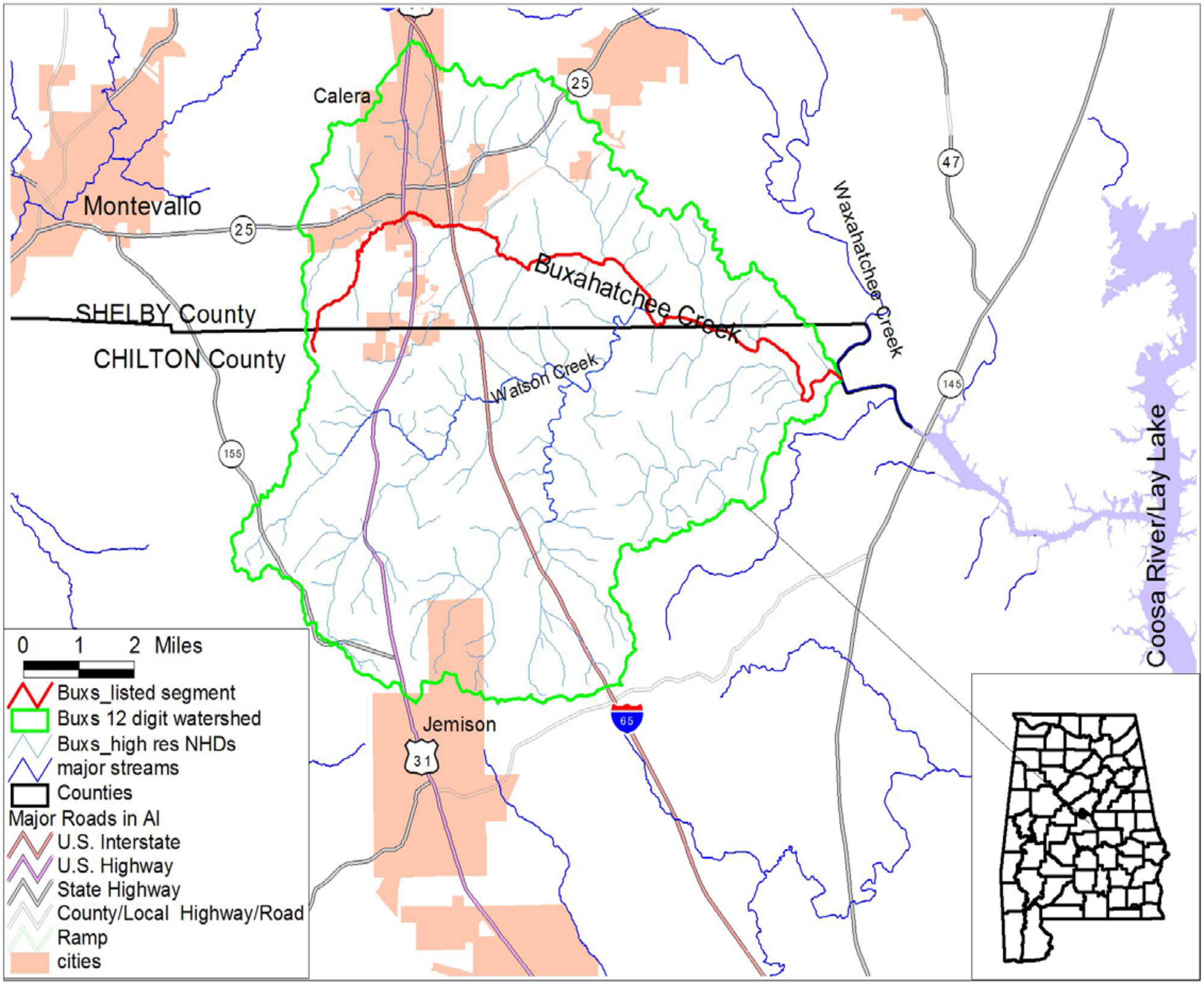
FINAL REVISED
Total Maximum Daily Load
Nutrients

Buxahatchee Creek
AL03150107-0502-100
Nutrients

Revision 1.0

Alabama Department of Environmental Management
Water Quality Branch
Water Division
February 2009

Figure 1.1: Map of Buxahatchee Creek Watershed



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1.0 Executive Summary

The Alabama Department of Environmental Management (ADEM) has identified Buxahatchee Creek of the Lower Coosa River Basin as being impaired for nutrients. Buxahatchee Creek, a tributary of Waxahatchee Creek, which eventually discharges to Lay Lake of the Coosa River, was originally listed on Alabama's 303(d) list in 1992, 1994, and 1996 for nutrients and organic enrichment/dissolved oxygen (OE/DO). The original listing was based on data provided by ADEM's 1988 and 1991 Clean Water Strategy (CWS) Reports.

In 1996, ADEM completed a Total Maximum Daily Load (TMDL) which addressed the organic enrichment/dissolved oxygen impairment within Buxahatchee Creek and the OE/DO TMDL was subsequently approved by the Environmental Protection Agency (EPA) in 1997. In March of 2008, ADEM completed and EPA approved a TMDL which addressed the nutrient impairments on Buxahatchee Creek. The approved nutrient TMDL included both total nitrogen (TN) and total phosphorus (TP) reductions to meet applicable water quality criteria. At that time, the TN reductions were included in the TMDL as a conservative measure to protect the downstream impairments in Lay Lake of the Coosa River.

The purpose of this TMDL Report is to document the findings of ADEM regarding the Buxahatchee Creek Nutrient TMDL. Thus, ADEM is revising the subject Buxahatchee Creek Nutrient TMDL based on additional modeling and data analysis which demonstrates that TP is the only nutrient parameter of concern and that TN reductions required in the previous TMDL are not necessary to protect existing uses of Buxahatchee Creek, as well as, the downstream uses of Lay Lake.

A map of the Buxahatchee Creek watershed can be found in Figure 1.1. The 303(d) listing details for Buxahatchee Creek are shown below:

Waterbody ID	Waterbody Name	Counties	Uses	Causes	Sources	Size	Support Status
AL/03150107-0502-100	Buxahatchee Creek	Shelby and Chilton	Fish and Wildlife (F&W)	Nutrients	Municipal and Urban Run-off	14 miles	Non

The pollutant of concern for the impaired segment is nutrients. Nutrients are of concern due to their ability to promote nuisance algal growth, which in turn affects the dissolved oxygen balance through photosynthesis, respiration, and the regeneration of organic materials. Normally, ADEM only targets total phosphorus (TP) as the nutrient of concern for a stream that is effluent-dominated such as Buxahatchee Creek. However, a nutrient TMDL was approved for Buxahatchee Creek which included total nitrogen (TN) to address downstream nutrient impairments in Lay Lake of the Coosa River. This was done prior to the completion of nutrient modeling analysis of the Coosa River Lakes (i.e. Lay Lake). Based on recent modeling conducted for the Coosa River Reservoirs, it has been determined that reductions in total phosphorus, without concurrent reductions in nitrogen, will result in the attainment of the Lay Lake chlorophyll *a* target. More specifically, the Lay Lake TMDL model was run with a reduction in TN that would meet the reduction required by the approved TMDL for Buxahatchee Creek. Results of the modeling analysis predict that the proposed TN reductions from the Buxahatchee Creek watershed would have a negligible effect on chlorophyll *a* concentrations in the Waxahatchee Creek embayment. Potential impacts of nitrogen downstream from these reservoirs were also considered as part of the Coosa Lakes TMDL analysis. Based on extensive water quality modeling and readily available data and information, there are no known nutrient or nutrient-related impairments downstream from the Coosa River reservoirs. Therefore, the Buxahatchee Creek Nutrient TMDL is being revised to reflect the Department's findings that total phosphorus is the only nutrient of concern that needs to be reduced in order to meet applicable water quality criteria, to include protecting the downstream uses.

Establishing a TP target that fully supports the designated uses of Buxahatchee Creek is part of the lengthy and complex process of TMDL development. The nutrient target was developed using a "reference condition" approach. The TP target concentration utilized for the Buxahatchee Creek TMDL was calculated to be 0.066 mg/l.

The TMDL results for the Buxahatchee Creek Nutrient TMDL are shown below:

	Existing loads		**Allowable loads**		**Reductions**	
Pollutant	**WLA**	**LA**	**WLA**	**LA**	**WLA***	**LA**
TP (lbs/day)	17.36	0.24	4.79	0.44	95%	0%

TMDL = WLA + LA + MOS*			
Pollutant	**TMDL**	**WLA**	**LA**
TP (lbs/day)	5.23	4.79	0.44

* Implicit MOS

Although there is no TP reduction required for the LA portion of this TMDL based on the method chosen to calculate the Buxahatchee Creek TMDL, there will be a required TP reduction to the Buxahatchee Creek Watershed based on the Lay Lake Nutrient TMDL (ADEM/EPA, 2008). This TMDL replaces the previous Buxahatchee Creek Nutrient TMDL established in March 2008.

2.0 Basis for §303(d) Listing

2.1 Introduction

Section 303(d) of the Clean Water Act (CWA), as amended by the Water Quality Act of 1987, and EPA's Water Quality Planning and Management Regulations [(Title 40 of the Code of Federal Regulations (CFR), Part 130)] require states to identify waterbodies which are not meeting water quality standards applicable to their designated uses and to determine the total maximum daily load (TMDL) for pollutants causing use impairment. The TMDL process establishes the allowable loading of pollutants for a waterbody based on the relationship between pollution sources and in-stream water quality conditions, so that states can establish water-quality based controls to reduce pollution from both point and non-point sources and restore and maintain the quality of their water resources (USEPA, 1991).

The Alabama Department of Environmental Management (ADEM) has identified Buxahatchee Creek of the Lower Coosa River Basin as being impaired for nutrients. Buxahatchee Creek, a tributary of Waxahatchee Creek, which eventually discharges to Lay Lake of the Coosa River, was originally listed on Alabama's 303(d) list in 1992, 1994, and 1996 for nutrients and organic enrichment/dissolved oxygen (OE/DO). The original listing was based on data provided by ADEM's 1988 and 1991 Clean Water Strategy (CWS) Reports.

In 1996, ADEM completed a Total Maximum Daily Load (TMDL) which addressed the organic enrichment/dissolved oxygen impairment within Buxahatchee Creek and the OE/DO TMDL was subsequently approved by the Environmental Protection Agency (EPA) in 1997. In March of 2008, ADEM completed and EPA approved a TMDL which addressed the nutrient impairments on Buxahatchee Creek. The approved nutrient TMDL included both total nitrogen (TN) and total phosphorus (TP) reductions to meet applicable water quality criteria. At that time, the TN reductions were included in the TMDL as a conservative measure to protect the downstream impairments in Lay Lake of the Coosa River.

The purpose of this TMDL Report is to document the findings of ADEM regarding the Buxahatchee Creek Nutrient TMDL. Thus, ADEM is revising the subject Buxahatchee Creek Nutrient TMDL based on additional modeling and data analysis which demonstrates that TP is the only nutrient parameter of concern and that TN reductions required in the previous TMDL are not necessary to protect existing uses of Buxahatchee Creek, as well as, the downstream uses of Lay Lake.

2.2 Problem Definition

Waterbody Impaired:	Buxahatchee Creek from Waxahatchee Creek to its source.
Waterbody length:	14 miles
Waterbody drainage area:	70 square miles
Water Quality Standard Violation:	Narrative criteria (nutrients)
Pollutants of Concern:	Total Phosphorus
Water Use Classification:	Fish and Wildlife

Usage of waters in the Fish and Wildlife category is described as follows in ADEM Admin. Code R. 335-6-10-.09(5) (a), (b), (c), and (d):

(a) Best usage of waters: fishing, propagation of fish, aquatic life, and wildlife, and any other usage except for swimming and water-contact sports or as a source of water supply for drinking or food-processing purposes.

(b) Conditions related to best usage: the waters will be suitable for fish, aquatic life and wildlife propagation. The quality of salt and estuarine waters to which this classification is assigned will also be suitable for the propagation of shrimp and crabs.

(c) Other usage of waters: it is recognized that the waters may be used for incidental water contact and recreation during June through September, except that water contact is strongly discouraged in the vicinity of discharges or other conditions beyond the control of the Department or the Alabama Department of Public Health.

(d) Conditions related to other usage: the waters, under proper sanitary supervision by the controlling health authorities, will meet accepted standards of water quality for outdoor swimming places and will be considered satisfactory for swimming and other whole body water-contact sports.

2.3 Water Quality Criteria

ADEM's decision to list Buxahatchee Creek as being impaired for nutrients was authorized under ADEM's Water Quality Standards Program, which employs both numeric and narrative criteria to ensure adequate protection of designated uses for surface waters of the State. Numeric criteria typically have quantifiable endpoints for given parameters such as pH, dissolved oxygen, or a toxic pollutant, whereas narrative criteria are qualitative statements that establish a set of desired conditions for all State waters.

These narrative criteria are more commonly referred to as "free from" criteria that enable States a regulatory avenue to address pollutants or problems that may be causing or contributing to a use impairment that otherwise cannot be evaluated against any numeric criteria. Typical pollutants that fall under this category are nutrients and siltation. Historically, in the absence of established numeric nutrient criteria, ADEM and/or EPA would use available data and information coupled with best professional judgment to determine overall use support for a given waterbody. Narrative criteria continue to serve as a basis for determining use attainability and subsequently listing/delisting of waters from Alabama's §303(d) List. ADEM's Narrative Criteria are shown in ADEM's Administrative Code 335-6-10-.06 as follows:

335-6-10-.06 **Minimum Conditions Applicable to All State Waters**. *The following minimum conditions are applicable to all State waters, at all places and at all times, regardless of their uses:*

(a) State waters shall be free from substances attributable to sewage, industrial wastes or other wastes that will settle to form bottom deposits which are unsightly, putrescent or interfere directly or indirectly with any classified water use.

(b) State waters shall be free from floating debris, oil, scum, and other floating materials attributable to sewage, industrial wastes or other wastes in amounts sufficient to be unsightly or interfere directly or indirectly with any classified water use.

(c) State waters shall be free from substances attributable to sewage, industrial wastes or other wastes in concentrations or combinations, which are toxic or harmful to human, animal or aquatic life to the extent commensurate with the designated usage of such waters.

3.0 Technical Basis for TMDL Development

3.1 Water Quality Target Identification

ADEM continues its efforts to develop comprehensive numeric nutrient criteria for all surface waters throughout Alabama, including rivers/streams, lakes/reservoirs, wetlands, and coastal/estuarine waters. However, until numeric nutrient criteria or some form of quantitative interpretation of ADEM's narrative criteria are developed, the Department will continue to use all available data and information coupled with best professional judgment to make informed decisions regarding overall use support and establishing targets for TMDLs.

Typically, the development of a water quality criterion for a given pollutant involves extensive research using information from many areas of aquatic toxicology. For example, development of numeric criteria for toxic pollutants, such as mercury, involves numerous toxicological studies such as dose/response relationships, bioaccumulation studies, fate and transport studies, and an understanding of both the acute and chronic effects to aquatic life. As part of the toxicological evaluations, EPA performs uncertainty analysis to help guide selection of the recommended water quality criterion for a given pollutant. For toxic pollutants, the more uncertainty revealed during the evaluation, the more conservative (i.e. the lower the value) the recommended criterion becomes.

Nutrients such as phosphorus and nitrogen are essential elements to aquatic life, but can be undesirable when present at sufficient concentrations to stimulate excessive plant growth. Even though these pollutants are generally considered non-toxic (the exception being un-ionized ammonia toxicity to aquatic life), they can impact aquatic life due to their indirect effects on water quality, either when in overabundance or when availability is limited.

ADEM's water quality criteria applying to nutrients are narrative; therefore, a numerical translator is needed to define the TMDL target. Based on the historical data collected on Buxahatchee Creek, there is evidence that designated uses are impaired by nutrient over-enrichment. However some uncertainty remains in the exact quantification of the nutrient target due to the complexity of the cause and effect relationship and the state of the science. This is a very common dilemma in nutrient water quality management, and often warrants an alternate approach. EPA recommends, in the absence of sufficient "effects-based" information, a reference condition approach for determining protective nutrient criteria. With this approach, a numerical value can be empirically developed that can be assumed to inherently protect uses supported in the reference waters. This approach can provide an initial target while continuing studies will allow further evaluation of the cause and effect relationships that might result in refinement of the initial target.

In developing a nutrient target for the Buxahatchee Creek Nutrient TMDL, ADEM has chosen to use a "reference condition" approach for determining the appropriate levels of nutrients necessary to support designated uses. This approach is based on using ambient water quality data from candidate reference streams that are located in characteristically similar regions of Alabama known as ecoregions. An ecoregion is defined as a relatively homogeneous area defined by similar climate, landform, soil, potential natural vegetation, hydrology and other ecologically relevant variables (USEPA, 2000b). "Reference streams" are defined as waterbodies that have been relatively undisturbed or minimally-impacted that can serve as examples of the natural biological integrity of a particular ecoregion. These "reference streams" can be monitored over time to establish a baseline to which other waters can be compared. Reference streams are not necessarily pristine or undisturbed by humans, however they do represent waters within Alabama that are healthy and fully support their designated uses, to include protection of aquatic life. The reference streams selected for a particular analysis depends primarily on the available number of reference streams and associated data within a particular ecoregion. Therefore, the total number of reference sites selected and the aerial scale (i.e. Ecoregion Level III, Level IV) used to represent a reference condition will often vary on a case-by-case basis. ADEM believes that the "reference condition" approach used to determine appropriate nutrient targets for the Buxahatchee Creek TMDL, is reasonable, scientifically defensible, protective of designated uses, and consistent with USEPA guidance.

Normally, ADEM only targets total phosphorus (TP) as the nutrient of concern for a stream that is effluent-dominated such as Buxahatchee Creek. However, a nutrient TMDL was approved in March of 2008 for Buxahatchee Creek which included total nitrogen (TN) to address downstream nutrient impairments in Lay Lake of the Coosa River. This was done prior to the completion of nutrient modeling analysis of the Coosa River Lakes (i.e. Lay Lake). Based on recent modeling efforts conducted for the Coosa River Reservoirs, it has been determined that reductions in total phosphorus, without concurrent reductions in nitrogen, will result in the attainment of the chlorophyll a target developed for the Lay Lake nutrient TMDL. In addition, the Lay Lake TMDL model was run with the required TN reductions as established in the March 2008 Buxahatchee Creek Nutrient TMDL. Results of the modeling analysis predict that the proposed TN reductions from the Buxahatchee Creek watershed would have a negligible effect on chlorophyll *a* concentrations in the Waxahatchee Creek embayment. Potential impacts of nitrogen downstream from these reservoirs were also considered as part of the Coosa Lakes TMDL analysis. Based on extensive water quality modeling and readily available data and information, there are no known nutrient or nutrient-related impairments downstream from the Coosa River reservoirs. Therefore, the Buxahatchee Creek Nutrient TMDL is being revised to reflect the Department's findings that total phosphorus is the only nutrient of concern that needs to be reduced in order to meet applicable water quality criteria, to include protecting the downstream uses.

In developing and establishing reference conditions from best available data, frequency distributions are recommended by the *Nutrient Criteria Technical Guidance Manual for Rivers and Streams* (USEPA, 2000b) as the preferred method for setting nutrient criteria. ADEM selected to use the 90th percentile of the data distributions from the selected eco-region reference sites to be used in establishing the TP target. The 90th percentile of the data distribution was considered an appropriate target, since it falls within an acceptable range of "least-impacted" conditions (i.e. upper quartile).

If the TP concentrations of the subject impaired stream are relatively the same or below reference condition levels, then the stream is considered not to be impaired for nutrients. If TP concentrations within the impaired stream are shown to be above reference conditions, then other water quality data and information are used in the evaluation. The additional data and information that can be used includes, but is certainly not limited to, diurnal dissolved oxygen readings, algal biomass measurements (periphyton or suspended algae), habitat assessments, and macroinvertebrate and fish community indices.

The Buxahatchee Creek TP target was calculated using a reference condition approach which utilizes data collected from streams that are within the same Level IV Ecoregions. Since Buxahatchee Creek lies within three different Level IV Ecoregions, the Department used a weighted average approach to determine the TP target. This approach consisted of calculating the percentage of total drainage area of Buxahatchee Creek watershed that comprises each of the three Level IV Ecoregions. Then a reference TP target value was calculated for each of the three Level IV Ecoregions using the 90th percentile value of all available TP data collected from selected reference reaches. Ecoreference station data and station location information employed to determine the TP target can be found in Appendix B. A summary of the TP calculations are shown below.

Summary of Calculations for the Total Phosphorus Target Buxahatchee Creek Watershed				
Level IV Ecoregion Name	Ecoregion Ref #	% of Watershed	Level IV Ecoregion TP Value (mg/L)	Weighted Average TP Value (mg/L)
Southern Inner Piedmont	45a	72%	0.066	0.048
Southern Limestone/Dolomite Valleys and Low Rolling Hills	67f	11%	0.053	0.006
Southern Shale Valleys	67g	17%	0.072	0.012
			TP Target =	**0.066**

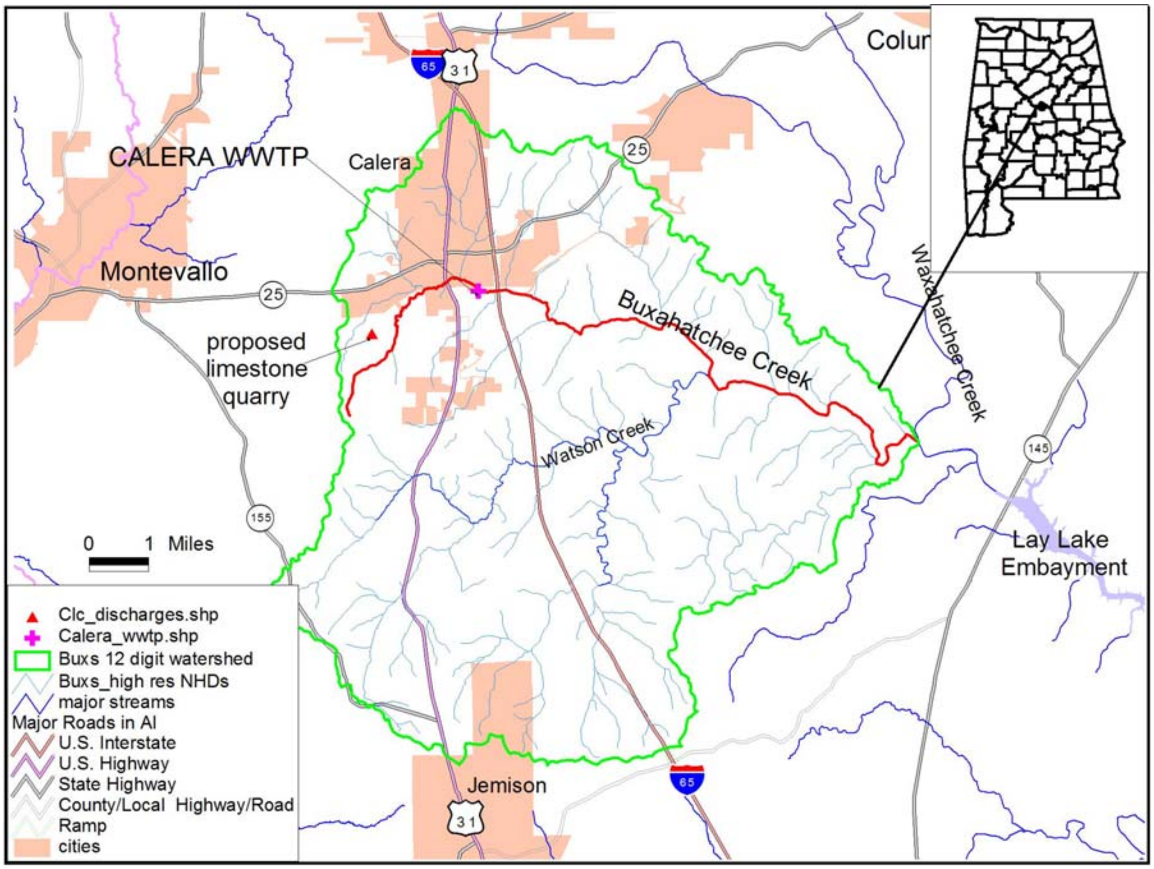
3.2 Source Assessment

Point Sources in the Buxahatchee Creek Watershed:
Point source considerations typically represent discharges from wastewater treatment plants, industrial operations, mining operations, etc. These operations generally result in some type of loading to the receiving stream. These loadings could be temperature, nutrients, organic matter, etc. There is one permitted point source in the Buxahatchee Creek watershed, the Calera Wastewater Treatment Plant (WWTP) and a proposed limestone quarry. The Calera facility's NPDES permit number is AL0050938, and it is currently permitted for a design flow of 1.5 mgd. Water quality data collected above and below the Calera WWTP discharge location indicates the point source is a significant source of nutrients to Buxahatchee Creek.

The WWTP's current permit includes a total phosphorus limit of 7.1 lb/day based upon a monthly average, which equates to 0.57 mg/l.

Buxahatchee Creek is not included in any Municipal Separate Storm Sewer Systems (MS4) area. The location of the point sources is provided in Figure 3.2.1.

