DRAFT PHASE I REPORT

Canadian River Wasteload Allocation Study

Union City to Wayne, Oklahoma

Association of Central Oklahoma Governments

March 3, 2009

Submitted by:
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March 3, 2009

Mr. John Harrington
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RE: Phase 1 Report, Field Quality Assurance Project Plan, and
Modeling Quality Assurance Project Plan

Dear John:

In accordance with our project requirements, enclosed you will find one bound copy and one CD-Rom for each of the following:

- *Draft Phase 1 Report, Canadian River Wasteload Allocation Study, Union City to Wayne, Oklahoma*
- *Draft Modeling Quality Assurance Project Plan, Canadian River Wasteload Allocation Study, Union City to Wayne, Oklahoma*

At this time, we will not be submitting the *Draft Field Quality Assurance Project Plan* due to an incomplete data set involving proposed sampling locations and the required access permission. Due to this missing data and some new thoughts regarding Phase 2, we are also not able to provide the detailed revised scope of services/cost estimate for Phase 2 of the project. Both of these deliverables will be provided pending receipt of information regarding proposed sampling locations and their accessibility.

It is our understanding that the Association of Central Oklahoma Governments (ACOG) will copy and distribute the reports to the Canadian River Project Group (CRPG) and the Oklahoma Department of Environmental Quality (ODEQ) for review. Subsequent to the review process, you will provide GUERNSEY with a set of consolidated written comments.

We appreciate your attention to and consideration of this matter. Please direct any further communication to me at 405.416.8140, or via e-mail at ken.senour@chguernsey.com.

Sincerely,

C.H. GUERNSEY & COMPANY

Ken Senour

Ken Senour, CEP, QEP
Sr. Vice President
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KCS:kd

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1.0 INTRODUCTION AND PURPOSE

1.1 INTRODUCTION

The Association of Central Oklahoma Governments (ACOG) has commissioned a wasteload allocation (WLA) study (WLAS) for the Canadian River, in central Oklahoma, from approximately Union City to Wayne, Oklahoma. ACOG contracted with C.H. Guernsey & Company (GUERNSEY) to accomplish this project. This section of the river was re-designated as a Warm Water Fishery (WWF), from its previous designation as Habitat Limited. In light of this re-designation, the Oklahoma Department of Environmental Quality (ODEQ) requested new sampling and modeling of this reach of the river. The WWF designation requires a more stringent dissolved oxygen (DO) standard for the river and thus impacts the point source dischargers within this reach. Future permits must reflect effluent chemistry and flows that will maintain the new standards. The endangered Arkansas River Shiner is a part of the river's aquatic community.

ACOG is coordinating this activity with a consortium of communities/entities (Canadian River Project Group [CRPG]) that discharge into this segment of the river that includes:

- Union City
- Minco
- Tuttle
- Mustang
- Newcastle
- Oklahoma City
- Moore
- Norman
- Noble
- Purcell
- Lexington
- Lexington Department of Corrections
- Chickasaw Nation/Riverwind Casino

The original scope of work, as outlined by ACOG in December 2007, addressed the following requirements:

- Develop receiving stream monitoring designs and quality assurance/quality control (QA/QC) plans for ODEQ approval; utilize existing data generated by Phase 2 stormwater programs; ODEQ and the Oklahoma Water Resources Board (OWRB) should be consulted prior to development of WLA survey plans.
- Perform WLA modeling based on water quality data using the Water Quality Analysis Simulation Program (WASP)
- The study should begin upstream an appropriate distance from downstream dischargers and should extend downstream for a distance acceptable to ODEQ.
- Address required WLA elements including:

    - Problem definition

- Endpoint identification
- Source analysis
- Linkage between sources and receiving water
- Margin of safety
- Loading allocation

➢ Address requirements for conducting the stream survey, performing WLA modeling, and recommending wasteload allocations for DO demanding substances including:

- Reconnaissance survey
- Monitoring design work plan
- Stream survey
- Calibration/verification report with recommended WLAS

Any other activity required by the regulatory agencies for successful project completion.

1.2 SCOPE OF WORK

The project has been divided into two phases including Phase 1 and Phase 2. Descriptions of these phases are provided below.

1.2.1 PHASE 1: PROJECT PLANNING, RECONNAISSANCE SURVEY, AND FIELD STUDY ORIENTATION

The project was divided into two phases for technical application and budgeting purposes. In Phase 1, a detailed Field Study Plan will be prepared based on a review of existing information that will provide the details of the two field studies proposed for this project. In Phase 2, the actual field studies will be conducted following the approved Field Study Plan.

The specific tasks for Phase 1 are as follows.

➢ Task 1: Pre-planning, Coordination and Kick-off Meeting
➢ Task 2: Compile and Review Background Information
➢ Task 3: Review Preliminary Desktop Model
➢ Task 4: Conduct Field Reconnaissance Survey

- Identify access points to the river and selected tributaries
- Address logistics and concerns regarding sampling activities (free flowing, unobstructed water)
- Confirm location of and access to point source discharges/outfalls
- Determine effluent information that dischargers will provide during field studies
- Measure cross-sections for calculating quantities of dye to use during the field studies

- Task 5: Develop Preliminary Draft of Field Quality Assurance Project Plan (QAPP), Modeling QAPP, and Phase 1 Report

  - Dischargers identified in this study region reach
  - Types of field data to be collected
  - Locations of data monitoring stations
  - Frequency of data collection at monitoring sites
  - In situ and analytical parameters to be measured
  - Required equipment
  - Methods to be used in the field and in the laboratory
  - Acceptable hydrologic conditions for conducting the field studies
  - QA/QC objectives and criteria
  - How each type of field data will be used in the water quality model

- Task 6: Address Review Comments from ACOG and the CRPG on the Preliminary Draft Field QAPP, Modeling QAPP, and Phase 1 Report
- Task 7: Attend Draft Report Meeting/Prepare Final Report

1.2.2 PHASE 2: FIELD STUDIES, MODELING, AND WLAS REPORT DEVELOPMENT

Phase 2 will be accomplished subsequent to Phase 1. Based on the results of Phase 1, there could be variations or changes to the Phase 2 scope. The proposed Phase 2 scope was defined as presented below.

- Task 8: Conduct First Field Study (the first field study will be conducted during low stream flows and high temperatures)

  - Field Data for Point Source Discharges
  - Collect Field Data for Ambient Inflow Sites (Tributaries)
  - Collect Field Data for Sampling Sites on the Canadian River
  - Perform Flow Measurements to Confirm US Geological Survey (USGS) Real Time Flows
  - Conduct Dye Studies to Measure Time of Travel (Velocity)
  - Deploy Continuous In Situ Monitors
  - Perform Light/Dark Bottle Measurements
  - Conduct Cross-Section Measurements

- Task 9: Conduct Second Field Study
- Task 10: Compile and Analyze Field Data and Prepare Data Summary Interim Report
- Task 11: Set-up, Calibrate, and Verify Water Quality Model and Prepare an Interim Modeling Report
- Task 12: Run Model Projections and Calculate Loads
- Task 13: Prepare Preliminary Draft WLA Report
- Task 14: Attend Preliminary Draft Report Meeting

- Task 15: Address Review Comments from ACOG and the CRPG on the Preliminary Draft WLA Report
- Task 16: Attend Draft Report Meeting
- Task 17: Address Review Comments from ODEQ and US Environmental Protection Agency (EPA) for the Draft WLA Report

2.0 BACKGROUND INFORMATION

2.1 GENERAL

The Canadian River originates in Colfax County, New Mexico and flows generally to the southeast and east through New Mexico and the Texas Panhandle. It enters Oklahoma as the boundary between Ellis and Roger Mills Counties in western Oklahoma. The river generally flows easterly/southeasterly through Oklahoma until it becomes the southwestern arm of Lake Eufaula and terminates at Robert S. Kerr Reservoir. The river has a total length of 1,190 miles, of which 460 miles is in Oklahoma. The total drainage area is 29,640 square miles, of which 6,786 square miles are in Oklahoma (OWRB 2007).

The WLAS addresses a significant portion of the Canadian River in Central Oklahoma—approximately 80 miles. The river flows to the east/southeast from the western extent of the study area, Union City (Canadian County), to the terminus, near Wayne in McLain County (see Site Location Map, Figure 1). Besides Canadian and McClain County, the other relevant counties in Central Oklahoma through which the river flows/borders include Cleveland and Grady. The river literally comprises a portion of or all of the political border/boundary between the following counties:

- Canadian and Grady
- Cleveland and McClain

The river generally traverses the southern portion of the metropolitan Oklahoma City area before turning south/southeast in the Norman area. Major urban areas include Oklahoma City, Moore, and Norman.

2.2 PHYSICAL CHARACTERISTICS

2.2.1 PHYSIOGRAPHY/ECOREGIONS

The Canadian River is located in the Interior Plains Physiographic Division, Rolling Plains, and is generally characterized by slightly to moderately tilted, older sedimentary rocks. In central Oklahoma, the river flows through two ecoregions including Cross Timbers and the Central Great Plains. ***Most of the WLAS area is located in the Central Great Plains.*** These two ecoregions are characterized below:

- **Cross Timbers:** transition between the once prairie and the forested low mountains of eastern Oklahoma; transitional cross timbers type vegetation includes little bluestem grassland, with scattered blackjack and post oak trees; predominant land cover is rangeland and pastureland; oil extraction is a major activity.
- **Central Great Plains:** once grassland, with scattered low trees and shrubs, much of this region is now cropland; the eastern boundary of this region marks the major winter wheat growing area of the United States.

The remainder of the river to east of the study area is in the Arkansas Valley Ecoregion, consisting mostly of forested valleys and ridges.

2.2.2 CLIMATE

In general, the climate of the study area is classified as sub-humid. Annual precipitation ranges from about 33 inches per year in Canadian County (western side of the study area) to about 39 inches in Garvin County (eastern side of the study area). Temperatures range from an average day time high of about 94°F in July to an average low of about 27°F in January. The average annual temperature is approximately 61°F. Thunderstorms are common in the spring and summer.

2.3 HYDROLOGY

The USGS has published stream flow data for the Canadian River at several gauging stations that are located in or near the area of interest for this project. Table 1 identifies these gauging stations and presents selected information for each one. The flow gages with real time data will be used to help determine when flows in the river are low enough to conduct the field studies in Phase 2 of this project. The locations of the flow gages are shown on Figure 2.

TABLE 1: LIST OF USGS FLOW GAGES IN OR NEAR AREA OF INTEREST

Gage Number	Gage Name	Period of Record for Daily Flows	Contributing Drainage Area (mi^2)	Real Time Flow Data Available?
07228500	Canadian River at Bridgeport	Oct. 1944 – Sep. 1964; Oct. 1969 – present	20,475	Yes
07228940	Canadian River near Mustang	May 2006 – present	not published	Yes
07229000	Canadian River near Newcastle	Oct. 1938 – Sep. 1945	20,962	No
07229050	Canadian River at Norman	Feb. 1996 – Sep. 1998; Oct. 2006 – present	21,052	Yes
07229100	Canadian River near Noble	Oct. 1959 – Jun. 1961; Oct. 1963 – Sep. 1975	21,110	No
07229200	Canadian River at Purcell	Oct. 1959 – Jun. 1961; Oct. 1979 – Sep. 1983; Oct. 1985 – present	21,138	Yes
07229300	Walnut Creek at Purcell	Oct. 1965 – Sep. 1993	202	No

Table 2 lists average annual flows and published 7Q2 flows for the flow gages with more than 20 years of data. A 7Q2 flow is the lowest seven-day average flow that is likely to occur in one out of every two years. The 7Q2 flow (or 1 cubic feet per second [cfs], whichever is higher) is used as the critical upstream flow for water quality modeling.

TABLE 2: PUBLISHED STATISTICS FOR FLOW GAGES WITH MORE THAN 20 YEARS OF DATA

Gage Number and Name	Average Annual Flow (cfs)	Data Used for Average Annual Flow	Published 7Q2 Flows [A]			Data Used for 7Q2 Flows
			Summer Value (cfs)	Winter Value (cfs)	Spring Value (cfs)	
07228500 Canadian River at Bridgeport	317 [B]	1969-2007	7.76	54.9	88.2	1970-1999
07229200 Canadian River at Purcell	765 [B]	1979-1983; 1985-2007	34.6	203	266	1980-1983; 1985-1999
07229300 Walnut Creek at Purcell	85 [A]	1965-1993	2.05	14.4	20.6	1966-1993

NOTES:

A. From "Statistical Summaries of Streamflow in Oklahoma through 1999" (USGS 2002).
B. From water year 2007 annual data reports on USGS website.

2.4 LAND USE

2.4.1 POPULATION CENTERS

The Canadian River WLAS area contains the following communities and their representative populations:

- Union City (Canadian County): 1,404
- Minco (Grady County): 1,781
- Tuttle (Grady County: 5,842
- Mustang (Canadian County): 17,190
- Newcastle (McClain County): 7,010
- Oklahoma City (Cleveland County portion): 54,748
- Oklahoma City (Oklahoma County portion): 457, 589
- Moore (Cleveland County): 51,106
- Norman (Cleveland County): 106,707
- Noble (Cleveland County): 5,707
- Purcell (McClain County): 6,072
- Lexington (Cleveland County): 2,100

2.4.2 GENERAL LAND USE

The Canadian River WLAS area, for discussion purposes, can be conveniently divided into three general land use sections:

- Western Section: Union City to Newcastle
- Central Section: Newcastle to Noble
- Southern Section: Noble to Wayne

Land use within the WLAS area is characterized by a broad spectrum of uses (see WLAS Land Use Map, Figure 3). The western section of the study area, defined as Union City to Newcastle, can generally be characterized as rural, with sporadic urbanization that is not necessarily adjacent to the river, but is somewhat distant based on communities being located along tributaries of the Canadian River. Union City, Minco, Tuttle, Mustang, and Newcastle are all regional communities that are generally associated with the Oklahoma City metropolitan area. The predominant land use along the river, west of Newcastle, is characterized as cropland and pasture, and herbaceous rangeland. Braum's Dairy Farm is a major commercial operation located west of Tuttle on the south side of the river.

Urbanization along the river significantly increases in the Newcastle area and becomes the predominant land use feature as the river turns to the south/southeast and flows adjacent to or through Oklahoma City, Moore, Norman, and Noble (central section). There are portions of the river in this section that represent transitional mixed rural and urban uses, but in general urbanization is the pronounced feature.

South of the Norman/Noble area (southern section) rural uses again are featured as the river flows in a more southerly direction toward the communities of Purcell and Lexington, which are physically/geographically divided by the river. Urban uses are featured in Purcell and Lexington, but upon exiting these communities and flowing toward Wayne, the river continues its journey to Lake Eufaula through mostly rural Oklahoma

Land use data were obtained from the USGS 2001 National Land Cover Database. These data were compiled for the drainage area that enters the Canadian River between the US Highway 81 Bridge (between Union City and Minco) and the confluence with Buckhead Creek near Rosedale. The land use data and the drainage area boundary are shown on Figure 3 and land use percentages within the drainage area are listed in Table 3. The land uses covering the most area are grassland, cultivated crops, and deciduous forest.

TABLE 3: LAND USE PERCENTAGES

Land Use Type	Percent of Total Area
Open Water	1.3%
Developed, Open Space	5.4%
Developed, Low Intensity	3.1%
Developed, Medium Intensity	1.4%
Developed, High Intensity	0.4%
Barren Land	0.6%
Deciduous Forest	12.3%
Evergreen Forest	1.3%
Shrub /Scrub	< 0.1%
Grassland / Herbaceous	44.5%
Pasture/Hay	6.2%
Cultivated Crops	23.4%
Emergent Herbaceous Wetlands	< 0.1%
TOTAL	**100.0%**

2.5 NONPOINT SOURCES

Nonpoint source (NPS) pollution comes from diffuse sources and is typically not defined by a single, isolated discharge location. NPS is caused by rainfall or snowmelt moving over or through the ground. Natural and man-made pollutants are accumulated by the runoff and carried/deposited in lakes, rivers, wetlands, and underground sources. Contaminants can include:

- Fertilizers, herbicides, and insecticides from agricultural practices
- Oil, grease, and toxic chemicals from urban sources
- Sediment from construction sites, crop and forest lands, and eroding stream banks
- Salt from irrigation activities
- Bacteria and nutrients from livestock and faulty septic systems

NPSs make large contributions to degraded water quality throughout the United States. EPA reports that NPS pollution is the Nation's largest source of water quality problems. In the Canadian River basin, and specifically within the study area, nonpoint sources are prevalent due to the varied land use activities. NPS pollution is aligned very closely with land use and the types of land use in an area. As described in Section 2.4.2, land uses in the study area include both rural and urban uses and the NPS pollution in the Canadian River Basin is consistent with the various types identified above.

Within Oklahoma, the Oklahoma Conservation Commission (OCC) is the lead technical agency with jurisdiction over NPS pollution in Oklahoma. The OCC works with 88 conservation districts within Oklahoma to address NPS pollution through various programs.

2.6 POINT SOURCES

Point sources are typically associated with a single discharge location (pipe, defined channel, etc.) of some type of waste effluent from municipal or industrial wastewater treatment facilities. The point source can include either treated or untreated waste. Within the study area, there are 13 facilities with Oklahoma Pollutant Discharge Elimination System (OPDES) permits that discharge oxygen-demanding wastewater either directly into the Canadian River or into a tributary of the Canadian River, within several miles of the river. Tables 4 and 5 provide general information, design flows, and permit limits for these facilities and the Point Source Map, Figure 4, identifies their discharge locations. Information in Tables 4 and 5 was derived from OPDES permits and fact sheets, the ODEQ Water Quality Management Plan (WQMP), and questionnaires that were completed by permit holders. Appendix A contains tables and plots of available effluent data that have been reported by each facility on discharge monitoring reports (DMRs).

TABLE 4: GENERAL INFORMATION FOR POINT SOURCE DISCHARGES

Name	OPDES Permit Number	Receiving Water	Type of Treatment System	Normal Discharge Frequency	Permit Expiration Date
Union City	OK0038393	Unnamed tributary, 1.9 miles to Canadian River	Lagoons (4)	None during summer, rarely during winter	9/30/2010
Minco	OKG580057 (formerly OK0032182)	Buggy Creek, 3.7 miles to Canadian River	Lagoons (4)	Rarely (only 3 months with discharges during Mar. 2007 – Jun. 2008)	6/30/2011
Tuttle	OKG580054	West Creek to Store Creek, 4.3 miles to Canadian River	Lagoons (6)	Every day	6/30/2011
Mustang	OK0026816	Canadian River	Activated sludge (sequential batch reactor)	Every day	8/31/2009
OG&E McClain Generating Station	OK0045250	Canadian River	Cooling towers, reverse osmosis, chlorination, and dechlorination	None to date (no outfall structure built yet)	10/31/2012
Oklahoma City (S. Canadian WWTP)	OK0038385	Unnamed tributary*, 2.5 miles to Canadian River	Activated sludge (sequential batch reactor)	Every day	9/30/2009
Moore	OK0027391	Unnamed tributary, 3.1 miles to Canadian River	Mechanical (rotating biological contactors)	Every day	12/31/2008
Newcastle	OK0028614	Tim's Creek to Pond Creek, 2.5 miles to Canadian River	Lagoon (1) and activated sludge	Every day	2/28/2010
Love's Country Store #260	OK0042889	Unnamed tributary, 1.3 miles to Canadian River	Sediment trap and oil/water separator	Assumed to have some discharge every day	2/29/2012
Norman	OK0029190	Canadian River	Conventional activated sludge	Every day	2/28/2010
Noble	OK0031755	Canadian River	Extended aeration	Every day	5/31/2009
Lexington	OK0022756	Canadian River	Extended aeration	Every day	6/30/2012
Purcell	OK0028533	Canadian River	Aerated lagoons (5)	Every day	7/31/2012

NOTE:

* The receiving stream is unnamed according to the USGS topographic maps and the OPDES permit, but it is known locally as Cow Creek.

TABLE 5: DESIGN FLOWS AND PERMIT LIMITS FOR POINT SOURCE DISCHARGES

Name	Design Flow (MGD)		Months	Current Monthly Average Limits (mg/L)			
	Current	Planned		BOD5	TSS	NH3-N	DO (inst. minimum)
Union City	0.20	0.20	Jun – Oct	No discharge allowed during Jun – Oct			
			Nov – May	30	90	no limit	no limit
Minco	0.15[A]	0.215[A]	Year round	30	90	no limit	no limit
Tuttle	0.186[A]	0.51[A]	Year round	30	90	no limit	no limit
Mustang	1.5	3.0	Apr – Oct	12[B]	15	4.1	5.0
			Nov – Mar	20	30	4.1	5.0
OG&E McClain Generating Station	0.189[C]	0.189[C]	Year round	no limit	no limit	no limit	no limit
Oklahoma City (S. Canadian WWTP)	6.0	10.0	Jun – Sep	15	30	4.1	5.0
			Oct – May	20	30	4.1	no limit
Moore	4.5	12.0	Jun – Sep	15	30	4.1	5.0
			Oct – May	25	30	4.1	no limit
Newcastle	0.54	1.2	Year round	20	30	no limit	no limit
Love's Country Store #260	0.00082[D]	0.00082[D]	Year round	Report only (no limit)	40 (daily max.)	no limit	no limit
Norman	12.0	17.0	Apr – Oct	13[B]	30	4.1	5.0
			Nov – Mar	25[B]	30	4.1	5.0
Noble	0.76	0.76	Year round	30	30	no limit	no limit
Lexington	0.25[A]	0.261[A]	Year round	30	30	no limit	no limit
Purcell	2.0[E]	2.0[E]	Year round	30	30	no limit	no limit

NOTES:

A. Current flows for Minco, Tuttle, and Lexington are from fact sheets in permits; planned flows are from the ODEQ WQMP.

B. These three limits are specified in the permits as carbonaceous biochemical oxygen demand (CBOD5); all other values in this column are specified in the permits as biological oxygen demand (BOD5).
C. The design flow rate for OG&E consists of 0.181 million gallons per day (MGD) of cooling tower blowdown plus 0.008 MGD of low volume wastewater (from page 2 of the fact sheet in the permit).
D. The flow rate for Love's Country Store was taken from DMRs; their application estimated a typical flow rate of 0.00024 MGD.
E. Purcell's facility is currently designed to treat 2.0 MGD, but their current mass limits are based on flow of 0.65 MGD from the WQMP.

