-corrected continuous stream level data and discrete open-channel flow measurements were collected at three stationary sites (EFCR2, LDC2, and HC2) during the 2007 study season. Discrete flow measurements were collected during weekly site visits. Measureable streamflow was present during each visit at all sites and ranged from a minimum of 0.02 cubic feet per second (cfs) at site EFCR2 to a maximum of 23 cfs at site LDC2 (Figure 15).

Rating curves relating level and flow were developed and used to calculate daily average flow at each site. Runoff records were excluded from the calculations (EFCR2 = 24% of records, HC2 = 16% of records, LDC2 = 4% of records). Discharge calculations were limited to stream levels at or below the maximum observed flow. Daily average discharge was 0.17, 0.49, and 0.54 cfs at sites EFCR2, HC2, and LDC2, respectively.

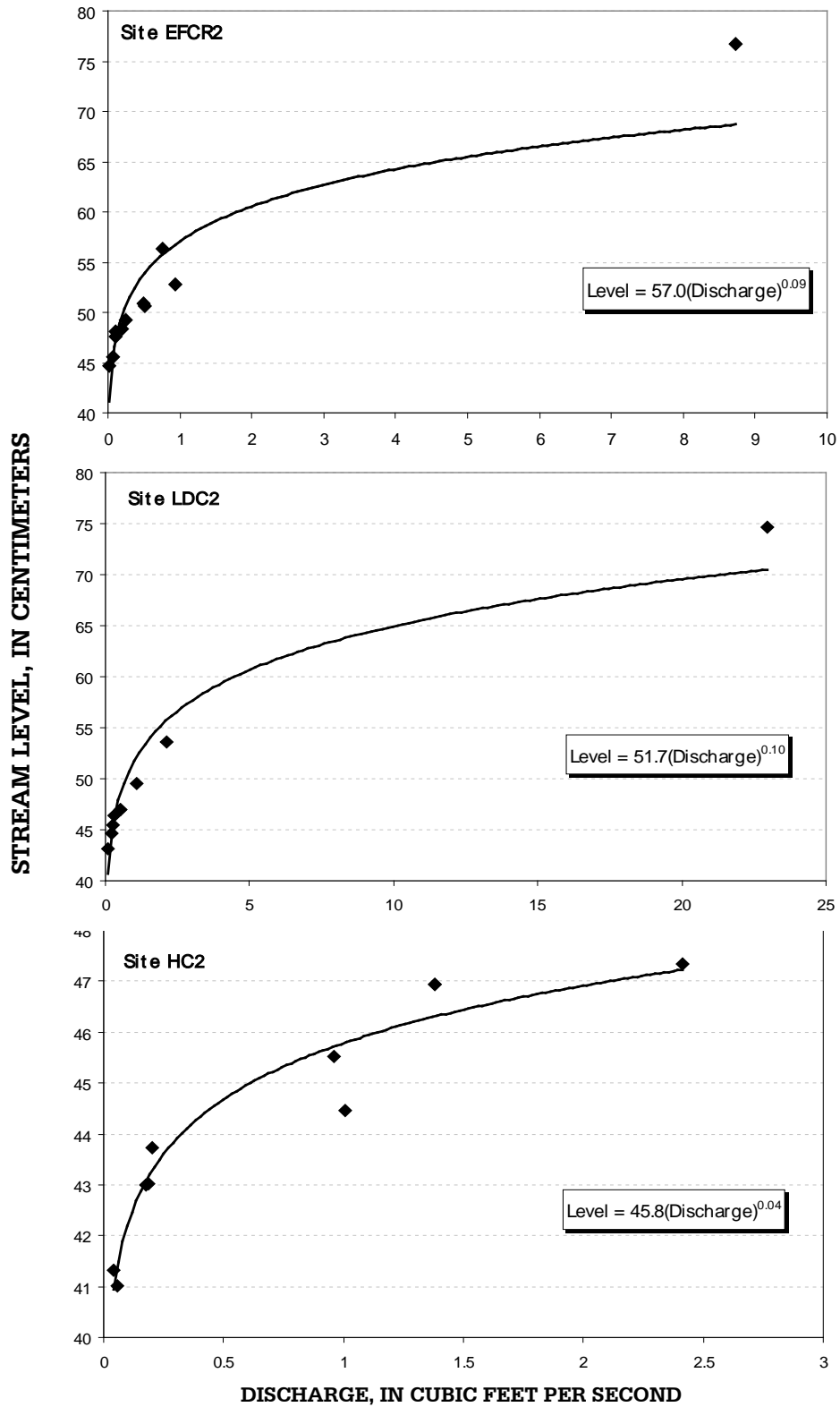


FIGURE 15. Rating Curves Developed from 2007 Study Season Level and Discharge Data Collected Between 7/18/2008 and 9/4/2008.

4.2.5. Specific Conductivity

Average conductivity ranged from 222 microsiemens per centimeter ($\mu\text{S}/\text{cm}$) at site LDC3 to 504 $\mu\text{S}/\text{cm}$ at site EFCR1. Maximum conductivity was measured at site EFCR1 (558 $\mu\text{S}/\text{cm}$) and the minimum conductivity observed was at site LDC2 (90 $\mu\text{S}/\text{cm}$). Conductivity was generally inversely related to streamflow. Conductivity data are summarized in Appendix F.