Figure 3.2.1: Point Sources in the Buxahatchee Creek Watershed



3.3 Landuse

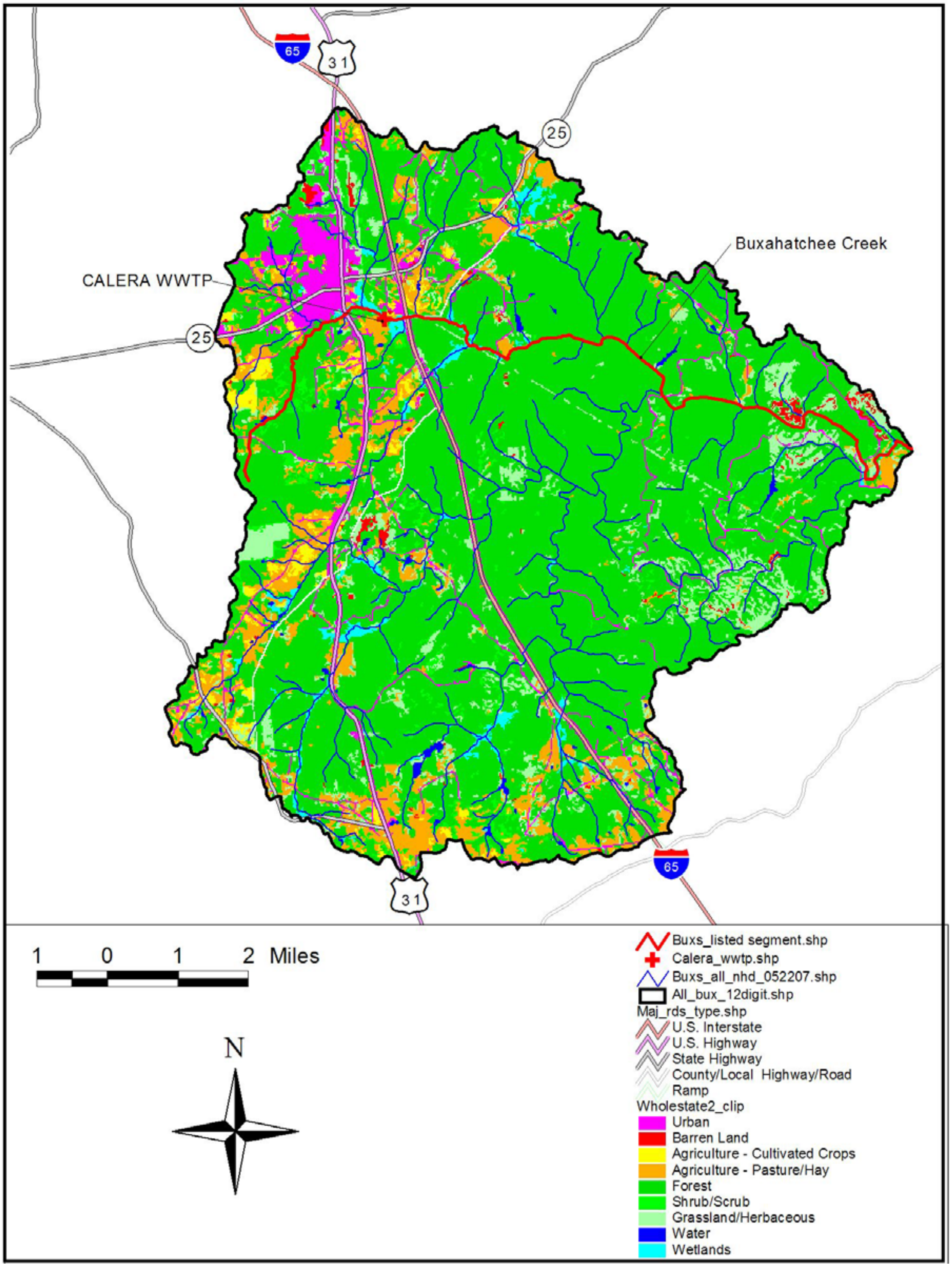
Nonpoint Sources in the Buxahatchee Creek Watershed:
Shown in Table 3.3.1 is a summary of the land usage in the Buxahatchee Creek watershed. The landuse map of the watershed is presented in Figure 3.3.1. The predominate land uses within the watershed are agriculture, forest, and developed lands (National Land Cover Dataset (NLCD), 2001).

Each landuse has the potential to contribute to the nutrient loading in the watershed due to nutrients on the land surface that potentially can be washed off into the receiving waters of the watershed. Possible non-point source contributions of impairment could include failing septic systems, agricultural runoff, and runoff from a local golf course in the watershed just east of I-65.

Table 3.3.1: Landuse in the Buxahatchee Creek Watershed

2001 NLCD name	**Buxahatchee Creek (sq. miles)**	**Buxahatchee Creek (%)**
Unclassified	0.24	0%
Open Water	0.36	1%
Developed Open Space	3.20	4%
Developed Low Intensity	1.32	2%
Developed Medium Intensity	0.28	0%
Developed High Intensity	0.10	0%
Barren Land (Rock/Sand/Clay)	0.49	1%
Deciduous Forest	26.93	38%
Evergreen Forest	19.91	28%
Mixed Forest	3.21	4%
Shrub/Scrub	1.79	3%
Grassland/Herbaceous	5.13	7%
Pasture/Hay	6.31	9%
Cultivated Crops	1.01	1%
Woody Wetlands	1.19	2%
Emergent Herbaceous Wetlands	0.00	0%
total	71.49	100%
Aggregate Landuse	**(sq. miles)**	**(%)**
all developed	4.90	7%
all agricultural	7.31	10%
all forest	50.05	70%
other	9.22	13%
total	71.49	100%

Figure 3.3.1: 2001 Landuse in the Buxahatchee Creek Watershed



3.4 Data Availability and Analysis

Note: All tables and figures discussed in this section can be found at the end of the section after completion of the narrative.

As stated in the introduction of this report, data from the State's Clean Water Strategy (CWS) initiatives of 1988 and 1991 suggested impairment of Buxahatchee Creek due to nutrients. Data was also acquired on the creek during the 1996 CWS initiative.

Additionally, there has been a considerable amount of attention devoted to Buxahatchee Creek since 2000, for nutrient impact assessment. The following discussion will be categorized by agency (i.e., agency collecting the data).

ADEM has collected four data sets which are listed below:

The first set, referred to as 303(d) data, was collected by the agency over about a 1-year time interval from April 2000 through April 2001. There were a total of six sampling stations. Data measured included field parameters, lab parameters, and fish, biological and habitat assessments. Field parameters refer to data measured in the field and include such items as flow, DO, temperature, and pH measurements. Lab parameters refer to samples taken in the field, preserved properly, and transported back to an ADEM lab for analysis. Lab parameters include such items as $CBOD_5$, NH_3-N, TP, NO2 + NO3-N, TKN and chlorophyll-a. Fish, macroinvertebrate and habitat assessments were also performed by ADEM's Field Operations personnel. A fish assessment is also referred to as an Index of Biotic Integrity for Fish (or fish IBI). It is an attempt to measure the health and diversity of the fisheries population in the watershed. The goal of a benthic macroinvertebrate assessment is to measure the health and diversity of the ecological communities that reside in the sediments of a stream (such as mayflies, caddisflies, and stoneflies). Relevant data from these stations can be found in Appendix B.

The second set of ADEM data is from two intensive water quality surveys conducted in the summer of 2000. The first survey was conducted from May 22-26; the second, from July 24-27. Data from the first survey consisted of field parameters, time-of-travel data, and diurnal DO data. Data from the second survey was the same as the first plus included lab parameters. The Calera wastewater treatment plant (WWTP) experienced a major upset during the second study. The cause of the upset was used motor oil from a local industrial facility. Station locations were the same as the 303(d) locations plus included three intermediate stations between BXHS-3 and BXHS-4 (identified as BXHS-3A, B and C). Based on field observations during the studies, BXHS-3A was considered to be the most impacted station in the watershed. Noted impacts include visually-observed high densities of periphyton and macrophytes. Relevant data from the two surveys can be found in Appendix B. This includes diurnal DO data at stations BXHS-2, 3, 3A, 4 and WTNS-1. An inspection of these plots reveals diurnal DO swings as large as 8 mg/L. Large DO swings such as this are indicative of photosynthetic/respiration cycles that occur as a result of excessive nutrient loading.

The third set of data collected by ADEM from Buxahatchee Creek was in 2003 as part of a tributary nutrient loading study to the Coosa River. Monthly data was collected from March – October and can be found in the Appendix (included in 303(d) data table).

Table 3.4.1 gives location descriptions for ADEM's 303(d) stations. Figure 3.4.1 is a map of these stations in the watershed.

The most recent ADEM data collection on Buxahatchee Creek occurred in 2005. Data measured included field and lab parameters (monthly March-October) and biological and habitat assessments including macroinvertebrate and periphyton community assessments. The 2005 monthly lab data is being used to determine Non-Point Source (NPS) load reductions and can be found in Appendix B. It should be noted that during this time period the Calera WWTP was in the process of expanding its design flow from 0.75 mgd to 1.5 mgd. During the expansion, process changes occurred which resulted in increased TP loading from the facility from July through the remaining sampling period. This can be clearly seen in the DMR results for the Calera WWTP. A formal report was written up detailing the results of the biological assessments and is included in Appendix C. The conclusion from the report is shown below.

"Macroinvertebrate assessment results indicated the macroinvertebrate communities above and below the Calera WWTP to be in *poor* condition. The poor conditions at BXHS-2 may be at least partly attributed to low flow and the lack of riffle-run habitat. Results of water quality sampling and periphyton bioassessments conducted during 2005 suggest that nutrient enrichment is also affecting the macroinvertebrate communities at BXHS-3a, and, to a lesser extent, BXHS-4. "

The National Council for Air and Stream Improvement (NCASI), a technical organization funded by the pulp and paper industry, has also collected a considerable amount of data in the watershed over the last five years. The purpose of NCASI's involvement was to demonstrate the degree of resources that would normally be required to perform a TMDL of this nature that can be considered technically sound. NCASI performed three intensive water quality surveys during 2001. The first two were performed under dry conditions in July and August of that year. The third study, performed under wet conditions, took place in December. Table 3.4.2 gives location descriptions for the NCASI stations. Figure 3.4.2 is a map of the stations in the watershed. The relevant NCASI data can be found in Appendix B. This includes diurnal DO data.

In addition to the three studies conducted by NCASI, two more studies were conducted by other agencies. The first of these was a sediment oxygen demand (SOD) study performed by EPA Region 4. The study was conducted the week of September 24, 2001. Table 3.4.3 lists location descriptions for the SOD study while Figure 3.4.3 is a map of the stations. Data from the SOD study can be found in Appendix B.

The second study was performed under contract to NCASI and was conducted by Limno-Tech of Ann Arbor, Michigan. It was a reaeration study done from September 11-13,

2002. Table 3.4.4 lists location descriptions for the reaeration study while Figure 3.4.4 is a map of the stations. Data from the reaeration study can be found in Appendix B.

Any data for Buxahatchee Creek not listed in Appendix B is available upon request.

Table 3.4.1: ADEM Sampling Station Location Descriptions

Station Number	Waterbody Name	County	Location Description	Latitude	Longitude
BXHS-1	Buxahatchee Creek	Shelby	Buxahatchee Creek @ US Hwy 31 in Calera.	33.0958	-86.7527
BXHS-2	Buxahatchee Creek	Shelby	Buxahatchee Creek upstream of the Calera WWTP outfall.	33.0943	-86.7439
BXHS-3	Buxahatchee Creek	Shelby	Buxahatchee Creek 100 feet upstream of the southbound lane of I-65.	33.0937	-86.7384
BXHS-3A	Buxahatchee Creek	Shelby	Buxahatchee Creek at power line crossing approx 0.2 mi downstream of unnamed tributary	33.08583	-86.72083
BXHS-4	Buxahatchee Creek	Shelby	Buxahatchee Creek upstream of Hiawatha Road (Shelby Co. Rd. 161) and Watson Branch.	33.0735	-86.6775
BXHS-5	Buxahatchee Creek	Shelby	Buxahatchee Creek downstream of Hiawatha Road (Shelby Co. Rd. 161) and Watson Branch.	33.07142	-86.67649
WTNS-1	Watson Creek	Shelby	Watson Creek upstream of Hiawatha Rd. (Shelby Co. Rd. 161) and Buxahatchee Creek.	33.0734	-86.6783
CAWW-1	Calera WWTP Outfall	Shelby	Calera WWTP outfall @ Buxahatchee Creek.	33.0941	-86.7444

Table 3.4.2: NCASI Sampling Station Location Descriptions

Station ID	Location Description	Longitude (dec. deg.)	Latitude (dec. deg.)
0B	Buxahatchee Creek at U.S. HWY 31. Same as ADEM station BXHS-1.	-86.75278	33.09553
2T	Mouth of unnamed tributary (UT) to Buxahatchee Creek just east of U.S. Hwy 31.	-86.74859	33.09683
1B	Buxahatchee Creek just upstream of 2T at 9th Street.	-86.74903	33.09641
12E	Calera WWTP effluent. Same as ADEM station CAWW-1.	-86.74538	33.09445
P1	Buxahatchee Creek just upstream of Calera WWTP. Same as ADEM station BXHS-2.	-86.74487	33.09501
P2	Buxahatchee Creek just west of Interstate 65. Same as ADEM station BXHS-3.	-86.73836	33.09364
3T	Mouth of UT draining through the golf course area.	-86.73553	33.09397
4B	Buxahatchee Creek near 3T.	-86.73507	33.0936
5T	Mouth of UT draining from South Calera area.	-86.72396	33.0866
P4	Buxahatchee Creek near 5T.	-86.72352	33.08669
6B	Buxahatchee Creek approximately 1 mile downstream of P4.	-86.71525	33.08359
P5	Buxahatchee Creek approximately 1 mile downstream of 6B.	-86.70799	33.08592
8T	Mouth of UT draining from the Ozan area.	-86.69079	33.08597
7B	Buxahatchee Creek approximately 1/3 mile downstream of 8T.	-86.68682	33.08489
10T	Watson Creek near its mouth. Same as ADEM station WTNS-1.	-86.67804	33.07308
9B	Buxahatchee Creek just upstream of the mouth of Watson Creek. Same as ADEM station BXHS-4.	-86.67765	33.07403
11B	Buxahatchee Creek aproximately two miles upstream of its mouth and not far upstream of Sawyer Cove.	-86.63386	33.06219

Table 3.4.3: EPA SOD Sampling Station Location Descriptions

Station I.D.	Location	GPS Coordinates
9B	Hiawatha Road below confluence of Buxahatchee Creek and Watson Creek	N 33° 04' 22.08" W 086° 40' 38.65"
4B	Timberline Golf Course downstream of golf course pond discharge to Buxahatchee Creek	N 33° 05' 38.20" W 086° 44' 08.52"
2B	Calera Wastewater Treatment Plant downstream of discharge	N 33°05" 37.85" W 086° 44' 37.88"
P1	Calera Wastewater Treatment Plant upstream of discharge	N 33°05'40.55" W 086°44'38.39"

Table 3.4.4: Limno-Tech Reaeration Sampling Station Location Descriptions

Station ID	Location Description	Longitude (dec. deg.)	Latitude (dec. deg.)
INJT1	Injection point of downstream reach	-86.73557	33.09382
SAMP1A	1st sampling point of downstream reach	-86.73478	33.09365
SAMP1B	2nd sampling point of downstream reach	-86.73340	33.09293
INJT2	Injection point of upstream reach	-86.74392	33.09403
SAMP2A	1st sampling point of upstream reach	-86.74352	33.09330
SAMP2B	2nd sampling point of upstream reach	-86.74023	33.09365

Figure 3.4.1: Map of ADEM Sampling Stations

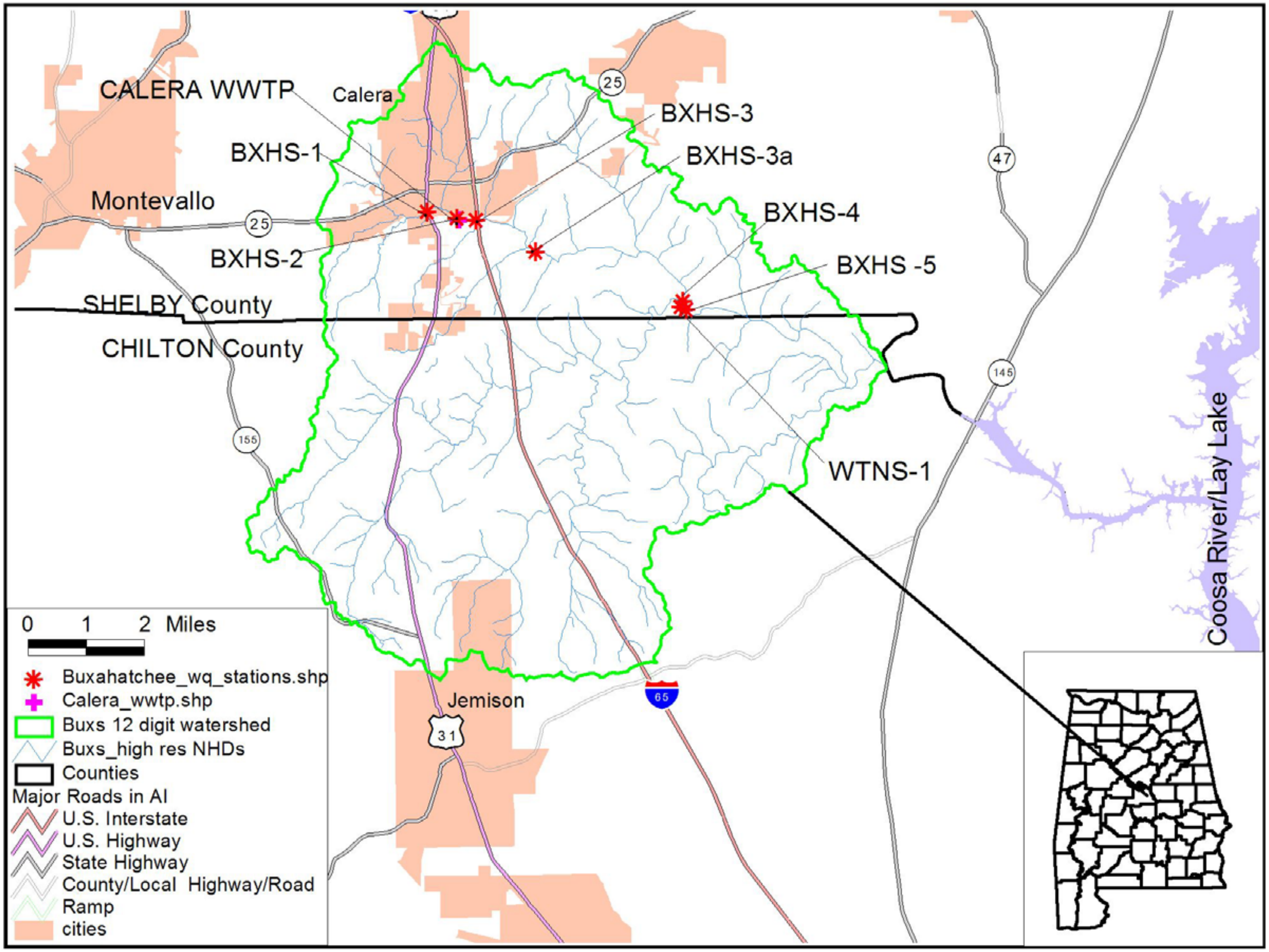


Figure 3.4.2: Map of NCASI Sampling Stations

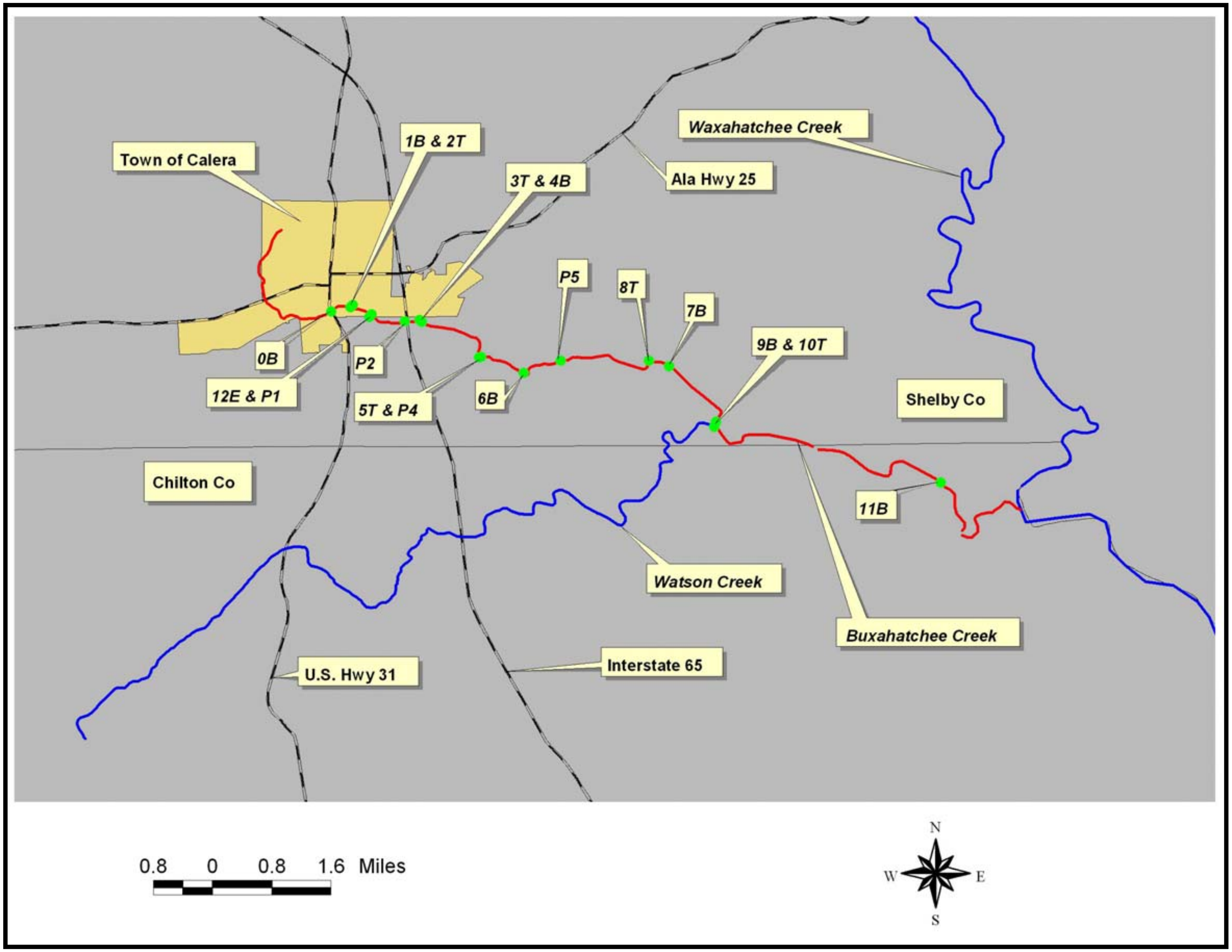


Figure 3.4.3: Map of EPA SOD Sampling Stations

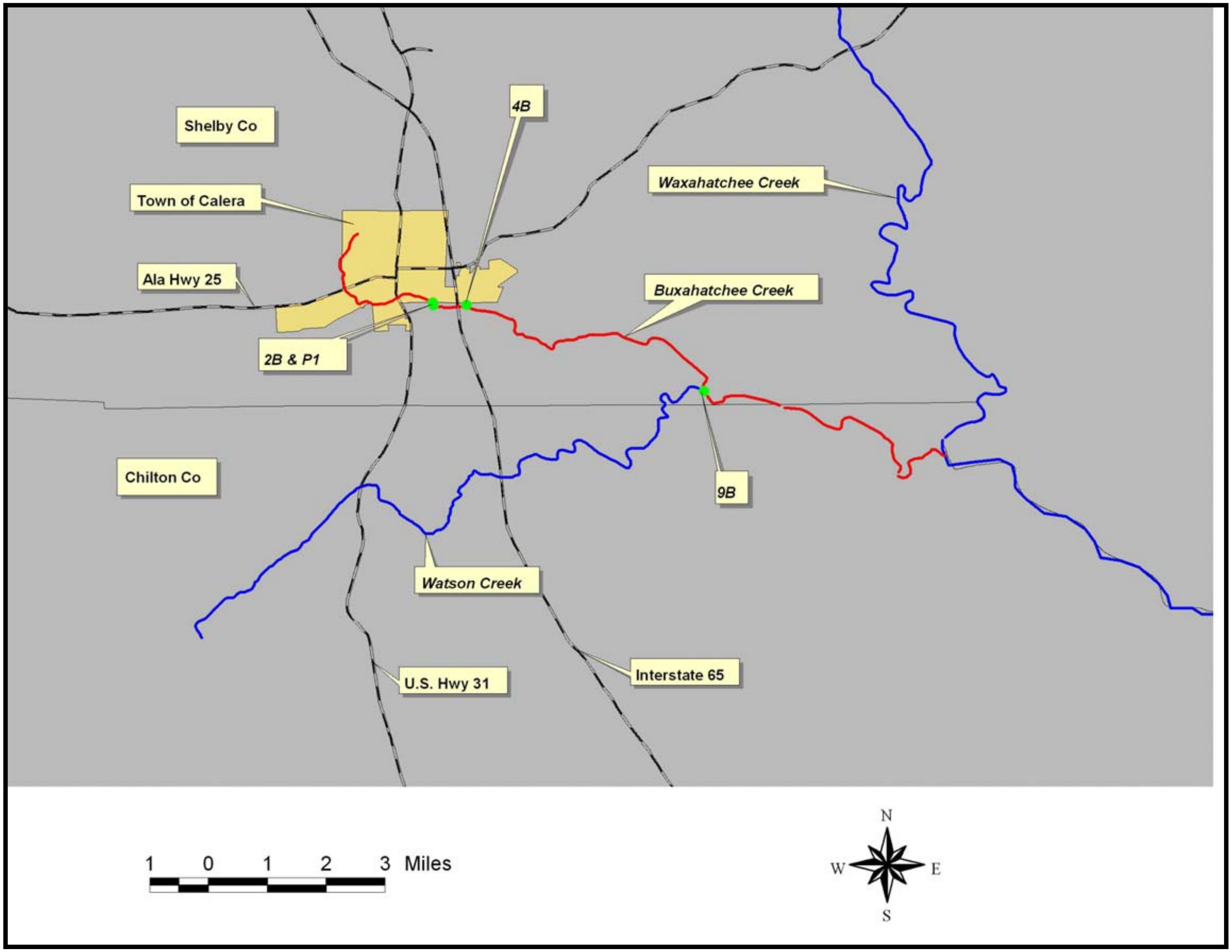
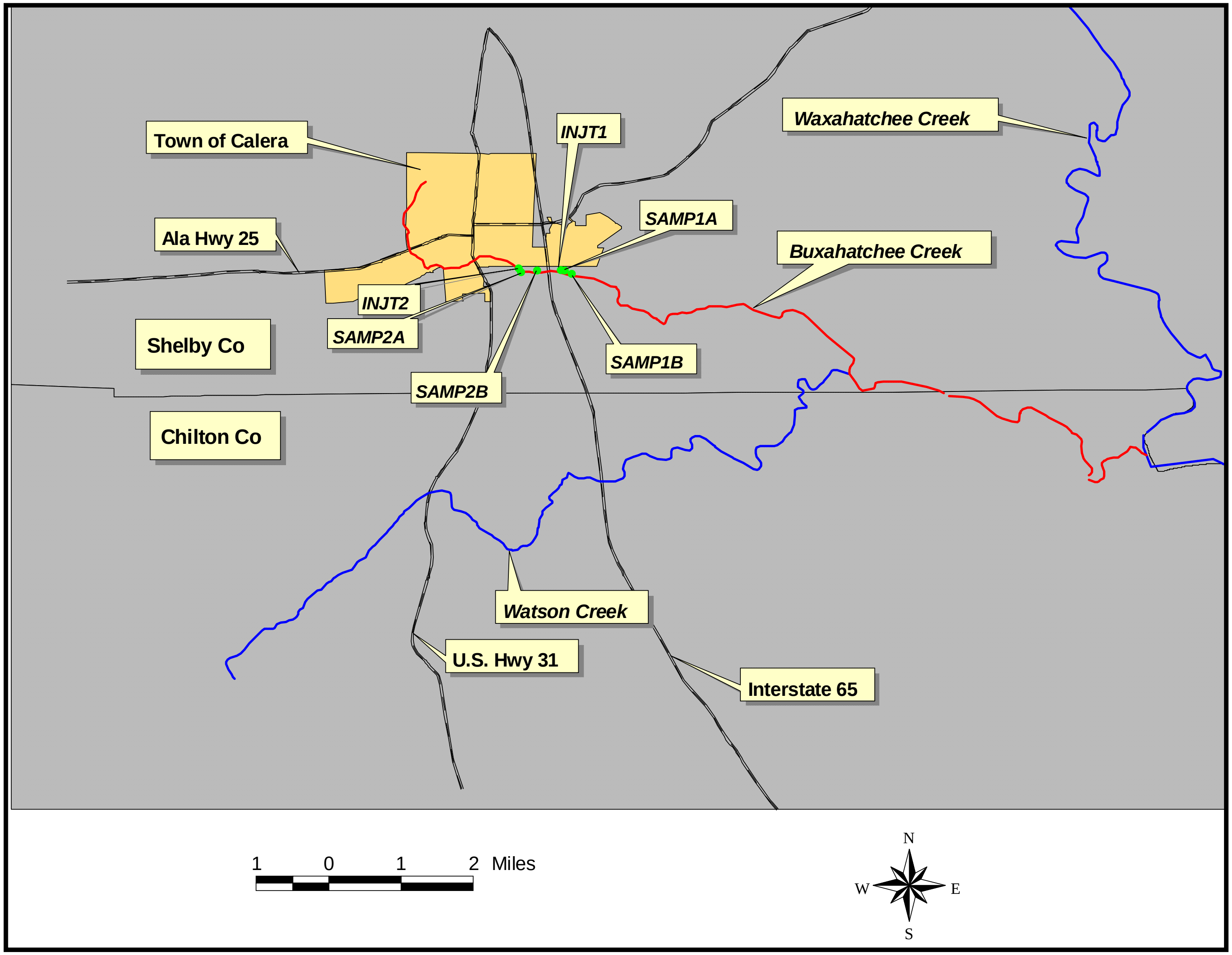