Three of the 13 facilities with oxygen-demanding effluent will not be included in the field studies and modeling to be performed in Phase 2 of this project because they appear to have little impact on water quality in the river. The discharge from Love's Country Store will not be included because it is very minimal and the effluent has to travel through a large pond with a long retention time and considerable dilution before it eventually enters the river. The wastewater treatment plants (WWTPs) for Union City and Tuttle will not be included because desktop modeling of their receiving streams showed that DO downstream of the WWTP discharges recovers and meets standards before reaching the river (see Section 2.7.3 of this report).

The Minco WWTP discharges infrequently, but it is still being included in Phase 2 of this project because the facility's current permit allows it to discharge continuously. The desktop modeling for Minco's receiving stream (Buggy Creek) showed that during critical conditions, DO concentrations do not completely recover before reaching the river.

The OG&E McClain Generating Station does not currently have an outfall structure to discharge to the Canadian River, but there are plans to build an outfall some time in the future. Currently they are disposing of wastewater by deep well injection. This facility will not be included in the field studies for Phase 2 of this project because there will be no discharge from which to collect data. However, this facility will be included in the projection simulations for Phase 2 of this project because they will need an allocation of the river's assimilative capacity in the future if they build an outfall structure and begin discharging to the river as allowed by their current OPDES permit.

Discharges of cooling water from an electric generating facility would not normally be considered to have a significant oxygen demand, but effluent from the OG&E facility could exert an oxygen demand in the river because about 95% of the source water for the facility is treated wastewater from the Oklahoma City South Canadian WWTP. The remainder of the source water is treated wastewater from the Moore WWTP and potable water from the City of Newcastle (according to the fact sheet for the OG&E discharge permit). During the summer, the wastewater that is piped from the Oklahoma City South Canadian WWTP to the OG&E facility comprises about half of the water that is treated at the South Canadian WWTP.

The Norman WWTP also diverts some of its treated wastewater for irrigation.

ODEQ requires that the WLAS be conducted using the design flow of each WWTP without subtracting any flow of treated wastewater that is sent to another location rather than discharged. This requirement is necessary in case a WWTP discontinues sending wastewater to another location and begins discharging all of its wastewater. Therefore, the current and planned effluent flow rates in Table 5 represent the design flows without subtracting any diversions of wastewater to other locations. The planned design flow rates in Table 5 are the values that will be used in the projection simulations for this WLAS. After this WLAS is completed and approved, ODEQ will use these planned design flows for permitting calculations (e.g., mass limits and reasonable potential analyses) when each permit is renewed.

2.7 <u>WATER QUALITY</u>

2.7.1 STANDARDS

Water quality standards, including designated uses, for water bodies in Oklahoma are established by the OWRB and published as Oklahoma Administrative Code (OAC) Title 785, Chapter 45 (OWRB 2008a). The designated uses for the Canadian River and other streams in the project area are listed in Table 6. The designated uses for specific streams in Table 6 are from Appendix A.5 of OAC 785:45 and the designated uses for "other streams" (the last row in the table) are the default designated uses that are specified in OAC 785:45-5-3. These default designated uses apply to the unnamed tributaries that receive discharges from the Oklahoma City (South Canadian) and Moore WWTPs. The last column in Table 6 lists WWTP discharges that flow into each stream.

TABLE 6: DESIGNATED USES FOR STREAMS

Stream	ID Number(s)	Designated Uses*	WWTP Discharges
Canadian River from the US Hwy. 81 bridge to its confluence with Buckhead Creek	520610010010, 520610020010, and 520610020150_00	AES, AG, WWAC, SBCR	Mustang, Norman, Noble, Lexington, Purcell
Tributary of Canadian River at SW 1/4, Sec. 3, T10N, R7W, IM	520610	AES, AG, HLAC, SBCR	Union City
Buggy Creek	520610020120	AES, AG, WWAC, PBCR, EWS	Minco
West Creek	520610020090	AES, AG, HLAC, SBCR	Tuttle
Store Creek	520610020080	AES, AG, WWAC, PBCR, PPWS	
Tributary of Pond Creek at NE 1/4, Sec. 14, T9N, R4W, IM (Tim's Creek)	520610010215	AES, AG, HLAC, SBCR	Newcastle
Pond Creek	520610010210	AES, AG, WWAC, PBCR, PPWS	
Other streams within the project area that are not listed above	--	AES, AG, WWAC, PBCR	Oklahoma City, Moore

NOTES:

Abbreviations for designated uses are:

AES = aesthetics
AG = agriculture
WWAC = warm water aquatic community
HLAC = habitat limited aquatic community
PBCR = primary body contact recreation
SBCR = secondary body contact recreation
PPWS = public and private water supply
EWS = emergency water supply

Prior to 2008, the main stem of the Canadian River from the US Highway 81 Bridge to the confluence with Buckhead Creek had been assigned a designated use of habitat limited aquatic community. In the 2008 update to the water quality standards, OWRB changed its designated use to warm water aquatic community based on field surveys where aquatic life that are indicative of a warm water aquatic community were found in this portion of the river.

The water quality standards also specify numeric criteria for protecting designated uses. The designated uses that are of primary interest for this project are warm water aquatic community and habitat limited aquatic community. The water quality standards specify criteria for various parameters for protecting aquatic life, but the parameters of interest for this project are DO, ammonia nitrogen, and nutrients. The criteria for DO are presented in Table 7. The DO criteria must be maintained at the seasonal temperatures in Table 7 as required in OAC 785:45-5-12(f)(1).

TABLE 7: NUMERIC CRITERIA FOR DO AND SEASONAL TEMPERATURES

Season	Criteria for Minimum DO (mg/L)		Seasonal Temperature (°C)
	Habitat Limited Aquatic Community	Warm Water Aquatic Community	
Early Life Stages (4/01 – 6/15)	4.0	6.0 *	25
Summer Conditions (6/16 – 10/15)	3.0	5.0 *	32
Winter Conditions (10/16 – 3/31)	3.0	5.0	18

NOTE:

* The following applies to the values marked with an asterisk: "Because of natural diurnal fluctuation, a 1.0 mg/L concentration deficit shall be allowed for not more than eight hours during any 24-hour period."

The water quality standards do not include numeric criteria for ammonia nitrogen, but OAC 785:45-5-12(f)(6) requires that permit limits for discharges of ammonia be set to prevent the discharge from causing acute toxicity at any location or chronic toxicity outside the mixing zone. The regulations for implementation of the water quality standards (OAC Title 785, Chapter 46) (OWRB 2008b) specify a maximum allowable ammonia nitrogen concentration of 6 mg/L outside the mixing zone (OAC 785:46-5-3(b)). This value was used by ODEQ to calculate ammonia nitrogen permit limits for the WWTPs for Mustang, Oklahoma City (South Canadian), Moore, and Norman.

The water quality standards do not specify numeric criteria for nutrients for protecting aquatic life, but the following narrative criterion applies to protection of aquatic life and is specified in OAC 785:45-5-9(d):

> "Nutrients from point source discharges or other sources shall not cause excessive growth of periphyton, phytoplankton, or aquatic macrophyte communities which impairs any existing or designated beneficial use."

As specified in EPA's regulations at 40 Code of Federal Regulations (CFR) 130.7(b)(2), applicable water quality standards include anti-degradation requirements. Oklahoma's anti-degradation requirements are presented in both the water quality standards (OAC Title 785, Chapter 45) and the implementation regulations (OAC Title 785, Chapter 46). None of the streams in Table 6 are specified as Outstanding Resource Waters, High Quality Waters, or Sensitive Water Supplies; therefore, the primary anti-degradation requirements for this project are:

- Application to beneficial uses: No water quality degradation which will interfere with the attainment or maintenance of an existing or designated beneficial use shall be allowed. (OAC 785:45-3-2(d)
- Application to improved waters: As the quality of any waters of the state improves, no degradation of such improved waters shall be allowed. (OAC 785:45-3-2(e))

2.7.2 AMBIENT WATER QUALITY DATA

The OWRB has collected ambient water quality data in the Canadian River at the US Highway 77 Bridge near Purcell, at the Interstate 35 Bridge near Norman, and at the US Highway 281 Bridge near Bridgeport. These data were downloaded from the OWRB website and values of DO (mg/L), DO percent saturation, ammonia nitrogen, total Kjeldahl nitrogen (TKN), nitrate nitrogen, ortho phosphorus, total phosphorus, and *chlorophyll a* are tabulated and plotted in Appendix B. The available data at Purcell and Bridgeport extend from February 1999 through the middle of 2008 and the data at Norman extend from March 2002 to September 2003.

At the Purcell station, only one out of 124 DO measurements was below the water quality criterion of 5.0 mg/L. Approximately 43% of the DO saturation values were above 100.0%. The median *chlorophyll a* concentration was 45 micrograms per liter (µg/L) and 10 of the 44 values were greater than 99 µg/L. These data indicate that there are high concentrations of algae at this location during certain times and the algae have a significant influence on DO during those times. The median nutrient concentrations were 0.38 mg/L total phosphorus, 0.14 mg/L ortho phosphorus, 1.55 mg/L TKN, 0.11 mg/L ammonia nitrogen, and 0.79 mg/L for the combined dataset of 98 nitrate values and 47 nitrite+nitrate values. These data indicate that there are sufficient amounts of nutrients to support high concentrations of algae at this location.

At the Norman station, data were collected on only 11 occasions. This dataset is too small to draw conclusions with a high degree of certainty. The data at this station were generally within the ranges of data observed at the Purcell station.

At the Bridgeport station, only two out of 130 DO measurements were below the water quality criterion of 5.0 mg/L. Approximately 40% of the DO saturation values were above 100.0%. The median *chlorophyll a* concentration was 16 µg/L and the maximum value was 84 µg/L. The median nutrient concentrations were 0.10 mg/L total phosphorus, 0.02 mg/L ortho phosphorus, 0.66 mg/L TKN, <0.05 mg/L ammonia nitrogen, and 0.21 mg/L for the combined dataset of 88 nitrate values and 47 nitrite+nitrate values. These DO values are not drastically different between Purcell and Bridgeport, but the nutrients and algae (*chlorophyll a*) are much lower at Bridgeport than at Purcell. The higher concentrations of nutrients and algae at Purcell are assumed to be due to wastewater discharges and other anthropogenic influences from the developed areas that drain into the river between the Bridgeport and Purcell stations.

The State of Oklahoma 2006 Water Quality Assessment Integrated Report addresses general trends in water quality throughout the state. Two stations on the Canadian River provide a characterization of water quality impairments above/upstream of the WLAS area and within the area as presented below:

- Bridgeport, upstream of WLAS area, OK520610020150-001AT: reflects impairments related to sulfates, total dissolved solids (TDS), turbidity, and Enterococcus.
- Purcell, within the WLAS area, OK520610010010-001AT: reflects impairment related to total fecal coliform.

2.7.3 PREVIOUS WATER QUALITY MODELING

Two water quality models of the Canadian River were developed in the 1990s. In the early 1990s, ACOG developed a desktop (uncalibrated) model of the Canadian River to simulate discharges from the City of Noble WWTP. The ACOG desktop model is not discussed in detail here because it was effectively superseded by a calibrated model of the Canadian River that was developed in the mid 1990s by Camp Dresser & McKee (CDM) for the purpose of simulating discharges from the City of Norman WWTP. The modeling for the Norman WWTP was addressed using the QUAL-TX model, which was calibrated based on field data collected in 1995. QUAL-TX is a steady-state, one-dimensional model that was used in this situation for simulating DO, BOD, nutrients (nitrogen and phosphorus), and algae. The QUAL-TX model for Norman started in the Canadian River 2.5 miles upstream of the Norman WWTP and ended approximately 14.0 miles downstream from the Norman WWTP, approximately 0.4 miles upstream of the US Highway 77 Bridge between Purcell and Lexington.

The field study to collect calibration data for the QUAL-TX model was conducted on August 30-31, 1995, and included collection of water quality data and flow measurements during a 24-hour period. DO and other in situ parameters were measured at six sites in the Canadian River during early afternoon and late afternoon on August 30, and during pre-dawn and late morning on August 31. DO values measured in the river ranged from 5.6 to 6.3 mg/L during pre-dawn and 8.7 to 16.0 mg/L during the afternoon. No DO measurements in the river were below 5.0

mg/L. Several water quality samples were collected at each site during this time. Measured values of *chlorophyll a* in the river generally increased with distance downstream, with values ranging from 43 to 190 µg/L (excluding two outliers that were believed to be erroneous). Time of travel measurements (dye studies) were conducted in May and August 1995. The flow rates that were measured in the river were approximately 360 cfs during the May time of travel study and 113 to 170 cfs during the August time of travel study and water quality data collection.

Hydraulic coefficients in the QUAL-TX model were based on time of travel studies, flow measurements during the field studies, and depths and velocities from historical flow measurements by the USGS at their gages on the Canadian River. During model calibration, several distributed inflows and outflows were added to the model so that the predicted flows at different locations would more closely match the measured flows from the field study. Kinetic coefficients in the model were initially based on default values and suggested ranges in the QUAL-TX User Manual as well as values used in the 1991 ACOG desktop model. Coefficient values were then adjusted to calibrate the model to observed data from the field study. Following are values of selected coefficients used in the QUAL-TX model:

- BOD decay rate = 0.15/day
- BOD settling rate = 0.01 m/day
- Background sediment oxygen demand (SOD) = 0.50 g/m2/day
- Ammonia decay (nitrification) rate = 0.50/day
- Denitrification rate = 1.0/day
- Secchi depth with no algae = 0.40 m
- Ratio of algae to *chlorophyll a* = 0.02 mg algae/µg *chlorophyll a*
- Algae settling rate = 0.01 m/day
- Algae maximum growth rate = 3.0/day
- Algae respiration rate = 0.25/day

The QUAL-TX model was initially set up to calculate reaeration coefficients with the O'Connor-Dobbins formula, which resulted in values from 18 to 20/day. The model was then set to impose a maximum reaeration rate of 10/day. However, each of the DO calibration targets was set to the average of the four values measured at different times of the day. These averages were all above 100% saturation. As a result, the report stated that "it is difficult to determine if the inputs and outputs to the DO mass balance are calibrated correctly." Algal photosynthesis was the largest source of DO, partly because predicted values of *chlorophyll a* were generally increasing in the downstream direction and did not level off, reaching a maximum concentration of over 140 µg/L at the downstream end of the model. The model was not set up to simulate oxygen demand from algae that die and settle to the stream bottom; therefore, higher predicted algae concentrations would likely result in higher predicted DO values.

The calibrated QUAL-TX model was used to simulate an increase in flow from the Norman WWTP during critical conditions (7Q2 flow and critical temperature). The modeling showed that water quality standards would be maintained with the Norman WWTP discharging at 16 MGD with summer effluent concentrations of 15 mg/L CBOD5, 5 mg/L DO, and 8 mg/L ammonia nitrogen.

Several years after the QUAL-TX model was used to evaluate the Norman WWTP's discharge, the model was extended upstream along the Canadian River to the Interstate 44 Bridge so that discharges from the City of Moore WWTP could be simulated. GUERNSEY were not given a formal report that documents the modeling for the City of Moore, but several model input and output files were provided along with a verbal explanation that the Norman model was extended upstream but not re-calibrated because no additional field data were collected. A review of this model input and output files indicate that some of the coefficients are set to different values than in the Norman modeling. Following are values of selected coefficients used in the QUAL-TX model that included the Moore WWTP:

- BOD decay rate = 0.01/day
- BOD settling rate = 0.005 m/day
- Background SOD = 0.05 g/m2/day
- Ammonia decay (nitrification) rate = 0.50/day
- Denitrification rate = 0.75/day
- Secchi depth with no algae = 1.00 m
- Ratio of algae to *chlorophyll a* = 0.09 mg algae/μg *chlorophyll a*
- Algae settling rate = 0.08 m/day
- Algae maximum growth rate = 3.0/day
- Algae respiration rate = 0.05/day

In the Moore model, the upper limit of 10/day for reaeration rates was removed, so the model used reaeration rates that exceeded 10/day. Most of these changes in coefficients made the Moore QUAL-TX model less conservative than the Norman model. The decrease in the BOD decay rate, the decrease in the background SOD, the decrease in the algae respiration rate, and the increase in reaeration rates all cause the predicted DO to increase.

The WASP desktop modeling discussed in Section 4.3 did not rely on most of the coefficient values in the Moore QUAL-TX model because it is less conservative than the Norman QUAL-TX model.

3.0 FIELD RECONNAISSANCE AND MEETING WITH THE ODEQ

The field reconnaissance of the Canadian River took place during the week of December 8, 2008. Participants included the following (some combination of these six individuals over the reconnaissance period):

- John Harrington, ACOG
- Philip Massirer, FTN
- Carey Miller, GUERNSEY
- Angela Aikman, GUERNSEY
- Tara Gross, GUERNSEY
- Ken Senour, GUERNSEY

3.1 RECONNAISSANCE ACTIVITIES

The team of individuals identified above spent important time in the field to become familiar with the Canadian River Corridor from Union City to the Purcell/Lexington area. The purpose of the reconnaissance activities was to visit potential sampling locations within the Canadian River and the tributaries that are receiving streams for the identified municipal discharges. Additionally, all municipal wastewater treatment plants were visited for familiarity with the systems and discharge characteristics. In some river/stream locations, cross-sections were measured for future reference. Photos were taken at all sampling sites and facilities that were visited.

The reconnaissance revealed that some sampling locations will be difficult to access. Those locations have been noted and identified for further attention (see below). For the sampling to be effective for Phase 2, it is necessary that ACOG obtain permission to access some of these locations either through contacts with landowners or operators of facilities in the area.

3.2 SAMPLING LOCATIONS IN NEED OF ACCESS

A list of the potential sampling locations (see map of locations and site descriptions in the Field QAPP) that ACOG needs to obtain access follows:

- BC-3 and CR-2: Locked gate at BC-2 with signs for Linn Operating and Western Oil & Gas Development Corp. For Linn Operating, Inc. the well name is Braum No. 5-14, which is located in the NW/NE of Section 14, Township 10 North, Range 7 West in Grady County. The phone number given is 405-756-3191. For Western Oil & Gas Development Corp. the well name is Braum No. 1-11, which is located in the SE/4 of Section 11, Township 10 North, Range 7 West in Canadian & Grady Counties. The phone number given is 405-235-4590.

- PC-2: Need to contact Mr. Moyer to access Pond Creek behind his house in Newcastle.

- UTOC-1: Need to contact homeowner at end of Hill Rd. or the oil company on next road to south. The sign located on the property is Southern Bay Operating, L.L.C. The well name is

B &W State No. 1-36, which is located in Section 36, Township10 North, Range 4 West in McClain County. The emergency phone number given is 1-800-249-8178.

- UTM-1 and UTOC-2: Farmer that leases pasture wants written liability protection.

- UTM-2: Farmer that leases pasture is checking with out-of-state landowner. The sign located on the property is Chesapeake Operating, Inc. The well name is Loman No. 1-6, which is located in the NE/4 of Section 32, Township 10 North, Range 3 West in Cleveland County. The phone number given is 405-756-8700.

- CR-4: The site is located off a lease road that had a locked gate with a sign for TXO Producing Properties. The well name is Payne 17-1, which is located in the SW/ SE of Section 17, Township 10 North, Range 5 West in Canadian County. The phone number given for TXO is 405-745-3453. The sign also had a clear sticker that was placed over the TXO Producing Properties that read, AEXCO Petroleum Inc. The phone number given for AEXCO is 303-863-1110. The address given is 1660 Lincoln Street Suite 2812, Denver, CO 80264.

- CR-8: The site is located off Rockwell Ave. and is accessible through residential/farm land. The sign located on the property was Hilltop Sportsman Club. A possible contact for access would be Hills Land & Construction, Inc. (405-392-5690).

- CR-7: The site is located off a lease road that had a locked gate with a sign for Linn Operating, Inc. The well name is Schroeder No. 1-23, which is located in the E/2 of the NE of Section 23, Township 10 North, Range 5 West in Grady County. The phone number given is 405-736-3191.

- CR-15: Need to contact Mr. Leroy Wheeler for possible access to the Canadian River.

- CR-18: The site is located on the west end of Cemetery Road and dead ends at a residence in Noble. Need to contact homeowner/landowner for access.

- CR-19: The site is located on the south end of 36th Burkett Avenue SE in Noble. There was a locked gate with a "keep out" sign that had a possible address listed on the gate post of 20878. Need to contact the landowner for access.

- CR-20: The site is located on the west end of Slaughterville Road. The path to the river had very thick vegetation. A better route would be on the south end of 60th Street using the west gate. Need to contact homeowner/landowner for access. The nearest residential address is 11400 60th Street.

- CR-21: The site is located on the west end of York Road and dead ends at a residence with an address (6700 York). Need to contact homeowner/landowner for access.

- CR-22: The site is located on the east side of the Purcell/Lexington Bridge. There was a fenced area with a sign that read "Trail and Off Road Park River Access." Need to contact Jenny with the City of Purcell for access under the bridge.

- CR-23: Need to contact homeowner/landowner for access. The closest residential address is 7740 Grider Lane.

- CR-24: The site is located on the north end of 160th Street to Cotton Gin Road. Need to contact Kernek Ranch for access.

- CR-25: The site is located near a residence that had an opened gate to a road that lead to the Canadian River. Need to contact homeowner/landowner to see if the gate can be left open for access.

3.3 SUMMARY OF ODEQ MEETING CONCERNING CANADIAN RIVER WLAS

During the reconnaissance effort, a meeting was held with ODEQ personnel on Wednesday, December 10, 2008. The purpose of this meeting was to discuss potential laboratory concerns with the proposed Phase 2 sampling activities and issues concerning the modeling. Discussion components of this meeting are provided below.

3.3.1 DISCUSSION OF LABORATORY ISSUES

The meeting addressed the following issues relating to laboratory concerns:

- For WWTPs without composite samplers, ODEQ prefers to not collect just morning and evening grab samples; instead they prefer to have the WWTP staff collect a number of samples at hourly intervals during the day and then composite them manually.
- ODEQ would prefer not to receive samples on Friday. It was decided that all samples would be collected earlier in the week and would arrive at ODEQ's lab prior to Friday.
- ODEQ will supply the sample bottles and the vials of preservatives for sample collection personnel to add in the field.
- ODEQ will provide an electronic copy of their chain of custody form.
- ODEQ will have QA/QC reports available upon request, but will not automatically provide those with the sample results.
- Sampling will include duplicate samples in the field study (quantities and types will be specified in the Field QAPP).
- The ETI Laboratory may have difficulty concerning *chlorophyll a* analyses because ODEQ normally receives the material that has already been filtered and extracted (ODEQ does not normally perform *chlorophyll a* analyses on water samples directly from the field).
- It will be specified in the Field QAPP whether *ortho P* needs to be run on filtered or unfiltered sample (will probably be on unfiltered sample). It is understood from ODEQ that *ortho P* analyses on unfiltered samples sometimes yield artificially high values due to interference from suspended particles.
- The ODEQ Laboratory Quality Assurance Plan will be reviewed on the ODEQ website.