4.2.6. Barometric Pressure

Barometric station pressure data were collected to correct stream level data for atmospheric pressure influences. Average site pressure over the deployment period was measured to be 746 mmHg at site EFCR2, 744 mmHg at site HC2, and 741 mmHg at site LDC2. Station pressure averages reflect elevation differences between streams.

4.2.7. Light Intensity

Continuous light intensity data were collected at both the stationary and roving sites. Light meters were placed within the stream channel at each sampling location and at one location (per stream) in the adjacent floodplain (open-field). Differences (relative intensity) between open-field and stream channel measurements represent shading from channel incision and riparian vegetation.

Median relative intensity ranged from 18% at sites LDC1 and LDC2 to 66% at site EFCR1 (Table 10). Maximum relative intensity during the study period occurred at site HC3 (85%) while the minimum was measured at site LDC1 (3%). Overall, East Fork Crooked River was least shaded and Little Drywood Creek was most shaded.

TABLE 10. Daily Average Relative Light Intensity (Stream Intensity/Open Field Intensity) Collected at Stationary and Roving Sondes During 2007 Summer Deployment Period (7/18/2007 – 9/4/2007).

Site	Median	Maximum	Minimum
EFCR1	66%	82%	35%
EFCR2	23%	44%	10%
LDC1	18%	26%	3%
LDC2	18%	61%	10%
LDC3	56%	82%	6%
LDC4	37%	47%	22%
LDC5	19%	32%	15%
HC1	26%	53%	16%
HC2	30%	65%	5%
HC3	62%	85%	16%

4.3. Reference Stream Discrete Data

Discrete water quality measurements were collected in AERDOR streams and their tributaries (Table 4, Table 5) between July 18, 2007 and November 9, 2007. Discrete data summaries are provided by parameter in the following sections.

4.3.1 Phosphorus

During the 2007 study season, site LDC2 had the lowest median (0.057 mg/L) total phosphorus (TP) concentration, followed by site EFCR2 (0.120 mg/L) and HC2 (0.151 mg/L). All samples (Figure 16) exceeded the regional TP benchmark suggested by EPA nutrient criteria guidance (EPA 2000a). In addition to benchmarks set forth in national guidance, the Regional Technical Assistance Group (RTAG) for EPA Region 7 identified a TP benchmark of 0.075 mg/L (G. Welker pers. comm.). On a median basis, both sites EFCR2 and HC2 exceeded the Region 7 RTAG benchmark but site LDC2 did not.

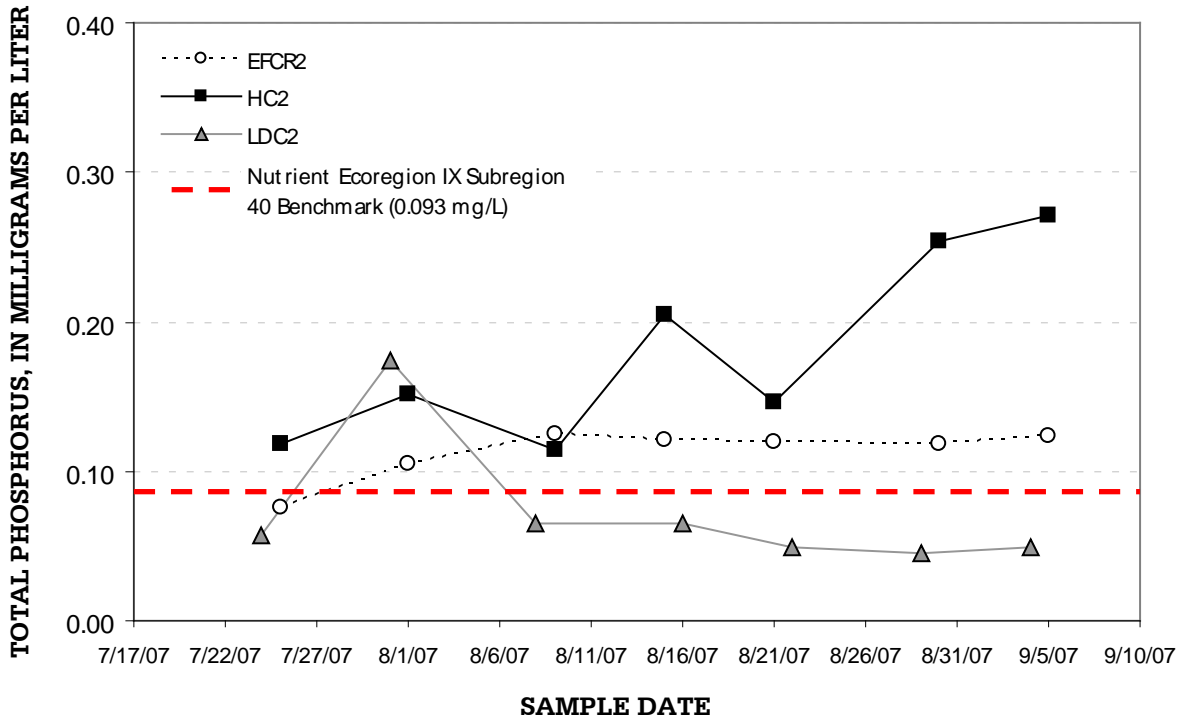


FIGURE 16. Total Phosphorus Concentrations in Relation to 25th Percentile Nutrient Ecoregion IX Subregion 40 Benchmark. Data Collected in AERDOR Reference Streams from 7/23/2007 to 9/5/2007 (n = 7 samples per stream).