Figure 3.4.4: Map of Limno-Tech Reaeration Sampling Stations



4.0 Total Maximum Daily Load Development for Buxahatchee Creek

This section presents the TMDL developed to address nutrients for Buxahatchee Creek. A TMDL is the total amount of a pollution load that can be assimilated by the receiving water while still achieving water quality standards. TMDLs can be expressed in terms of mass per time or by other appropriate measures. TMDLs are comprised of the sum of individual waste load allocations (WLAs) for point sources, load allocations (LAs) for non-point sources, and natural background levels. In addition, the TMDL must include a margin of safety (MOS), either implicitly or explicitly, that accounts for the uncertainty in the relationship between pollutant loads and the quality of the receiving waterbody. Conceptually, this definition is denoted by the following equation:

$$TMDL = \Sigma WLAs + \Sigma LAs + MOS$$

In order to develop the TMDL, the following steps will be defined:

1. Numeric Target for TMDL
2. Existing/Baseline Conditions
3. Critical Conditions
4. Margin of Safety
5. Seasonal Variation
6. TMDL Calculation Method and Results

4.1 TMDL Numeric Targets

The TMDL endpoints represent the in-stream water quality target used in quantifying the load reduction that maintains water quality standards. The TMDL endpoints can be a combination of water quality standards, both numeric and narrative, and surrogate parameters that would ensure the standards are being met.

Normally, ADEM only targets total phosphorus (TP) as the nutrient of concern for a stream that is effluent-dominated such as Buxahatchee Creek. However, a nutrient TMDL was approved for Buxahatchee Creek which included total nitrogen (TN) to address downstream nutrient impairments in Lay Lake of the Coosa River. This was done prior to the completion of nutrient modeling analysis of the Coosa River Lakes (i.e. Lay Lake). Based on revised modeling efforts conducted for the Coosa River Reservoirs, it has been determined that reductions in total phosphorus, without concurrent reductions in nitrogen, will result in the attainment of the chlorophyll a target developed for the Lay Lake nutrient TMDL. More specifically, the Lay Lake TMDL model was run with a reduction in TN that would meet the reduction required by the approved TMDL for Buxahatchee Creek. Results of the modeling analysis predict that the proposed TN reductions from the Buxahatchee Creek watershed would have a negligible effect on chlorophyll *a* concentrations in the Waxahatchee Creek embayment. The results of the model runs are shown below:

Lay Lake/Waxahatchee Creek Embayment					
Chlorophyll *a* (ug/L) results					
				Year	
Scenario				**1997**	**2000**
Lay Lake TMDL run				7.92	4.59
TN reduction to meet Buxahatchee TMDL				7.88	4.57
			difference	**0.04**	**0.02**

Potential impacts of nitrogen downstream from these reservoirs were also considered as part of the Coosa Lakes TMDL analysis. Based on extensive water quality modeling and readily available data and information, there are no known nutrient or nutrient-related impairments downstream from the Coosa River reservoirs. Therefore, the Buxahatchee Creek Nutrient TMDL is being revised to reflect the Department's findings that total phosphorus is the only nutrient of concern that needs to be reduced in order to meet applicable water quality criteria, to include protecting the downstream uses.

Establishing a TP target that fully supports the designated uses of Buxahatchee Creek is part of the lengthy and complex process of TMDL development. The nutrient target was developed using a "reference condition" approach. The TP target concentration utilized for the Buxahatchee Creek TMDL was calculated to be 0.066 mg/l. Refer to Section 3.1 for more details on target development.

4.2 Existing/Baseline Conditions

The results of using in-stream data and discharge monitoring report (DMR) data provide the existing condition for Buxahatchee Creek. Existing conditions for non-point source loading for Buxahatchee Creek will be based on the most recent data collected, which is from 2005. Station BXHS-2 was selected as the most appropriate location for non-point source (NPS) load calculations because it is upstream of any point source discharge; therefore, it has no influence from point sources. Data and calculations for NPS loads can be seen in Section 4.6.

Existing conditions for point source loading to Buxahatchee Creek will be based on DMR data reported to ADEM for the 2006 growing season. The reason for using 2006 is further described in Section 4.6.1

4.3 Critical Conditions

It is important when developing a TMDL that it is protective of water quality over a range of possible conditions that might occur within the listed segment. In EPA's Nutrient Criteria Technical Guidance Manual: Rivers and Streams, it states that 'Nutrient and algal problems are frequently seasonal in streams and rivers, so sampling periods can be targeted to the seasonal periods associated with nuisance problems.' ADEM has determined that the seasonal period associated with nutrient enrichment that results in nuisance algal problems for Buxahatchee Creek is the growing season of April through October. Typically, critical conditions specify a flow that will represent an extreme low flow regime or a loading that represents a high possible value. If the growing season median concentration is less than the target concentration, then the loading to the system is said to be protective of water quality. However, if the growing season median concentration is greater than the target, then the loading may not be protective of water quality. This loading, therefore, needs to be reduced until the target concentrations are met. The loading that is referred to in this system is total phosphorus.

Two critical conditions were employed for this TMDL. The first is the growing season months (April-October) for algal populations. The second is the permit, or design wastewater flows, for the Calera WWTP. The Calera WWTP is currently permitted for a design wasteflow of 1.5 MGD.

4.4 Margin of Safety

There are two methods for incorporating a MOS in the analysis: a) by implicitly incorporating the MOS using conservative model assumptions to develop allocations; b) by explicitly specifying a portion of the TMDL as the MOS and using the remainder for allocations.

The MOS in this TMDL is implicit since the total phosphorus target was derived using ecological reference streams, which are considered to represent least impacted conditions. Also, a mass balance procedure was employed to estimate allowable TP loads to Buxahatchee. Since no algal uptake is considered in this approach, the allowable TP loads will be conservative.

4.5 Seasonal Variation

The TP numeric target is a single value which represents the range of values measured over multiple-year growing seasons at the designated reference sites. Therefore, application and interpretation of the nutrient targets for Buxahatchee Creek should consider that ambient TP concentrations may exceed the target at times while still maintaining conditions similar to those in streams that fully support the designated use of aquatic life, as long as the growing season median concentrations are maintained. Application of the proposed nutrient target of 0.066 mg/l for TP must consider the methodology of the ecoregion reference stream approach that was used to develop the targets. Ecoregion reference stream site data were assessed on a growing-season basis that accounts for natural variability. Therefore, it would be inappropriate to expect Buxahatchee Creek not to exhibit natural variability during the growing season including higher, as well as lower, levels of phosphorus and nitrogen while attaining the growing season median target values. The April-October growing season was determined to be the appropriate time frame for managing TP to control algal growth in Buxahatchee Creek. It was determined that winter reductions (i.e., non-growing season) would not be necessary since high flows, cool temperatures, and low availability of substrate and light, limit algal production. Application of the TP target may be reviewed based on future research as effects-based links become more tangible. It is a valid observation that certain streamflow and wastewater discharge conditions will combine to result in TP levels higher and lower than the target. From a permitting standpoint, WWTPs are required to meet nutrient discharge levels on a monthly average basis during the growing season.

4.6 TMDL Calculation Method and Results

4.6.1 Waste Load Allocation (WLA)

There is only one permitted point source in the Buxahatchee Creek watershed – the Calera Wastewater Treatment Plant (WWTP) and one proposed mining discharge from a planned limestone quarry. Therefore, a total existing WLA was calculated only for the Calera WWTP facility. The existing WLA is based on the growing season median loads using monthly DMR data. DMR data from 2006 was chosen to calculate the growing season median load. 2005 DMR data was not used since the WWTP expanded its design flow from 0.75 mgd to 1.5 mgd approximately mid-year. During this expansion several process changes occurred that resulted in non-typical nutrient loads to be discharged from the WWTP. Therefore, the median monthly average TP loads for the 2006 growing season would be the most represented values to use for existing WLA loads.

The allowable WLA for the Calera WWTP was calculated using the WWTP permitted design flow (1.5 mgd) and the instream target values described in Section 4.1. For the proposed limestone quarry, only an allowable WLA was calculated since there is no existing load from this facility. A summary of the existing, permitted and allowable TP loads for the Calera WWTP are shown in Table 4.6.2 below.

Table 4.6.1 – WLA Summary for the Calera WWTP

WLA Summary for Calera WWTP	
DMR Summary Data Year 2006	**Monthly Average DMR for TP (lbs/day)**
April	82.45
May	47.89
June	32.85
July	17.36
August	10.62
September	6.11
October	3.48
Growing Season Median (Existing Condition)	17.36
Current NPDES Permit Limit (Permitted Condition)	7.1
TMDL - WLA (Allowable Condition)	0.83
Percent Reduction based on Permit Limit	88%
Percent Reduction based on DMR data	95%

The allowable TP waste load allocation for the proposed quarry was calculated using the projected discharge flow for the facility's process outfall as specified in the permit application. The calculation resulted in an allowable TP WLA of 3.96 lbs/day for the proposed quarry. This load assumes a discharge of 7.2 MGD for the process outfall.

4.6.2 Load Allocation (LA)

The LA for the Buxahatchee Creek watershed was calculated based upon water quality data collected at station BXHS-2 located just upstream of the Calera WWTP discharge. Station BXHS-2 was determined to be the most representative of non-point source (NPS) pollution to Buxahatchee Creek since it is not influenced from the WWTP discharge. It was determined that the ADEM 303(d) 2005 data set for BXHS-2 would be most representative of current NPS loadings to Buxahatchee Creek. The 2005 data set is the most current data collected on Buxahatchee Creek and monthly samples were collected through the growing season with the exception of September.

After the data set was chosen, TP loads were calculated for each sampling event. The median load value was then calculated from the growing season months (April – October). The median TP load value is considered to be the existing TP load allocations (LA) for Buxahatchee Creek. The allowable LA was calculated using the same hydraulic conditions as used to compute the existing LA and the in-stream target values described in Section 4.1. Then the percent reductions were calculated from the existing load to the allowable load. The monthly and median LA existing loads, LA allowable loads, and the percent reduction needed to meet the allowable load are shown in Table 4.6.2 of the following page.

Table 4.6.2 – Load Allocation Calculations for Buxahatchee Creek

Station ID	Date	Stream Flow (cfs)	Total-P (mg/l)	Total-P (lbs/day)
BXHS-2	3/23/2005 *	28.6	0.061	9.40
BXHS-2	4/12/2005	21.5	0.082	9.50
BXHS-2	5/10/2005	1.1	0.038	0.23
BXHS-2	5/31/2005	4.4	0.042	1.00
BXHS-2	7/5/2005	0.7	0.038	0.14
BXHS-2	8/9/2005	1.4	0.034	0.26
BXHS-2	10/20/2005	0.4	0.005	0.01
Growing Season Median Load (Existing Load)				0.24
* this sample included for information purposes only,however was not used in LA calculation				
		Allowable load		0.44
		Percent Reduction		0%

Although there is no TP reduction required for the LA portion of this TMDL based on the method chosen to calculate the Buxahatchee Creek TMDL, there will be a required TP reduction to the Buxahatchee Creek Watershed based on the Lay Lake Nutrient TMDL (ADEM/EPA, 2008).

A summary of the existing, allowable loads for both the WLA and LA are provided below:

	Existing Loads		Allowable Loads		Reductions	
Pollutant	**WLA**	**LA**	**WLA**	**LA**	**WLA***	**LA**
TP (lbs/day)	17.36	0.24	4.79	0.44	95%	0%

* The WLA Percent Reduction is calculated using only the allowable load and existing load for the Calera WWTP. In addition, the WLA Percent Reduction based on current permit limits for TP would equate to 88%. The allowable WLA includes 3.96 lbs/day TP from the proposed quarry and 0.83 lbs/day TP from the Calera WWTP.

The allowable WLA in the table above was calculated using the design discharge flows for the Calera WWTP and the proposed quarry of 1.5 and 7.2 MGD, respectively, and a TP concentration of 0.066 mg/l. For NPDES permitting purposes, the WLA will be implemented as a monthly average TP concentration of 0.066 mg/l.

4.6.3 TMDL

The WLA and the LA components of the TMDL employ the same hydraulic conditions as used to calculate the allowable loads discussed above. The TMDL values are shown below.

TMDL = WLA + LA + MOS*			
Pollutant	**TMDL**	**WLA**	**LA**
TP (lbs/day)	5.23	4.79	0.44

* implicit margin of safety

5.0 Follow Up Monitoring

ADEM has adopted a basin approach to water quality management; an approach that divides Alabama’s fourteen major river basins into five groups. Each year, ADEM’s resources for water quality monitoring are concentrated in one of the basin groups. One goal is to continue to monitor §303(d) listed waters. Monitoring will help further characterize water quality conditions resulting from the implementation of best management practices in the watershed. This monitoring will occur in each basin according to the schedule shown in Table 7.1.

Table 7-1 5-Year Major Basin Rotation Sampling Schedule

River Basin Group	Schedule
Choctawhatchee, Chipola, Perdido-Escambia and Chattahoochee	2008
Tennessee	2009
Tallapoosa, Alabama and Coosa	2010
Escatawpa, Lower Tombigbee, Upper Tombigbee, Mobile	2011
Cahaba, Black Warrior	2012

Monitoring will help further characterize water quality conditions resulting from the implementation of WLA reductions and best management practices in the watershed.

6.0 Public Participation

As part of the public participation process, this TMDL was placed on public notice and made available for review and comment. The public notice was prepared and published in the four major daily newspapers in Montgomery, Huntsville, Birmingham, and Mobile, as well as submitted to persons who have requested to be on ADEM's postal and electronic mailing distributions. In addition, the public notice and subject TMDL was made available on ADEM's Website: www.adem.state.al.us. The public can also request paper or electronic copies of the TMDL by contacting Mr. Chris Johnson at 334-271-7827 or cljohnson@adem.state.al.us. The public was given an opportunity to review the TMDL and submit comments to the Department in writing. At the end of the public review period, all written comments received during the public notice period became part of the administrative record. ADEM considered all comments received by the public prior to finalization of this TMDL and subsequent submission to EPA Region 4 for final review and approval.

Appendix A

References

United States Environmental Protection Agency. 1991. Guidance for Water Quality-Based Decisions: The TMDL Process, Office of Water, EPA 440/4-91-001.

Alabama Clean Water Strategy Water Quality Assessment Report, May 1989.

Alabama Clean Water Strategy Water Quality Assessment Report, December 1992.

Alabama Clean Water Strategy Water Quality Assessment Report, 1996.

United States Environmental Protection Agency. 1999. Protocol for Developing Nutrient TMDLs, Office of Water, EPA 841-B-99-007.

USEPA 2000a. Ambient Water Quality Criteria Recommendations: Information Supporting the Development of State and Tribal Nutrient Criteria. Rivers and Streams in Ecoregion XI. United States Environmental Protection Agency, Office of Water. EPA 822-B-00-020.

USEPA 2000b. Nutrient Criteria Technical Guidance Manual: River and Streams. United States Environmental Protection Agency, Office of Water. EPA 822-B-00-002.

Draft Nutrients, Organic Enrichment/Dissolved Oxygen (OE/DO) and pH Total Maximum Daily Loads for Lake Neely Henry, Logan Martin Lake, Lay Lake and Lake Mitchell

Appendix B
Water Quality Data

Ecoregion/Subregion	Station_ID	Date	Total P (mg/l)
45a	HAT-3	3/30/2005	0.022
45a	HAT-3	4/14/2005	0.018
45a	HAT-3	5/11/2005	0.061
45a	HAT-3	6/14/2005	0.028
45a	HAT-3	7/13/2005	0.044
45a	HAT-3	8/8/2005	0.075
45a	HAT-3	10/11/2005	0.041
45a	HCR-1	5/12/1998	0.002
45a	HCR-1	6/29/1998	0.002
45a	HCR-1	9/1/1998	0.050
45a	HCR-1	5/20/1999	0.002
45a	HCR-1	6/22/1999	0.002
45a	HCR-1	7/20/1999	0.002
45a	HCR-1	8/19/1999	0.061
45a	HCR-1	9/16/1999	0.002
45a	HCR-1	2/25/2004	0.026
45a	HCR-1	3/16/2004	0.020
45a	HCR-1	4/7/2004	0.020
45a	HCR-1	5/6/2004	0.031
45a	HCR-1	6/3/2004	0.015
45a	HCR-1	7/15/2004	0.049
45a	HCR-1	8/18/2004	0.019
45a	HCR-1	9/2/2004	0.045
45a	HCR-1	10/14/2004	0.021
45a	HCR-1	3/28/2005	0.018
45a	HCR-1	4/27/2005	0.031
45a	HCR-1	5/17/2005	0.030
45a	HCR-1	6/22/2005	0.009
45a	HCR-1	7/25/2005	0.012
45a	HCR-1	8/16/2005	0.055
45a	HCR-1	10/4/2005	0.046
45a	HTTC-1	3/16/2005	0.046
45a	HTTC-1	4/5/2005	0.032
45a	HTTC-1	5/3/2005	0.038
45a	HTTC-1	6/14/2005	0.036
45a	HTTC-1	7/5/2005	0.030
45a	HTTC-1	8/2/2005	0.031
45a	HTTC-1	10/24/2005	0.002
45a	JCKC-1	3/17/2005	0.079
45a	JCKC-1	4/6/2005	0.049
45a	JCKC-1	5/4/2005	0.067
45a	JCKC-1	6/8/2005	0.039

45a	JCKC-1	7/13/2005	0.044
45a	JCKC-1	8/4/2005	0.034
45a	JCKC-1	10/19/2005	0.002
45a	JNSC-16	3/18/2004	0.018
45a	JNSC-16	4/29/2004	0.057
45a	JNSC-16	5/25/2004	0.066
45a	JNSC-16	7/1/2004	0.036
45a	JNSC-16	7/12/2004	0.031
45a	JNSC-16	8/24/2004	0.030
45a	JNSC-16	9/23/2004	0.044
45a	JNSC-16	10/28/2004	0.029
45a	JNSC-16	11/23/2004	0.015
45a	JNSC-16	3/30/2005	0.005
45a	JNSC-16	5/24/2005	0.067
45a	JNSC-16	6/28/2005	0.009
45a	JNSC-16	7/13/2005	0.025
45a	JNSC-16	8/8/2005	0.030
45a	JNSC-16	9/28/2005	0.024
45a	JNSC-16	10/31/2005	0.002
45a	KETC-1	3/28/2005	0.040
45a	KETC-1	4/28/2005	0.082
45a	KETC-1	5/18/2005	0.031
45a	KETC-1	6/23/2005	0.034
45a	KETC-1	7/26/2005	0.016
45a	KETC-1	8/17/2005	0.057
45a	KETC-1	10/5/2005	0.066
45a	PNTC-11	3/20/2003	0.038
45a	PNTC-11	4/10/2003	0.019
45a	PNTC-11	5/8/2003	0.083
45a	PNTC-11	6/9/2003	0.034
45a	PNTC-11	7/10/2003	0.026
45a	PNTC-11	8/4/2003	0.039
45a	PNTC-11	9/4/2003	0.029
45a	PNTC-11	10/16/2003	0.042
45a	PNTC-11	11/13/2003	0.036
45a	PNTC-11	3/21/2005	0.034
45a	PNTC-11	4/7/2005	0.053
45a	PNTC-11	5/4/2005	0.065
45a	PNTC-11	6/7/2005	0.042
45a	PNTC-11	7/13/2005	0.043
45a	PNTC-11	8/3/2005	0.042
45a	PNTC-11	10/18/2005	0.011
45a	SOCC-1	3/30/2005	0.037
45a	SOCC-1	4/11/2005	0.049
45a	SOCC-1	5/10/2005	0.062
45a	SOCC-1	6/15/2005	0.037
45a	SOCC-1	7/14/2005	0.055
45a	SOCC-1	8/18/2005	0.091

45a	SOCC-1	10/11/2005	0.073
45a	WEKE-1	3/17/2005	0.070
45a	WEKE-1	4/7/2005	0.052
45a	WEKE-1	5/5/2005	0.063
45a	WEKE-1	6/7/2005	0.043
45a	WEKE-1	7/13/2005	0.048
45a	WEKE-1	8/3/2005	0.044
45a	WEKE-1	10/19/2005	0.002
45a	WGFC-1	5/14/1998	0.008
45a	WGFC-1	7/28/1998	0.002
45a	WGFC-1	9/9/1998	0.002
		90th percentile	0.066

Ecoregion/Subregion	Station_ID	Date	Total P (mg/l)
67g	DRYE-4	3/27/2002	0.074
67g	DRYE-4	4/25/2002	0.03
67g	DRYE-4	5/9/2002	0.05
67g	DRYE-4	7/24/2002	0.027
67g	DRYE-4	8/20/2002	0.062
67g	DRYE-4	10/24/2002	0.087
67g	DRYE-4	11/12/2002	0.067
67g	OHTC-6	3/29/2005	0.033
67g	OHTC-6	4/6/2005	0.017
67g	OHTC-6	5/5/2005	0.063
67g	OHTC-6	6/8/2005	0.041
67g	OHTC-6	7/20/2005	0.048
67g	OHTC-6	8/24/2005	0.005
67g	OHTC-6	10/6/2005	0.003
		90th percentile	0.072

Ecoregion/Subregion	Station_ID	Date	Total P (mg/l)
67f	CHEC-1	3/29/2005	0.020
67f	CHEC-1	4/6/2005	0.039
67f	CHEC-1	5/3/2005	0.063
67f	CHEC-1	6/7/2005	0.043
67f	CHEC-1	7/13/2005	0.012
67f	CHEC-1	8/3/2005	0.036
67f	CHEC-1	10/25/2005	0.002
67f	DRYT-9	3/27/2002	0.037
67f	DRYT-9	4/24/2002	0.020
67f	DRYT-9	5/9/2002	0.032
67f	DRYT-9	7/10/2002	0.025
67f	DRYT-9	7/24/2002	0.032
67f	DRYT-9	8/20/2002	0.053
67f	DRYT-9	10/24/2002	0.037
67f	DRYT-9	11/12/2002	0.067
67f	FRMB-8	3/28/2002	0.045
67f	FRMB-8	4/30/2002	0.027
67f	FRMB-8	5/21/2002	0.026
67f	FRMB-8	6/27/2002	0.048
67f	FRMB-8	7/11/2002	0.031
67f	FRMB-8	7/18/2002	0.056
67f	FRMB-8	8/15/2002	0.036
67f	FRMB-8	12/10/2002	0.051
67f	FRMB-8	3/27/2003	0.04
67f	FRMB-8	4/24/2003	0.013
67f	FRMB-8	5/27/2003	0.019
67f	FRMB-8	7/10/2003	0.015
67f	FRMB-8	7/31/2003	0.02
67f	FRMB-8	8/28/2003	0.002
67f	FRMB-8	9/11/2003	0.002
67f	FRMB-8	11/13/2003	0.002
67f	FRMB-8	12/3/2003	0.027
67f	HNMB-4	3/21/2002	0.040
67f	HNMB-4	5/9/2002	0.036
67f	HNMB-4	6/26/2002	0.031
67f	HNMB-4	7/10/2002	0.021
67f	HNMB-4	7/16/2002	0.027
67f	HNMB-4	11/13/2002	0.038
67f	HNMB-4	12/9/2002	0.032
67f	HNMB-4	3/19/2003	0.002
67f	HNMB-4	4/2/2003	0.042
67f	HNMB-4	5/7/2003	0.019
67f	HNMB-4	6/4/2003	0.028
67f	HNMB-4	7/16/2003	0.047