3.3.2 DISCUSSION OF MODELING ACTIVITIES

Subsequent to the laboratory discussion, modeling activities were addressed and included the following:

- ODEQ has concerns about previous modeling, primarily with impacts of nutrients.
- ODEQ indicates that data collected by OWRB at Purcell has shown high *chlorophyll a* concentrations that are similar to those measured during mid 1990s field study for a previous WLA.
- The WASP model will be used with both nutrients and algae turned on.
- Diurnal DO data will be collected at a number of locations (exact number to be specified in the Field QAPP). Diurnal DO data is considered critical because of concerns about nutrient impacts on DO.
- Projection simulations for Oklahoma City and Norman must be based on design flows without subtracting flows that are being sent to the OG&E power plant or the golf course.
- Cow Creek will be simulated in the model from the South Canadian WWTP to the river.
- The receiving stream for the Moore WWTP will be simulated from the discharge point to the river in the calibration model. There was no decision how to simulate this stream, considering that some of the effluent may not be making its way to the Canadian River. This topic may need to be discussed further after the field data are collected.
- For the projection scenarios, Moore might be extending their effluent line to the Canadian River as part of an upgrade to their WWTP plant.
- Norman's discharge is close enough to the river and travel time from the outfall to the river is short enough that Norman will be simulated as a direct discharge to the river.
- For small cities whose effluent travels several miles through a tributary before reaching the river (Union City, Minco, Tuttle, and Newcastle), the desktop model will be run to determine if the DO in the various tributaries recovers prior to reaching the river. If it does recover, that WWTP will not need to be included in the Canadian River WLAS and the tributary into which it discharges can be sampled near the mouth and simulated like a nonpoint source inflow to the river.
- ODEQ will provide a copy of their latest desktop model (in spreadsheet format) to ACOG.
- For the desktop modeling of the tributaries, cross-section measurements will be used from the reconnaissance survey and default kinetic coefficients in ODEQ's spreadsheet model.

3.4 ACTION ITEMS

The results of the reconnaissance survey and the discussions with ODEQ identified the following action items that required attention:

- ACOG is to address "difficult-to-access-areas" by contacting landowners or operators to obtain permission for the sampling to be conducted in July 2009.
- ODEQ will provide an electronic copy of their chain of custody form.
- ODEQ will provide a copy of their latest desktop model (in spreadsheet format) to ACOG.

4.0 DESKTOP WATER QUALITY MODELING

4.1 PURPOSE

A "desktop" water quality model is simply a model that is developed without field data and is based on information that can be obtained from published literature and other sources of existing information. A model that has been calibrated to field data collected during critical conditions produces results with less uncertainty than results from a desktop model, but desktop modeling is still useful for many situations such as simulations of small discharges where extensive field data collection is not warranted, or preliminary analyses prior to developing calibrated modeling.

The two primary reasons for developing desktop water modeling for Phase 1 of this project include:

- The spreadsheet modeling was developed for four Canadian River tributaries that receive small point source discharges to determine whether or not the model of the river (WASP) needs to be extended into those tributaries.
- The desktop model of the river (WASP) was developed to help identify field data needs and to anticipate issues that may need to be addressed later during model calibration in Phase 2 of this project. This desktop WASP model should not be used as an indication of recommended permit limits that will be developed with calibrated modeling in Phase 2 of this project.

4.2 SPREADSHEET MODELING FOR TRIBUTARIES

4.2.1 MODEL SETUP

The ODEQ spreadsheet model (OSM) was applied to four tributaries of the Canadian River that receive small point source discharges. The OSM is a Streeter-Phelps model that simulates CBOD, ammonia nitrogen, and DO under steady state conditions (i.e., it cannot simulate changes in water quality over time). The processes that are included in the model are reaeration, sediment oxygen demand (SOD), CBOD decay, CBOD settling, and nitrification. The tributaries to which the OSM was applied were:

- Unnamed Tributary downstream of the Union City WWTP
- Buggy Creek downstream of the Minco WWTP
- West Creek / Store Creek downstream of the Tuttle WWTP
- Tim's Creek / Pond Creek downstream of the Newcastle WWTP

Each tributary was simulated from the WWTP outfall to the confluence with the Canadian River. It should be noted that West Creek flows into Store Creek and Tim's Creek flows into Pond Creek.

4.2.2 HYDRAULICS

The model input values for flow rates and hydraulic parameters are shown in Table 8. Stream slopes were measured from USGS 7.5 minute topographic maps. The inputs for channel side slope and *Manning's n* were determined by iteratively adjusting these values until the predicted values of depth and width were similar to values from cross sections measured during the field reconnaissance in December 2008. No cross sections were measured for the unnamed tributary downstream of Union City because there was no flow in the stream during the reconnaissance. Therefore, the inputs for channel side slope and *Manning's n* for the Union City unnamed tributary were assumed to be the same as for West Creek downstream of Tuttle (based on observations during the field reconnaissance). The length of each tributary from the outfall to the confluence with the Canadian River was measured using the ODEQ Data Viewer website with 2008 aerial photos in the background.

TABLE 8: FLOW RATES AND HYDRAULIC PARAMETERS USED IN ODEQ MODEL

Stream	Discharge	Upstream Flow (cfs)	Effluent Flow (MGD)	Velocity (ft/sec)	Depth (ft)	Width (ft)	Stream Length (miles)
Unnamed tributary	Union City	1.0	0.20	0.51	0.34	7.5	1.9
Buggy Creek	Minco	1.0	0.215	0.25	0.23	23.0	3.7
West Creek / Store Creek	Tuttle	1.0	0.51	0.42	0.44	9.7	4.3
Tim's Creek / Pond Creek	Newcastle	1.0	1.20	0.39	0.56	13.1	2.5

4.2.3 KINETIC COEFFICIENTS AND UPSTREAM WATER QUALITY

For the kinetic coefficients (decay rates, settling rates, and SOD), the default values that were already programmed into the OSM were used. The following input values were used in all of the spreadsheet simulations:

- CBOD decay rate = 0.40/day
- CBOD settling rate = 0.05/day
- NBOD decay (nitrification) rate = 0.30/day
- Upstream DO = 85% saturation
- Upstream CBOD5 = 2.0 mg/L
- Upstream NH3-N = 0.10 mg/L

Table 9 shows the SOD values and reaeration rates that were used in the model. The SOD values were calculated as a function of effluent CBOD5 concentration using the equation already programmed into the spreadsheet. For reaeration, the Turney-Harris equation was selected because ODEQ typically uses that equation for small streams.

TABLE 9: VALUES USED IN ODEQ MODEL FOR SOD AND REAERATION

Stream	Discharge	SOD		Reaeration Rate (1/day)
		(g/ft2/day)	(g/m2/day)	
Unnamed tributary	Union City	0.149	1.60	16.6
Buggy Creek	Minco	0.149	1.60	12.4
West Creek / Store Creek	Tuttle	0.149	1.60	13.1
Tim's Creek / Pond Creek	Newcastle	0.105	1.13	11.2

4.2.4 MODEL RESULTS

Effluent concentrations of CBOD5 and ammonia nitrogen were input to the model based on current permit limits for each discharge. A monthly average permit limit of 30 mg/L BOD5 is considered by ODEQ to be equivalent to 25 mg/L CBOD5, and 20 mg/L BOD5 is considered equivalent to 18 mg/L CBOD5. The effluent concentrations and predicted DO values for different seasons and upstream flow values are presented in Table 10.

TABLE 10: EFFLUENT CONCENTRATIONS AND PREDICTED DO FOR ODEQ MODEL

Season	Effluent Concentrations			Predicted DO (mg/L) With 0 cfs Upstream		Predicted DO (mg/L) With 1 cfs Upstream	
	CBOD5 (mg/L)	NH3-N (mg/L)	DO (mg/L)	Minimum	At mouth	Minimum	At mouth
Union City receiving stream – Unnamed Tributary							
Summer	no discharge allowed during June – October						
Spring	25	15.4	6	4.3	4.4	6.5	6.6
Winter	25	7.2	6	5.7	5.7	7.6	7.9
Minco WWTP receiving stream – Buggy Creek							
Summer	25	7.2	5	< 0	1.1	3.6	3.9
Spring	25	7.2	6	2.0	2.9	5.3	5.5
Winter	25	15.4	6	3.6	4.4	6.9	7.0
Tuttle WWTP receiving stream – West Creek / Store Creek							
Summer	25	7.2	5	2.3	3.3	4.4	4.8
Spring	25	7.2	6	4.2	4.8	5.9	6.1
Winter	25	15.4	6	5.4	5.9	7.1	7.4
Newcastle WWTP receiving stream – Tim's Creek / Pond Creek							
Summer	18	12.0	5	2.5	2.9	3.9	4.1
Spring	18	12.0	6	4.4	4.6	5.5	5.6
Winter	18	12.0	6	6.0	6.4	6.7	7.3

The predicted DO values were compared with DO criteria from the water quality standards. The DO criteria already programmed into the ODEQ spreadsheet were:

- 2.0 mg/L for all seasons when the upstream flow is zero

- 5.0 mg/L for summer with the upstream flow at 7Q2 or 1.0 cfs (whichever is higher)
- 6.0 mg/L for spring and winter with the upstream flow at 7Q2 or 1.0 cfs (whichever is higher)

For the Union City unnamed tributary, the predicted minimum DO values are above the applicable criteria in all four simulations (spring with 0 cfs upstream, winter with 0 cfs upstream, spring with 1 cfs upstream, and winter with 1 cfs upstream). The predicted DO values at the mouth are not much higher than the minimum DO values, but this is partly due to the relatively short travel time between the WWTP and the Canadian River.

For Buggy Creek downstream of the Minco WWTP, the predicted minimum DO values are below the applicable criteria for three of the six simulations (summer with 0 cfs upstream, summer with 1 cfs upstream, and spring with 1 cfs upstream). The predicted DO values at the mouth are below the applicable criteria for both summer simulations.

The predicted minimum DO values downstream of the Tuttle WWTP are above the criteria for all the simulations except summer and spring with 1 cfs upstream. The only predicted DO value at the mouth that was below the criterion was 4.8 mg/L, which was minimally below the 5.0 mg/L criterion.

For the Newcastle WWTP receiving stream, simulations for summer and spring with 1 cfs upstream showed predicted minimum DO values below the criteria as well as predicted DO values at the mouth that are below the criteria.

Based on these results, it was determined to extend the WASP model of the Canadian River into Buggy Creek upstream to the Minco WWTP, and into Pond Creek and Tim's Creek upstream to the Newcastle WWTP. The WASP model does not need to be extended into Store Creek and West Creek (downstream of the Tuttle WWTP) because the predicted DO recovered above the criteria in all of the simulations except one where the predicted DO at the mouth is only 0.2 mg/L below the criterion. The WASP model does not need to be extended into the Union City unnamed tributary because the predicted DO values for that stream were all above the criterion. Flow that enters the river from Store Creek and from the Union City unnamed tributary will be simulated in WASP as direct inflows to the river based on field data that will be collected in these two tributaries just upstream of their confluences with the river.

4.3 WASP MODELING

4.3.1 MODEL SETUP

For the modeling of the Canadian River, the WASP model was used as specified in the scope of work for this project. The US Environmental Protection Agency (EPA) developed the WASP model several decades ago and they are still actively supporting and enhancing the latest version of the model (7.31). For this project, the WASP model was set up to simulate DO, CBOD from point sources, CBOD from ambient sources, organic nitrogen, ammonia nitrogen, nitrate nitrogen, organic phosphorus, ortho phosphorus (*ortho P*), and algae (represented in the input and output as *chlorophyll a*).

WASP is a dynamic model; it simulates changes in water quality over time. For this project, the time variable inputs were specified as constants over the duration of the simulation. The model was run for approximately 30 days so that it would reach "steady state with diurnal variations." In other words, the predicted water quality would vary throughout the day and night due to the effects of photosynthesis and respiration of algae, but the predictions for one day would be the same as the next day. Running the model long enough to reach steady state from day to day provides two benefits. First, it prevents the final output from being influenced by rough estimates of initial conditions that must be specified by the user in the model. Second, it allows the model to demonstrate stability in the predictions; the effect of unreasonable model coefficients could be masked with a short simulation.

The model was set up to simulate critical summer conditions, with upstream flow rates set to 7Q2 conditions, water temperatures set to the critical summer temperature (32°C), effluent flow rates set to planned design flows, and effluent concentrations set to current monthly average permit limits. After field data are collected and a calibrated model is developed in Phase 2 of this project, simulations for other seasons (spring and winter) will be run with WASP. As mentioned in Section 4.1, the WASP modeling presented here is a desktop analysis for the purpose of identifying field data needs and anticipating model calibration issues, not evaluating permit limits.

The WASP model was applied to the Canadian River from the confluence of the Union City WWTP receiving stream (just upstream of the US Highway 81 Bridge) to the confluence of Buckhead Creek near Rosedale. This corresponds to the same section of the Canadian River for which the aquatic life designated use was changed from habitat limited aquatic community to warm water aquatic community (see Section 2.7.1). The model was extended into the two unnamed tributaries receiving discharges from the Oklahoma City South Canadian WWTP and the Moore WWTP. As discussed in Section 4.2.4, the WASP model was also extended to simulate Buggy Creek upstream to the Minco WWTP and Pond Creek and Tim's Creek upstream to the Newcastle WWTP.

The WASP model simulates a stream as a series of "boxes" along the length of the stream. The WASP model refers to these boxes as segments. The stream lengths and the lengths of the individual segments are shown in Table 11. The length of the Canadian River study area as defined by ACOG (127 km or 78.9 miles) was measured from 2008 aerial photographs that were provided by ACOG. This length may be different if measured from older aerial photographs due to movement of the river channel. Segment length along the Canadian River was set to 0.5 km for most areas and 0.2 km immediately downstream of point sources or tributaries with point sources. The purpose of the shorter segments was to provide greater resolution to simulate any DO sags downstream of point sources. Segment length for all of the tributary segments was 0.1 km.

TABLE 11: LENGTHS OF STREAMS AND SEGMENTS IN WASP MODEL

Stream	Stream Length (km)	Number of Segments	Segment Length (km)
Canadian River	127.0	383	0.5, 0.2
Unnamed tributary below Oklahoma City WWTP	4.1	41	0.1
Unnamed tributary below Moore WWTP	5.2	52	0.1
Buggy Creek below Minco WWTP	6.0	60	0.1
Tim's Creek / Pond Creek below Newcastle WWTP	4.0	40	0.1
Totals	**146.3**	**576**	**--**

4.3.2 HYDRAULICS

Hydraulic input data for each segment included hydraulic coefficients (multipliers and exponents for depth and velocity), volume, and slope.

One of the ways that depths and velocities can be specified in WASP is through the hydraulic coefficients, where depth and velocity are each calculated as power functions with multipliers and exponents (velocity = a*Q^b and depth = c*Q^d and Q = flow). Based on discussions with ODEQ, the hydraulic coefficients for the Canadian River were set to the same values that were used in the QUAL-TX modeling for the City of Norman WWTP. One set of coefficients was used upstream of the USGS flow gage at Purcell and a second set was used downstream of the gage (the same way it was done in the QUAL-TX model). For the tributaries, the exponents for velocity (b) and depth (d) were assumed to be 0.43 and 0.45, respectively. These exponent values are presented in the WASP User Manual as an average of values for 158 USGS flow gaging stations. Then the coefficients for velocity (a) and depth (c) in the tributaries were back calculated using the exponents and values for velocity and depth based on cross section measurements and visual observations during the December 2008 field reconnaissance. The values used in the model are shown in Table 12.

TABLE 12: HYDRAULIC COEFFICIENTS USED IN WASP MODEL

Stream	Velocity Multiplier (a)	Velocity Exponent (b)	Depth Multiplier (c)	Depth Exponent (d)
Canadian River upstream of Purcell gage	0.2514	0.237	0.196	0.246
Canadian River downstream of Purcell gage	0.3096	0.242	0.192	0.292
Unnamed tributary below Moore WWTP	0.059	0.430	0.994	0.450
Unnamed tributary below OKC South Canadian WWTP	0.093	0.430	1.056	0.450
Buggy Creek below Minco WWTP	0.135	0.430	0.473	0.450
Tim's Creek / Pond Creek below Newcastle WWTP	0.214	0.430	0.698	0.450

The segment volumes that were entered into the model were obtained by multiplying values of depth, width, and length for each segment. Slopes along the length of each stream were estimated from USGS topographic maps.

4.3.3 KINETIC COEFFICIENTS

The WASP model requires numerous kinetic coefficients for simulating algae (phytoplankton) and nutrients along with DO. Some of the values that were used in the QUAL-TX modeling for the City of Norman WWTP were used as starting values for WASP. Other values were initially based on recommended values in the WASP User Manual, from EPA 2008, and ranges of values reported in the "Rates, Constants, Kinetics" manual from EPA in 1985. After running the model, initial values of some kinetic coefficients were adjusted within normal ranges to achieve models results that were considered reasonable based on historical water quality data collected by OWRB and water quality data collected in 1995 for the QUAL-TX modeling. The evaluation of model results was subjective because the existing water quality data does not consist of a set of data that were collected during low flow conditions over the entire length of streams being simulated.

The previous modeling with QUAL-TX used the O'Connor-Dobbins equation for calculating reaeration rates, but EPA recommends that equation for deeper streams and yields rather high values for shallow streams. The reaeration equations recommended by ODEQ for this project were the QUAL-TX equation for large streams and the Turney-Harris equation for small streams. Because WASP does not include either of these equations as options in the model, the reaeration rates were calculated manually (i.e., outside of the model) and entered directly in WASP. The reaeration rates (Ka) at 32°C were calculated for individual segments using the following equations:

$$Ka = [\ 4.022 \times V^{0.273}/H^{0.894}\ ] \times 1.024^{(32-20)} \quad \text{(Texas equation)}$$
$$Ka = [\ 1.33 \times S^{0.32}/n^{0.64}\ ] \times 1.024^{(32-20)} \quad \text{(Turney-Harris equation)}$$

where: V = velocity (ft/sec)
H = stream depth (ft)
S = stream slope (ft/mile)
n = Manning's n for channel roughness (unitless)

The adjustment for water temperature ($1.024^{(32-20)}$) was included in these manual calculations because WASP does not apply a temperature adjustment for segment-specific reaeration rates (it applies the temperature adjustment only if the user specifies one of the equations in WASP). The resulting reaeration rates at 32°C varied between 6.6/day and 9.4/day in the main stem of the Canadian River and 1.4/day to 7.4/day in the tributaries.

Most of the other kinetic coefficients besides reaeration rates either are not allowed to vary spatially in WASP or they were input with a spatially constant value for this application of the model. Input values used for the global kinetic coefficients are summarized in Table 13.

TABLE 13: KINETIC COEFFICIENTS USED IN WASP MODEL

Description of Coefficient	Value
Nitrification Rate Constant @ 20 °C (per day)	0.3
Nitrification Temperature Correction Coefficient	1.08
Half Saturation Constant for Nitrification Oxygen Limit (mg O/L)	1.5
Denitrification Rate Constant @ 20 °C (per day)	0.75
Denitrification Temperature Correction Coefficient	1.08
Half Saturation Constant for Denitrification Oxygen Limit (mg O/L)	0.1
Dissolved Organic Nitrogen Mineralization Rate Constant @ 20 °C (per day)	0.001
Dissolved Organic Nitrogen Mineralization Temperature Correction Coefficient	1.08
Fraction of Phytoplankton Death Recycled to Organic Nitrogen	0.8
Orthophosphate Partition Coefficient to Water Column Solids, L/kg	0.01
Mineralization Rate Constant for Dissolved Organic P @ 20 °C (per day)	0.1
Dissolved Organic Phosphorus Mineralization Temperature Correction Coefficient	1.08
Fraction of Phytoplankton Death Recycled to Organic Phosphorus	0.8
Phytoplankton Maximum Growth Rate Constant @ 20 °C (per day)	2
Phytoplankton Growth Temperature Correction Coefficient	1.06
Include Algal Self Shading Light Extinction in Steele (1=Yes, 0=No)	1
Phytoplankton Carbon to Chlorophyll Ratio	40
Phytoplankton Half-Saturation Constant for Nitrogen Uptake (mg N/L)	0.3
Phytoplankton Half-Saturation Constant for Phosphorus Uptake (mg P/L)	0.04
Phytoplankton Endogenous Respiration Rate Constant @ 20 °C (per day)	0.125
Phytoplankton Respiration Temperature Correction Coefficient	1.06
Phytoplankton Death Rate Constant (Non-Zooplankton Predation) (per day)	0.05
Phytoplankton Phosphorus to Carbon Ratio	0.025
Phytoplankton Nitrogen to Carbon Ratio	0.2
Phytoplankton Half-Sat. for Recycle of Nitrogen and Phosphorus (mg Phyt C/L)	0.005
Light Option (1 uses input light; 2 uses calculated diel light)	2
Daily Solar Radiation (langleys/day)	545
Fraction of Day Between Sunrise and Sunset	0.6
Phytoplankton Optimal Light Saturation	350
Background Light Extinction Multiplier	0.5
Detritus & Solids Light Extinction Multiplier	0.017
DOC Light Extinction Multiplier	0.017
Oxygen to Carbon Stoichiometric Ratio	2.66
Effluent CBOD Decay Rate Constant @ 20 °C (per day)	0.2
Effluent CBOD Decay Rate Temperature Correction Coefficient	1.047
Effluent CBOD Half Saturation Oxygen Limit (mg O/L)	0.2
Ambient CBOD Decay Rate Constant @ 20 °C (per day)	0.1
Ambient CBOD Decay Rate Temperature Correction Coefficient	1.047
Ambient CBOD Half Saturation Oxygen Limit (mg O/L)	0.2
Sediment Oxygen Demand (g/m2/day) – input as spatially constant	0.5
Sediment Oxygen Demand Temperature Correction Coefficient	1.065

Some of the kinetic coefficients that were adjusted from the QUAL-TX modeling included the CBOD decay rates, nitrification rate, and algae maximum growth rate.

The CBOD decay rates used in WASP were slightly different than in the QUAL-TX modeling because WASP was set up to simulate CBOD from point sources separately from CBOD from ambient (nonpoint) sources. The CBOD decay rates used in WASP were 0.2/day for effluent CBOD and 0.1/day for ambient CBOD; these are similar to the value used in the Norman QUAL-TX model (0.15/day).