4.3.2 Nitrogen

The highest median total nitrogen (TN) concentration was measured at site EFCR2 (0.884 mg/L), followed by sites LDC2 (0.670 mg/L) and HC2 (0.598 mg/L). All samples collected at site EFCR2 exceeded the regional TN benchmark suggested by EPA (2000a) whereas only three samples at both LDC2 and HC2 were above this threshold (Figure 17). The TN measured at site LDC2 on 7/31/07 was collected during a runoff period and does not reflect TN concentrations during baseflow conditions.

The EPA Region 7 RTAG has identified a TN benchmark of 0.9 mg/L (G. Welker pers. comm.). On a median basis, all sites were below the Region 7 RTAG benchmark for TN. Only 4 (19%) of all TN samples collected exceeded the RTAG TN benchmark.

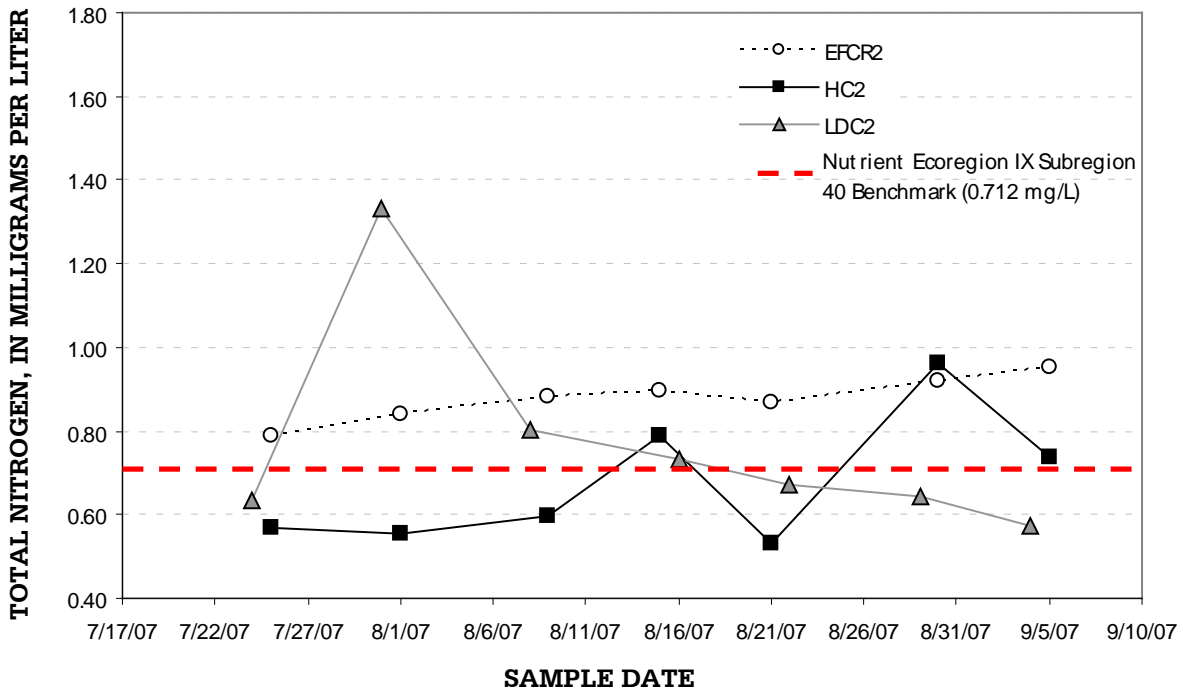


FIGURE 17. Total Nitrogen Concentrations in Relation to 25th Percentile Nutrient Ecoregion IX Subregion 40 Benchmark. Data Collected in AERDOR Reference Streams from 7/23/2007 to 9/5/2007 (n = 7 samples per stream).

Median nitrite plus nitrate nitrogen (NO₂+NO₃N) concentrations at sites EFCR2, HC2, and LDC2 were 0.13 mg/L, 0.08 mg/L, and 0.06 mg/L, respectively. Eight out of twenty-one samples were above the suggested 25th percentile nutrient benchmark (EPA 2000a). The maximum NO₂+NO₃N concentration measured (0.39 mg/L at site LDC2) was collected during a runoff period and was substantially higher than the greatest baseflow value (0.39 mg/L vs. 0.15 mg/L) at the same site (Figure 18).

Total ammonia nitrogen (NH₃N) concentrations were low at all sites. Median concentrations were at or below 0.05 mg/L at all sites and 62% of the samples were below the detection limit (0.02 mg/L). All samples were below applicable chronic and acute aquatic life criteria (Carnahan 2006). Eutrophication-based NH₃N benchmarks have not been established by EPA or the MDNR.