67f	HNMB-4	8/5/2003	0.023
67f	HNMB-4	9/10/2003	0.002
67f	HNMB-4	10/8/2003	0.048
67f	HNMB-4	11/13/2003	0.037
67f	HRC-1	5/11/1999	0.002
67f	HRC-1	6/8/1999	0.002
67f	HRC-1	7/13/1999	0.055
67f	HRC-1	8/3/1999	0.054
67f	HRC-1	9/7/1999	0.015
		90th percentile	0.053

Station Location Information

ECOREGION_	STATION_ID	Stream_name	LATITUDE	LONGITUDE
67f	CHEC-1	Cheaha Cr	33.48861	-85.95933
67g	DRYE-4	Dry Cr	34.01093	-85.81723
67f	DRYT-9	Dry Cr	33.36568	-86.08963
67f	FRMB-8	Fourmile Cr	33.07702	-86.97035
45a	HAT-3	Hatchet Cr	33.13050	-86.05500
45a	HCR-1	Hurricane Cr	33.17546	-85.59829
67f	HNMB-4	Hendrick Mill Br	33.87612	-86.56885
67f	HRC-1	Hurricane Cr	34.00280	-85.57900
45a	HTTC-1	Hatchet Cr	33.19137	-86.04696
45a	JCKC-1	Jack's Creek	32.91720	-86.13375
45a	JNSC-16	Jones Cr	32.90492	-86.29758
45a	KETC-1	Ketchepedrakee Creek	33.46342	-85.70072
67g	OHTC-6	Ohatchee Creek	33.89680	-85.87570
45a	PNTC-11	Paint Cr	33.01838	-86.44741
45a	SOCC-1	Socapatoy Creek	32.96560	-86.14960
45a	WEKE-1	Weoka Creek	32.75053	-86.23225
45a	WGFC-1	Weogufka Cr	33.07288	-86.24847

ADEM 2000-2001 303(d) data

Station Number	Date	Flow (cfs)	Total P (mg/l)
BXHS-001	4/13/2000	***	0.03
BXHS-001	5/2/2000	***	0.007
BXHS-001	1/18/2001	***	0.004
BXHS-001	2/21/2001	***	0.004
BXHS-001	3/8/2001	***	0.004
BXHS-001	4/19/2001	***	0.08
BXHS-002	4/13/2000	3.8	0.008
BXHS-002	5/2/2000	0.6	0.027
BXHS-002	7/26/2000	***	0.328
BXHS-002	7/26/2000	***	0.085
BXHS-002	7/27/2000	***	0.292
BXHS-002	9/5/2000	***	0.085
BXHS-002	10/4/2000	.009	0.032
BXHS-002	1/18/2001	12.7	0.094
BXHS-002	2/21/2001	5.7	0.004
BXHS-002	3/8/2001	8.0	0.054
BXHS-002	4/19/2001	2.4	0.06
BXHS-003	4/13/2000	3.8	0.158
BXHS-003	5/2/2000	***	0.561
BXHS-003	7/26/2000	***	0.085
BXHS-003	7/26/2000	***	6.199
BXHS-003	7/26/2000	***	3.654
BXHS-003	7/26/2000	***	2.609
BXHS-003	7/27/2000	***	1.017
BXHS-003	9/5/2000	***	4.24
BXHS-003	10/4/2000	***	4.869
BXHS-003	1/18/2001	***	0.374
BXHS-003	2/21/2001	***	0.004
BXHS-003	3/8/2001	***	0.175
BXHS-003	4/19/2001	***	0.33

*** no flow taken

Station Number	Date	Flow (cfs)	Total P (mg/l)
BXHS-004	4/13/2000	14.5	0.035
BXHS-004	5/2/2000	2.6	0.049
BXHS-004	7/26/2000	***	0.062
BXHS-004	7/26/2000	***	0.098
BXHS-004	7/27/2000	***	0.809
BXHS-004	9/5/2000	1.8	0.085
BXHS-004	10/4/2000	0.1	0.192
BXHS-004	1/18/2001	48.8	0.091
BXHS-004	2/21/2001	18.5	0.004
BXHS-004	3/8/2001	28.0	0.019
BXHS-004	4/19/2001	6.8	0.07
CAWW-001	4/13/2000	.68	0.782
CAWW-001	5/2/2000	.59	0.004
CAWW-001	7/27/2000	***	5.273
CAWW-001	9/5/2000	.834	0.421
CAWW-001	10/4/2000	.52	3.802
CAWW-001	1/18/2001	1.2376	0.929
CAWW-001	2/21/2001	1.238	0.974
CAWW-001	3/8/2001	.99	0.855
CAWW-001	4/19/2001	1.22	0.94
WTNS-001	4/13/2000	25.2	0.004
WTNS-001	5/2/2000	3.9	0.936
WTNS-001	7/26/2000	***	0.044
WTNS-001	7/26/2000	***	0.065
WTNS-001	7/27/2000	***	0.218
WTNS-001	9/5/2000	***	0.01
WTNS-001	10/4/2000	***	0.285
WTNS-001	1/18/2001	66.1	0.004
WTNS-001	2/21/2001	51.7	0.004
WTNS-001	3/8/2001	52.6	0.004
WTNS-001	4/19/2001	17.3	0.06

ADEM -2003- 303(d) DATA

Station_ID	Date	Total-P (mg/l)	Stream Flow (cfs)	Reason No Flow
BXHS -5	3/20/03	0.039	162.5	
BXHS -5	4/3/03	0.068	22.4	
BXHS -5	5/8/03	0.101		not wadeable (too deep)
BXHS -5	6/5/03	0.034		not wadeable (too deep)
BXHS -5	7/17/03	0.203		flow conditions dangerous
BXHS -5	7/17/03	0.203		flow conditions dangerous
BXHS -5	8/7/03	0.094	62.5	
BXHS -5	9/11/03	0.106	16.7	
BXHS -5	10/9/03	0.334	6	
Growing Season Median		0.1035		

ADEM 2005 Lab Data & Calera WWTP DMR Data

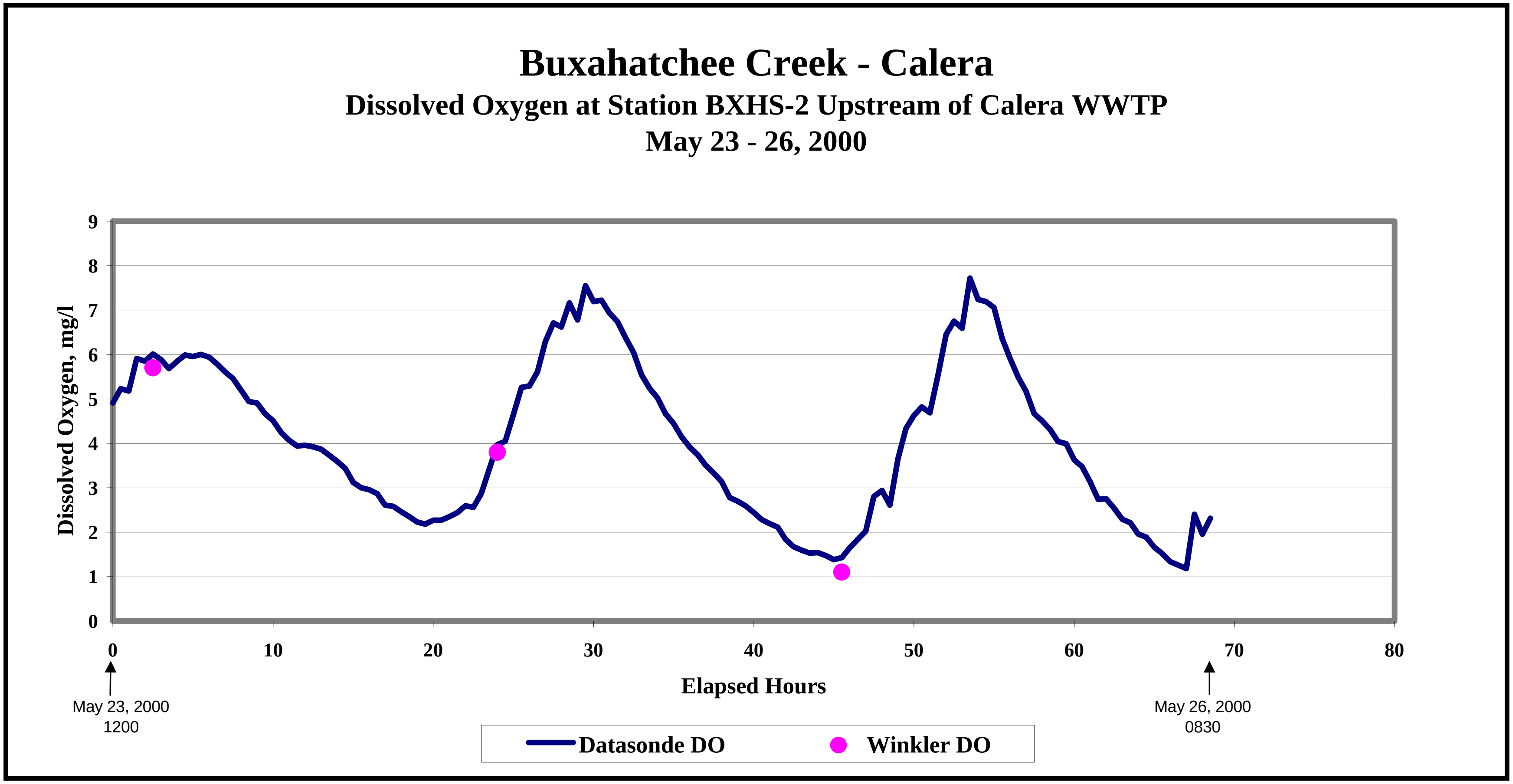
Station_ID	Date	Measured Stream Flow (cfs)	* Ratioed Stream Flows based off BXHS-4	Total-P (mg/l)	** Total-P (lbs/day)
BXHS-2	3/23/2005	28.6	29.98	0.061	9.40
BXHS-2	4/12/2005	21.5	19.87	0.082	9.50
BXHS-2	5/10/2005	1.1	2.12	0.038	0.23
BXHS-2	5/31/2005	4.4	6.19	0.042	1.00
BXHS-2	7/5/2005	0.7	1.48	0.038	0.14
BXHS-2	8/9/2005	1.4	2.23	0.034	0.26
BXHS-2	10/20/2005	visible but not detectable	0.40	0.005	0.01
Growing Season median flow-concentration-loads			**2.178**	**0.038**	**0.24**
BXHS-3	3/23/2005	29.9	37.07	0.118	19.02
BXHS-3	4/12/2005	not measured	24.58	0.101	13.38
BXHS-3	5/10/2005	not measured	2.63	0.752	10.65
BXHS-3	5/31/2005	not measured	7.66	0.103	4.25
BXHS-3	7/5/2005	2.8	1.83	1.736	26.20
BXHS-3	8/9/2005	not measured	2.76	5.766	85.81
BXHS-3	10/20/2005	not measured	0.49	2.275	6.01
Growing Season median flow-concentration-loads			**2.694**	**1.244**	**12.02**
BXHS-3A	3/23/2005	56	56.00	0.09	27.17
BXHS-3A	4/12/2005	not measured	37.13	0.086	17.21
BXHS-3A	5/10/2005	not measured	3.97	0.384	8.21
BXHS-3A	5/31/2005	not measured	11.57	0.106	6.61
BXHS-3A	7/6/2005	not measured	2.76	0.524	7.79
BXHS-3A	8/9/2005	not measured	4.17	0.461	10.36
BXHS-3A	10/20/2005	not measured	0.74	1.597	6.37
Growing Season median flow-concentration-loads			**4.069**	**0.423**	**8.00**
BXHS-4	3/23/2005	flow conditions too dangerous-ratio from BXHS-3A	83.26	0.073	32.76
BXHS-4	4/12/2005	55.2	55.2	0.069	20.53
BXHS-4	5/11/2005	5.9	5.9	0.154	4.90
BXHS-4	6/9/2005	17.2	17.2	0.085	7.88
BXHS-4	7/6/2005	4.1	4.1	0.486	10.74
BXHS-4	8/9/2005	6.2	6.2	0.223	7.45
BXHS-4	10/20/2005	1.1	1.1	0.751	4.45
Growing Season median flow-concentration-loads			**6.050**	**0.189**	**7.67**

* If instream flow was not measured on day of sample collection for a station, then a flow was estimated using drainage area ratio method

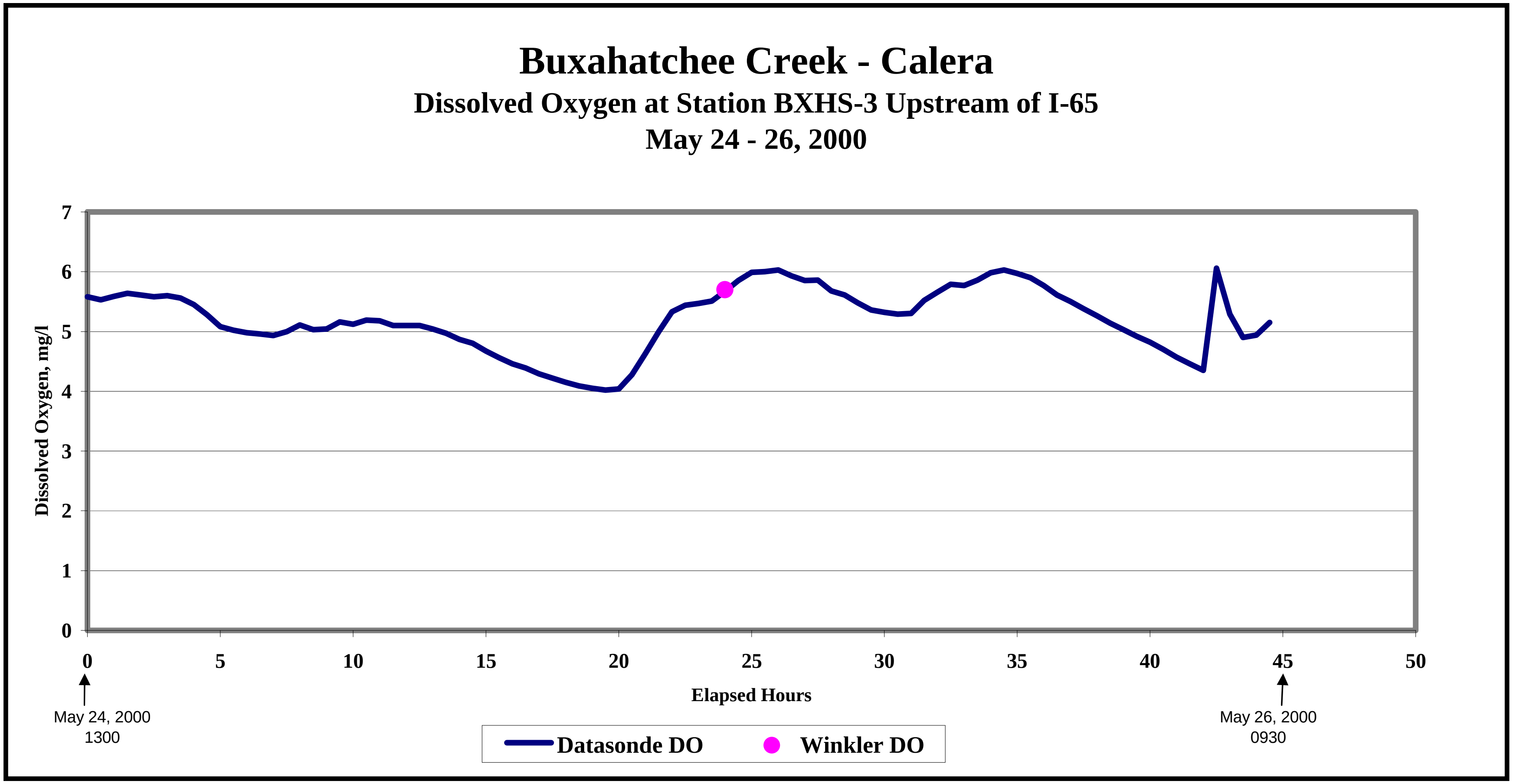
** If stream flow was measured during sample collection then that flow was used to calculate load. If stream flow was not measured then a ratioed flow was used to calculate loads.

303(d) Physical Data						
Station Number	Date	Biological Indicators2	Biological Indicators3	Biological Indicators1	Biological Indicators4	Comments
BXHS-001	5/25/00					Low head dam present; dam exposed. Steram flowing around edge of dam. Stream flow minimal. No PC/HA, no field parameters, no stream flow taken.
BXHS-001	8/24/00	Fish	Filamentous	Periphyton		No flow. Creek consists of one stagnant pool.
BXHS-002	11/2/00	Fish	Filamentous	Periphyton		One large pool due to beaver-dam construction. Bottom sediments black; anaerobic conditions are a remnant of past problems with the WWTP
BXHS-002	6/21/00	Macrophytes	Fish	Periphyton	Filamentous	
BXHS-003	8/24/00	Macrophytes	Fish	Periphyton	Filamentous	Flow very slow. Power line right-of-way affects this reach.
BXHS-003	11/2/00	Macrophytes	Fish	Periphyton		Heavy impact from petroleum-contaminated sludge from Calera WWTP. Black-colored sludge layered on bottom of stream.
BXHS-003	6/21/00	Macrophytes	Fish	Periphyton	Other	Algal bloom present, possibly due to recent removal of 4-ft. beaver dam. Odor of water and sediment may be due to this event. Odor is that found in eutrophic conditions.
BXHS-004	5/25/00	Macrophytes	Fish	Periphyton		
BXHS-004	8/24/00	Macrophytes	Fish	Periphyton	Filamentous	Large number of snails. Sand and gravel deposition. Scattered relic mussel shells.
WTNS-001	8/24/00	Macrophytes	Fish	Periphyton	Other	
WTNS-001	5/24/00	Fish		Macrophytes		

ADEM INTENSIVE SURVEY DATA



ADEM INTENSIVE SURVEY DATA (Continued)



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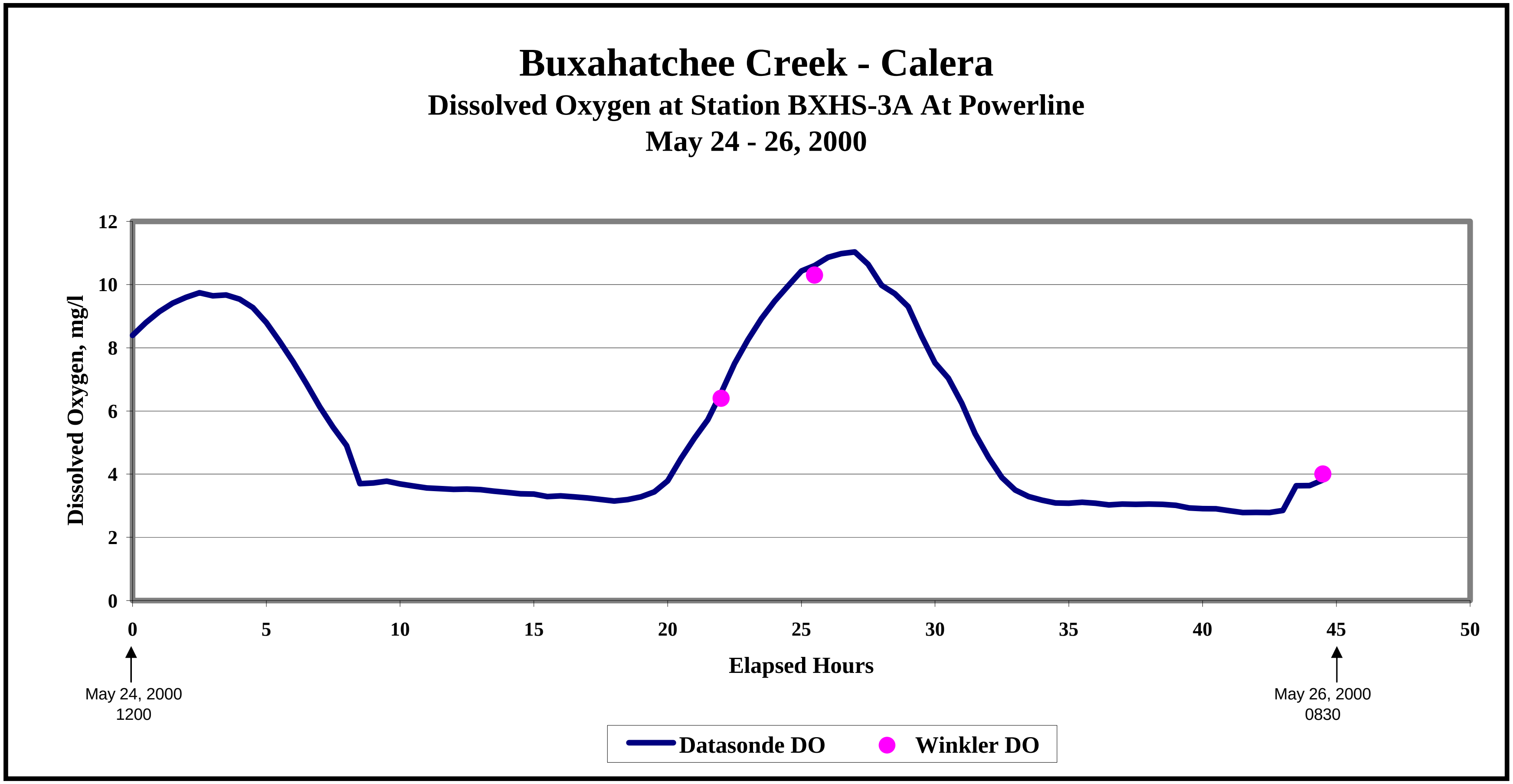

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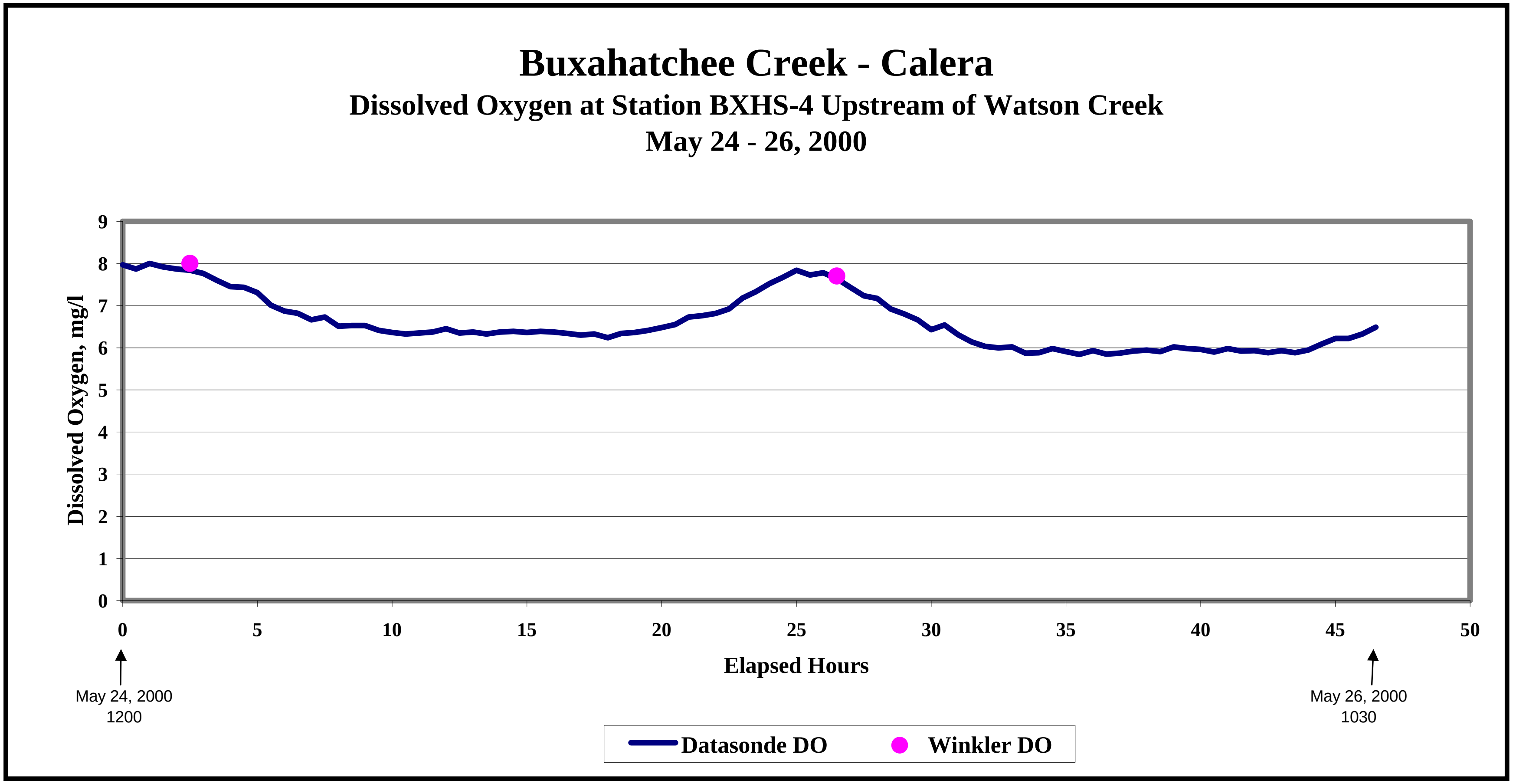