The nitrification rate (ammonia nitrogen decay rate) was set to 0.5/day in the QUAL-TX modeling but was reduced to 0.3/day for WASP. The value of 0.3/day is the default value used by ODEQ in their spreadsheet model.

The maximum algae growth rate used in the QUAL-TX modeling was 3.0/day but was reduced to 2.0/day for WASP. A maximum growth rate of 3.0/day is within the range of values reported in the literature, but it is at the higher end of the range. Initial model results indicated that a maximum growth rate of 3.0/day would result in algae concentrations that would increase rapidly in the downstream direction without leveling off or even slowing the rate of increase before reaching the downstream end of the model. Additional simulations showed that this rapid increase in the downstream direction could be eliminated by using a maximum growth rate between 1.0/day and 1.5/day, but the resulting algae concentrations seemed unreasonably low.

For each segment and each time step, the WASP model adjusts the maximum algae growth rate based on temperature, nutrients, and light.

The model calculates variation of light during each day based on a sine function and the fraction of the day that occurs between sunrise and sunset (input as 0.6 in WASP). The total amount of daily solar radiation was input as 545 langleys/day, which is the same value used in the QUAL-TX modeling. WASP also has a shading factor to reduce the amount of solar radiation reaching the stream due to shading (tree canopies). For each of the tributaries except Buggy Creek, the shading factor was set to 0.7 so that 30% of the light was blocked from reaching the stream. In the main stem of the Canadian River and in Buggy Creek, where there is very little canopy, the shading factor was set to 1.0 because it was assumed that all of the light reaches the stream. Initial model results showed that light has the most significant impact on the algae growth rate.

WASP calculates the light limitation factor for algae growth based on light intensity below the surface of the water and the saturating light intensity of phytoplankton. Light transmission below the surface of the water is reduced due to natural and algal related turbidity, solids, and dissolved organic carbon. The model uses the light intensity at a particular time and the saturating light intensity to calculate the light limitation factor, which is multiplied by the maximum growth rate to obtain the light-limited growth rate. The simulated values of the light limitation factor averaged approximately 0.53 (i.e., algae could grow at 53% of the maximum rate) in the Canadian River and ranged from 0.5 to 0.6 in the tributaries.

The WASP model calculates the impact of nutrients on algae growth using Michaelis-Menton half saturation equations, where growth is limited by either the level of dissolved inorganic nitrogen or dissolved inorganic phosphorus, whichever one results in the lower growth rate.

The values used for the half saturation coefficients in the WASP model were 0.3 mg/L of nitrogen and 0.04 mg/L of phosphorus. In the first 30 km of the Canadian River, nitrogen was slightly more limiting to algae growth than phosphorus, with nutrient limitation factors ranging between 0.7 and 0.8 (i.e., the maximum growth rate was multiplied by 0.7 to 0.8). In the remaining segments of the Canadian River and in all of the tributaries, the predicted nitrogen and phosphorus concentrations were significantly higher, resulting in nutrient limitation factors between 0.90 and 0.97.

4.3.4 POINT SOURCE INPUTS

The WASP model explicitly simulated 10 of the 13 point source discharges listed in Section 2.6. The three discharges that were not included in the WASP model were Love's Country Store, the Town of Union City WWTP, and the City of Tuttle WWTP. These discharges were not explicitly simulated because they were considered to have little impact on the river. The flows entering the river from the receiving streams for the Union City WWTP and the Tuttle WWTP were simulated as ambient inflows to the river at the mouth of each receiving stream.

Discharges from the WWTPs for Minco, Oklahoma City (South Canadian), Moore, and Newcastle were simulated as discharges into tributaries whose flow is being simulated as it moves downstream to the river. The other six discharges were simulated as direct discharges to the river. The actual discharge location for the City of Norman WWTP is slightly off the main channel of the river, but ODEQ recommended simulating it as a direct discharge to the river due to the very short travel time from the outfall to the river.

The flow from each facility was set to the planned design flow listed in Section 2.6. Effluent concentrations of CBOD, NH3-N, and DO were set at current monthly average permit limits. Permit limits for BOD5 or CBOD5 were multiplied by 2.3 to estimate CBODu values that were input to WASP. For facilities without permit limits for ammonia nitrogen, the ammonia nitrogen concentrations were assumed based on the type of treatment system and default effluent concentrations in the ODEQ spreadsheet model. Effluent concentrations for organic nitrogen, nitrate, organic phosphorus, *ortho P*, and *chlorophyll a* were assumed based on effluent samples from the 1995 field study for the City of Norman WWTP. The following concentrations were used for all of the discharges:

- Nitrate nitrogen = 6 mg/L
- Organic nitrogen = 2.7 mg/L
- Ortho phosphorus = 2.5 mg/L
- Organic phosphorus = 1.0 mg/L
- DO = 5 mg/L

Other effluent concentrations used in the model are shown in Table 14.

TABLE 14: EFFLUENT CONCENTRATIONS USED IN WASP MODEL

Discharge	Treatment Type	CBODu (mg/L)	NH3-N (mg/L)	*Chlorophyll a* (ug/L)
Minco	Lagoons	69.0	7.2	100
Mustang	Mechanical	27.6	4.1	5
Oklahoma City (South Canadian)	Mechanical	34.5	4.1	5
Moore	Mechanical	34.5	4.1	5
Newcastle	Mechanical	46.0	7.2	5
Norman	Mechanical	29.9	4.1	5
Noble	Mechanical	69.0	7.2	5
Lexington	Mechanical	69.0	7.2	5
Purcell	Ponds	69.0	7.2	100
OG&E	--	no flow in model (not yet discharging to the river)		

4.3.5 AMBIENT INFLOWS

Upstream inflows were specified in the model for the Canadian River and for each of the four tributaries into which the model was extended. The only other ambient inflows to the model were the Union City unnamed tributary, Store Creek (downstream of the Tuttle WWTP), and Walnut Creek. The QUAL-TX modeling included outflows (losses to subsurface water) in certain locations for balancing flows, but those outflows were not included in WASP because recent field data is needed to determine if the outflows are appropriate for current conditions.

The upstream flow rate for the Canadian River was set at 7.76 cfs (0.22 m3/sec), which is the published 7Q2 value for the USGS flow gage on the Canadian River at Bridgeport (see Section 2.3). There is also a published 7Q2 value for the USGS flow gage at Purcell, but a large portion of the base flow at this gage consists of flow from point sources located within the modeled portion of the Canadian River. The flow rate for Walnut Creek was set to 2.05 cfs (0.058 m3/sec), which is the published 7Q2 value for the USGS gage on Walnut Creek at Purcell. For each of the four tributaries into which the model was extended, a default upstream flow rate of 1 cfs (0.028 m3/sec) was specified. For the Store Creek inflow to the river, the flow rate was set equal to the planned design flow for the Tuttle WWTP (0.51 MGD or 0.022 m3/sec).

The concentrations that were used for ambient inflows were based on various assumptions and historical water quality data collected by the OWRB in the Canadian River at Bridgeport (significantly) upstream of the influence of major point source discharges). Inflow DO was assumed to be at 80% saturation. CBOD5 concentrations were assumed to be 2.0 mg/L and the CBODu:CBOD5 ratio was assumed to be 2.3. The same values were used for all ambient inflows. These values are shown in Table 15.

TABLE 15: AMBIENT INFLOW CONCENTRATIONS USED IN WASP MODEL

Parameter	Concentration
Ammonia nitrogen	0.1 mg/L
Nitrate nitrogen	0.4 mg/L
Organic nitrogen	0.65 mg/L
Ortho phosphorus	0.03 mg/L
Organic phosphorus	0.12 mg/L
Chlorophyll a	20 µg/L
DO	5.8 mg/L
CBODu	4.6 mg/L

4.3.6 MODEL RESULTS

The output from the desktop WASP model was reviewed with respect to the purpose of the modeling, which is to help identify field data needs and to anticipate issues that may need to be addressed later during model calibration in Phase 2 of this project.

For the main stem of the Canadian River, the predicted velocities ranged from 0.17 to 0.38 m/sec (0.56 to 1.25 ft/sec) and predicted depths ranged from 0.14 to 0.25 m (0.46 to 0.82 ft). The depths seem rather shallow, but these predictions are for 7Q2 conditions rather than typical flow conditions. This reinforces the need for the field data in Phase II to be collected during low flow conditions.

The predicted velocities in the tributaries were 0.03 m/sec (0.10 ft/sec) in Buggy Creek, 0.05 m/sec (0.16 ft/sec) in the Unnamed Tributary below the Moore WWTP, and 0.07 m/sec (0.23 ft/sec) in both Pond Creek and the Unnamed Tributary below the South Canadian WWTP. The predicted depths were approximately 0.75 m (2.5 ft) in the unnamed tributaries below the Moore and Oklahoma City WWTPs, 0.2 m (0.66 ft) in Pond Creek, and 0.1 m (0.33 ft) in Buggy Creek.

Model output from CBODu showed that levels increased along the Canadian River in response to point source inputs and decreased due to the first order decay rates. Predicted concentrations varied from 2 to 18 mg/L. CBODu levels in the tributaries were highest at the upstream ends at the location of the point sources, and decreased due to decay before reaching the Canadian River. Levels of CBODu were as high as 35 mg/L in the tributaries because they are dominated by flow from the effluents. Graphs showing predicted CBODu concentrations from the WASP model are included in Appendix C.

The model output for concentrations of ammonia nitrogen, nitrate nitrogen, organic nitrogen, *ortho P*, and total phosphorus were evaluated and compared to OWRB historical data for the Canadian River at Purcell (OWRB data are presented in Section 2.7.2). The WASP model results showed nutrient concentrations that are higher than historical values. This is likely due to the fact that the model results represent the 7Q2 low flows with point sources discharging at their planned design flows. The historical data were collected when the point sources were discharging at levels lower than their design flows. The resulting instream nutrient levels are also strongly influenced by assumed effluent concentrations of nitrogen and phosphorus. The field data to be collected in Phase 2 of this project will provide measured effluent concentrations that will replace the assumed effluent concentrations used here. Graphs showing predicted nutrient concentrations from the WASP model are included in Appendix C.

The model results reflect predicted ammonia nitrogen concentrations are as high as 2.1 mg/L for the main stem of the Canadian River and even higher in the tributaries, reaching 4.7 mg/L in Pond Creek. It should be noted that the maximum allowable instream ammonia nitrogen concentrations to avoid ammonia toxicity is 2.0 mg/L at a pH of 7.0 and a temperature of 32°C (EPA 1999). The modeled concentrations exceed this level in all of the tributaries.

The model predicted algae concentrations in the Canadian River that increased from a background level of 20 µg/L of *chlorophyll a* at the upstream end of the model to a level of almost 70 µg/L at the downstream end. The value of 70 µg/L is within the range of historical data at Purcell and is comparable to observed data from the 1995 field study for the Norman QUAL-TX modeling. However, the trend of the predicted values is a concern because the algae concentrations are still increasing at the downstream end of the model and would be expected to continue increasing if the model is extended farther downstream. This reinforces the need for the Phase 2 field data collection to extend downstream past Lexington and Purcell to determine what the actual longitudinal trends are for algae. Graphs showing predicted *chlorophyll a* concentrations from the WASP model are included in Appendix C.

Predicted algae concentrations in the tributaries were more varied. The levels of *chlorophyll a* ranged from 6 to 10 µg/L in the Unnamed Tributary below the South Canadian WWTP and from 5 µg/L to 17 µg/L in the Unnamed Tributary below the Moore WWTP. In Pond Creek, the levels ranged from 10 µg/L to 14 µg/L. Buggy Creek had the highest predicted *chlorophyll a* concentrations, with concentrations as high as 90 ug/L at the lower end of the tributary. This can be partly explained because Buggy Creek has a much shallower depth and a lower velocity than the other tributaries. However, field data are needed in each of these tributaries to refine these predictions.

The algae growth rates vary during the day due to the amount of sunlight that is available in the water column. The maximum growth rates occurred in the early morning hours (7:00 am) and in the late afternoon (5:00 pm) in most segments. During the middle of the day, algae growth in most segments is limited by photoinhibition (too much solar radiation for optimum growth). Photoinhibition occurs when the light intensity at the water surface is greater than the algae optimal light saturation. This occurs in most segments from 10:00 am to 3:00 pm.

The desktop model results showed that predicted DO concentrations are below the 5.0 mg/L criterion in the water quality standards in some areas of the Canadian River and in the tributaries. It should be noted, however, that these are initial desktop model results, which will be updated after the field study and model calibration in Phase 2 of this project. Graphs showing predicted DO concentrations from the WASP model are included in Appendix C. The graphs show the model output at 5:00 am and 5:00 pm on day 30 of the simulation. The highest daily DO levels occur at approximately 5:00 pm and the lowest DO levels occur at approximately 5:00 am. The diurnal DO variation (the difference between the plotted lines of minimum and maximum DO) was less than 2 mg/L at the downstream end of the model. This diurnal DO variation seems low based on the predicted *chlorophyll a* concentration of approximately 70 µg/L. This emphasizes the need to collect continuous DO data in the Phase 2 field study.

The locations in the Canadian River with the lowest predicted DO are immediately downstream of each of the unnamed tributaries that receive effluent from the South Canadian and the Moore WWTPs. The low DO values that are predicted in these two tributaries caused the predicted DO in the river to be low. This shows the importance of collecting field data and accurately simulating DO and other constituents in these two tributaries. This also emphasizes the need to collect field data under low flow conditions so that the flow from these two tributaries is not diluted too much in the main stem of the Canadian River.

5.0 PHASE 2 ACTIVITIES

5.1 PROPOSED APPROACH AND TENTATIVE SCHEDULE

The ultimate objective of Phase 2 is to determine appropriate permit limits for known point source discharges. The process for accomplishing that objective is outlined below along with tentative dates for different activities and milestones. The schedule may require some alteration to incorporate meetings with ACOG (any further reference to ACOG in this section also includes the CRPG and ODEQ) as needed. The approach identified below represents a departure from previously identified Phase 2 activities based on what is now known and the realities of obtaining useful data. It is realized that the revised approach will require additional discussion. ACOG desires to review the data from the first field study before conducting the second study. There is simply not enough time between field studies to analyze all the data and understand all the requirements. If this view is not representative of ACOG's wishes, then the original approach of conducting both field studies in one summer and then doing all the modeling (calibration, verification, and projections) in one continuous process can be readdressed, but the contention is that the revised Phase 2 approach will be more accommodating, efficient, and effective.

July or August 2009, Conduct field study for model calibration data: This field study should be conducted when stream flows are low and water temperatures are warm. Section 5.2 provides more information on the field study. If stream flows do not drop to acceptable levels during this time period, all the subsequent dates presented below would be delayed.

August 2009, Collect additional hydraulic data: Several weeks after the calibration field study, additional hydraulic data (cross sections, flows, and time of travel) should be collected under slightly different flow conditions than the calibration field study. This would provide the data that is necessary to calculate the hydraulic coefficients (multipliers and exponents) for depths and velocities in the WASP model.

September 30, 2009, Submit interim report for calibration field data: This report will be a compilation of the data from the calibration field study and the additional hydraulic data collected several weeks later.

A second comprehensive field study potentially cannot be conducted during the summer of 2009 because the period of low flows and probable warm water temperatures will end before the field data can be compiled by and then reviewed by ACOG. It is understood that ACOG wants to review the data from the first field study (the calibration field study) before proceeding with the second field study (the verification field study). Therefore, the proposed approach is to proceed with model calibration after one field study and then evaluate whether or not a second field study is desired.

December 18, 2009, Submit interim report for model calibration: The purpose of submitting the model calibration at this stage of the project (as opposed to later) is to allow ACOG and EPA to review the calibrated model so that any necessary revisions can be made before proceeding to the projection runs. It is recommended that this interim report be submitted to EPA to avoid getting comments from EPA at the end of the project that would require going back and revising the calibration (which would then cause all the projections runs to be revised).

January 29, 2010, Receive comments from ACOG and EPA on model calibration: ACOG will provide consolidated written comments from EPA and the CRPG on the model calibration report.

February 26, 2010, Submit interim report for revised model calibration: Submission of this report will allow ACOG and EPA to review the calibration after any comments have been addressed. At this time, if ODEQ or EPA believe that the uncertainty in the model based on one field study is unacceptable, then preparation would begin for a verification field study (skip projections and go to steps under "PATH B").

March 31, 2010, Submit interim report for preliminary projection results: After the model is calibrated, projection simulations will be made and submitted to the ACOG for review. These projection runs will be made with a 15% margin of safety as required by the Oklahoma Continuing Planning Process (CPP). Recommended permit limits will be based on effluent concentrations used in the projection simulations.

April 30, 2010, Receive feedback from ACOG on preliminary projections: If the results of the preliminary projection runs are acceptable to ACOG, then the project can move forward as outlined below as "PATH A." However, if permittees feel that the permit limits resulting from the projections are unreasonable, or that the model uncertainty is too great to justify a treatment upgrade that might be required as a result of the model predictions, then ACOG may want to conduct a second field study so that the margin of safety in the model can be reduced from 15% to 5% and the model uncertainty can be reduced also. If ACOG wants to conduct a second field study, the project would proceed from here following the steps outlined below as "PATH B."

5.1.1 PATH A (FINISH WLAS WITHOUT SECOND FIELD STUDY)

June 30, 2010, Submit draft WLAS report: This report will include the documentation that was previously identified as interim reports (field data, model calibration, and model projections). This report will be reviewed by ACOG and EPA.

July 30, 2010, Receive comments from ACOG and EPA on draft WLAS report: ACOG will provide consolidated written comments from EPA and the CRPG on the draft WLAS report.

August 31, 2010, Submit final WLAS report: The final WLAS report will be provided.

5.1.2 PATH B (CONDUCT SECOND FIELD STUDY)

May 2010, Prepare for the second field study: Planning and preparation for the second field study will be addressed.

July – August 2010, Conduct verification field study: This field study would need to be conducted when stream flows are low and water temperatures are warm (like the calibration field study). At this time, it is anticipated that this field study would be almost identical to the calibration field study with regard to the amount of data and type of data to be collected. However, the locations of data collection, the type of data to be collected at each location, and other aspects of the verification field study may differ from the calibration field study based on the results of the calibration field study.

<u>September 30, 2010, Submit interim report for verification field data</u>.

<u>November 20, 2010, Submit interim report for model verification</u>: The model verification will include results from simulating conditions during the verification field survey using the calibrated model with no adjustments to calibration parameters. After documenting those results, the original calibration will be revised slightly to obtain the best results for both the calibration field study and the verification field study using a single set of values for the model calibration parameters.

<u>January 3, 2011, Receive comments from ACOG on model verification</u>: ACOG will provide consolidated written comments from the CRPG and EPA on the draft WLAS report.

<u>January 31, 2011, Submit interim report for projection results</u>: This report will document results of projection simulations based on the revised calibration resulting from the model verification.

<u>February 28, 2011, Receive comments from ACOG on projections</u>: ACOG will provide consolidated written comments from the CRPG and EPA on the projections.

<u>April 29, 2011, Submit draft WLAS report</u>: This report will include the documentation that was previously as interim reports (field data, model calibration, and model projections). This report will be reviewed by ACOG and EPA.

<u>May 31, 2011, Receive comments from ACOG on draft WLAS report</u>: ACOG will provide consolidated written comments from the CRPG and EPA on the draft WLAS report.

<u>June 30, 2011, Submit final WLAS report</u>.

5.2 <u>FIELD STUDIES</u>

The purpose of the field studies in Phase 2 is to collect field data for calibrating the WASP model. *Details for the field studies will be developed after determining where access can be obtained along the river and in the tributaries.* These details will be presented in the QAPP for the field studies. The field QAPP will be completed and submitted to ACOG after access locations are determined.

5.2.1 ACCEPTABLE CONDITIONS FOR CONDUCTING FIELD STUDIES

After the model is calibrated, projection simulations will be run to determine appropriate permit limits for each discharge during critical conditions at which the water quality standards have to be maintained. These critical conditions consist of a water temperature of 32°C (during summer) and upstream flows equal to published values for the 7Q2 (lowest 7-day average flow that is likely to occur in one out of every two years). The projection simulations will be run at these critical conditions, so it is desirable that the model be calibrated with field data collected during conditions that are as close as possible to critical conditions (7Q2 flows and 32°C temperatures). If the model is calibrated with field data collected under conditions that are close to critical conditions, then the calibrated model will be considered to be representative of critical conditions and there will more certainty in the predictions for critical conditions.

Based on historical stream flow data, we propose to collect field data for this project only when the flow in the Canadian River is 40 cfs or less at the Bridgeport USGS gage. The value of 40 cfs is higher than the published 7Q2 flow at the Bridgeport gage (7.76 cfs) but it is lower than the upstream flow during the 1995 field study for the City of Norman WWTP. The upstream flow during the 1995 field study was approximately 113 cfs, but this was taken downstream of discharges from several WWTPs (including Mustang, Oklahoma City, and Moore), so it is not directly comparable to flows at the Bridgeport gage. It is desirable to collect field data when flows at Bridgeport are 20 cfs or less, but this is considered too restrictive based on the need to collect data during 2009 rather than waiting another year or more for acceptably low flows to occur. Historical median flows for each day of the year for the Bridgeport USGS gage (based on water years 1970 through 2008) are 40 cfs or less from July 17 through October 16, but they are 20 cfs or less only between August 3 and August 28. These historical data indicate a good probability of obtaining flows less than 40 cfs at the Bridgeport gage during late July or August.

During the summer of 2009, real-time flow data will be monitored on the USGS website in order to know when conditions are acceptable for conducting the field studies. Therefore, the exact dates of the field studies cannot be established more than a week or two ahead of time. In early July, USGS will be requested to check their rating curve and real-time flow readings for the Bridgeport gage (and for the other real-time gages at Mustang, Norman, and Purcell), because frequent shifts in the sandy stream channel over time can cause inaccuracies in the flow readings.