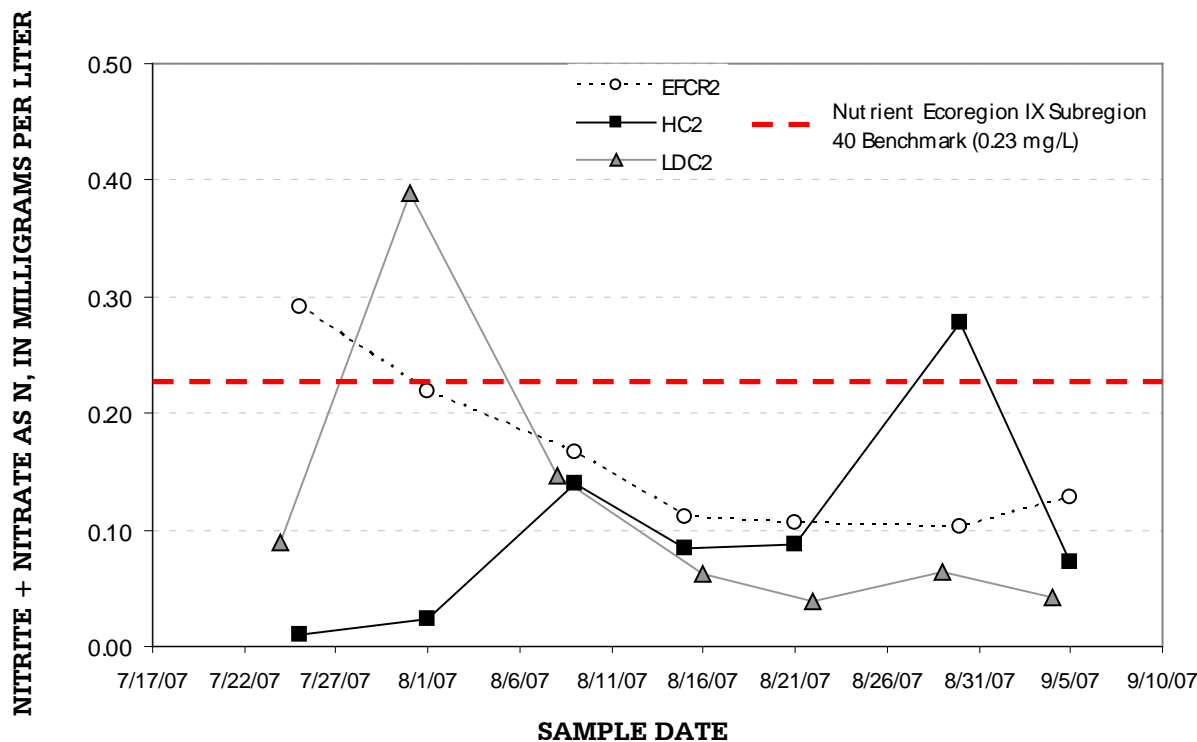


FIGURE 18. Nitrite Plus Nitrate (As N) Concentrations in Relation to 25th Percentile Nutrient Ecoregion IX Subregion 40 Benchmark. Data Collected in AERDOR Reference Streams from 7/23/2007 to 9/5/2007 (n = 7 samples per stream).

4.3.3. Chlorophyll-a

Suspended chlorophyll-a (S-Chla) concentrations at sites EFCR2 and LDC2 were generally near (Figure 19) EPA's suggested benchmarks (2000a) but were high at site HC2. Median S-Chla concentrations for sites EFCR2, LDC2, and HC2 were 3 ug/L, 4 ug/L, and 15 ug/L, respectively. The EPA Region 7 RTAG has identified a S-Chla benchmark of 8 ug/L (G. Welker pers. comm.). On a median basis, only site HC2 exceeded this benchmark.

Median benthic chlorophyll-a (P-Chla) concentrations at sites EFCR2, LDC2, and HC2 were 3, 3, and 60 mg Chla/m², respectively. Suggested P-Chla criteria are not available for Nutrient Ecoregion 40; however, EPA suggests a value of 20.35 mg Chla/m² for the aggregate Ecoregion IX streams (2000a). Region 7 RTAG has identified a P-Chla benchmark of 40 mg Chla/m² for use in Nebraska, Iowa, Kansas, and Missouri. Like S-Chla, median P-Chla was generally below the eutrophication benchmarks at sites EFCR2 and LDC2 but not at site HC2 (Figure 20). Six of the seven samples at site HC2 were above the RTAG benchmark.

Percent bottom coverage of periphyton was observed at or below 20% of total substrate area at most sites during single-day surveys conducted in late summer. Little Drywood Creek and East Fork Crooked River lacked favorable periphyton attachment substrate (<10%) while up to 100% (site HC2) of streambed area in Heaths Creek was conducive to benthic algal growth.