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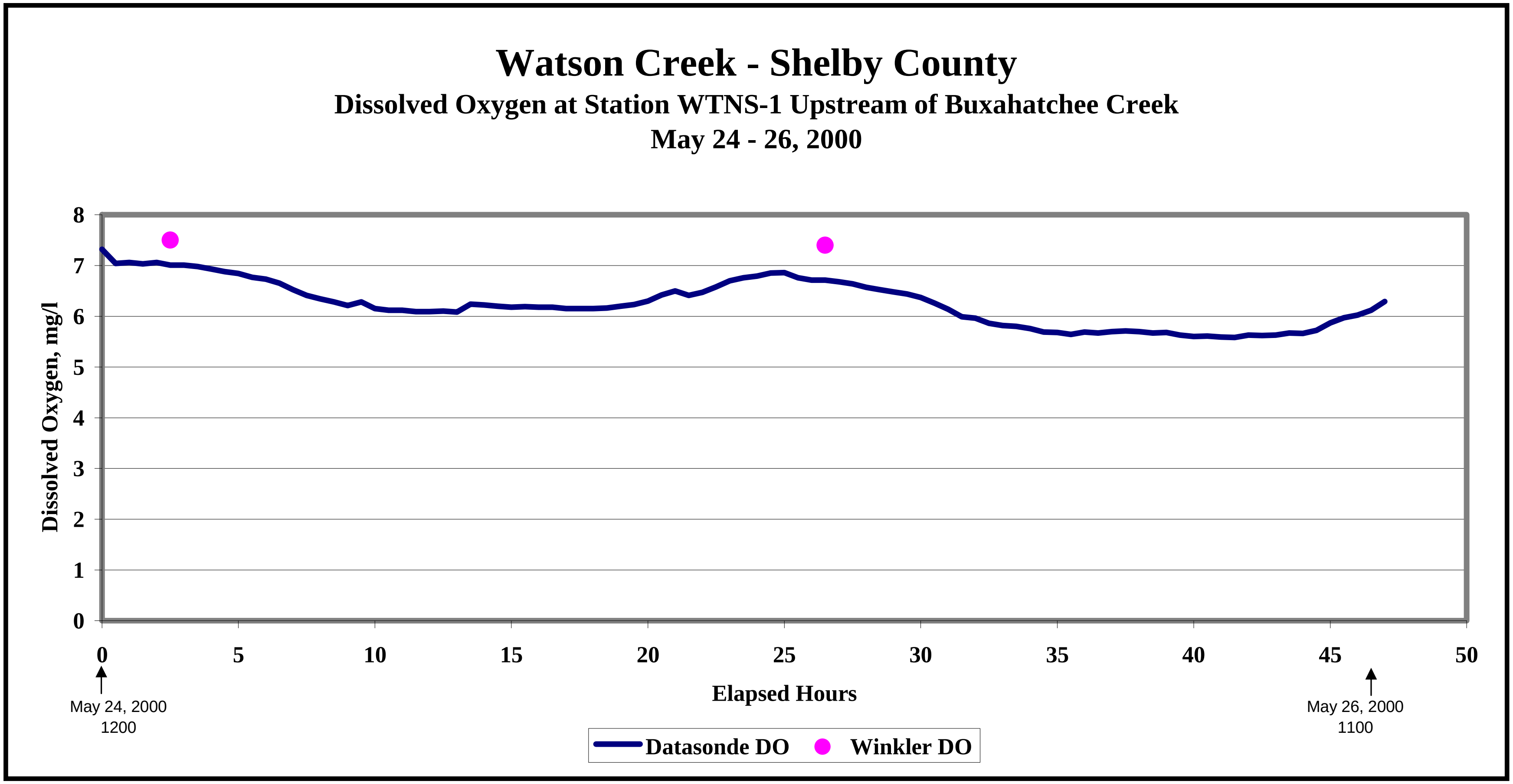

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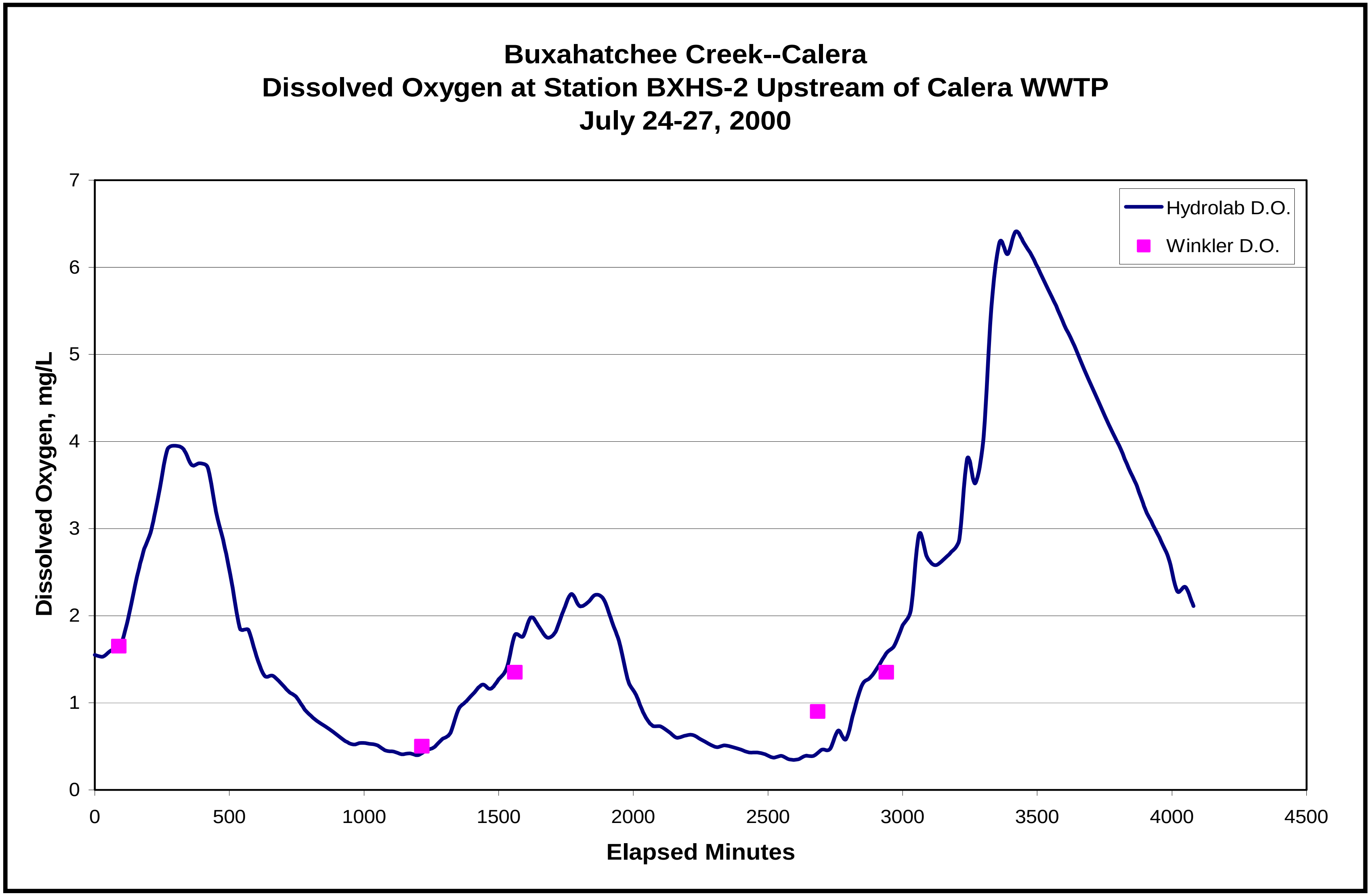

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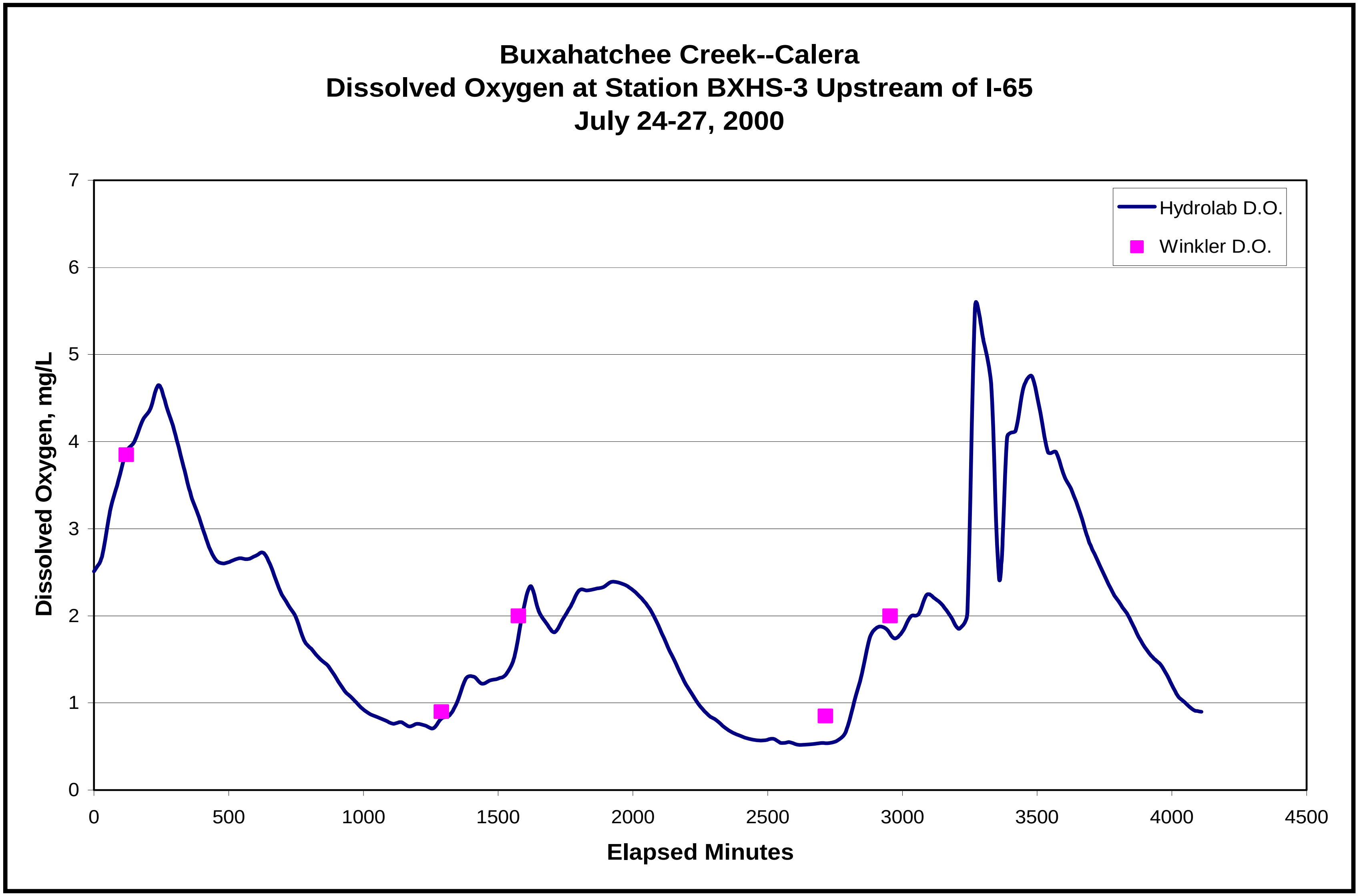

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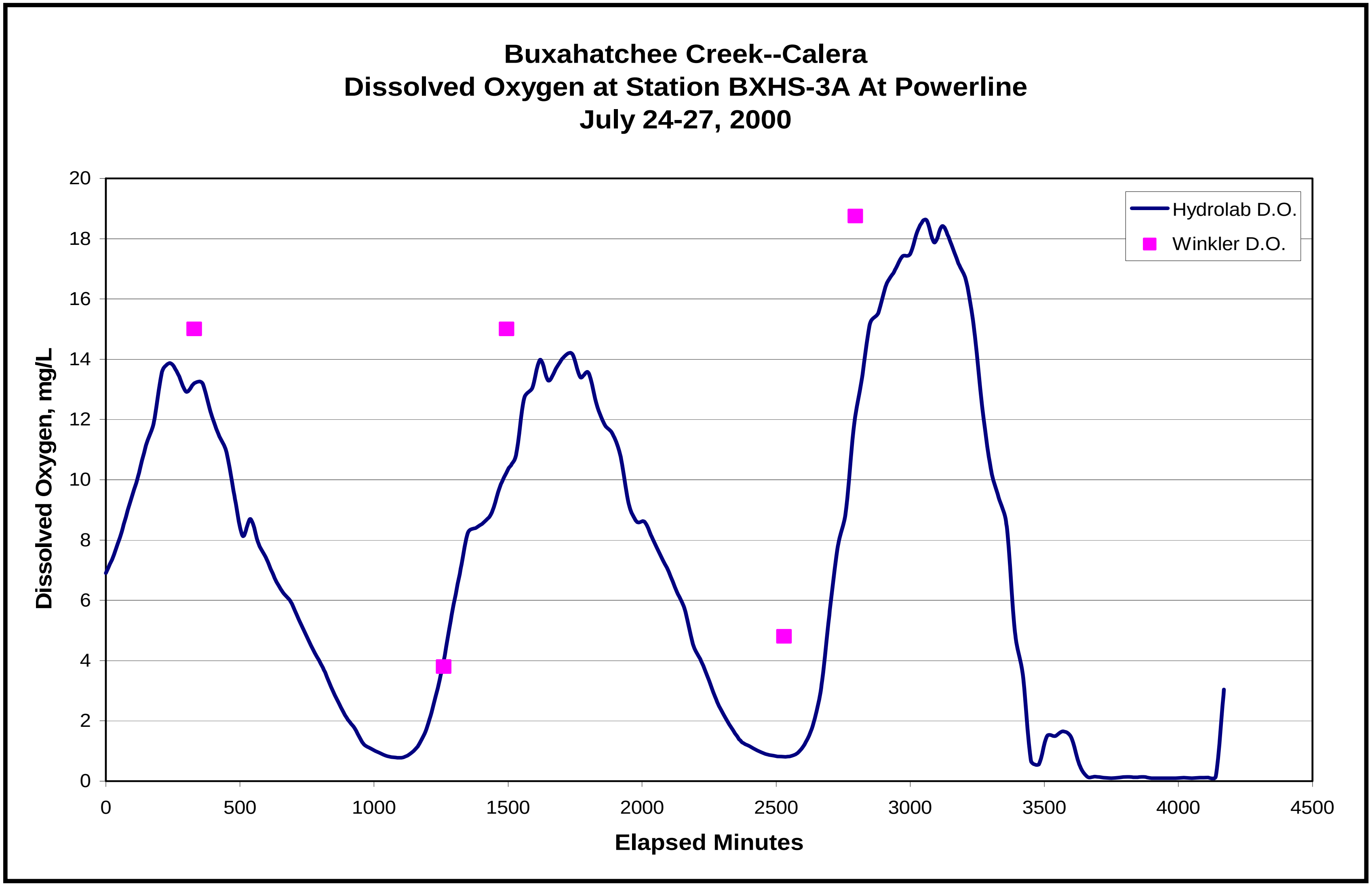

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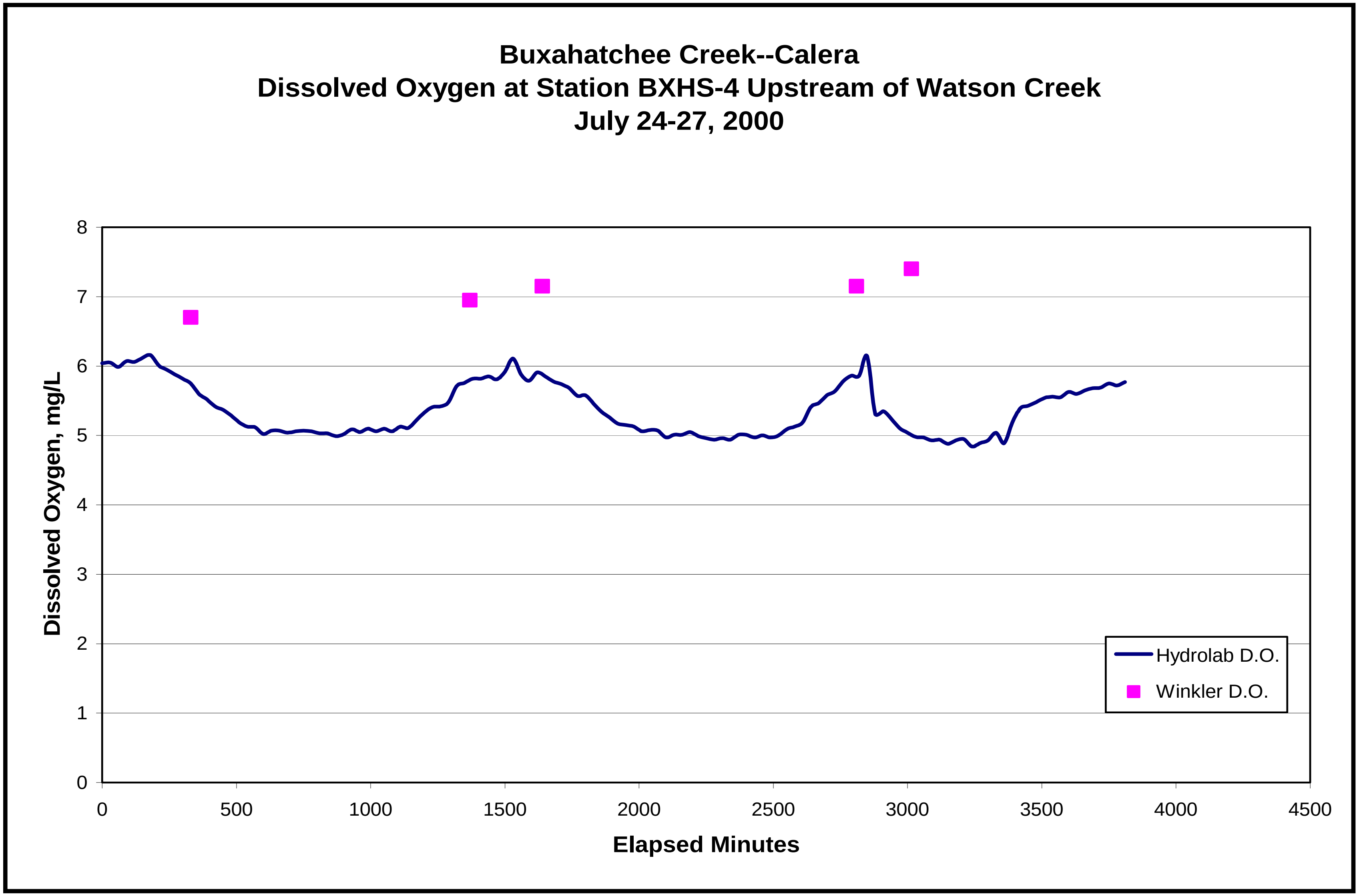
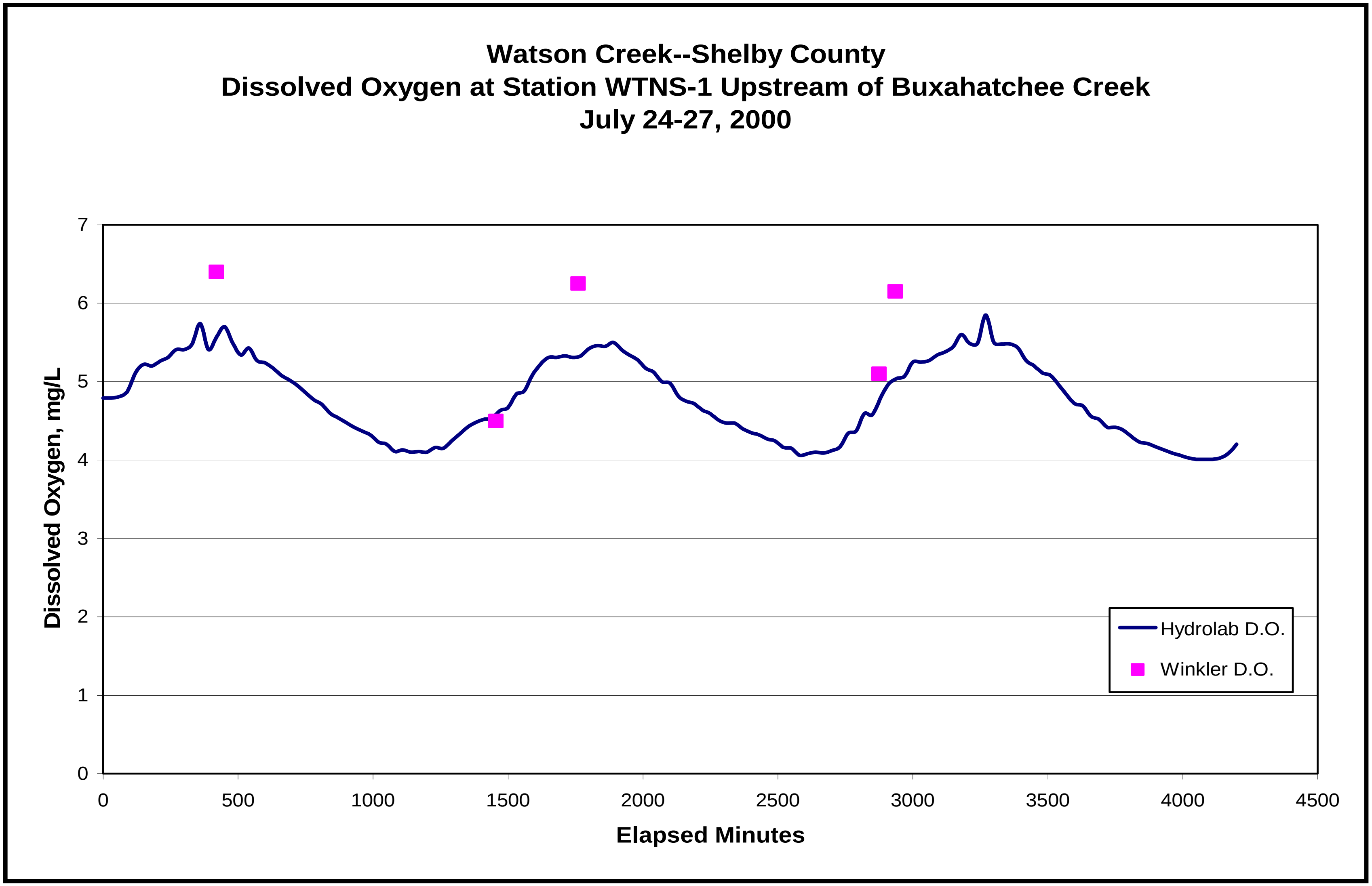
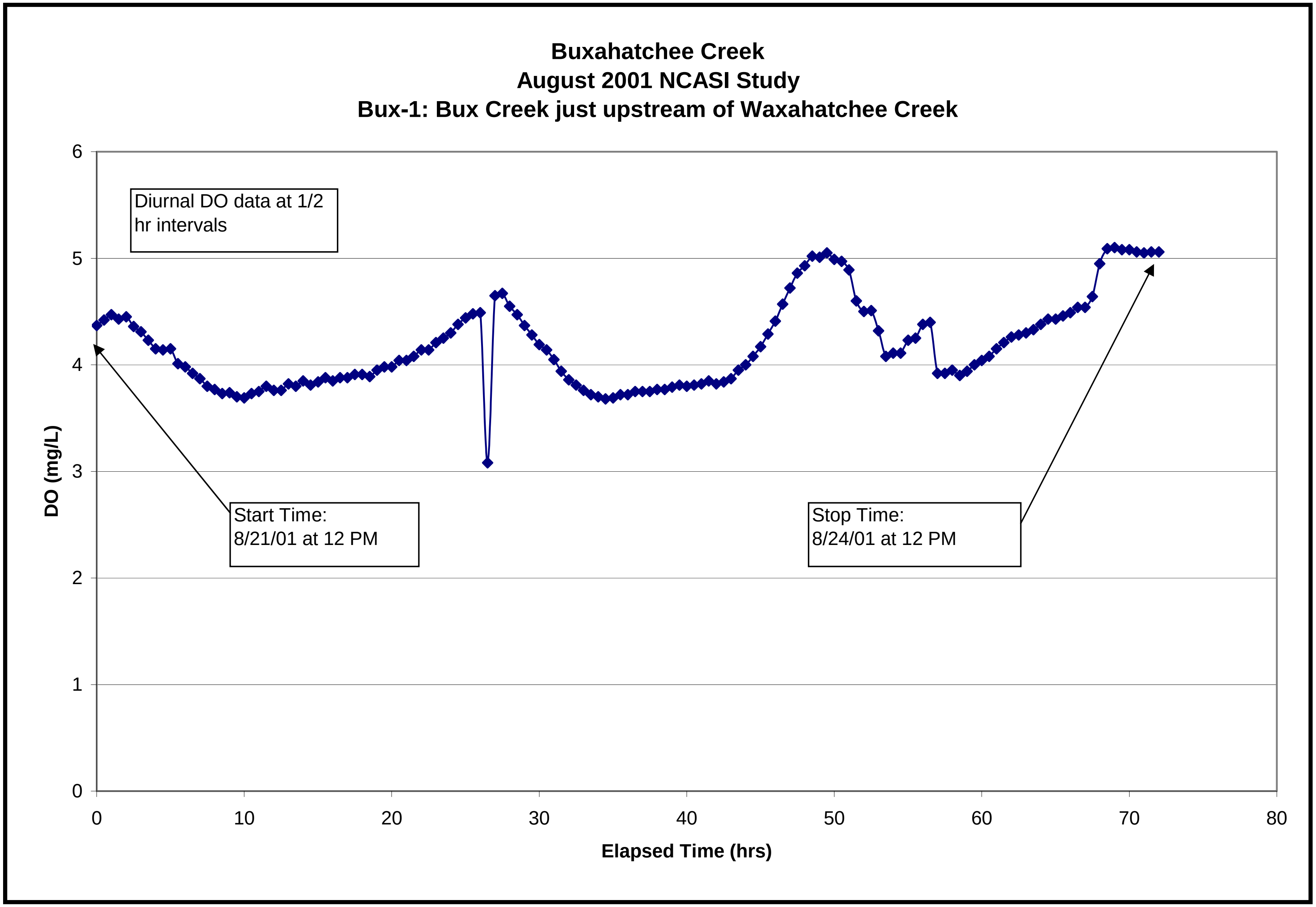