5.2.2 FIELD DATA TO BE COLLECTED

As mentioned above, the field QAPP will contain details of the field studies, including specific sites for collecting field data and which types of data will be collected at each site. The types of field work to be conducted are:

- Cross-section measurements
- Time of travel measurements (dye studies)
- Flow measurements for streams and effluent discharges
- Continuous in situ measurements (temperature, DO, conductivity, and pH)
- Sample collection for effluent and ambient water
- In situ measurements of effluent and ambient water at the time of sampling
- Secchi disk measurements

The laboratory parameters for which each water sample will be analyzed are:

- 20-day CBOD time series
- *chlorophyll a*

- Total Kjeldahl nitrogen (TKN)
- Ammonia nitrogen
- Nitrate+nitrite nitrogen
- Total phosphorus
- Ortho phosphorus
- Total suspended solids (TSS)

The ODEQ laboratory in Oklahoma City will analyze samples for all parameters except 20-day CBOD time series and *chlorophyll a*. The ODEQ laboratory does not have enough incubator space to perform the 20-day CBOD time series analyses and they do not have analysts that are experienced in the entire process required for *chlorophyll a* analyses. Therefore, the 20-day CBOD time series and *chlorophyll a* analyses will be performed by American Interplex Corporation laboratory in Little Rock, AR. Sample bottles for those two analyses will be shipped overnight to Little Rock so that these analyses can be performed within the 48-hour holding time.

The field data collection will address existing data gaps, some of which have been identified through the desktop WASP modeling. Examples of some ways that data gaps will be addressed are:

- Cross section and time of travel measurements will be made at various locations along the entire reach of the Canadian River between the US Highway 81 Bridge and the confluence with Buckhead Creek. Existing hydraulic data (from the 1995 field study) were collected only between the Interstate 35 Bridge near Norman and the US Highway 77 Bridge between Purcell and Lexington.

- Water quality data (including *chlorophyll a*) will be collected downstream of Lexington and Purcell to determine whether or not *chlorophyll a* concentrations continue to increase with distance downstream as predicted by both the QUAL-TX modeling for Norman and the desktop WASP modeling in this project.

- Water quality data will be collected at multiple locations in all tributaries into which the model has been extended (the receiving streams for WWTPs for Minco, Oklahoma City, Moore, and Newcastle). These data will help determine whether or not the DO values are lower downstream of the Oklahoma City and Moore WWTPs as predicted the desktop WASP model.

- Water quality data will be collected for effluent samples so that the assumed values that were used in the desktop WASP model (for parameters that are not reported by the permittees) can be replaced with measured values.

- Continuous in situ data will be collected so that the model can be calibrated to reproduce observed diurnal variations in DO. The diurnal DO variations predicted by the desktop WASP model appeared small based on the algae concentrations.

- The 20-day CBOD time series data will be used to calculate laboratory decay rates for CBOD. These decay rates will tentatively be used as the lower end of the range of acceptable CBOD decay rates in the model.

5.3 WATER QUALITY MODELING

The desktop WASP model from Phase 1 (presented in Section 4.3) will be calibrated using the field data discussed above, and then used to make projection runs that will simulate the effect of different discharge scenarios during critical conditions.

Many of the input values will be revised during model calibration, but the basic model configuration and setup will not change much from the desktop analysis. The model will still cover the same reach of the Canadian River and the same four tributaries, and the model will still simulate the same state variables (DO, CBOD from point sources, CBOD from ambient sources, organic nitrogen, ammonia nitrogen, nitrate nitrogen, organic phosphorus, ortho phosphorus, and algae expressed as *chlorophyll a*). The model will still be run for approximately 30 days so that it will reach "steady state with diurnal variations" as discussed in Section 4.3.1.

The model will be calibrated to observed values of DO, CBODu (calculated from the 20-day CBOD time series data), organic nitrogen (calculated as TKN minus ammonia nitrogen), ammonia nitrogen, nitrate+nitrite nitrogen, organic phosphorus (estimated as total phosphorus minus ortho phosphorus), ortho phosphorus, and *chlorophyll a*. For DO, the model output will be compared with observed data for both the diurnal DO fluctuation and the minimum DO in the early morning.

Adjustment of model coefficients during calibration will stay within ranges of values reported in the literature unless properly justified and documented. The goal of model calibration is not just to obtain a close match between predicted and observed data, but also to accurately represent the physical, chemical, and biological processes in the stream so that the calibrated model will be applicable for conditions other than just the field survey.

If a verification field study is conducted, the model (which will already be calibrated from the calibration field study) will be verified by simulating conditions during the verification field study without changing any of the calibration parameters in the model. The model inputs that will be different between the calibration run and the verification run will be the boundary conditions such as ambient inflow rates and concentrations, effluent flow rates and concentrations, and water temperatures. After documenting those results, the original calibration will be revised slightly to obtain the best results for both the calibration field study and the verification field study using a single set of values for the model calibration parameters.

Projection simulations will be run for all three seasons (summer, winter, and spring). The headwater flows for the Canadian River will be set to the published seasonal 7Q2 values for the Canadian River at Bridgeport (7.76 cfs for summer, 54.9 cfs for winter, and 88.2 cfs for spring; see Table 2. The headwater flows for each of the four tributaries being simulated will be set to 1.0 cfs. The water temperatures will be set to the critical temperatures specified in the water quality standards (32°C for summer, 18°C for winter, and 25°C for spring; see Table 7. The effluent flows will be set to the planned design flows in Table 5. The effluent concentrations will initially be based on current monthly average permit limits (for parameters included in permit) and observed concentrations from the field study (for parameters not included in the permit). The effluent concentrations may be adjusted if necessary for the model predictions to meet the DO criteria of 5.0 mg/L for summer, 5.0 mg/L for winter, and 6.0 mg/L for spring. For spring and summer, the water quality standards allow a 1.0 mg/L deficit for not more than 8 hours in any 24-hour period (see Table 7). Therefore, the predicted DO values for the summer and spring projection runs will be checked to make sure the minimum DO values in the morning do not drop more than 1.0 mg/L below the criteria, and that the duration of any values below the criteria does not exceed eight hours in any 24-hour period. The predicted DO values for the winter simulation will be checked to make sure the minimum DO values in the morning do not drop below the criterion (5.0 mg/L).

As required in the CPP, the margin of safety for the projection simulations will be 15% if the model is calibrated (i.e., if only one field study was conducted) or 5%if the model is calibrated and verified (i.e., if two field studies are conducted).

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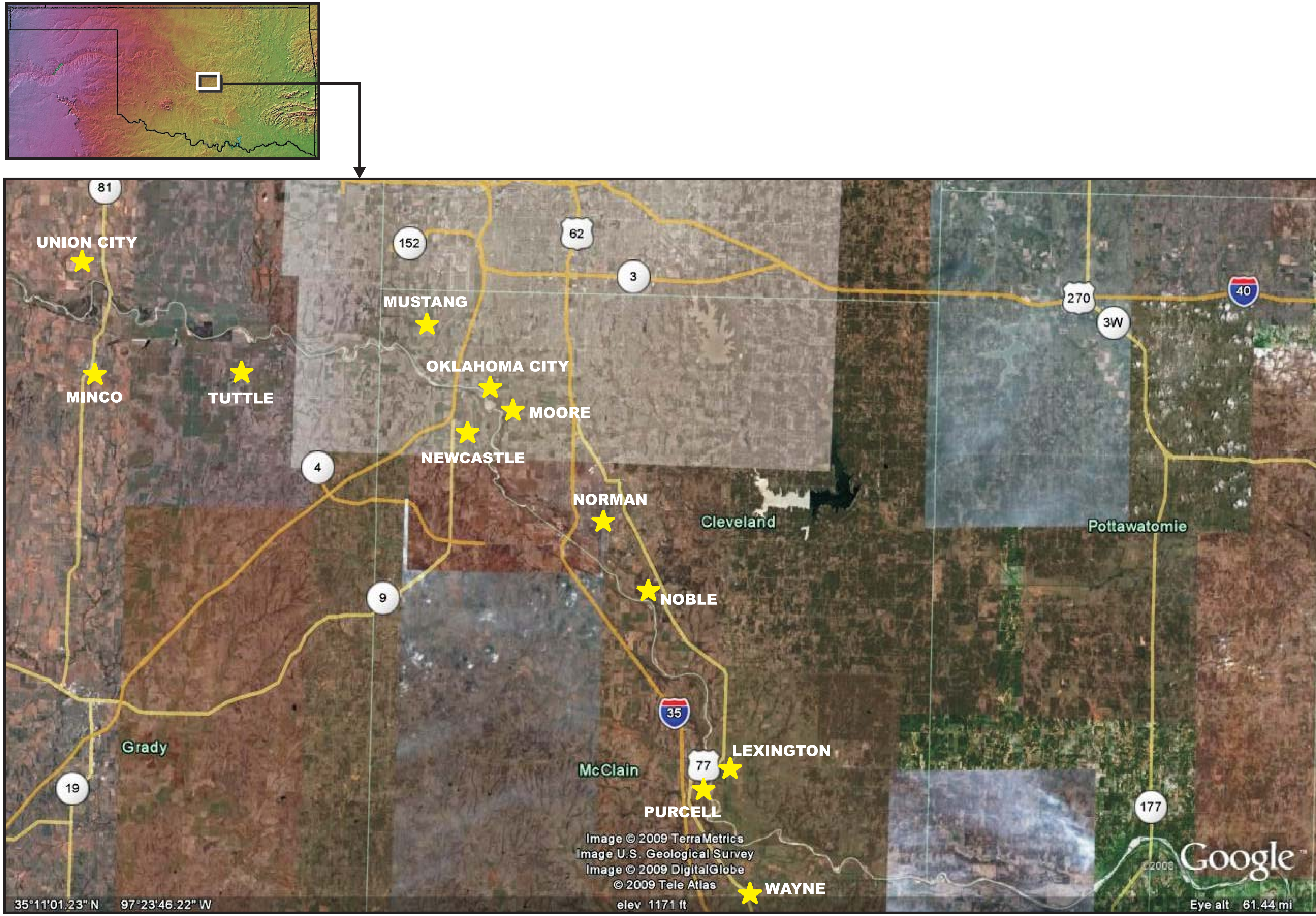

NOT TO SCALE

GUERNSEY
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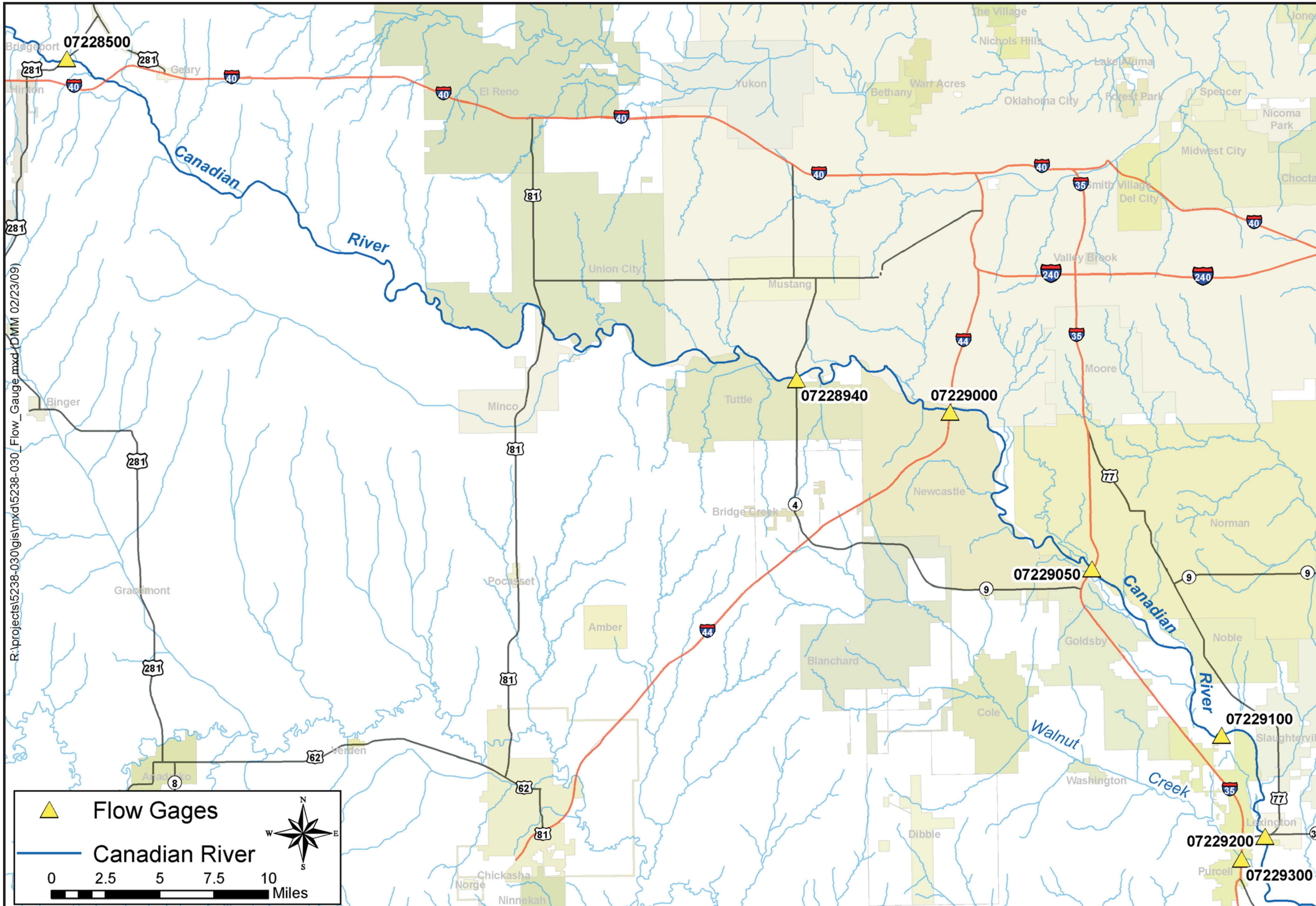
SITE LOCATION MAP

CANADIAN RIVER
WASTELOAD ALLOCATION STUDY

PREPARED BY: ALA
APPROVED BY: CBM
DATE: FEBRUARY 20, 2009
JOB NO: OK07865000

FIGURE 1



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FLOW GAGE LOCATION MAP

CANADIAN RIVER
WASTELOAD ALLOCATION STUDY

FIGURE 2

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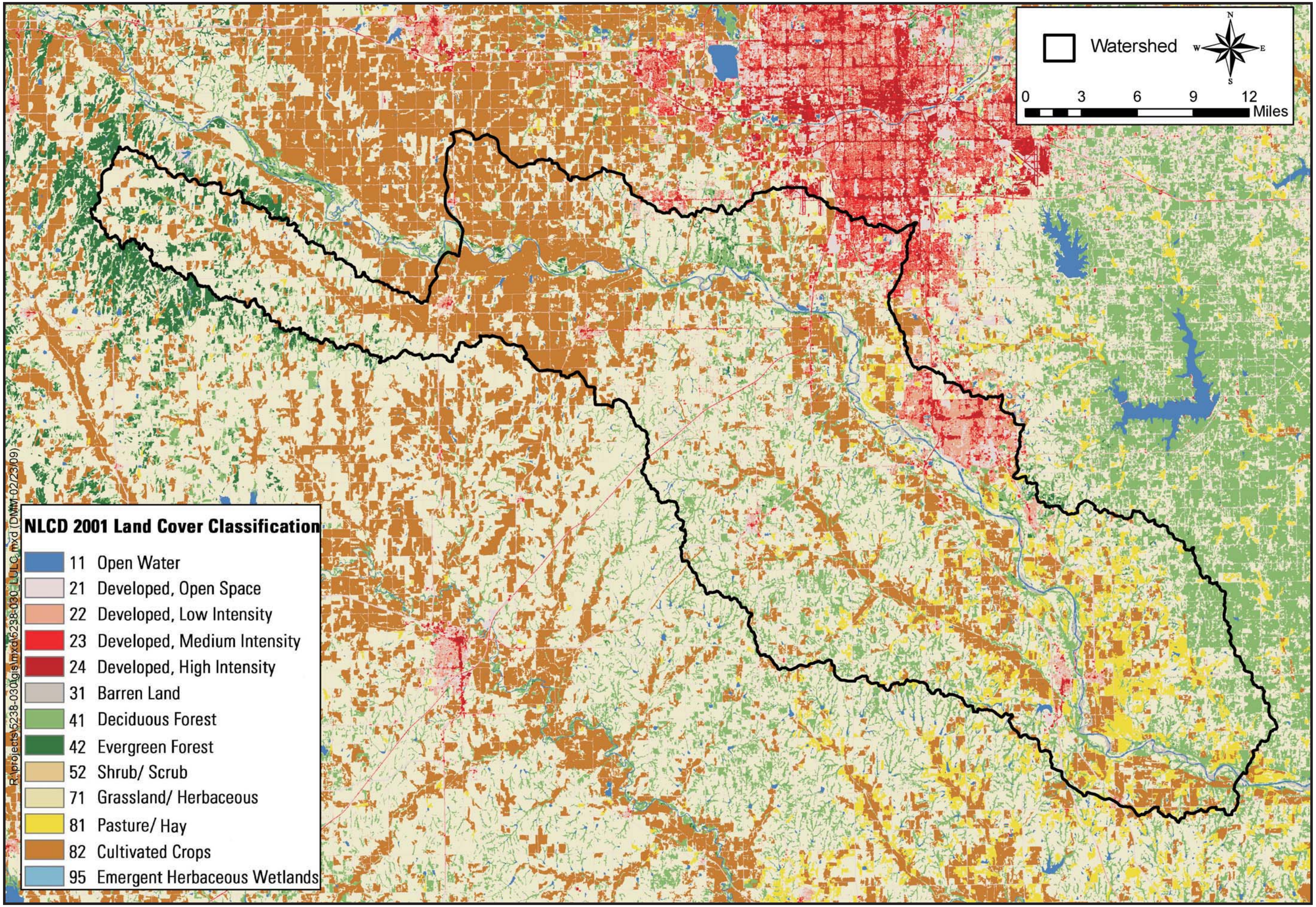

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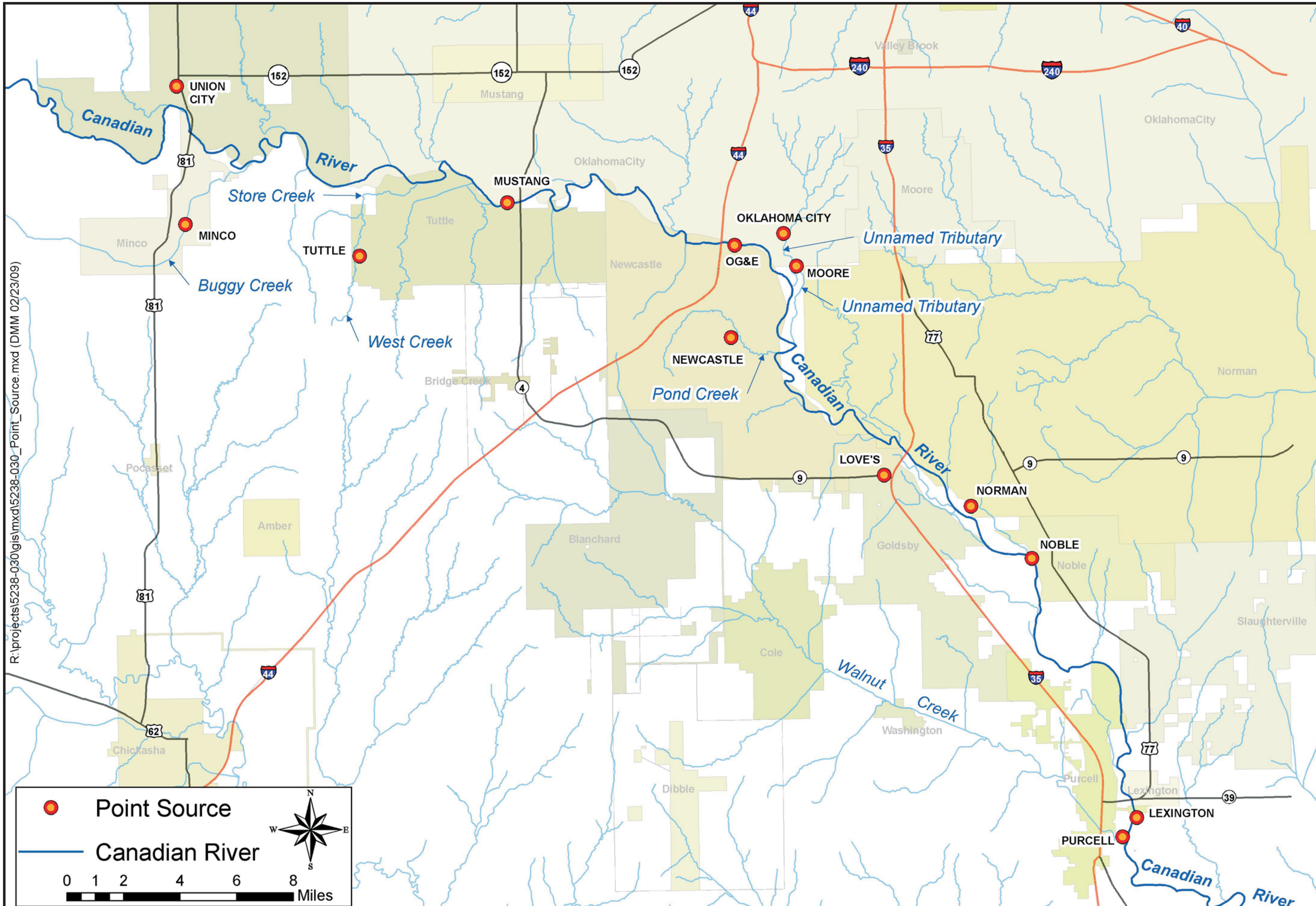
LAND USE MAP

CANADIAN RIVER
WASTELOAD ALLOCATION STUDY

PREPARED BY: ALA
APPROVED BY: CBM
DATE: FEBRUARY 20, 2009
JOB NO: OK 07855000

FIGURE 3



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POINT SOURCE LOCATION MAP

CANADIAN RIVER
WASTELOAD ALLOCATION STUDY

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FIGURE 4

APPENDIX A

REPORTED EFFLUENT DATA

FROM CRPG COMMUNITIES

EFFLUENT DATA FOR UNION CITY WWTP

Month	Monthly average parameters Flow (MGD)	BOD5 (mg/L)	CBOD5 (mg/L)	TSS (mg/L)	NH3-N (mg/L)	Inst. min. DO (mg/L)
Jan-98	0					
Feb-98	0					
Mar-98	0					
Apr-98	0					
May-98	0					
Jun-98	0					
Jul-98	0					
Aug-98	0					
Sep-98	0					
Oct-98	0					
Nov-98	0					
Dec-98	0					
Jan-99	0					
Feb-99	0					
Mar-99	0					
Apr-99	0					
May-99	0					
Jun-99	0					
Jul-99	0					
Aug-99	0					
Sep-99	0					
Oct-99	0					
Nov-99	0					
Dec-99	0					
Jan-00	0					
Feb-00	0					
Mar-00	0					
Apr-00	0					
May-00	0					
Jun-00	0					
Jul-00	0					
Aug-00	0					
Sep-00	0					
Oct-00	0					
Nov-00	0					
Dec-00	0					
Jan-01	0					
Feb-01	0.187	81.2		77		
Mar-01	0.026	77.9		89		
Apr-01	0					
May-01	0					
Jun-01	0					
Jul-01	0					
Aug-01	0					
Sep-01	0					
Oct-01	0					
Nov-01	0.187	98.1		92		
Dec-01	0					
Jan-02	0					