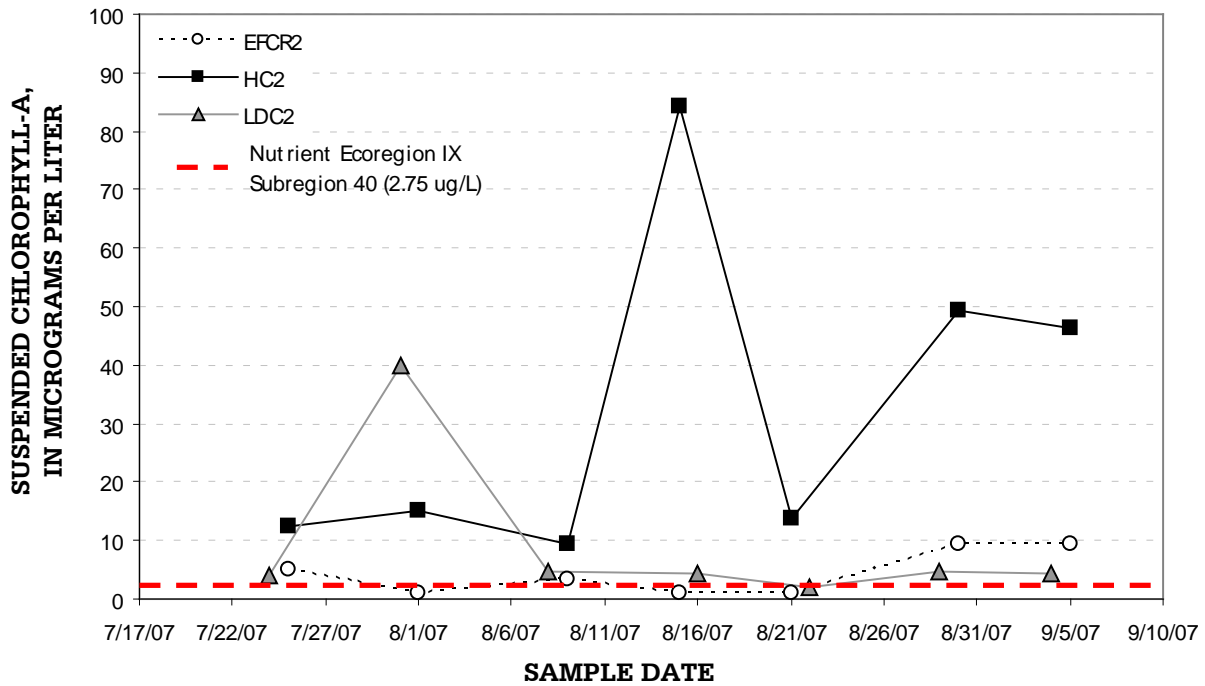


FIGURE 19. Suspended Chlorophyll-a Concentrations in Relation to Nutrient Ecoregion IX Subregion 40 Benchmark. Data Collected in AERDOR Reference Streams from 7/23/2007 to 9/5/2007 (n = 7 samples per stream). Non-Detect Values Reported as One-Half Detection Limit for Graphing Purposes.

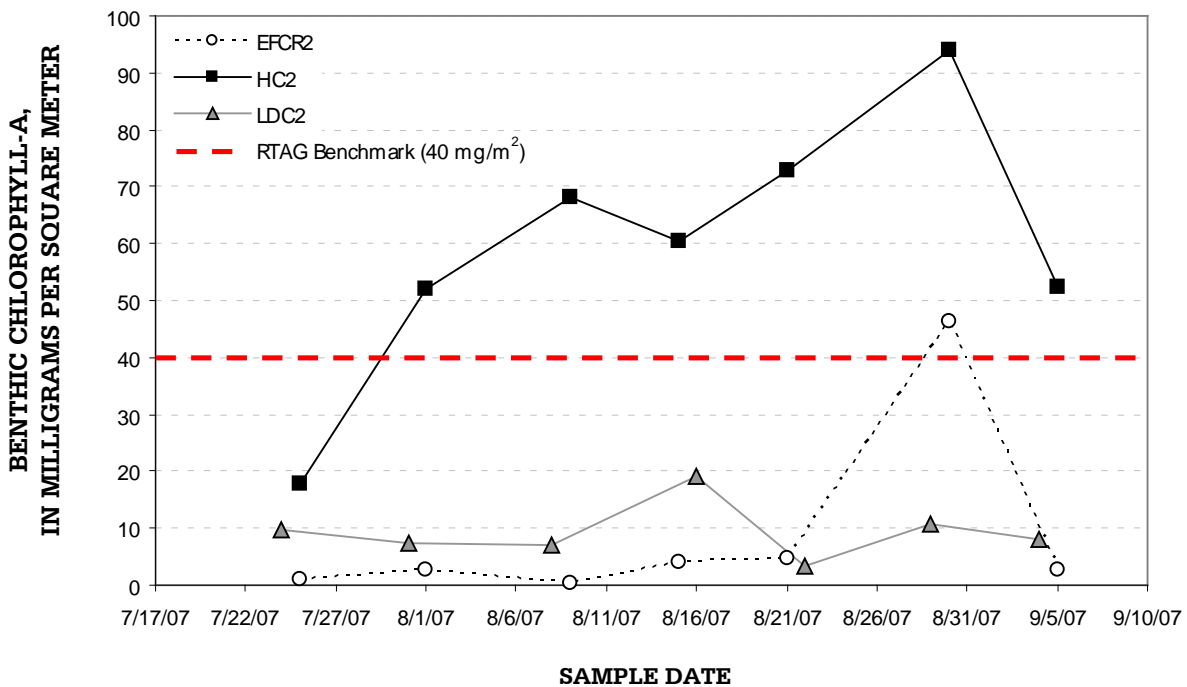


FIGURE 20. Benthic Chlorophyll-a in Relation to USEPA Region 7 Regional Technical Assistance Group Benchmark. Data Collected in AERDOR Reference Streams from 7/23/2007 to 9/5/2007 (n = 7 samples per stream).