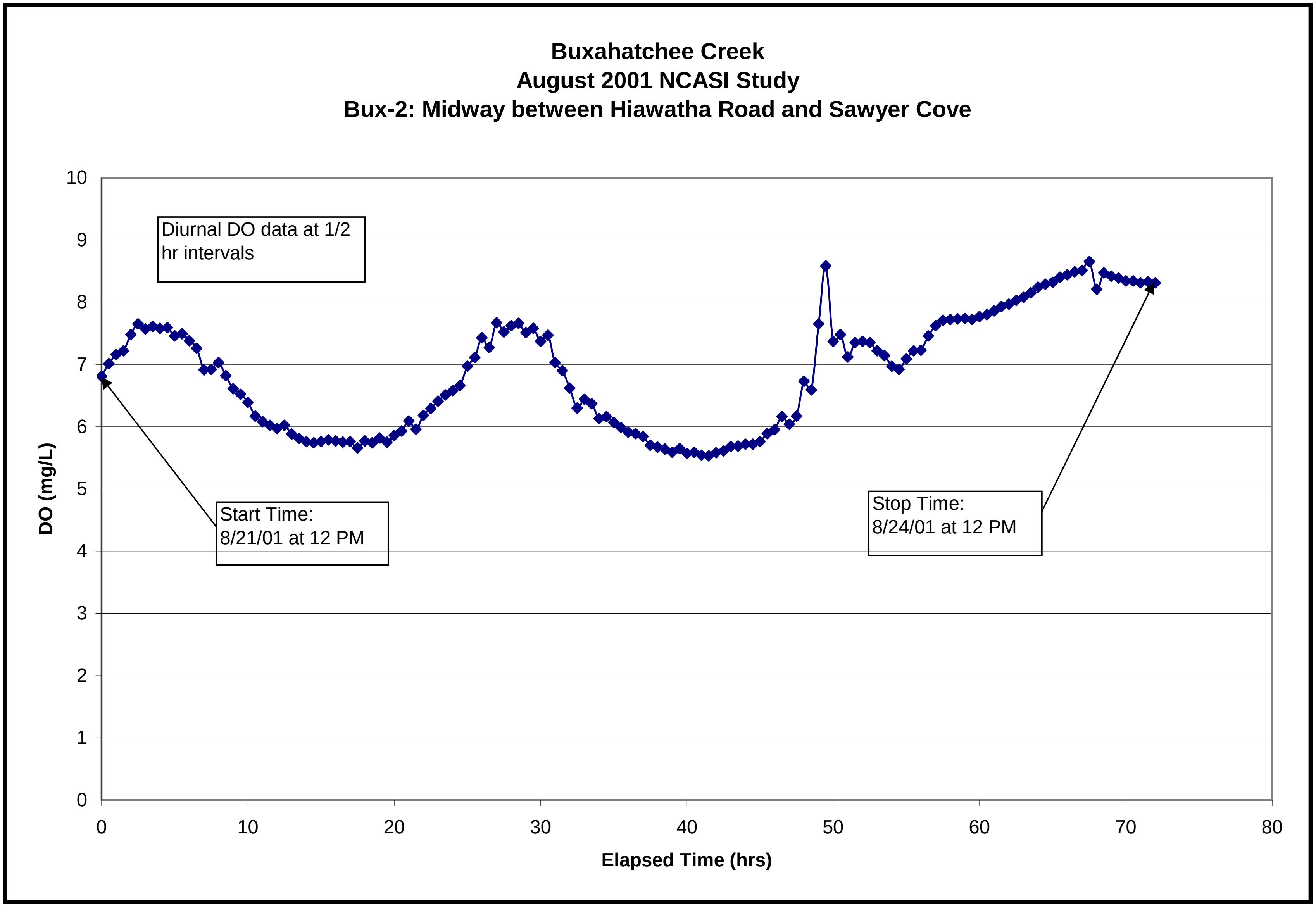
ADEM INTENSIVE SURVEY DATA (Continued)



NCASI DATA


Buxahatchee Creek
August 2001 NCASI Study
Bux-1: Bux Creek just upstream of Waxahatchee Creek
Diurnal DO data at 1/2 hr intervals
Start Time:
8/21/01 at 12 PM
Stop Time:
8/24/01 at 12 PM
DO (mg/L)
Elapsed Time (hrs)
0
1
2
3
4
5
6
0
10
20
30
40
50
60
70
80

NCASI DATA (Continued)



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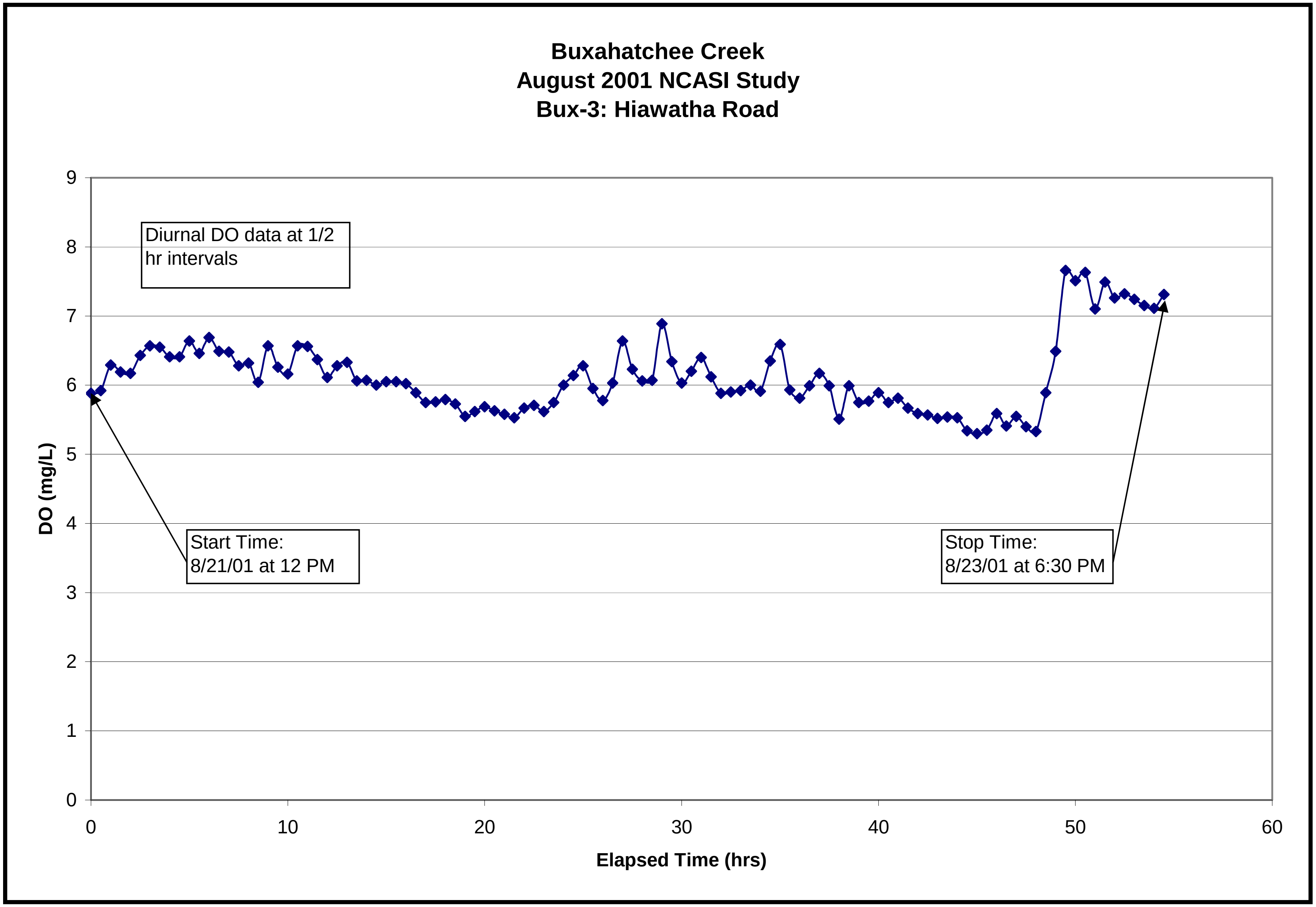

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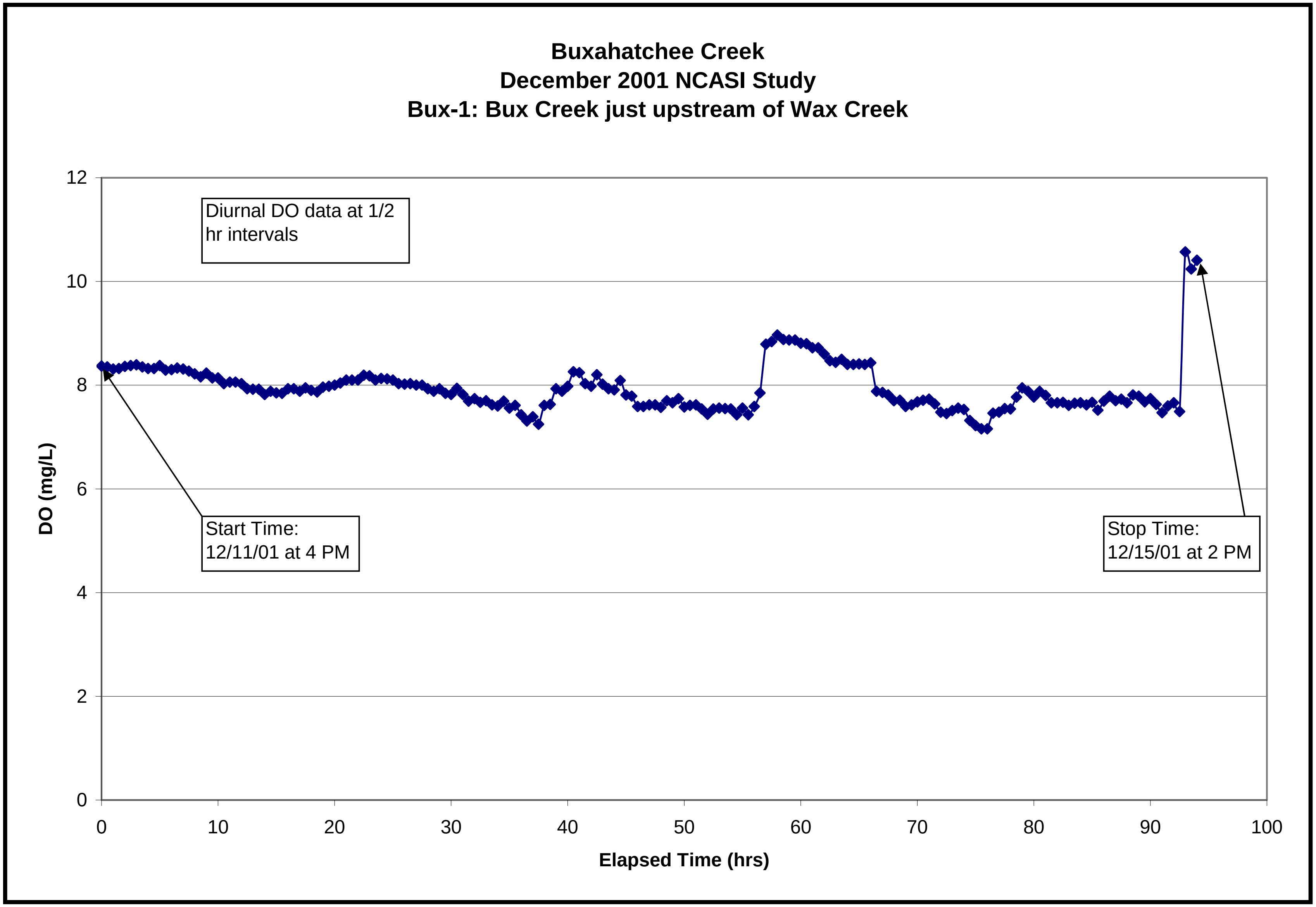

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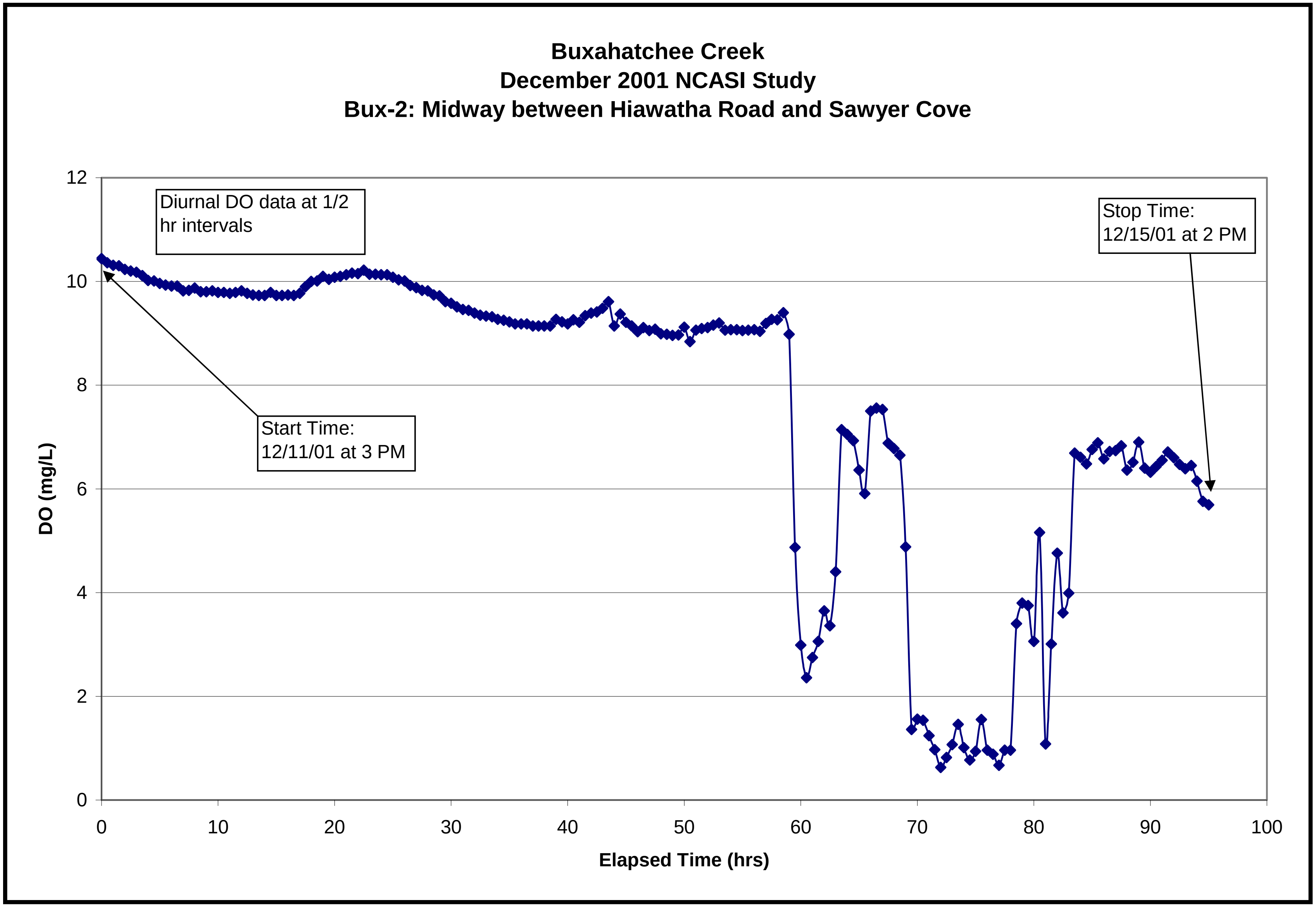

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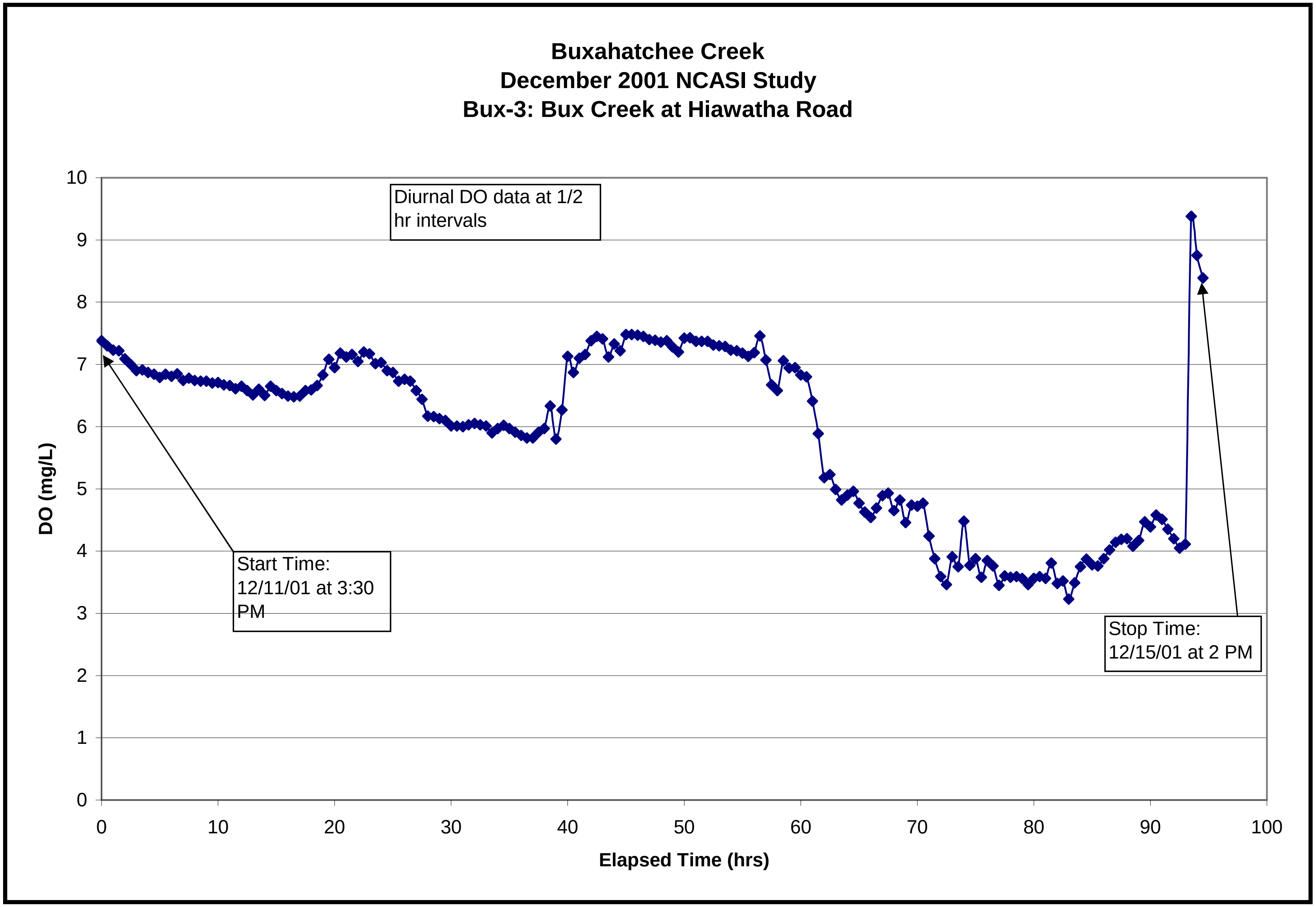

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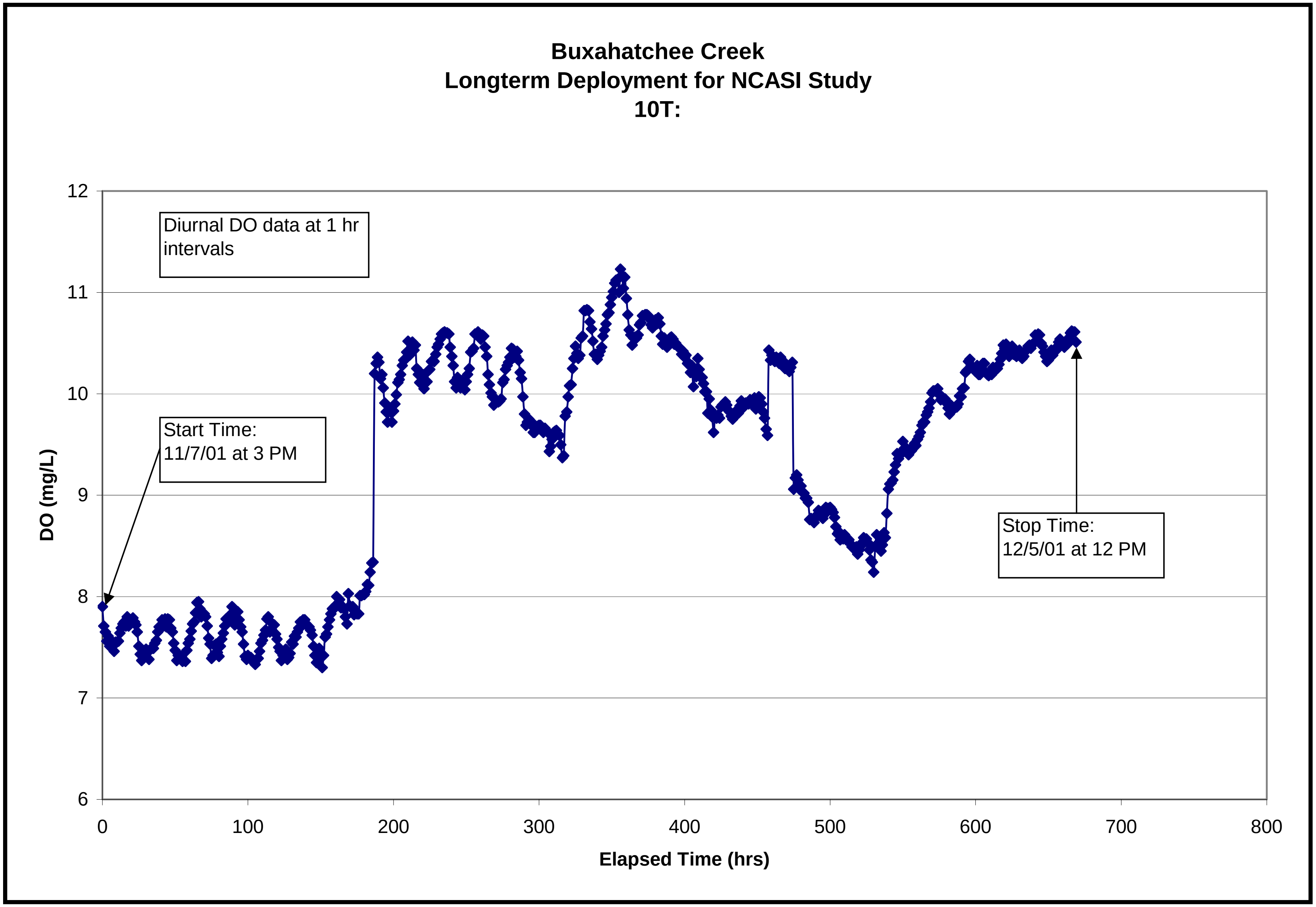

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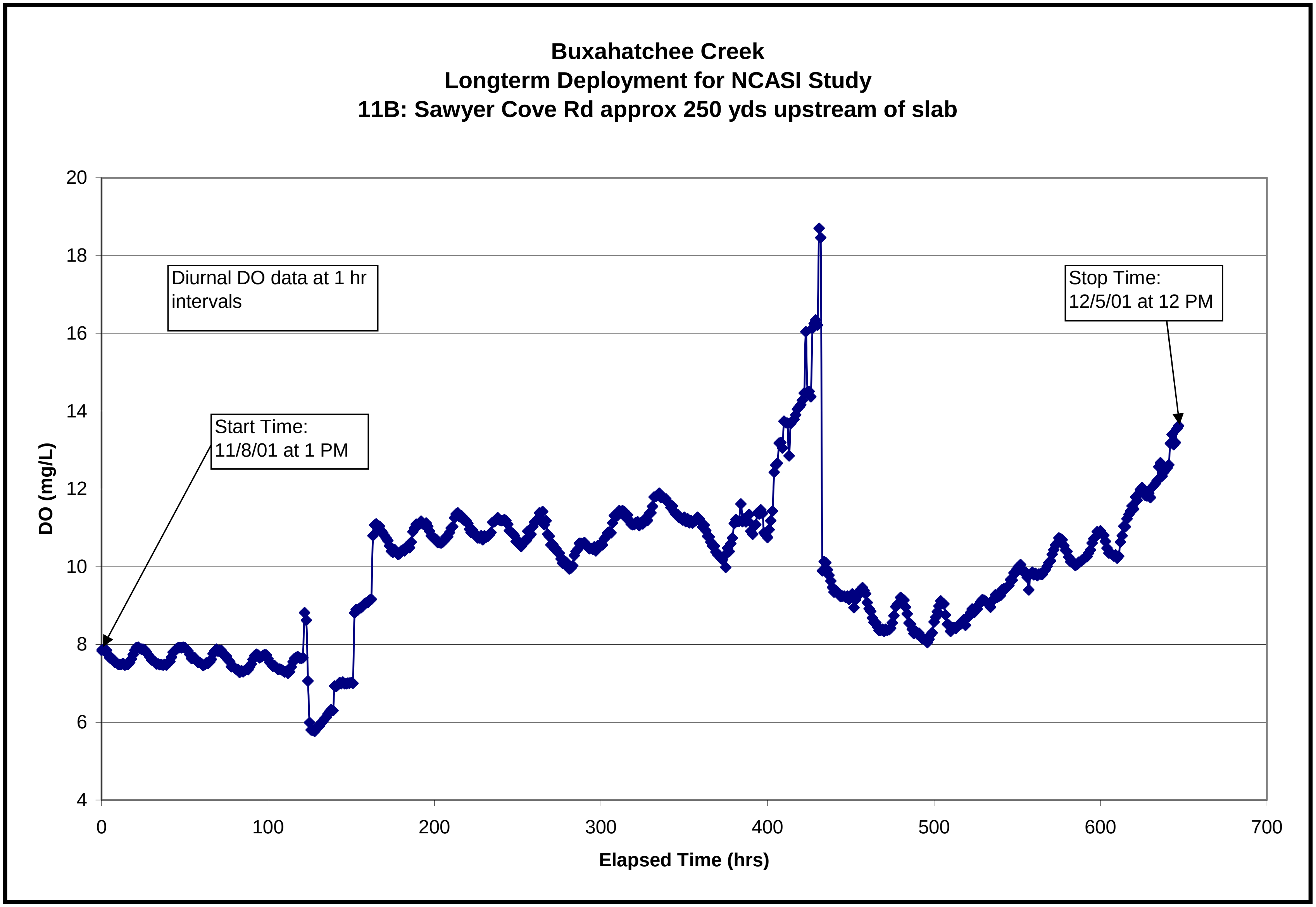