EFFLUENT DATA FOR UNION CITY WWTP

Month	Monthly average parameters Flow (MGD)	BOD5 (mg/L)	CBOD5 (mg/L)	TSS (mg/L)	NH3-N (mg/L)	Inst. min. DO (mg/L)
Feb-02	0					
Mar-02	0					
Apr-02	0					
May-02	0					
Jun-02	0					
Jul-02	0					
Aug-02	0					
Sep-02	0					
Oct-02	0					
Nov-02	0					
Dec-02	0					
Jan-03	0					
Feb-03	0					
Mar-03	0					
Apr-03	0					
May-03	0					
Jun-03	0					
Jul-03	0					
Aug-03	0					
Sep-03	0					
Oct-03	0					
Nov-03	0					
Dec-03	0					
Jan-04	0					
Feb-04	0					
Mar-04	0					
Apr-04	0					
May-04	0					
Jun-04	0					
Jul-04	0					
Aug-04	0					
Sep-04	0					
Oct-04	0					
Nov-04	0					
Dec-04	0					
Jan-05	0					
Feb-05	0					
Mar-05	0					
Apr-05	0					
May-05	0					
Jun-05	0					
Jul-05	0					
Aug-05	0					
Sep-05	0					
Oct-05	0					
Nov-05	0					
Dec-05	0					
Jan-06	0					
Feb-06	0					

Month	Monthly average parameters Flow (MGD)	BOD5 (mg/L)	CBOD5 (mg/L)	TSS (mg/L)	NH3-N (mg/L)	Inst. min. DO (mg/L)
Mar-06	0					
Apr-06	0					
May-06	0					
Jun-06	0					
Jul-06	0					
Aug-06	0					
Sep-06	0					
Oct-06	0					
Nov-06	0					
Dec-06	0					
Jan-07	0					
Feb-07	0					
Mar-07	0					
Apr-07	0					
May-07	0.003	12		73		
Jun-07	0.030	no data		no data		
Jul-07	0.024	no data		no data		
Aug-07	0					
Sep-07	0					
Oct-07	0					
Nov-07	0					
Dec-07	0.024	12.5		52		
Jan-08	0					
Feb-08	0					
Mar-08	0.029	23.6		49		
Apr-08	0.021	19		44		
May-08	0.008	75		98		
Jun-08	0					
Jul-08	0					
Aug-08	0					
Sep-08	0					

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Month	Monthly average parameters Flow (MGD)	BOD5 (mg/L)	CBOD5 (mg/L)	TSS (mg/L)	NH3-N (mg/L)	Inst. min. DO (mg/L)
Jan-07						
Feb-07	no data before March 2007					
Mar-07	0					
Apr-07	0					
May-07	0.021	not meas.		not meas.		
Jun-07	no data for June 2007					
Jul-07	0					
Aug-07	0					
Sep-07	0					
Oct-07	0					
Nov-07	0					
Dec-07	0					
Jan-08	0					
Feb-08	0					
Mar-08	0					
Apr-08	0					
May-08	0.136	8.95		14		
Jun-08	0.159	10.25		41		
Jul-08						
Aug-08	no data after June 2008					
Sep-08						

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EFFLUENT DATA FOR TUTTLE WWTP

Month	Monthly average parameters					Inst. min.
	Flow (MGD)	BOD5 (mg/L)	CBOD5 (mg/L)	TSS (mg/L)	NH3-N (mg/L)	DO (mg/L)
Jul-06						
Aug-06	no data before Sept. 2006					
Sep-06	0.055	8.7		79.2		
Oct-06	0.055	17.7		51.0		
Nov-06	0.055	19.0		31.2		
Dec-06	0.055	29.4		31.7		
Jan-07	0.055	10.1		18.6		
Feb-07	0.055	8.9		15.4		
Mar-07	0.055	17.9		26.2		
Apr-07	0.055	10.8		27.1		
May-07	0.055	9.4		17.4		
Jun-07	0.055	8.5		31.1		
Jul-07	0.055	8.3		35.4		
Aug-07	0.055	9.4		20.7		
Sep-07	0.055	8.0		16.5		
Oct-07	0.055	6.6		19.0		
Nov-07	0.055	7.3		27.5		
Dec-07	0.055	5.6		20.0		
Jan-08	0.055	4.6		9.6		
Feb-08	0.055	8.5		20.4		
Mar-08	0.055	8.8		24.5		
Apr-08	0.055	4.4		21.4		
May-08	0.055	3.4		17.9		
Jun-08	0.055	4.2		19.5		
Jul-08	no data for July 2008					
Aug-08	0.055	5.8		14.1		
Sep-08	0.055	3.7		5.6		

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EFFLUENT DATA FOR MUSTANG WWTP

Month	Monthly average parameters					Inst. min.
	Flow (MGD)	BOD5 (mg/L)	CBOD5 (mg/L)	TSS (mg/L)	NH3-N (mg/L)	DO (mg/L)
Jan-98	1.567	2.0		5.0		5.1
Feb-98	1.672	5.0		14.0		5.0
Mar-98	1.881	2.0		5.0		5.0
Apr-98	1.571		3.0	9.0	0.3	5.0
May-98	1.393		2.0	8.0	0.6	5.0
Jun-98	1.069		2.0	5.0	0.2	5.0
Jul-98	0.841		2.0	6.0	0.5	5.0
Aug-98	0.805		2.0	3.0	0.5	5.0
Sep-98	0.769		6.0	7.0	0.3	5.0
Oct-98	0.913		9.0	8.0	0.7	5.0
Nov-98	1.057	11.0		16.0		5.0
Dec-98	1.168	7.0		22.0		5.0
Jan-99	1.073	4.0		12.0		5.0
Feb-99	1.210	4.0		11.0		5.3
Mar-99	1.349	6.0		17.0		5.4
Apr-99	1.349		4.0	13.0	0.1	5.1
May-99	1.616		2.0	5.0	0.3	5.0
Jun-99	1.483		4.0	10.0	0.2	5.0
Jul-99	1.508		5.0	12.0	0.1	5.0
Aug-99	1.087		5.0	5.0	2.0	5.0
Sep-99	1.038		7.4	12.9	3.0	5.0
Oct-99	0.921		4.0	7.0	0.6	5.0
Nov-99	0.905	5.1		10.0		5.0
Dec-99	0.928	8.8		18.4		6.0
Jan-00	0.922	5.4		11.6		5.9
Feb-00	0.892	8.8		16.6		5.1
Mar-00	1.067	5.7		9.3		5.0
Apr-00	1.113		2.6	9.0	0.0	5.0
May-00	1.230		2.0	3.5	0.2	5.0
Jun-00	1.330		3.9	8.6	1.4	5.0
Jul-00	1.220		3.5	8.1	2.4	5.0
Aug-00	0.887		2.1	6.9	0.4	5.2
Sep-00	0.907		1.9	2.5	0.2	5.0
Oct-00	1.050		1.5	2.9	0.1	5.5
Nov-00	1.160	4.1		2.5		6.0
Dec-00	1.126	13.3		16.8		5.9
Jan-01	1.197	7.4		12.4		5.2
Feb-01	1.607	5.0		6.1		5.1
Mar-01	1.494	9.2		6.4		5.0
Apr-01	1.439		2.5	4.4	0.2	5.2
May-01	1.345		2.7	11.0	0.6	5.0
Jun-01	1.590		6.8	29.8	1.0	2.8
Jul-01	0.990		7.0	15.0	0.6	4.1
Aug-01	1.020		6.0	6.0	1.0	5.0
Sep-01	0.930		9.0	16.0	1.0	5.0
Oct-01	0.930		7.0	12.0	4.0	5.0
Nov-01	1.000	6.0		14.3		5.1
Dec-01	1.060	8.5		11.6		5.0
Jan-02	0.930	14.0		25.0		5.0

Month	Monthly average parameters					Inst. min.
	Flow (MGD)	BOD5 (mg/L)	CBOD5 (mg/L)	TSS (mg/L)	NH3-N (mg/L)	DO (mg/L)
Feb-02	1.030	10.9		12.3		5.2
Mar-02	1.130	17.0		30.5		5.1
Apr-02	1.340		9.2	13.3	0.5	5.1
May-02	1.240		6.8	4.8	4.7	5.0
Jun-02	1.170		7.8	8.7	2.6	5.0
Jul-02	1.120		9.0	6.5	2.7	5.0
Aug-02	1.040		9.2	5.7	4.4	5.0
Sep-02	0.990		6.5	7.0	4.7	5.1
Oct-02	0.990		4.5	5.0	2.9	5.0
Nov-02	1.020	5.8		6.5		5.1
Dec-02	1.090	10.1		4.5		8.1
Jan-03	1.030	18.8		8.1		7.8
Feb-03	1.030	26.7		16.8		9.5
Mar-03	1.000	48.9		49.4		5.9
Apr-03	1.060		7.4	22.2	1.3	6.3
May-03	1.050		8.9	11.3	3.1	5.0
Jun-03	1.130		9.3	10.0	2.3	5.0
Jul-03	0.990		3.0	4.5	1.7	5.3
Aug-03	0.890		3.6	6.7	4.4	5.1
Sep-03	1.010		2.3	3.9	1.4	5.4
Oct-03	1.000		2.6	2.6	1.2	5.2
Nov-03	0.970	5.5		2.1		5.6
Dec-03	0.980	7.6		10.1		5.6
Jan-04	0.900	6.8		4.9		5.2
Feb-04	1.020	5.1		5.0		6.3
Mar-04	1.110	4.5		4.0		5.6
Apr-04	1.200		2.6	8.2	0.2	5.6
May-04	0.990		2.9	4.7	2.9	5.6
Jun-04	1.010		3.4	3.2	2.7	5.3
Jul-04	1.090		2.5	2.1	3.7	5.2
Aug-04	1.110		2.8	4.2	1.0	5.1
Sep-04	1.090	no data		2.8	2.2	5.4
Oct-04	1.150	no data		4.4	3.8	5.9
Nov-04	1.380	no data		5.3		5.9
Dec-04	1.520	no data		14.9		10.3
Jan-05	1.650	no data		16.8		7.1
Feb-05	1.900	no data		12.1		7.4
Mar-05	1.810	no data		13.8		7.1
Apr-05	1.680		4.5	7.1	1.0	6.6
May-05	1.710		4.5	8.3	4.8	5.5
Jun-05	1.820		2.6	2.1	2.6	6.2
Jul-05	1.280		7.4	2.7	3.0	5.3
Aug-05	1.080		3.1	2.7	1.6	5.6
Sep-05	1.000		3.3	3.0	1.5	5.8
Oct-05	1.090		4.9	7.3	1.2	6.1
Nov-05	0.890	16.6		9.9		5.7
Dec-05	0.930	no data		12.2		6.0
Jan-06	0.910	12.3		21.5		6.2
Feb-06	0.880	10.4		14.8		5.6

	Monthly average parameters					Inst. min.
Month	Flow (MGD)	BOD5 (mg/L)	CBOD5 (mg/L)	TSS (mg/L)	NH3-N (mg/L)	DO (mg/L)
Mar-06	0.970	8.2		10.1		5.1
Apr-06	0.980		3.3	5.8	5.8	5.2
May-06	0.940		2.2	4.4	4.0	5.1
Jun-06	0.970		2.5	4.4	2.5	5.2
Jul-06	1.010		6.6	9.7	1.9	5.0
Aug-06	0.940		7.8	5.4	4.4	5.1
Sep-06	0.920		5.0	3.9	4.3	5.1
Oct-06	0.950		6.2	3.5	1.7	5.2
Nov-06	0.850	19.0		9.3		5.2
Dec-06	1.120	20.9		12.4		5.3
Jan-07	1.040	23.2		11.8		5.1
Feb-07	1.070	20.6		14.3		5.4
Mar-07	1.160	29.4		18.6		5.2
Apr-07	1.380		3.9	16.9	0.8	5.2
May-07	1.610		3.5	7.6	2.4	5.0
Jun-07	1.850		4.2	12.7	2.8	5.0
Jul-07	2.140		3.0	9.6	4.2	4.2
Aug-07	1.580		5.3	8.3	9.0	5.0
Sep-07	1.640		3.8	8.5	6.6	5.1
Oct-07	1.380		3.6	10.1	6.8	4.2
Nov-07	1.280	18.7		21.6	11.4	5.0
Dec-07	1.340	29.7		14.3	9.1	5.0
Jan-08	1.420	29.8		11.9	6.0	5.0
Feb-08	1.570	46.0		16.8	4.5	5.0
Mar-08	1.830	45.2		26.4	4.6	5.0
Apr-08	1.780		8.8	13.8	4.9	4.5
May-08	1.680		13.0	14.8	6.6	4.7
Jun-08	1.700		13.4	13.4	9.2	4.7
Jul-08	1.440		26.3	14.2	14.5	5.0
Aug-08	1.670		11.6	12.3	10.8	5.0
Sep-08	1.710		3.7	14.8	9.4	5.0

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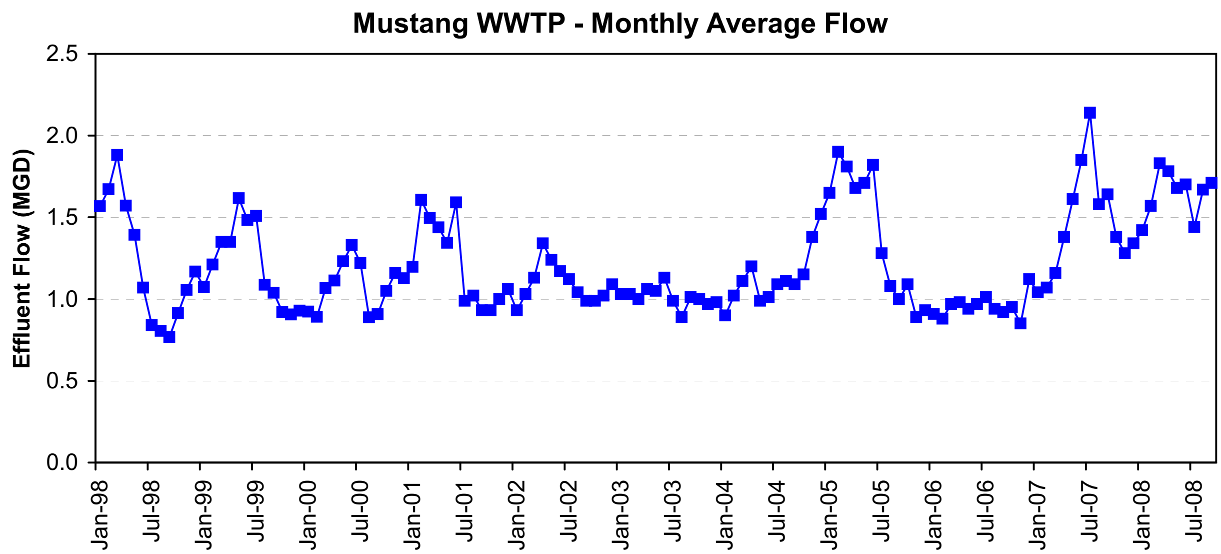

Mustang WWTP - Monthly Average Flow
Effluent Flow (MGD)
2.5
2.0
1.5
1.0
0.5
0.0
Jan-98
Jul-98
Jan-99
Jul-99
Jan-00
Jul-00
Jan-01
Jul-01
Jan-02
Jul-02
Jan-03
Jul-03
Jan-04
Jul-04
Jan-05
Jul-05
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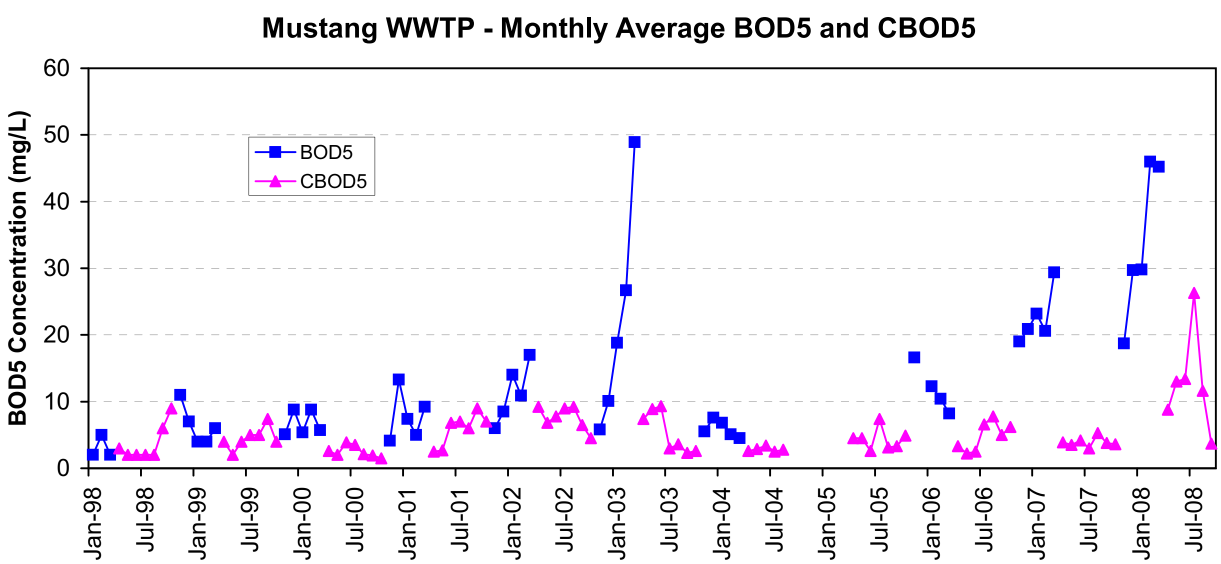
Jan-07
Jul-07
Jan-08
Jul-08



Mustang WWTP - Monthly Average BOD5 and CBOD5
BOD5 Concentration (mg/L)
60
50
40
30
20
10
0
BOD5
CBOD5
Jan-98
Jul-98
Jan-99
Jul-99
Jan-00
Jul-00
Jan-01
Jul-01
Jan-02
Jul-02
Jan-03
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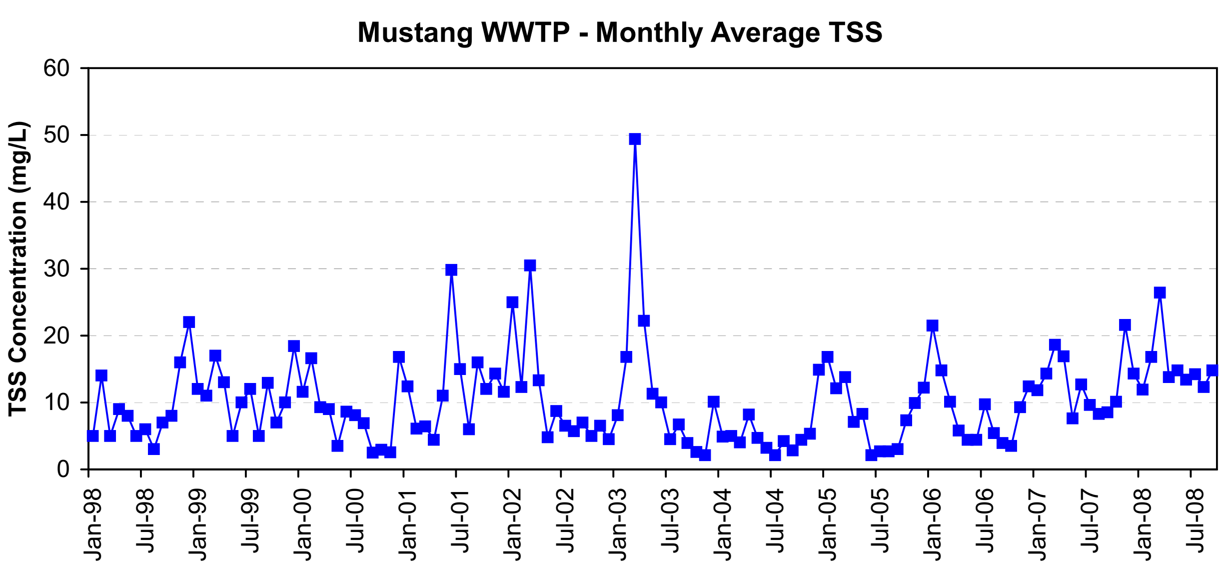
Jan-07
Jul-07
Jan-08
Jul-08



Mustang WWTP - Monthly Average TSS
TSS Concentration (mg/L)
60
50
40
30
20
10
0
Jan-98
Jul-98
Jan-99
Jul-99
Jan-00
Jul-00
Jan-01
Jul-01
Jan-02
Jul-02
Jan-03
Jul-03
Jan-04
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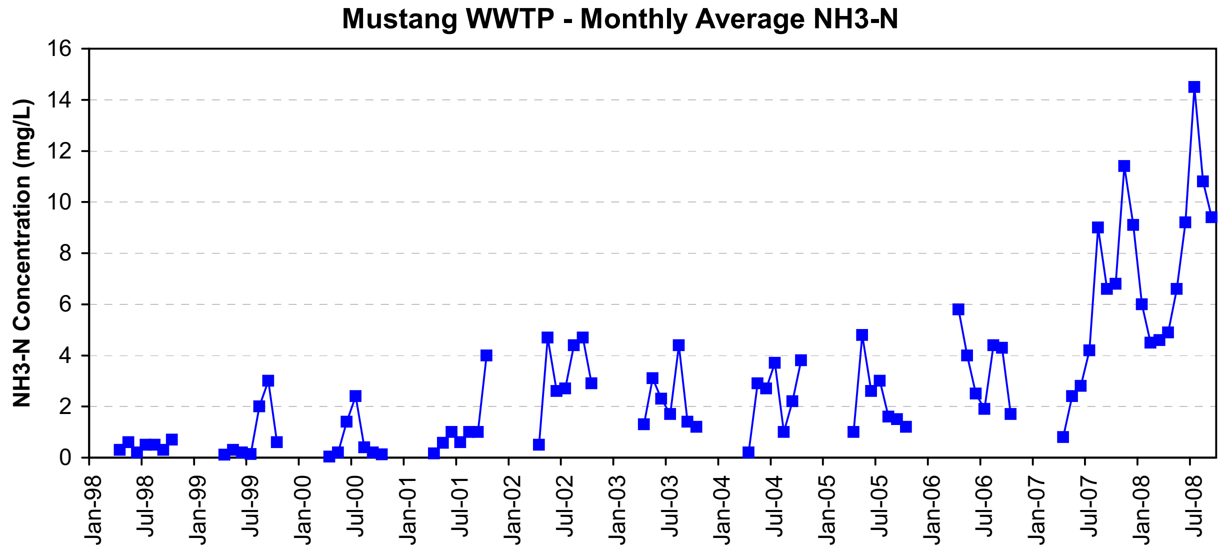
Jul-07
Jan-08
Jul-08