4.3.4. Solids

Overall, solids concentrations were higher at site EFCR2 than at site HC2 or LDC2 (Table 11). Median total suspended solids (TSS) ranged from 4 mg/L at site LDC2 to 21 mg/L at site EFCR2. Total suspended solids were generally composed of greater than 50% (Table 11) non-volatile suspended solids (NVSS). Detectable levels (> 4 mg/L) of volatile suspended solids (VSS) were observed at all sites however on a median basis, only site EFCR2 exceeded 4 mg/L (Table 11).

TABLE 11. Total, Volatile, and Non-Volatile Suspended Solids Data Collected in AERDOR Reference Streams from 7/23/2007 to 9/5/2007 (n = 7 samples per stream).

Monitoring Site (ID)	Median Total Suspended Solids (mg/L)	Median Volatile Suspended Solids (mg/L)	Non-Volatile Suspended Solids (TSS-VSS)
EFCR2	21	5	16
HC2	8	< 4	6
LDC2	4	< 4	< 4

4.3.5 Oxygen Demand

Water column carbonaceous biochemical oxygen demand was measured as an unfiltered twenty-day nitrification-inhibited measurement (CBOD-20). Median CBOD-20 values at sites EFCR2, HC2, and LDC2 were 2 mg/L, 4 mg/L, and 3 mg/L, respectively. Ultimate nitrogenous BOD (NBODU) was estimated by multiplying observed ammonia plus estimated organic nitrogen by a 4.57 stoichiometric conversion (Chapra 1997). CBOD-20 and NBODU data were summed to represent Total Biochemical Oxygen Demand (TBODU). Mean TBODU concentrations at sites EFCR2, HC2, and LDC2 were 6 mg/L, 7 mg/L, and 6 mg/L, respectively.

Average percent bottom coverage of sediment oxygen (SOD) demand ranged widely at the sampling sites at sites. Maximum SOD bottom coverages were observed in East Fork Crooked River (up to 100% at both sites) while levels in Heaths Creek were lowest (<5% at site HC2). Average SOD coverage was between 20 and 65% at Little Drywood Creek.

4.3.6. Hydrogeometry

Average stream widths ranged from 12.1 to 42.5 ft in the monitored reaches (Table 12). Mean depth was less than 1.0 ft at 70% of the reaches with site LDC4 having the greatest average depth (3.05 ft).

4.4 Tributary Discrete Data

Site LDC6 had the highest median early morning DO (4.8 mg/L) while site HC4 (1.8 mg/L) experienced the lowest (Table 13). Early morning temperature, specific conductance, and pH values measured in reference reach tributaries are generally typical of summer conditions (Table 14).

TABLE 12. Summary of Hydrogeometry Measurements Collected in AERDOR Reference Streams from 9/4/2007 to 9/5/2007.

Site (ID)	Date (m/d/yy)	Mean Width (feet)	Mean X-Sectional Area (feet ²)	Mean Depth (feet)	Transects/Reach (n)
EFCR1	9/5/07	18.0	19.6	0.92	9
EFCR2	9/5/07	12.1	9.9	0.69	9
HC1	9/5/07	28.4	15.8	0.45	9
HC2	9/5/07	27.0	24.8	0.41	9
HC3	9/5/07	29.9	80.9	1.83	9
LDC1	9/4/07	15.3	5.2	0.25	9
LDC2	9/4/07	21.9	19.2	0.75	8
LDC3	9/4/07	17.6	12.6	0.63	9
LDC4	9/4/07	42.5	76.4	3.05	2
LDC5	9/4/07	32.1	52.7	1.49	8

TABLE 13. Median Early Morning Dissolved Oxygen Concentration and Percent Saturation Collected in Reference Stream Tributaries During the 2007 Study Season.

Site	Tributary	Median Dissolved Oxygen (mg/L)	Median Percent Saturation (%)	Sample Number
HC4	Greer Br.	1.8	22.2	3
HC5	Long Grove Br.	2.8	33.0	3
HC6	Pointer Br.	4.2	47.2	4
HC7	Marlin Br.	4.5	50.1	4
LDC6	Pleasant Cr.	4.8	57.0	3
LDC7	Pleasant Cr.	3.7	44.9	3

TABLE 14. Median Temperature, Specific Conductance, and pH Values Collected in AERDOR Reference Stream Tributaries during the 2007 Study Season.