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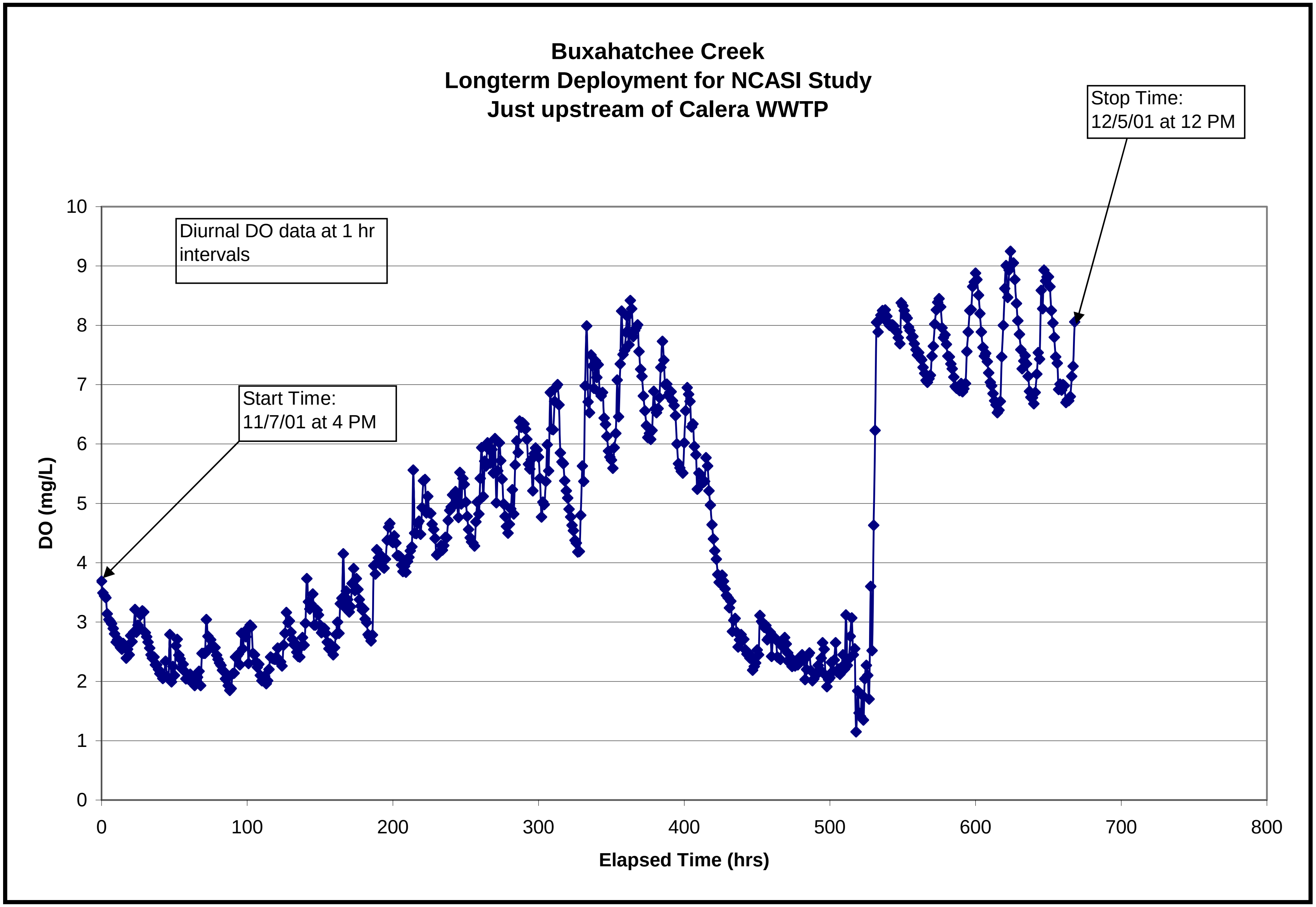

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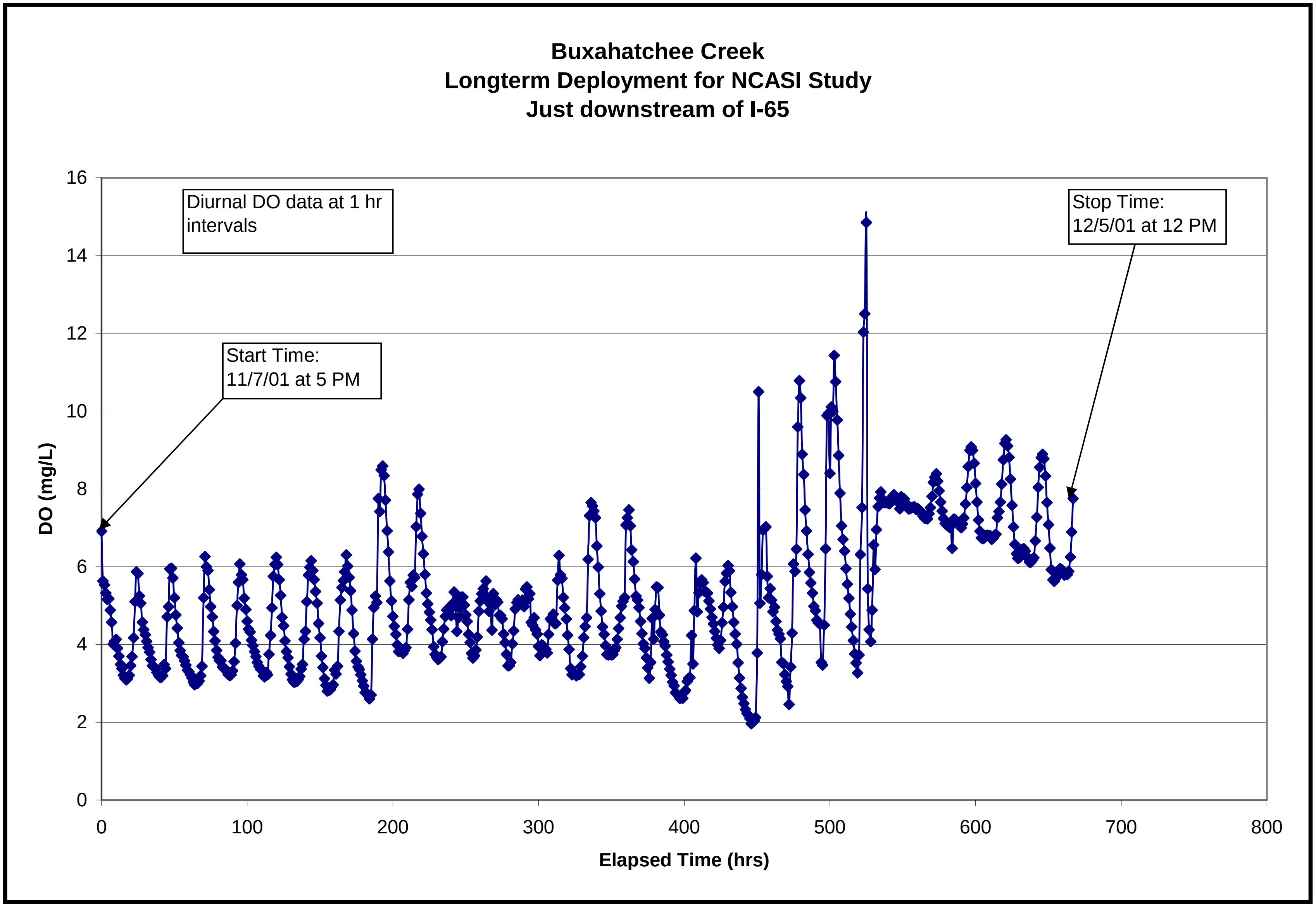

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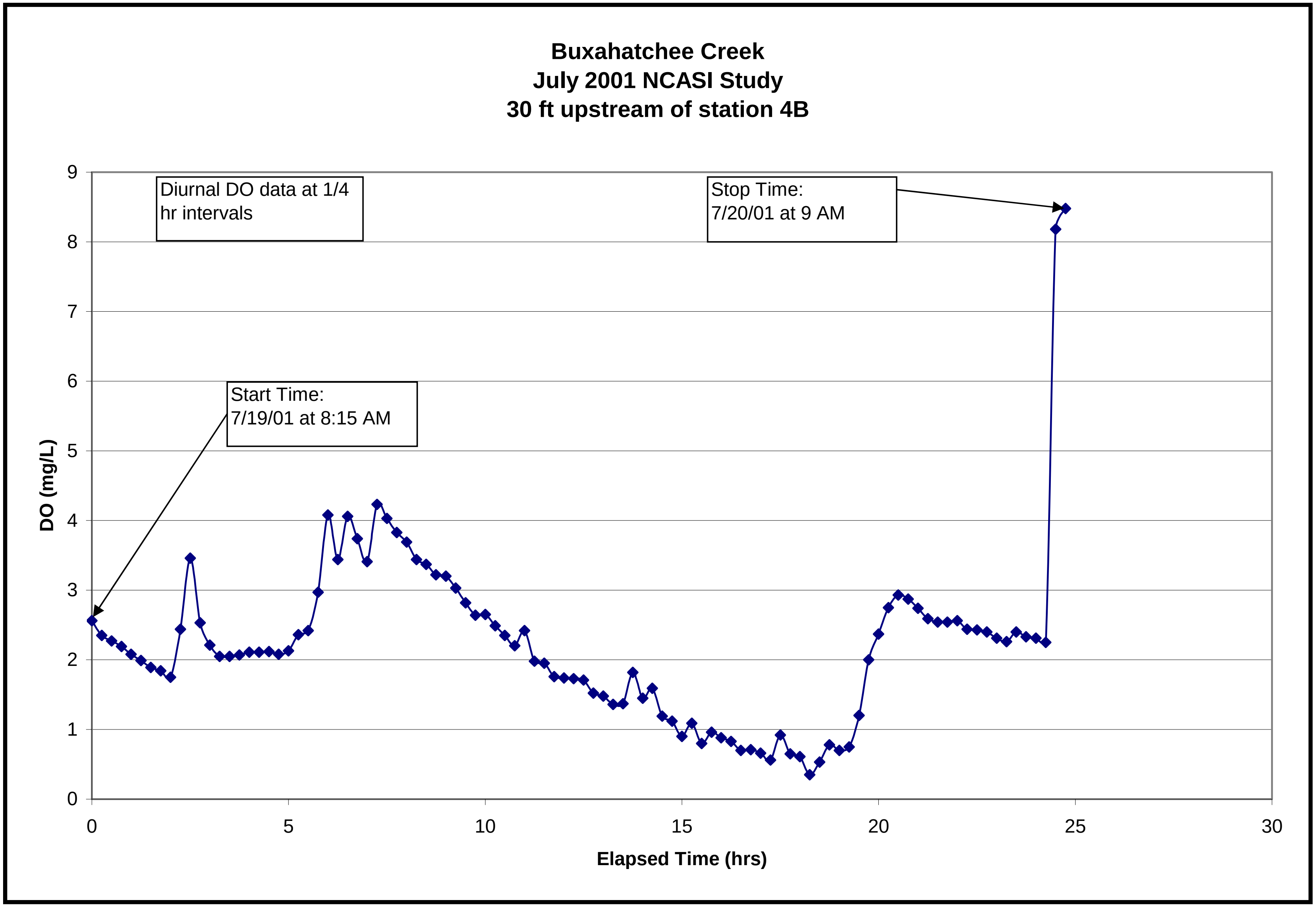

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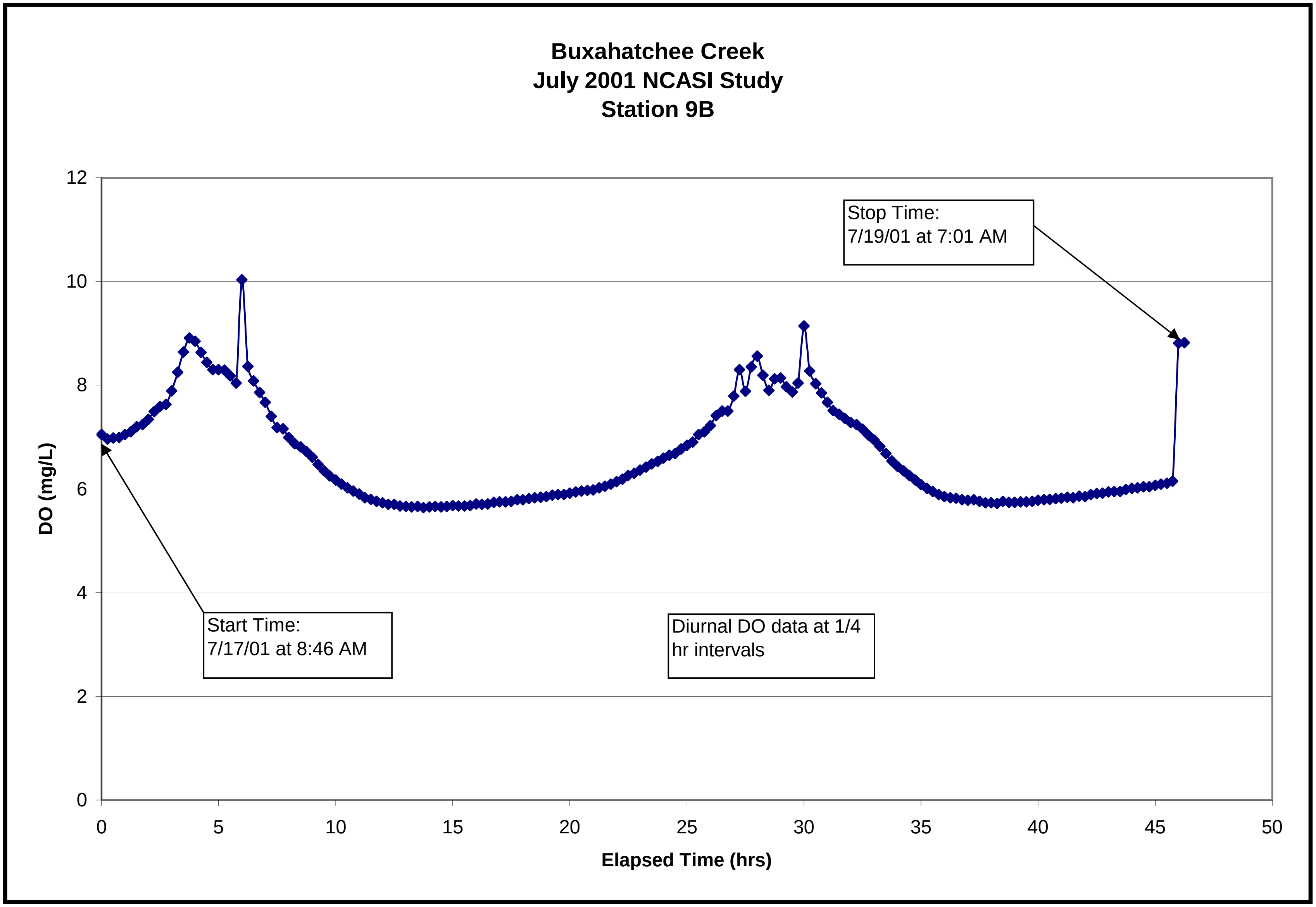

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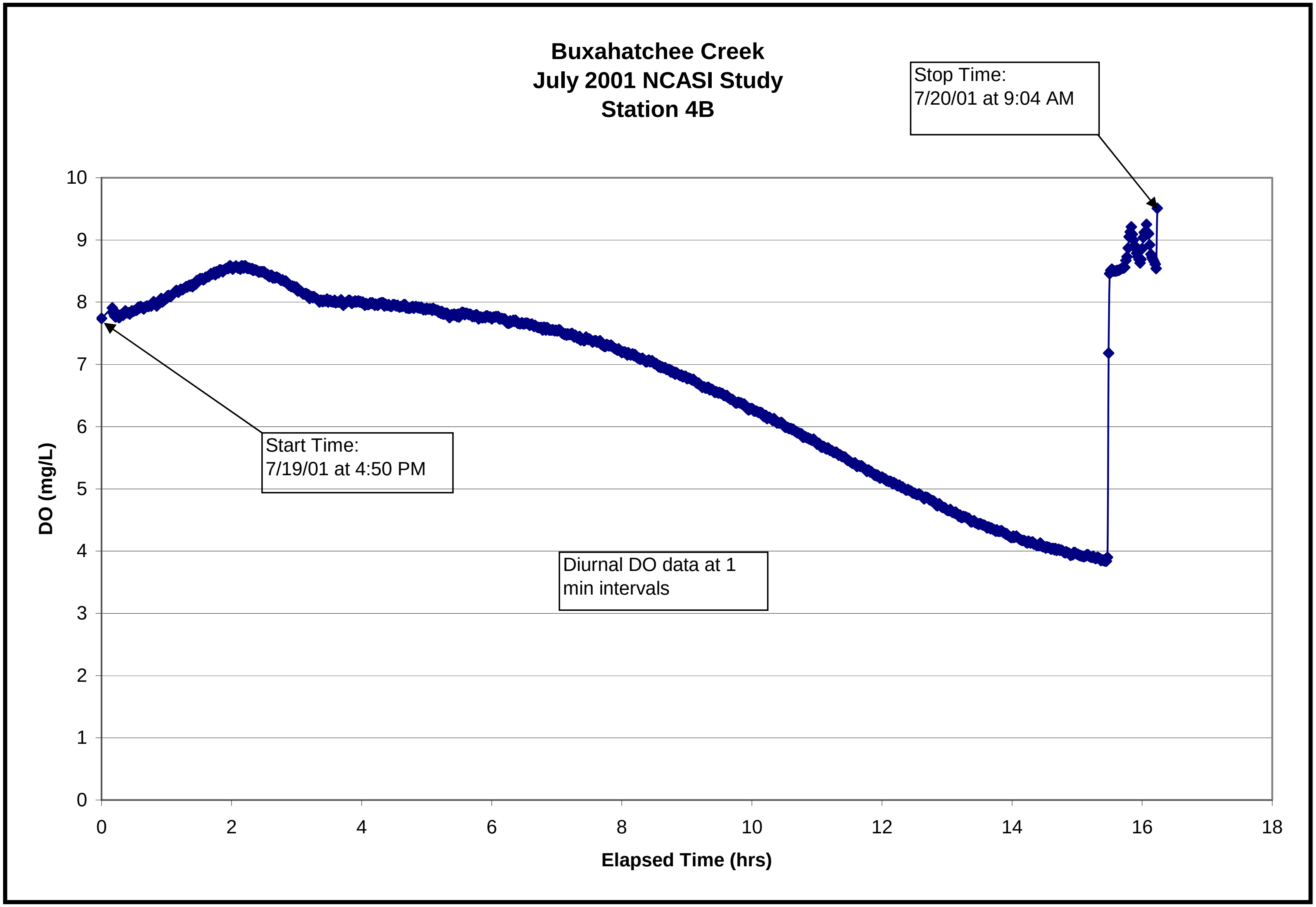

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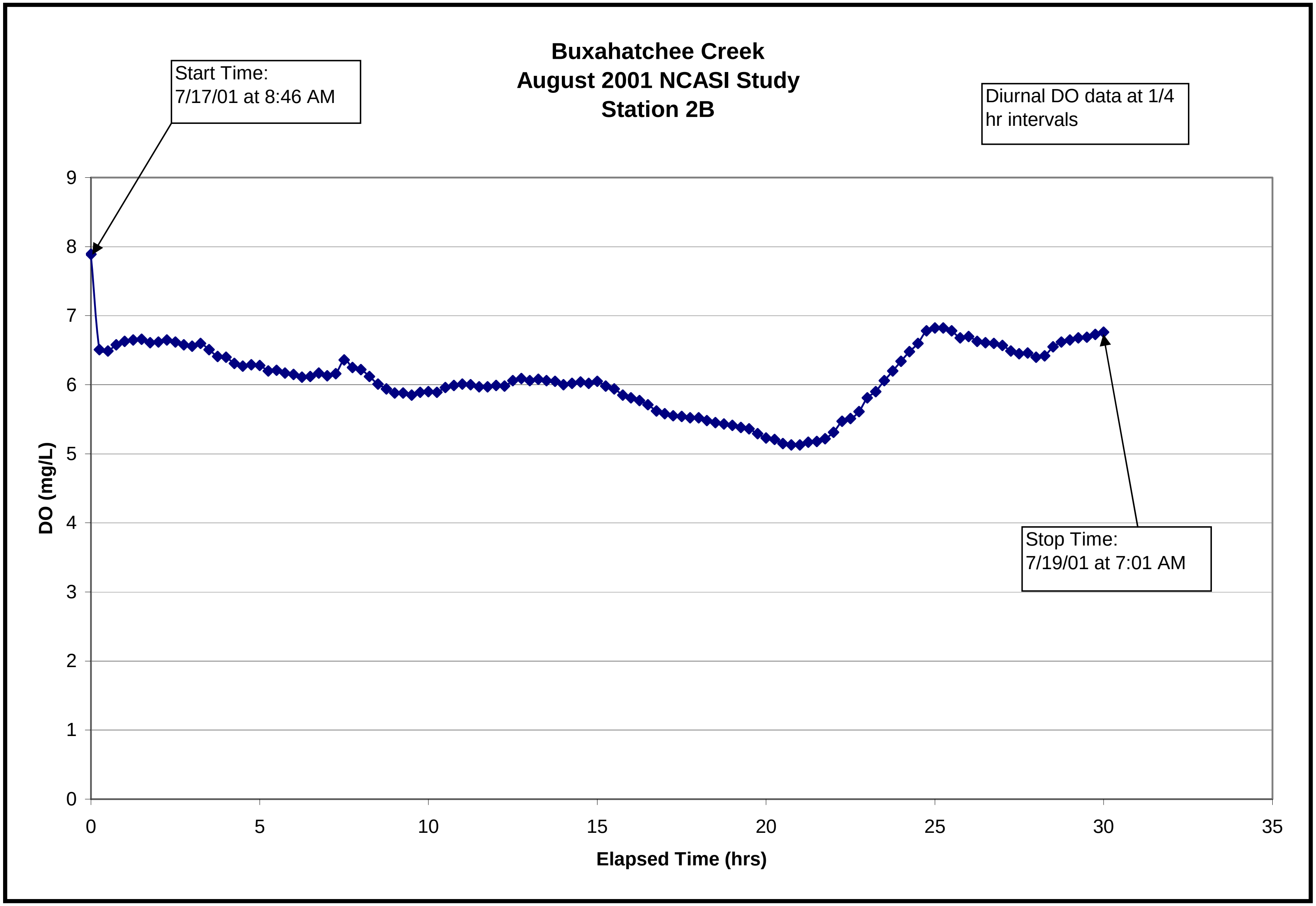