Mustang WWTP - Monthly Average NH3-N
NH3-N Concentration (mg/L)
0
2
4
6
8
10
12
14
16
Jan-98
Jul-98
Jan-99
Jul-99
Jan-00
Jul-00
Jan-01
Jul-01
Jan-02
Jul-02
Jan-03
Jul-03
Jan-04
Jul-04
Jan-05
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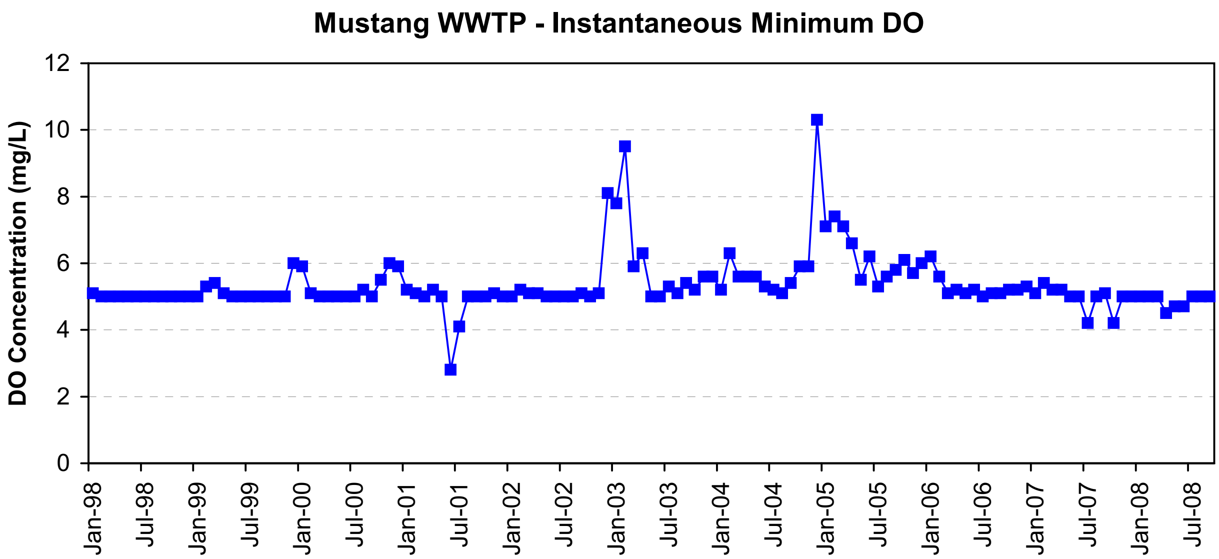
Jul-06
Jan-07
Jul-07
Jan-08
Jul-08


Mustang WWTP - Instantaneous Minimum DO
DO Concentration (mg/L)
0
2
4
6
8
10
12
Jan-98
Jul-98
Jan-99
Jul-99
Jan-00
Jul-00
Jan-01
Jul-01
Jan-02
Jul-02
Jan-03
Jul-03
Jan-04
Jul-04
Jan-05
Jul-05
Jan-06
Jul-06
Jan-07
Jul-07
Jan-08
Jul-08

EFFLUENT DATA FOR OKLAHOMA CITY WWTP

	Monthly average parameters					Inst. min.
Month	Flow (MGD)	BOD5 (mg/L)	CBOD5 (mg/L)	TSS (mg/L)	NH3-N (mg/L)	DO (mg/L)
Jan-98	3.840	4.0		2.0		
Feb-98	3.290	4.0		2.0		
Mar-98	3.960	9.0		6.0		
Apr-98	3.300	5.0		2.0		
May-98	3.110	8.0		4.0		
Jun-98	3.140	6.0		3.0	4.6	6.0
Jul-98	2.800	7.0		4.0	5.0	5.9
Aug-98	2.780	3.0		2.0	0.1	6.1
Sep-98	2.930	4.0		2.0	0.1	5.8
Oct-98	3.090	4.0		2.0		
Nov-98	3.120	5.0		2.0		
Dec-98	3.140	3.0		4.0		
Jan-99	3.100	3.0		3.0		
Feb-99	3.470	4.0		3.0		
Mar-99	4.160	6.0		4.0		
Apr-99	4.670	5.0		7.0		
May-99	3.510	3.0		1.0		
Jun-99	4.410	3.0		2.0	0.3	6.5
Jul-99	3.830	3.0		2.0	0.6	6.1
Aug-99	3.040	8.0		3.0	3.5	5.1
Sep-99	3.110	6.0		6.0	0.3	5.6
Oct-99	2.830	5.0		8.0		
Nov-99	2.740	4.0		2.0		
Dec-99	3.150	6.0		4.0		
Jan-00	2.970	8.0		15.0		
Feb-00	3.240	4.0		5.0		
Mar-00	3.910	5.0		3.0		
Apr-00	4.050	5.0		3.0		
May-00	3.384	6.0		4.0		
Jun-00	3.250	4.0		2.0	0.3	5.2
Jul-00	3.689	4.0		3.0	0.2	7.7
Aug-00	2.763	6.0		3.0	0.3	7.0
Sep-00	2.692	9.0		3.0	1.5	6.8
Oct-00	3.358	7.0		5.0		
Nov-00	4.083	6.0		6.0		
Dec-00	4.482	16.0		22.0		
Jan-01	5.034	16.0		18.0		
Feb-01	5.162	23.0		12.0		
Mar-01	4.220	7.0		6.0		
Apr-01	3.767	10.0		7.0		
May-01	3.874	12.0		7.0		
Jun-01	3.426	9.0		3.0	1.5	7.0
Jul-01	3.004	6.0		4.0	5.0	5.4
Aug-01	2.784	8.0		5.0	1.2	6.0
Sep-01	3.233	5.0		2.0	0.5	6.4
Oct-01	3.056	4.0		2.0		
Nov-01	2.774	11.0		5.0		
Dec-01	3.004	5.0		3.0		
Jan-02	2.891	5.0		3.0		

EFFLUENT DATA FOR OKLAHOMA CITY WWTP

Month	Monthly average parameters					Inst. min.
	Flow (MGD)	BOD5 (mg/L)	CBOD5 (mg/L)	TSS (mg/L)	NH3-N (mg/L)	DO (mg/L)
Feb-02	3.270	5.0		3.0		
Mar-02	3.248	5.0		3.0		
Apr-02	4.333	9.0		11.0		
May-02	3.595	6.0		4.0		
Jun-02	3.247	6.0		3.0	0.2	6.4
Jul-02	3.460	13.0		5.0	2.0	6.2
Aug-02	1.520	12.0		6.0	3.0	5.6
Sep-02	1.597	5.0		2.0	1.0	5.6
Oct-02	3.348	6.0		4.0		
Nov-02	3.148	4.0		2.0		
Dec-02	3.092	10.0		4.0		
Jan-03	3.637	25.0		17.0		
Feb-03	2.921	16.0		12.0		
Mar-03	2.957	7.0		3.0		
Apr-03	3.155	4.0		3.0		
May-03	2.657	5.0		3.0		
Jun-03	3.158	4.0		4.0	1.0	5.6
Jul-03	1.601	4.0		4.0	6.0	5.4
Aug-03	1.254	7.0		4.0	7.0	5.3
Sep-03	2.047	3.0		3.0	1.0	5.3
Oct-03	1.786	3.0		3.0		
Nov-03	2.086	4.0		3.0		
Dec-03	2.203	5.0		5.0		
Jan-04	2.521	12.0		18.0		
Feb-04	2.389	5.0		10.0		
Mar-04	2.770	6.0		3.0		
Apr-04	1.057	4.0		2.0		
May-04	0.810	3.0		3.0		
Jun-04	2.451	7.0		12.0	0.8	6.3
Jul-04	2.354	5.0		4.0	1.5	5.4
Aug-04	1.430	5.0		2.0	1.0	5.4
Sep-04	0.690	6.0		6.0	1.0	5.7
Oct-04	1.461	8.0		5.0		
Nov-04	4.023	10.0		8.0		
Dec-04	2.103	10.0		5.0		
Jan-05	2.962	19.0		21.0		
Feb-05	2.958	21.0		30.0		
Mar-05	1.356	6.0		4.0		
Apr-05	0.854	10.0		5.0		
May-05	1.299	6.0		8.0		
Jun-05	1.713	4.0		3.0	0.2	6.1
Jul-05	2.029	5.0		8.0	0.3	5.4
Aug-05	2.234	7.3		4.6	1.0	5.2
Sep-05	1.934	11.4		10.6	2.0	5.1
Oct-05	2.097	7.5		9.1		
Nov-05	1.159	5.0		7.8		
Dec-05	1.428	7.0		12.2		
Jan-06	1.560	12.5		19.6		
Feb-06	1.888	41.8		77.4		

	Monthly average parameters					Inst. min.
Month	Flow (MGD)	BOD5 (mg/L)	CBOD5 (mg/L)	TSS (mg/L)	NH3-N (mg/L)	DO (mg/L)
Mar-06	1.716	26.0		30.0		
Apr-06	1.699	30.9		36.3		
May-06	1.395	13.4		7.1		
Jun-06	0.883	13.4		8.7	7.1	5.1
Jul-06	0.564	5.2		2.4	2.3	5.3
Aug-06	0.761	8.2		5.8	6.4	5.1
Sep-06	1.151	16.6		7.1	17.5	5.1
Oct-06	1.153	13.6		6.5		
Nov-06	0.951	9.3		11.4		
Dec-06	1.606	18.0		20.9		
Jan-07	2.603	11.5		16.2		
Feb-07	2.240	14.4		18.5		
Mar-07	3.102	14.1		27.8		
Apr-07	3.011	17.7		16.2		
May-07	5.457	11.9		12.3		
Jun-07	5.739	5.5		4.2	6.4	5.1
Jul-07	5.059	12.1		11.8	7.8	5.9
Aug-07	3.300	13.1		27.8	2.6	5.3
Sep-07	3.081	2.6		1.9	0.5	6.2
Oct-07	2.709	3.3		2.8	0.4	
Nov-07	2.175	2.8		1.9	0.1	
Dec-07	3.417	8.7		4.2	2.1	
Jan-08	2.990	11.3		20.2	1.3	
Feb-08	3.655	7.5		11.7	0.2	
Mar-08	4.016	6.9		11.9	0.2	
Apr-08	4.300	5.8		5.4	0.2	
May-08	3.878	2.7		5.9	0.5	
Jun-08	4.218	2.4		4.7	0.4	6.1
Jul-08	2.497	4.5		1.3	2.9	5.1
Aug-08	3.354	3.2		5.3	0.3	6.6
Sep-08	2.418	3.7		4.7	1.0	6.7

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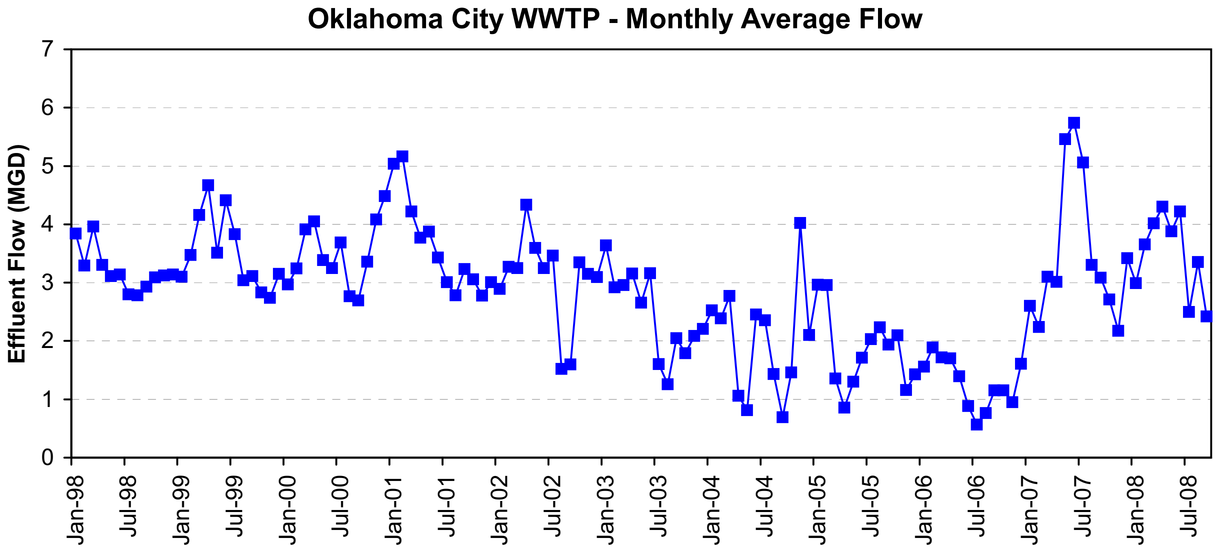
Oklahoma City WWTP - Monthly Average Flow
Effluent Flow (MGD)
0
1
2
3
4
5
6
7
Jan-98
Jul-98
Jan-99
Jul-99
Jan-00
Jul-00
Jan-01
Jul-01
Jan-02
Jul-02
Jan-03
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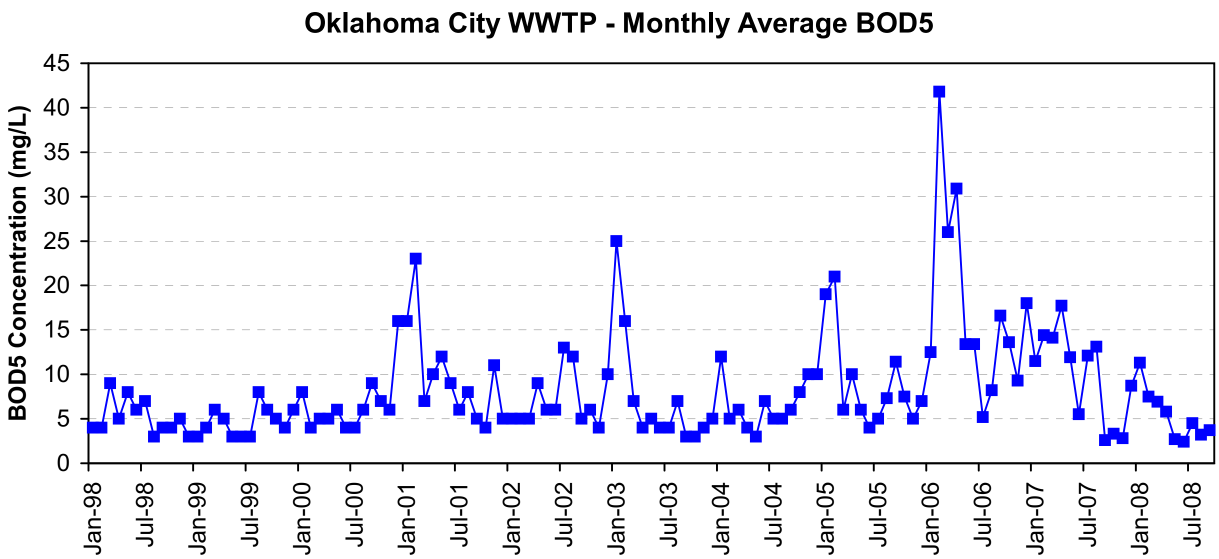
Jul-07
Jan-08
Jul-08


Oklahoma City WWTP - Monthly Average BOD5
BOD5 Concentration (mg/L)
0
5
10
15
20
25
30
35
40
45
Jan-98
Jul-98
Jan-99
Jul-99
Jan-00
Jul-00
Jan-01
Jul-01
Jan-02
Jul-02
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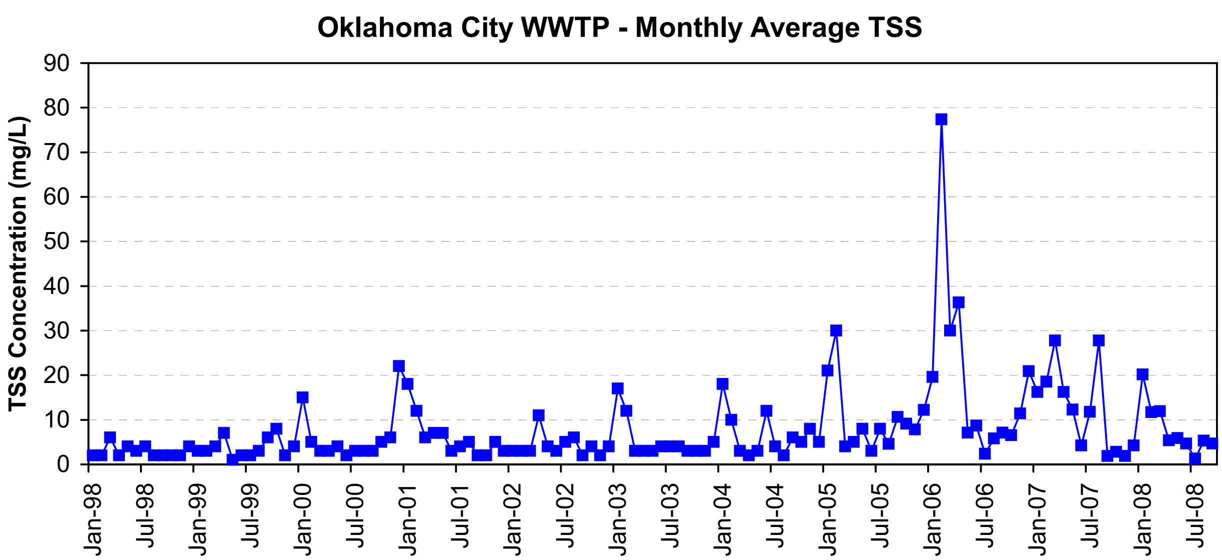
Jul-07
Jan-08
Jul-08


Oklahoma City WWTP - Monthly Average TSS
TSS Concentration (mg/L)
0
10
20
30
40
50
60
70
80
90
Jan-98
Jul-98
Jan-99
Jul-99
Jan-00
Jul-00
Jan-01
Jul-01
Jan-02
Jul-02
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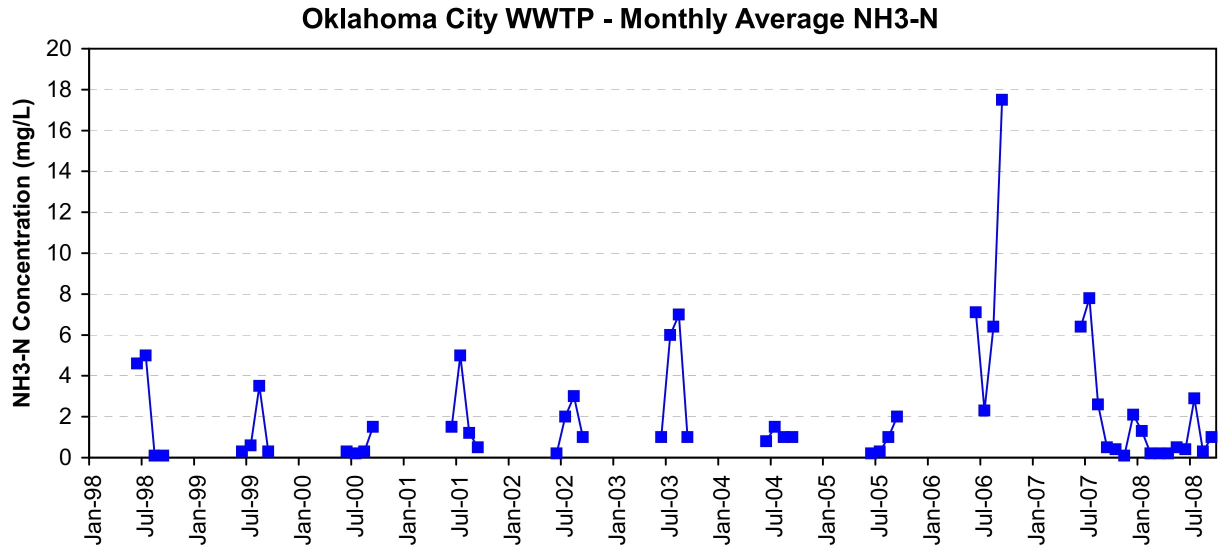
Jul-07
Jan-08
Jul-08


Oklahoma City WWTP - Monthly Average NH3-N
NH3-N Concentration (mg/L)
0
2
4
6
8
10
12
14
16
18
20
Jan-98
Jul-98
Jan-99
Jul-99
Jan-00
Jul-00
Jan-01
Jul-01
Jan-02
Jul-02
Jan-03
Jul-03
Jan-04
Jul-04
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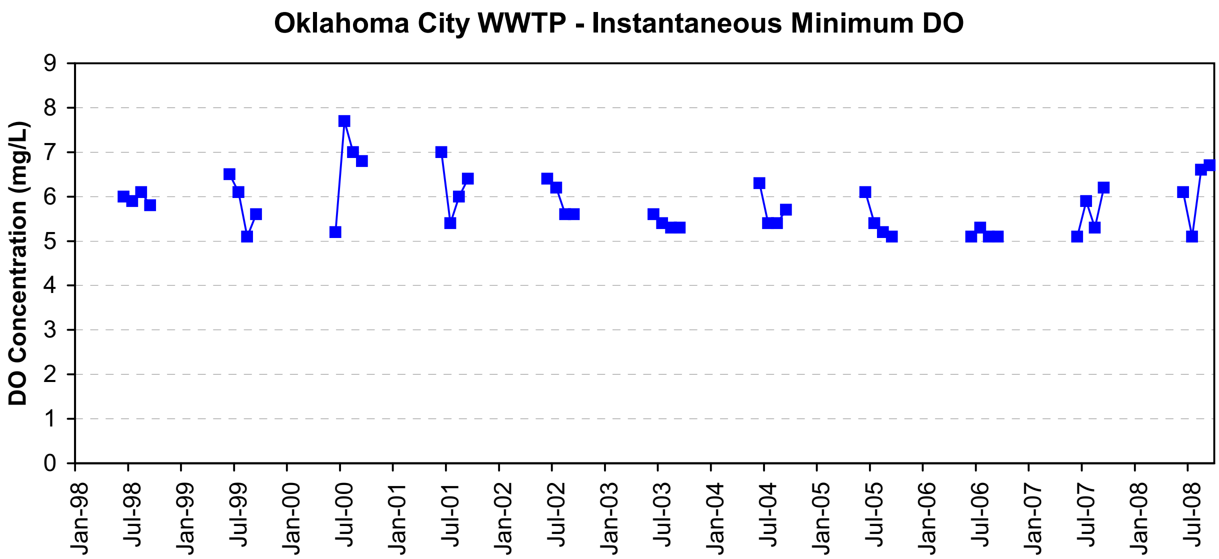
Jul-07
Jan-08
Jul-08