Site	Tributary	Median Temperature (°C)	Median Specific Conductance (uS cm ⁻¹)	Median pH (SU)
HC4	Greer Br.	22.2	466	7.6
HC5	Long Grove Br.	22.8	441	7.5
HC6	Pointer Br.	20.9	454	7.6
HC7	Marlin Br.	20.6	495	7.5
LDC6	Pleasant Cr.	23.0	252	6.9
LDC7	Pleasant Cr.	22.8	257	7.0

4.5. Stream Metabolism Rates for 2007 Study Season

Observed oxygen reaeration rates (adjusted to 20°C) ranged from 0.3 day⁻¹ to 3.0 day⁻¹ at the study sites (Appendix G). On a median basis, site HC2 exhibited the highest reaeration and site EFCR2 the lowest (Table 15). Median photosynthesis to respiration (P:R) ratios suggest that sites HC2 and LDC2 were heterotrophic (<1.0). Data indicate that site EFCR2 may be slightly autotrophic (Table 15).

TABLE 15. Median Oxygen Reaeration, Community Photosynthesis, and Community Respiration Rates Observed in 2007 Study Season. All rates are adjusted to 20° Celsius.

Metabolism Parameter	Site HC2	Site LDC2	Site EFCR2
Oxygen Reaeration (day ⁻¹)	2.0	1.6	0.5
Community Photosynthesis (mg O ₂ L ⁻¹ day ⁻¹)	5.0	1.3	3.5
Community Respiration (mg O ₂ L ⁻¹ day ⁻¹)	9.3	10.3	3.0
P:R Ratio	0.5	0.1	1.1

Modeling results indicate that SOD was a major DO sink (Figure 21) that accounted for between 35% and 93% of total community respiration at the three monitoring sites (Figure 21). Algal respiration and BOD were considerable sinks at site HC2 but were minimal at sites EFCR2 and LDC2 (Figure 21).

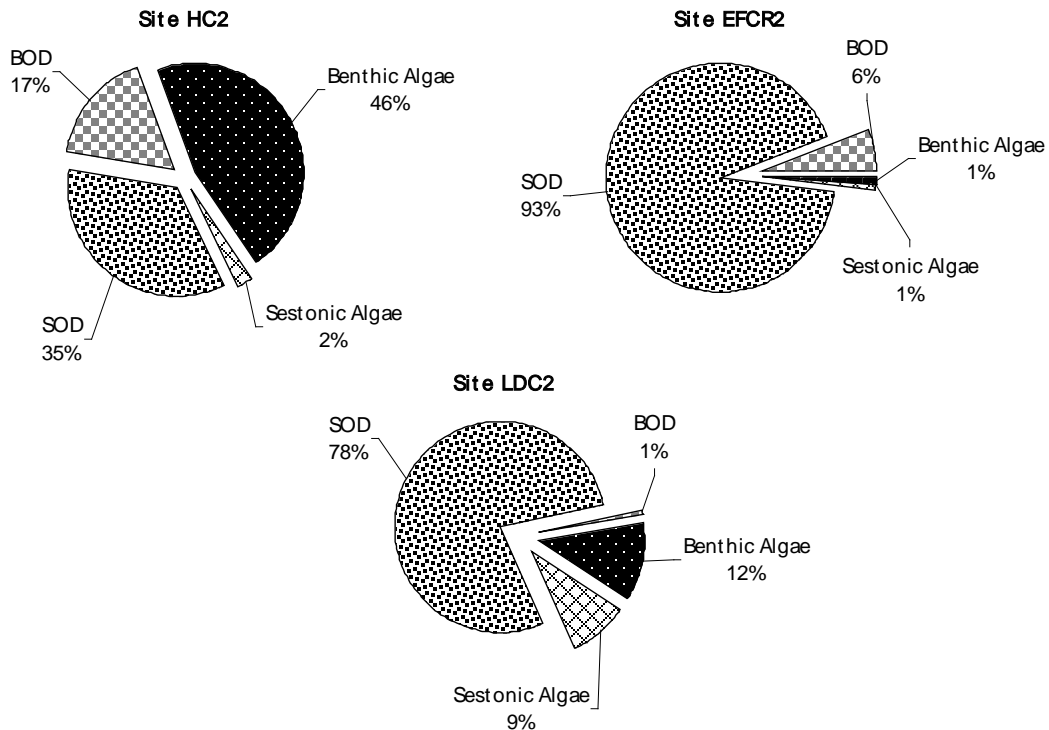


FIGURE 21. Calibrated Respiration Components for Stationary AERDOR Monitoring Sites Where Discrete Water Quality Data Were Collected.

4.6. Dissolved Oxygen Correlations for 2007 Study Season

Spearman Rank correlations and regression analyses were conducted to assess relationships between DO and chemical, physical, and environmental factors outlined in Section 3.2. Only those sites (EFCR2, LDC2, and HC2) at which hydrogeometry, water chemistry, and continuous data were collected were analyzed. Analyses were conducted on data from each site individually and on data pooled across sites.

Results indicate that depth and discharge were significantly ($p \leq 0.10$) correlated to daily average and minimum DO at sites EFCR2 and LDC2 (Tables 16 and 17). At site HC2, mean hydraulic depth and discharge were positively related to DO but relationships were not significant (Tables 16 and 17). When data were pooled across sites depth was not significantly related to either measure of DO and, unlike individual stream correlations, was negatively correlated. Lack of significant or positive correlations in the pooled data suggests individual streams exhibit unique relationships between depth and DO that cannot be generalized across streams or regions.