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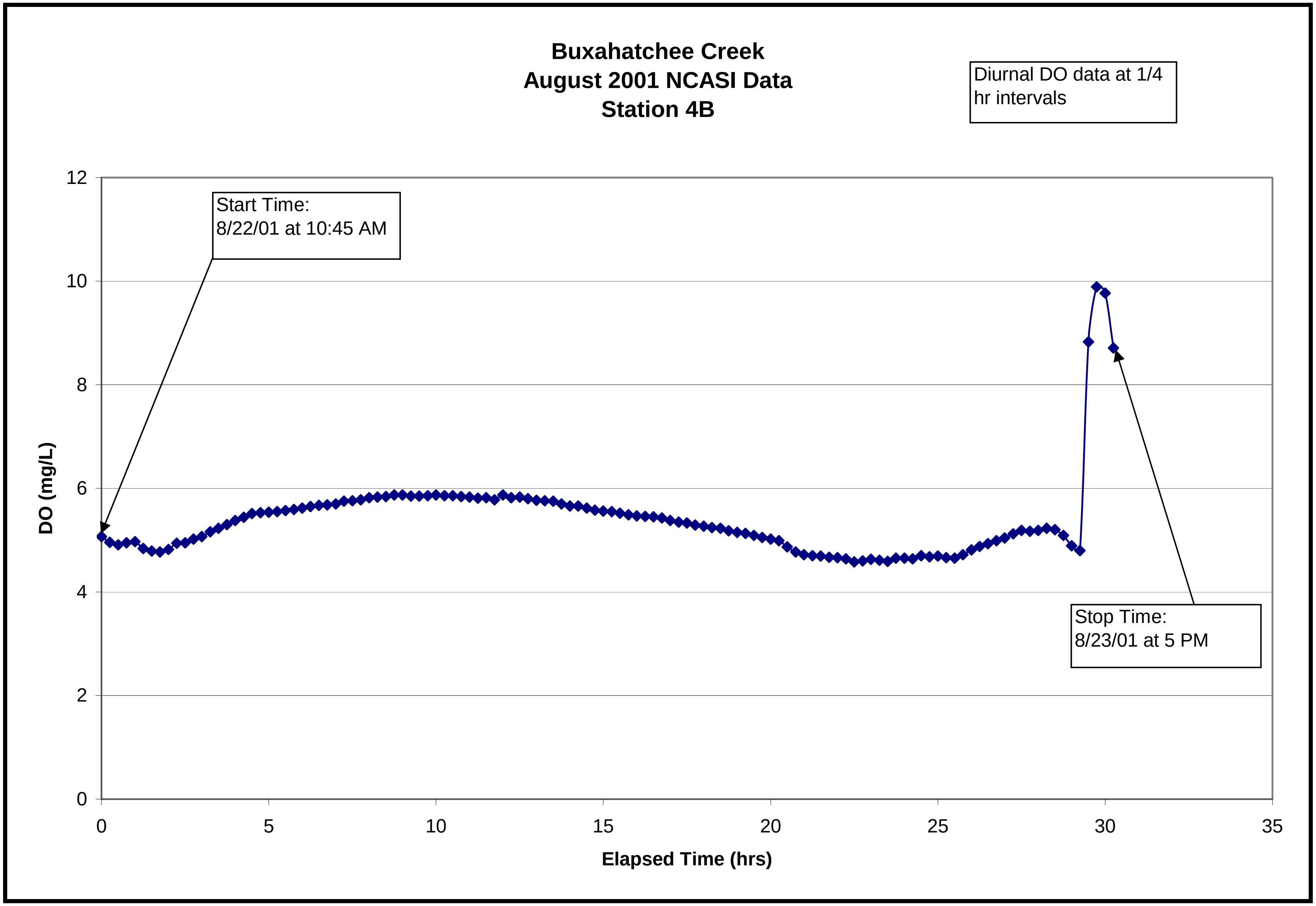

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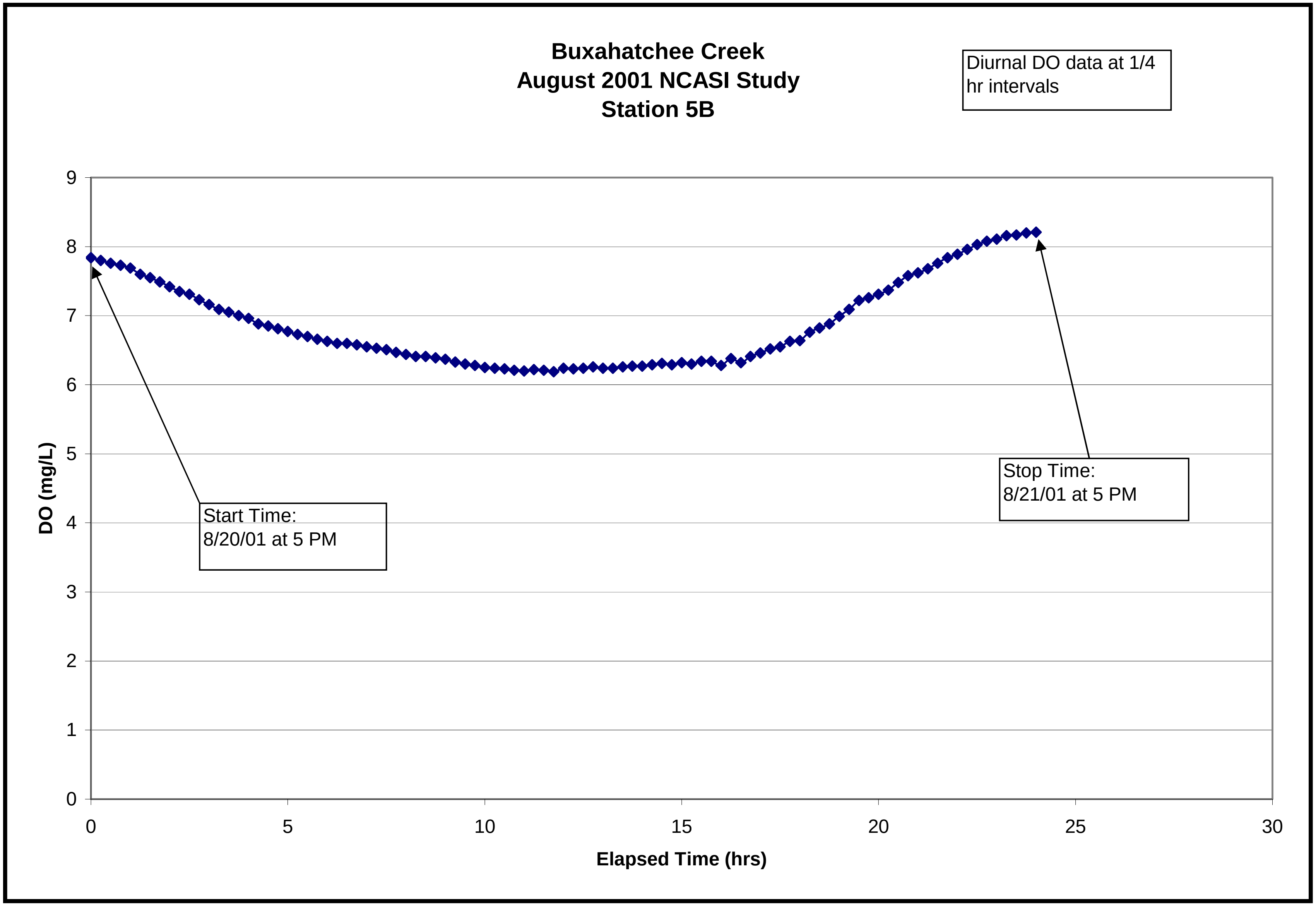

SOD Data from EPA

STATION	REP	DATE	TIME	UNADJ. D.O. RATE (mg/l/min)	ADJ. D.O. RATE (mg/l/min)	W. COLUMN RESP. (mg/l/min)	SOD** (gr O2/m2/d)	STND. DEV. (gr O2/m2/d)	CV (As Percent)
9B - Hiawatha Road	*1	9/25/2001		NA	NA				
	2		0922-1442	0.00489	0.00454		1.56200		
	3		0927-1442	0.00516	0.00481		1.65316		
	4		0932-1037	0.00515	0.00480		1.64945		
	0		0942-1437			0.00035			
	00		0957-1437			0.00035			
STA MEAN				**0.00380**	**0.00354**	**0.00035**	**1.21615**	**0.05159**	**4.24232**
4B - Timberline	***1	9/26/2001		NA	NA				
Golf Course	2		0932-1307	-0.00586	-0.00570		-1.96011		
	3		0937-1307	-0.00553	-0.00537		-1.84569		
	4		0937-1307	-0.00633	-0.00617		-2.12049		
	0		1012-1307			-0.00016			
	00		1017-1307			0.00037			
STA MEAN				**-0.00591**	**-0.00575**	**0.00011**	**1.97543**	**0.13804**	**6.98777**
2B - Calera	1	9/27/2001	0847-1117	0.00637	0.00566		1.94512		
WWTP D/S	2		0847-1127	0.00498	0.00428		1.47060		
	3		0847-1127	0.00422	0.00352		1.20825		
	4		0852-1127	0.00539	0.00469		1.61094		
	0		0852-1122			0.00071			
	00		0852-1122			0.00076			
STA MEAN				**0.00524**	**0.00454**	**0.00073**	**1.55873**	**0.30694**	**19.69142**
P1 - Calera	1	9/27/2001	1352-1602	0.02022	0.01983		6.81653		
WWTP U/S	2		1352-1607	0.01539	0.01500		5.15640		
	3		1352-1602	0.01666	0.01627		5.59204		
	4		1352-1607	0.01306	0.01267		4.35429		
	0		1347-1557			0.00039			
	00		1342-1557			0.00031			
STA MEAN				**0.01633**	**0.01594**	**0.00035**	**5.47982**	**1.02807**	**18.76107**

*SEAL ON CHAMBER WAS BREECHED. NO DATA WAS OBTAINED FROM CHAMBER 1.
** ADJUSTED FOR WATER COLUMN RESPIRATION
***PUMP ON CHAMBER MALFUNCTIONED. NO DATA WAS OBTAINED FROM CHAMBER 1.

Reaeration Data from Limno-Tech

Table 1. Buxahatchee Creek Reaeration Survey Location and Descriptive Information

	Upstream Reach (above I-65)	Downstream Reach (below I-65)
Survey Dates	9/12-13/02	9/11-12/02
Injection Point	River Mile 0.42 (at Calera, AL sewage treatment plant outfall)	River Mile 0.93 (below tributary from golf course (location 3T))
Upstream Sampling Station	River Mile 0.49 (336 ft d.s. of injection point)	River Mile 0.98 (254 ft d.s. of injection point)
Downstream Sampling Station	River Mile 0.66	River Mile 1.07
Estimated Average Surface Water Slope	0.0027 ft/ft	0.0019 ft/ft
Average Stream Width Range	Approx. 3-30 feet	Approx. 25-30 feet
Average Stream Depth Range	Approx. 0.3-3+ feet	Approx. 1.3-2.4 feet
Notable Characteristics	Variable depths and widths between riffles and pools, two 90 degree bends in stream, a small tributary and a beaver dam between sampling stations	Fairly uniform and straight channeled stream reach, no riffles, no obstructions, no tributaries in the reach

Table 1. Buxahatchee Creek Reaeration Survey Results

	Upstream Reach Survey 9/12-13/02		Downstream Reach Survey 9/11-12/02	
	Upstream Station	Downstream Station	Upstream Station	Downstream Station
Time of Travel to Dye Peak (min)	70	635	172	477
Peak Dye Concentration (ug/L)	320.6	31.3	154.5	36.6
Peak Propane Concentration (ug/L)	97	2.3	24	1.9
Dye Recovery Ratio*	0.86	0.88	0.95*	0.80*
Propane Gas Desorption Rate Coefficient between Stations (1/hr)*	0.15		0.20	
Stream Reaeration Rate Coefficient (at 20^{o}C) between Stations (1/hr)*	0.18		0.25	

* Results using literature values for Recovery Ratio

Appendix C

2005 Buxahatchee Creek Report

Results of Macroinvertebrate and Periphyton Community Assessments

3 October 2006

**Environmental Indicators Section –
Field Operations Division**

Background

Buxahatchee Creek, a tributary of the Coosa River basin, drains approximately 70 mi^2 in Chilton and Shelby Counties. A 13-mile segment of Buxahatchee Creek has been included on Alabama's biennial §303(d) lists since 1996 for impairments caused by nutrient enrichment. Municipal and urban runoff/storm sewers were identified as the sources of the impairment on the 2000 §303(d) list.

Objectives

At the request of the Water Quality Branch of ADEM's Water Division, macroinvertebrate community bioassessments were conducted at three segments of Buxahatchee Creek. The objectives of these assessments were twofold:

1. To assess the condition of the macroinvertebrate communities in Buxahatchee Creek using ADEM's intensive-level macroinvertebrate bioassessment (MB-I) method; and,
2. To provide baseline macroinvertebrate bioassessment data that can be used to measure any changes in water quality due to development and implementation of Total Maximum Daily Load(s) (TMDL).

Methods

Buxahatchee Creek 2005 Assessment Database: To assist with data analysis and reporting, all information and data associated with the 2005 Buxahatchee Creek assessment was compiled into one ACCESS database. The five tables contain all field parameters, chemical samples, and habitat assessment results. The four forms can be used to view and print station descriptions, requested parameters and sampling frequency, Habitat Assessment/Physical Characterization information, and results of laboratory analyses.

Station Locations: Water samples were requested at two stations upstream and five locations downstream of the Calera WWTP outfall. Samples could not be collected at BXHS-1, the most upstream station, however, due to a lack of flow. Samples could also not be collected at BXHS-5 and BXHS-6, the two downstream-most locations.

Water quality sample collection: Field parameters, flows, and intensive water quality sampling was conducted March, April, May, July, and August at BXHS-2, BXHS-3, BXHS-3A, and BXHS-4. Samples were also collected during June and October at BXHS-4. At the request of ADEM's Director, samples were not collected during September due to the gasoline shortage caused by Hurricane Katrina. Duplicate field parameters were collected during 10% of the sampling events. Duplicate water quality samples were collected during 5% of the sampling events.

Chemical analyses of water samples were conducted by ADEM's Central Laboratory in Montgomery. Water quality samples for laboratory analysis were collected, preserved, and transported to ADEM's Laboratory as described in ADEM Field Operations Standard Operating Procedures and Quality Control Assurance Manual, Volume I - Physical/Chemical (ADEM 2000c). Laboratory analyses were conducted in accordance with ADEM's Quality Assurance Manual for the Alabama Department of Environmental Management Central Laboratory (ADEM 1999d).

Sample handling and chain-of-custody procedures were used for all biological and chemical samples as outlined in ADEM Field Operations Standard Operating Procedures and Quality Control Assurance Manual, Volumes I and II to ensure the integrity of all samples collected (ADEM 1999a, 2000c).

Water Quality Assessment guidelines: The four Buxahatchee Creek stations are located within the Piedmont (45a) and Ridge and Valley (67g) ecoregions. Median and average values of water quality parameters were assessed as *exceeding* or *not exceeding* background levels as defined by the 90^{th} percentile of data collected at least-impaired ecoregional reference reaches within that subecoregion from 1991-2001 (ADEM 2004a). The 5^{th} and 95^{th} percentile were treated as outliers and removed before analysis. These values are provided in Table 1.

Table 1. Ecoregional reference guidelines (90th percentile of ecoregional reference reach data minus 5th and 95th percentiles)

Subecoregion	**67g**					**45a**	
	Final 90th	**Final N**	**Min**	**Max**	**Median**	**Final 90th**	**Final N**
F COL (col/100ml)	360	17	41	1110	130	573	20
Chl a (mg/m^3)	1.924	19	0.270	2.400	1.000	1.070	1
Alk, total (mg/l)	55.0	22	18.0	56.0	34.5	21.8	27
Hard (mg/l)	50.0	21	20.0	56.0	34.0	21.3	31
CBOD-5 (mg/l)	2.5	14	0.2	5.3	0.9	1.5	9
COD (mg/L)	7.5	9	2.0	10.0	2.0	2.0	4
TSS (mg/l)	17.0	23	1.0	28.0	7.0	16.0	27
TDS (mg/l)	102.0	21	59.0	116.0	78.0	66.0	21
TOC (mg/l)	9.179	20	2.267	12.678	4.957	3.125	20
Total-P (mg/l)	0.073	22	0.020	0.106	0.050	0.050	34
NO2+NO3-N (mg/l)	0.158	23	0.003	0.229	0.060	0.158	33
NH3-N (mg/l)	0.058	23	0.015	0.079	0.015	0.033	33
TKN (mg/l)	0.629	22	0.150	0.726	0.335	0.278	32
DRP (mg/l)	0.025	23	0.004	0.029	0.011	0.017	15
AL-T (mg/l)	1.590	10	0.200	2.070	0.748	0.200	6
AL, Dis (mg/l)	0.200	10	0.100	0.200	0.200	0.108	2
Fe-T (mg/l)	1.820	10	0.358	2.170	1.109	0.981	12
Fe, Dis (mg/l)	0.482	10	0.123	0.507	0.324	0.241	2
Mn-T (mg/l)	0.082	3	0.058	0.087	0.062	0.124	12
Mn, Dis	0.050	4	0.042	0.050	0.048		0

(mg/l)							

Macroinvertebrate bioassessment sample collection and processing: Habitat and macroinvertebrate assessments were conducted at three locations on Buxahatchee Creek (BXHS-4, BXHS-3A, and BXHS-2). Station descriptions are provided in the Station Locations Table of the 2005 Buxahatchee Creek Database. Assessments were conducted May 12th, 2005 using ADEM's Standard Operating Procedures and Quality Assurance Manual, Volume II-Freshwater Macroinvertebrate Biological Assessment (ADEM 1999). Macroinvertebrate samples were also processed and identified in accordance with ADEM 1999.

Macroinvertebrate assessments: Macroinvertebrate bioassessments were based on ADEM's 2005 Ecoregional Guidelines (ADEM 2005) for Piedmont (45; BXHS-3A and BXHS-4) and Ridge and Valley (BXHS-2) streams. Description of metrics and criteria are provided in Tables 2-4.

Table 2. Interpretation of metrics

Metric	ADEM 2005	Description
Total taxa richness	X	Total number of taxa (genera or lowest taxonomic level) collected at a site. Generally decreases with decreasing water quality, but can increase at low levels of nutrient enrichment.
EPT taxa richness	X	EPT taxa richness is the total number of distinct taxa (genera) within the generally pollution-sensitive orders Ephemeroptera, Plecoptera, and Trichoptera. This metric generally increases with increasing water quality, but may also increase due to low-level organic enrichment.
% EPT organisms	X	Percent of organisms collected at a site that are members of the EPT orders (see above). Generally decreases with decreasing water quality; but can increase at low levels of nutrient enrichment.
NCBI	X	Index between 1 and 10 calculated by multiplying the number of organisms within a single taxon by the tolerance value of that taxon (also 1-10). ADEM's tolerance values are based on those developed by North Carolina (Lenat 1993), but calibrated to ADEM's method and level of taxonomic identification (ADEM 1999, ADEM 2005). The biotic index increases as water quality decreases.
% Dominant taxon	X	Percent contribution of the numerically dominant taxon. This metric generally increases with decreasing water quality.
% Nutrient-tolerant taxa		Percent contribution of 13 taxa generally found to be tolerant of nutrient enriched conditions, including *Baetis*, *Stenacron*, *Cheumatopsyche*, *Chironomus*, *Polypedilum*, *Rheotanytarsus*, *Cricotopus*, *Simulium*, *Psephenus*, *Stenelmis*, *Lirceus*, *Physella*, *Elimia*, Oligochaeta (Brumley et al. 2003). ADEM modified this metric by using percent contribution of the families Baetidae, Simuliidae, and Physidae. Percent nutrient tolerant taxa is generally 44% or lower at ADEM's ecoregional reference reaches.

Table 3. Scoring criteria for ADEM's Ridge and Valley (67) bioregion.

Bioregion 67				
Score	**0**	**1**	**3**	**5**
Total taxa richness	<28	28-55	56-65	>65

EPT taxa richness	<8	8-15	16-19	>19
% EPT organisms	<18	18-37	38-52	>52
NCBI	>7.65	5.30-7.65	4.50-5.30	<4.5
% Dominant taxon	>48	24-48	14-24	<14
Final Assessment	**Poor**	**Fair**	**Good**	**Excellent**
Final Score	<10	11-15	16-21	>21

Table 4. Scoring criteria for ADEM's Piedmont (45) bioregion.

Bioregion 45				
Score	**0**	**1**	**3**	**5**
Total taxa richness	<24	24-47	48-57	>58
EPT taxa richness	<7	7-13	14-18	>18
% EPT organisms	<14	14-27	28-37	>37
NCBI	>7.6	5.2-7.6	5.2-4.9	<4.9
% Dominant taxon	>65	33-65	22-32	13-22
Final Assessment	**Poor**	**Fair**	**Good**	**Excellent**
Final Score	<12	12-16	17-20	>20

Periphyton bioassessment sample collection and processing: Periphyton bioassessments were conducted at BXHS-4, BXHS-3A and BXHS-2. Station descriptions are provided in the Station Locations Table of the 2005 Buxahatchee Creek Database. Assessments were conducted using ADEM's 2005 Standard Operating Procedures and Quality Assurance Manual (ADEM 2005b). Rapid periphyton surveys (RPSs) were conducted at BXHS-2 and BXHS-3a on May 12^{th}. Periphyton biomass as chlorophyll *a* and an RPS was collected at BXHS-4 during April, May, and October of 2005.

Periphyton assessments: Periphyton bioassessments of the bioassessments conducted in May were based on ADEM's 2002 Periphyton Bioassessment Guidelines (ADEM 2004). Description of metrics and criteria are provided in Table 5.

Table 5. Interpretation of periphyton metrics.

Metric	75^{th} %ile of Ecoregional Reference Sites (ADEM 2004)	**Description**
Periphyton Biomass as Chlorophyll *a*	33	One of the four variables currently recommended to initiate nutrient criteria development (USEPA 2000). Measured as mg/m2 using standard methods. Generally increases with increasing nutrient enrichment. It can difficult to accurately measure in streams due to the patchy distribution, scouring, and occurrence on non-uniform stream bottoms. It is also possible to miss peak biomass.
% Cover Filamentous Algae	29	% of stream bottom covered with filamentous (nuisance) algae (visually estimated). Also subject to scouring.

Periphyton Thickness	0.8	Visual estimate of periphyton thickness in mm. Increases with increasing nutrient enrichment.

Results

Macroinvertebrate assessment results are summarized in Table 6. Periphyton assessment results are summarized in Table 7.

BXHS-2: Buxahatchee Creek at BXHS-2, located upstream of the Calera WWTP, drains the city of Calera. The stream reach was estimated to be 100% pool habitat. Flows and stream velocity were generally low. The site was characterized by sand (45%), gravel (25%), and silt (17%) substrates and a lack of riparian buffer.

The macroinvertebrate community at BXHS-2 appeared to be in worse condition than the downstream sites, with the highest NCBI value (8.0) and an EPT taxa richness score of 0. These results may be at least partly attributed to low flow and the lack of riffle-run habitat.

Periphyton bioassessment results indicated percent cover as filamentous algae and periphyton thickness to be higher than expected at ADEM's ecoregional reference reaches. However, these results may also be due in part to the slower velocities and lack of scouring at the site.

Median and average nutrient concentrations at the site were generally similar to the 90th percentile of nutrient concentrations at ADEM's ecoregional reference reaches in Ecoregion 67g. The chlorophyll *a* concentration in May was 9.08 mg/L in May, however, and median and average chlorophyll *a* values were higher than values expected at ADEM's reference reaches. Fecal coliform was measured at 3,200 colonies/100mL during a high-flow event in April.

BXHS-3: Buxahatchee Creek at BXHS-3 is located downstream of the Calera WWTP. The stream reach was characterized by 70% cobble substrate and 95% run habitat. The habitat assessment rated habitat quality as *good* using the riffle-run habitat assessment matrix.

A macroinvertebrate assessment was not conducted at the site.

Median and average nutrient concentrations at the site exceeded values expected at ADEM's reference reaches located in Ecoregion 67g. The dissolved oxygen concentration in July was measured at 4.3 mg/L. Flow was not measured during any of the site visits. Fecal coliform was measured at 2,800 colonies/100mL during a high-flow event in April. Total suspended solids, total dissolved solids, alkalinity, and hardness were also elevated at the site.

BXHS-3A: Buxahatchee Creek at BXHS-3A is located downstream of the Calera WWTP. The stream reach was dominated by run habitat with some riffle areas. Bottom substrates were composed of 43% sand and silt and 57% stable substrates. The habitat assessment rated habitat quality as *good* using the riffle-run habitat assessment matrix.

The macroinvertebrate community at BXHS-3A was assessed as *poor*, based on ADEM's 2005 Ecoregional Assessment Guidelines. Eighty percent of the organisms collected were classified as nutrient tolerant taxa, suggesting that nutrient enrichment is affecting the diversity and composition of the macroinvertebrate community. Conditions were improved from BXHS-2, however, due to increased flow and aeration of water through the riffle areas.

Periphyton bioassessment results also suggest nutrient enrichment. Filamentous algae was estimated to cover 65% and 43% of the stream bottom within the macroinvertebrate and periphyton bioassessment sampling reaches, respectively. Average periphyton thickness was 13.5mm.

Median and average nutrient concentrations at the site exceeded values expected at ADEM's reference reaches located in Ecoregion 45a. Flow was not measured during any of the site visits. Total dissolved solids, alkalinity, and hardness were also elevated at the site.

BXHS-4: Buxahatchee Creek at BXHS-4, the downstream-most site, was estimated to be 30% riffle and 40% run habitat. Bedrock (40%), sand (20%) boulder (15%), and cobble (15%) were the dominant substrate types. The habitat assessment rated habitat quality as *excellent* using the riffle-run habitat assessment matrix.

The macroinvertebrate community at BXHS-4 was improved from BXHS-2 and BXHS-3a, probably due to the improved habitat conditions. The macroinvertebrate community was assessed as *poor*, however, based on ADEM's 2005 Ecoregional Assessment Guidelines. Close to 65% of the organisms collected were classified as nutrient tolerant taxa.

Percent filamentous algal cover and periphyton biomass as chlorophyll a were similar to ecoregional reference conditions.

Median and average nutrient concentrations at the site exceeded values expected at ADEM's reference reaches located in Ecoregion 45a. Total dissolved solids, alkalinity, and hardness were also elevated at the site.

Table 6. Summary of macroinvertebrate assessment results.

Metric	BXHS-2	BXHS-3a	BXHS-4
Total Taxa Richness	33	36	39
EPT Taxa Richness	0	5	6
% EPT Organisms	0	21	30
% Dominant Taxon	32	22	26
NC Biotic Index	8.0	7.3	6.0
% Nutrient Tolerant	67	80	64
EPT Families	0	4	5
Assessment Score	2	7	8
Final Assessment	Poor	Poor	Poor

Table 7. Summary of periphyton assessment results.

Metric	75th %ile of Ecoregional Reference Sites	BXHS-2	BXHS-3a	BXHS-4
Sampling Date		5/12/2005	5/12/2005	5/11/2005
Periphyton Biomass as	33	---	---	41.9
% Cover Filamentous	29	53	43	22
Average Periphyton	0.8	7.5	13.5	4.7

Conclusions

Macroinvertebrate assessment results indicated the macroinvertebrate communities above and below the Calera WWTP to be in *poor* condition. The poor conditions at BXHS-2 may be at least partly attributed to low flow and the lack of riffle-run habitat. Results of water quality sampling and periphyton bioassessments conducted during 2005 suggest that nutrient enrichment is also affecting the macroinvertebrate communities at BXHS-3a, and, to a lesser extent, BXHS-4.

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