Mean daily discharge was significantly (and positively) correlated with both measures of DO at sites EFCR2 and LDC2 but not at site HC2 (Tables 16 and 17). Lack of significant correlation between discharge and DO at site HC2 may be due to inexact discharge estimates rather than absence of a relationship.¹ Nevertheless, significant, positive correlations were apparent in pooled data (Tables 16 and 17); suggesting that discharge may affect DO similarly across regions.

TABLE 16. Spearman Rank Correlation Analysis Results for Daily Average Dissolved Oxygen Data. Rho values in parentheses indicate significant relationship ($p \leq 0.10$).

Category	Predictor Variable (Daily Average)	Daily Average Dissolved Oxygen							
		EFCR2		LDC2		HC2		All Sites	
		rho	n	rho	n	rho	n	rho	n
Chemical	TP	-0.414	7	0.413	7	-0.018	7	0.311	21
	TN	-0.393	7	0.450	7	0.036	7	-0.224	21
	NO3	(0.847)	7	(0.835)	7	-0.324	7	0.085	21
	NH3	0.198	7	0.412	7	0.664	6	0.022	20
	P-Chl	0.337	7	-0.627	7	-0.182	7	(0.477)	21
	S-Chl	-0.667	7	-0.191	7	0.270	7	0.168	21
Physical	Temperature	-0.175	49	-0.152	47	-0.145	47	-0.066	143
	Hydraulic Depth	(0.705)	49	(0.834)	43	0.185	38	-0.128	130
	Discharge	(0.696)	49	(0.832)	43	0.164	38	(0.451)	130
Environ.	Light Intensity	0.250	49	(-0.291)	47	(0.431)	48	(0.260)	144
	Watershed Area*	----	----	----	----	----	----	(-0.503)	20
	Land Use*	No significant relationships (n=10)							

*Includes data from both stationary and roving monitoring sites.

¹ Mean daily discharge estimates were calculated from rating curves fit to observed flow data (see Section 4.2.4.). Observed flow values used to develop the rating curve (see Figure 13) for site HC2 exhibited significantly more variation than the other sites and may have introduced error into final discharge estimates. Further refinement of the level-discharge relationship is needed at site HC2.

Nitrate and P-Chl were the only chemical parameters that exhibited a significant relationship with DO however the relationships were not consistent across datasets for either parameter. Two environmental parameters, light intensity and watershed area, were significantly correlated with both measures of DO (Tables 16 and 17).

The overall relationship between light intensity and DO was not clear as the two variables were inversely related at site LDC2 but positively related at site HC2 and in the pooled data. The inverse relationship at site LDC2 is uncommon since increasing light availability generally stimulates algal production, thereby raising average DO (Hill 1996). The inverse relationship may have been caused by photoinhibition (light hinders photosynthetic activity instead of stimulating it) although the occurrence is rare in nature (Hill 1996).

TABLE 17. Spearman Rank Correlation Analysis Results for Daily Minimum Dissolved Oxygen Data. Rho values in parentheses indicate significant relationship ($p \leq 0.10$).

Category	Predictor Variable (Daily Average)	Daily Minimum Dissolved Oxygen							
		EFCR2		LDC2		HC2		All Sites	
		rho	n	rho	n	rho	n	rho	n
Chemical	TP	-0.450	7	0.764	7	-0.25	7	0.292	21
	TN	-0.464	7	0.607	7	-0.179	7	-0.209	21
	NO3	(0.847)	7	(0.946)	7	-0.107	7	0.162	21
	NH3	0.252	7	0.408	7	0.655	6	0.038	20
	P-Chl	0.337	7	-0.685	7	0.054	7	(0.457)	21
	S-Chl	-0.631	7	0.000	7	-0.107	7	0.119	21
Physical	Temperature	(-0.305)	49	-0.024	47	-0.006	47	-0.107	143
	Hydraulic Depth	(0.700)	49	(0.770)	43	0.243	38	-0.048	130
	Discharge	(0.696)	49	(0.774)	43	0.224	38	(0.497)	130
Environ.	Light Intensity	0.278	49	(-0.386)	47	(0.318)	48	(0.208)	144
	Watershed Area*	----	----	----	----	----	----	(-0.635)	20
	Land Use*	No significant relationships (n=10)							

*Includes data from both stationary and roving monitoring sites.

Watershed area was inversely correlated ($p \leq 0.10$) to average and minimum DO (Tables 16 and 17) which suggest that as watershed area increases, daily average and minimum DO decrease. This inverse relationship seems to contradict the apparent positive relationship between DO and discharge. It is well-known that stream discharge increases with watershed area; therefore, DO would be expected to increase as well.

It is important to note that in order to have sufficient data points for the analysis, data from all monitoring sites (stationary and roving) were included in the DO:watershed area correlations. Small DO sample sizes (Table 7) and large watershed areas at the roving sites (specifically site LDC5) may have caused the inverse correlation observed in the data. Therefore, it is unclear whether the relationship is ecologically relevant. More data are needed to more fully describe the DO:watershed area relationships in AERDOR streams.