Oklahoma City WWTP - Instantaneous Minimum DO
DO Concentration (mg/L)
0
1
2
3
4
5
6
7
8
9
Jan-98
Jul-98
Jan-99
Jul-99
Jan-00
Jul-00
Jan-01
Jul-01
Jan-02
Jul-02
Jan-03
Jul-03
Jan-04
Jul-04
Jan-05
Jul-05
Jan-06
Jul-06
Jan-07
Jul-07
Jan-08
Jul-08

EFFLUENT DATA FOR MOORE WWTP

Month	Monthly average parameters					Inst. min.
	Flow (MGD)	BOD5 (mg/L)	CBOD5 (mg/L)	TSS (mg/L)	NH3-N (mg/L)	DO (mg/L)
Jan-98	3.000	16.5		9.4		
Feb-98	3.000	12.3		7.3		
Mar-98	5.150	12.1		9.2		
Apr-98	4.000	13.1		9.2		
May-98	3.560	15.5		13.9		
Jun-98	3.150	13.0		10.0	1.5	5.5
Jul-98	2.790	10.0		7.0	1.3	6.2
Aug-98	2.750	12.0		7.0	1.0	5.7
Sep-98	2.960	14.0		11.0	1.1	5.4
Oct-98	3.100	13.0		10.0		
Nov-98	3.680	12.0		8.0		
Dec-98	3.380	12.3		7.5		
Jan-99	3.064	7.0		9.5		
Feb-99	3.868	6.5		5.6		
Mar-99	4.345	7.9		5.2		
Apr-99	4.456	6.9		5.5		
May-99	4.355	14.7		10.3		
Jun-99	5.344	10.5		10.4	0.8	6.2
Jul-99	4.088	11.3		9.6	1.3	6.6
Aug-99	3.441	11.8		11.0	1.5	6.3
Sep-99	3.711	13.2		11.0	0.9	5.4
Oct-99	3.028	12.3		11.6		
Nov-99	2.975	7.5		9.7		
Dec-99	3.190	10.6		9.1		
Jan-00	2.936	7.2		5.6		
Feb-00	3.800	8.4		6.4		
Mar-00	4.211	7.3		6.0		
Apr-00	4.424	12.6		6.1		
May-00	4.468	10.3		7.7		
Jun-00	4.758	10.0		8.5	1.6	6.3
Jul-00	4.081	10.6		11.8	1.2	5.6
Aug-00	3.570	12.9		11.6	1.6	5.8
Sep-00	3.432	11.2		10.8	1.5	5.8
Oct-00	4.125	8.6		9.3		
Nov-00	5.048	7.7		7.0		
Dec-00	4.067	12.7		7.8		
Jan-01	5.575	10.2		7.0		
Feb-01	6.154	9.5		7.0		
Mar-01	4.708	12.9		8.6		
Apr-01	4.259	11.7		7.5		
May-01	4.487	15.4		9.5		
Jun-01	3.733	13.5		7.4	2.2	5.4
Jul-01	3.525	13.6		12.6	1.9	5.7
Aug-01	3.585	9.8		6.6	1.3	5.8
Sep-01	3.678	11.8		7.7	1.4	5.5
Oct-01	3.850	12.1		8.8		
Nov-01	3.258	13.0		9.2		
Dec-01	3.242	12.8		6.7		
Jan-02	3.230	16.0		8.0		

EFFLUENT DATA FOR MOORE WWTP

Month	Monthly average parameters					Inst. min.
	Flow (MGD)	BOD5 (mg/L)	CBOD5 (mg/L)	TSS (mg/L)	NH3-N (mg/L)	DO (mg/L)
Feb-02	3.500	15.0		6.9		
Mar-02	3.300	11.0		7.0		
Apr-02	4.190	11.0		6.0		
May-02	3.650	12.0		7.1		
Jun-02	3.600	13.0		8.0	4.0	6.4
Jul-02	3.300	13.0		8.9	4.5	5.7
Aug-02	2.900	13.0		14.0	4.0	6.4
Sep-02	3.000	11.0		5.5	3.9	5.5
Oct-02	3.100	10.0		7.0		
Nov-02	3.200	14.0		9.1		
Dec-02	3.300	12.0		6.9		
Jan-03	3.298	11.0		7.0		
Feb-03	3.782	10.0		7.0		
Mar-03	3.276	12.0		6.0		
Apr-03	3.286	18.0		9.0		
May-03	2.830	18.0		5.0		
Jun-03	3.170	11.0		2.0	3.0	6.4
Jul-03	2.480	3.0		3.0	5.0	6.4
Aug-03	2.380	8.0		2.0	6.0	6.3
Sep-03	2.820	4.0		3.0	3.0	5.6
Oct-03	2.494	6.0		4.0		
Nov-03	2.238	7.0		3.0		
Dec-03	2.875	11.0		5.0		
Jan-04	3.970	9.2		6.7		
Feb-04	4.050	12.0		7.0		
Mar-04	4.741	13.0		5.0		
Apr-04	3.778	15.0		11.0		
May-04	3.807	18.0		6.0		
Jun-04	4.446	12.1		2.5	6.2	7.0
Jul-04	5.289	8.1		3.0	4.6	7.0
Aug-04	5.263	9.4		7.5	3.9	6.0
Sep-04	4.497	11.5		2.0	4.4	6.0
Oct-04	4.195	15.0		2.0		
Nov-04	7.292	14.0		2.0		
Dec-04	6.921	14.0		3.0		
Jan-05	6.296	14.0		2.0		
Feb-05	5.509	11.0		6.0		
Mar-05	4.494	13.0		6.0		
Apr-05	4.020	15.0		4.0		
May-05	4.029	19.1		7.3		
Jun-05	4.360	8.9		4.0	1.9	6.0
Jul-05	4.125	7.6		4.5	3.8	6.0
Aug-05	4.333	6.5		7.1	4.4	6.0
Sep-05	4.153	9.9		6.0	6.2	6.0
Oct-05	3.974	10.0		2.0		
Nov-05	3.500	14.0		6.0		
Dec-05	3.516	16.0		6.0		
Jan-06	3.289	18.0		8.0		
Feb-06	3.411	22.0		3.0		

	Monthly average parameters					Inst. min.
Month	Flow (MGD)	BOD5 (mg/L)	CBOD5 (mg/L)	TSS (mg/L)	NH3-N (mg/L)	DO (mg/L)
Mar-06	3.794	15.0		4.0		
Apr-06	3.887	16.0		4.0		
May-06	4.058	13.6		2.5		
Jun-06	3.950	19.8		6.0	6.0	7.0
Jul-06	3.471	17.8		5.1	5.4	6.0
Aug-06	3.674	10.1		1.0	4.1	6.0
Sep-06	3.460	9.7		4.0	2.7	7.0
Oct-06	3.506	12.0		4.0		
Nov-06	3.435	19.0		3.0		
Dec-06	4.003	16.0		3.0		
Jan-07	4.596	13.0		5.0		
Feb-07	4.356	14.0		6.0		
Mar-07	5.713	18.0		10.0		
Apr-07	5.858	17.0		7.0		
May-07	6.486	17.8		7.0	9.4	
Jun-07	7.576	8.2		3.5	10.4	6.0
Jul-07	8.153	8.1		6.5	7.3	6.0
Aug-07	5.942	7.5		5.5	13.4	6.0
Sep-07	5.550	5.8		3.0	9.4	6.0
Oct-07	4.895	13.0		2.0	10.1	
Nov-07	4.493	16.0		4.0	16.0	
Dec-07	5.814	18.0		3.0	12.3	
Jan-08	4.715	14.0		11.0	18.5	
Feb-08	5.284	18.0		20.0	16.7	
Mar-08	6.302	16.0		10.0	14.4	
Apr-08	6.825	11.0		9.0	11.5	
May-08	7.474	18.0		5.0	14.5	
Jun-08	7.553	14.6		5.5	11.6	7.0
Jul-08	5.532	11.1		5.0	17.4	7.0
Aug-08	6.066	10.6		3.0	12.4	5.0
Sep-08	5.465	19.9		11.4	13.6	7.0

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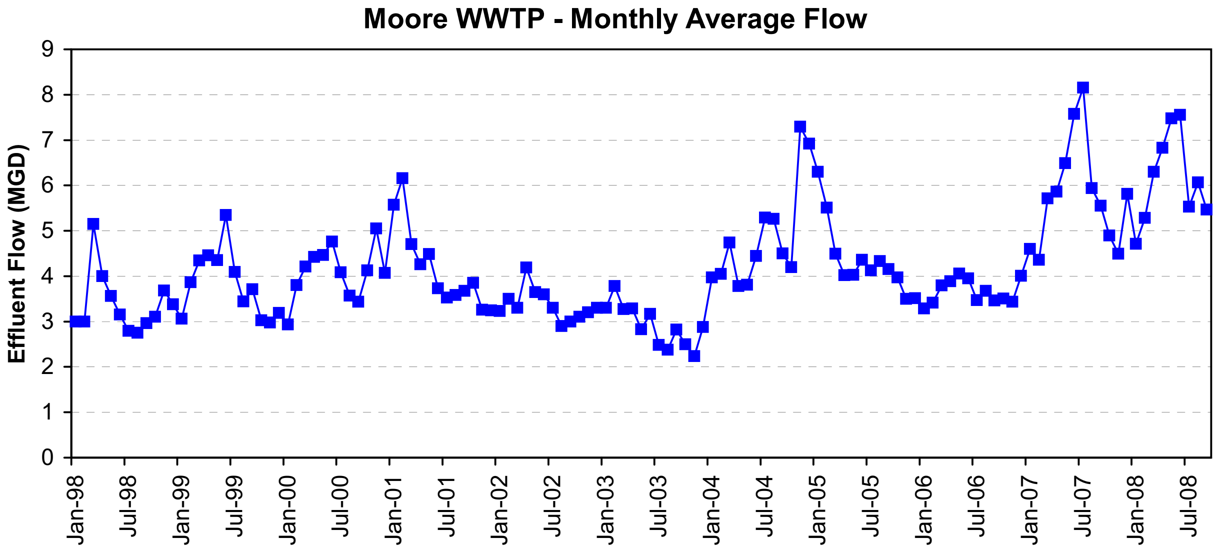
Moore WWTP - Monthly Average Flow
Effluent Flow (MGD)
0
1
2
3
4
5
6
7
8
9
Jan-98
Jul-98
Jan-99
Jul-99
Jan-00
Jul-00
Jan-01
Jul-01
Jan-02
Jul-02
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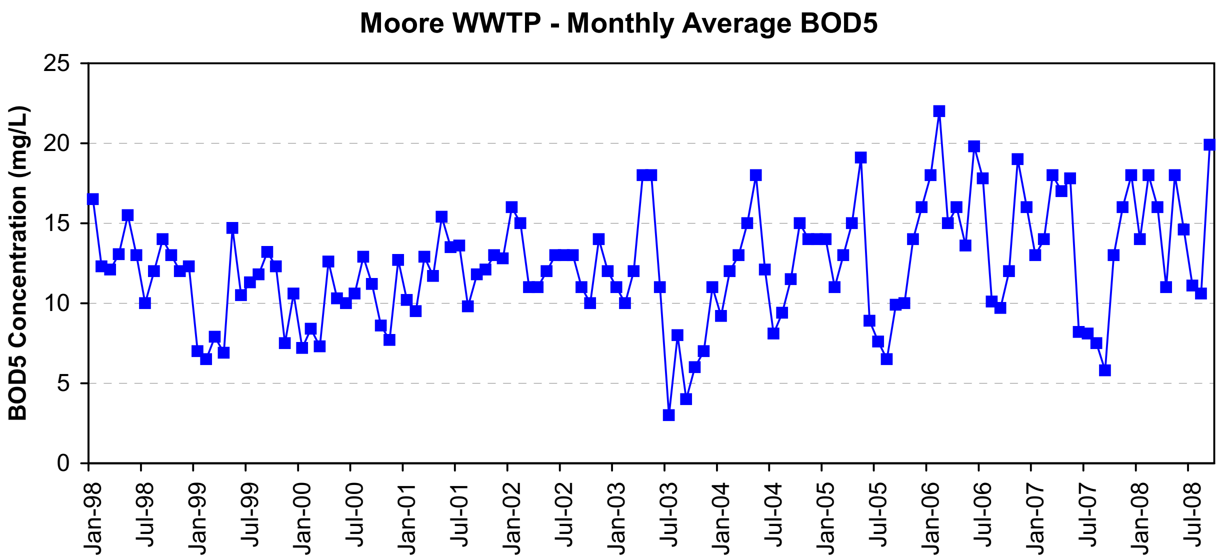
Jul-07
Jan-08
Jul-08


Moore WWTP - Monthly Average BOD5
BOD5 Concentration (mg/L)
0
5
10
15
20
25
Jan-98
Jul-98
Jan-99
Jul-99
Jan-00
Jul-00
Jan-01
Jul-01
Jan-02
Jul-02
Jan-03
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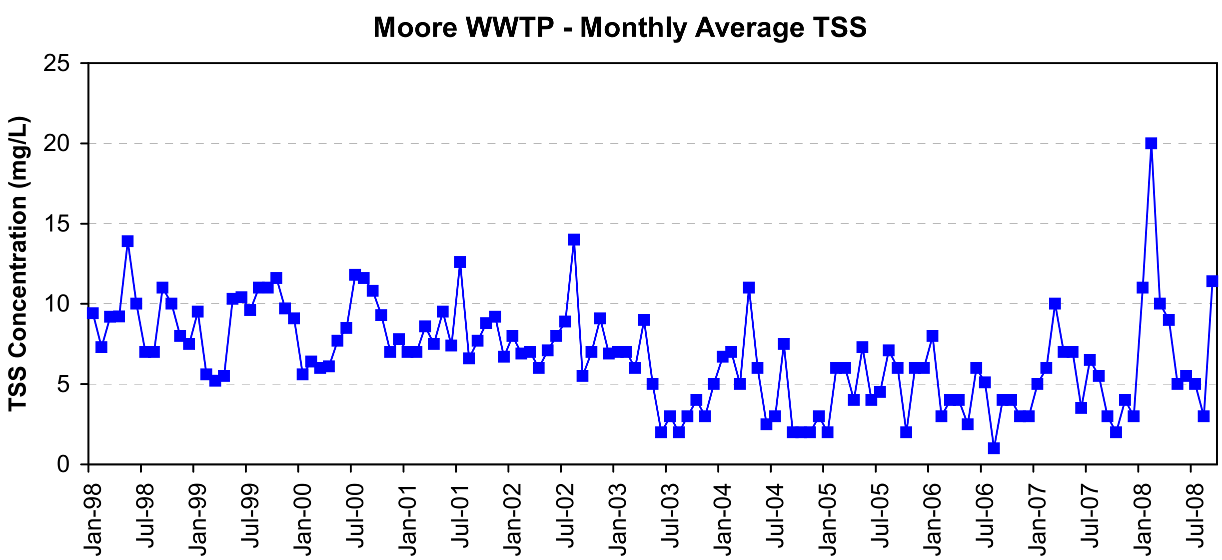
Jul-07
Jan-08
Jul-08


Moore WWTP - Monthly Average TSS
TSS Concentration (mg/L)
0
5
10
15
20
25
Jan-98
Jul-98
Jan-99
Jul-99
Jan-00
Jul-00
Jan-01
Jul-01
Jan-02
Jul-02
Jan-03
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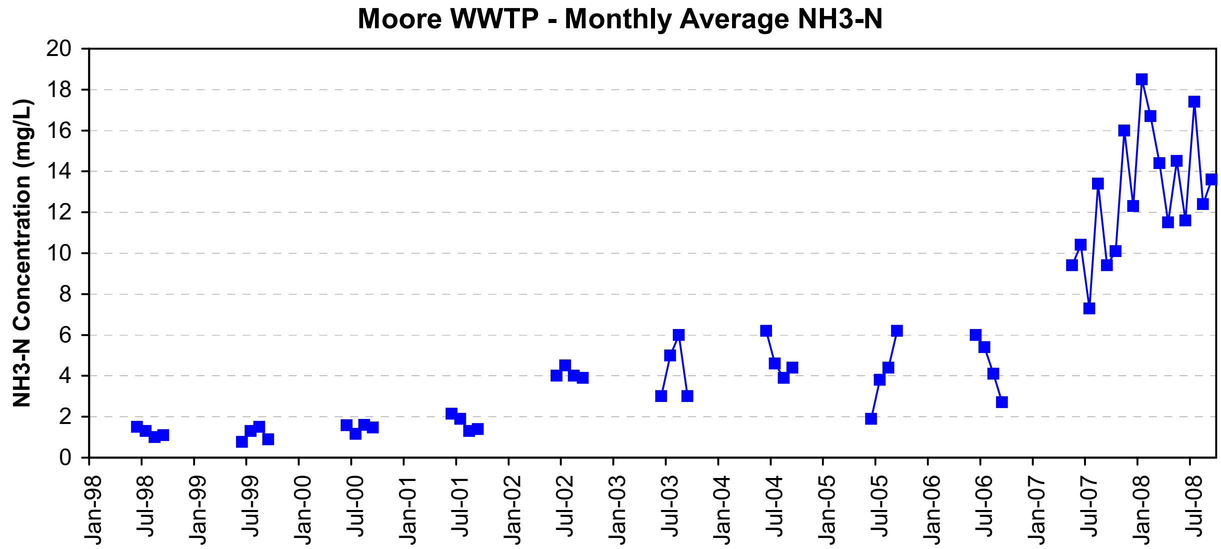
Jul-07
Jan-08
Jul-08


Moore WWTP - Monthly Average NH3-N
NH3-N Concentration (mg/L)
0
2
4
6
8
10
12
14
16
18
20
Jan-98
Jul-98
Jan-99
Jul-99
Jan-00
Jul-00
Jan-01
Jul-01
Jan-02
Jul-02
Jan-03
Jul-03
Jan-04
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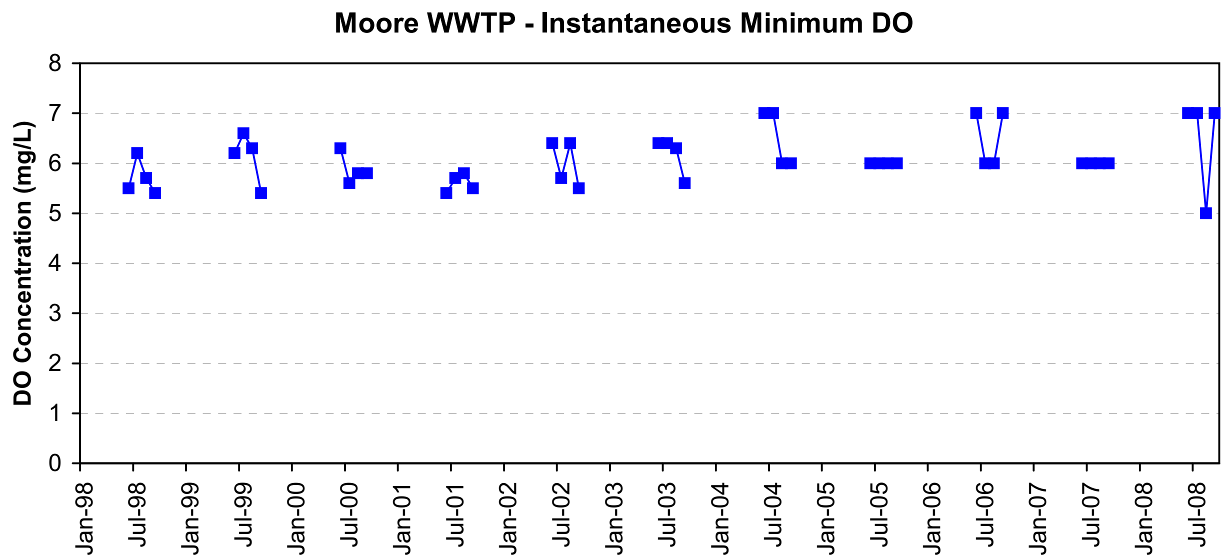
Jul-07
Jan-08
Jul-08


Moore WWTP - Instantaneous Minimum DO
DO Concentration (mg/L)
0
1
2
3
4
5
6
7
8
Jan-98
Jul-98
Jan-99
Jul-99
Jan-00
Jul-00
Jan-01
Jul-01
Jan-02
Jul-02
Jan-03
Jul-03
Jan-04
Jul-04
Jan-05
Jul-05
Jan-06
Jul-06
Jan-07
Jul-07
Jan-08
Jul-08

EFFLUENT DATA FOR NEWCASTLE WWTP

Month	Monthly average parameters Flow (MGD)	BOD5 (mg/L)	CBOD5 (mg/L)	TSS (mg/L)	NH3-N (mg/L)	Inst. min. DO (mg/L)
Jan-98	0.247	12.0		8.0		
Feb-98	0.251	3.6		4.4		
Mar-98	0.375	10.0		5.3		
Apr-98	0.232	10.0		4.0		
May-98	0.212	16.0		4.0		
Jun-98	0.177	17.6		2.3		
Jul-98	0.184	5.3		2.3		
Aug-98	0.177	9.3		4.4		
Sep-98	0.170	7.3		2.3		
Oct-98	0.165	13.3		2.6		
Nov-98	0.161	10.0		2.6		
Dec-98	0.171	10.3		14.5		
Jan-99	0.162	17.3		8.8		
Feb-99	0.178	8.6		6.4		
Mar-99	0.197	4.0		4.0		
Apr-99	0.238	2.6		6.7		
May-99						
Jun-99	0.212	2.0		10.0		
Jul-99	0.152	5.0		8.0		
Aug-99	0.187	4.6		5.8		
Sep-99	0.171	18.3		4.4		
Oct-99	0.157	12.6		7.3		
Nov-99	0.151	13.0		5.0		
Dec-99	0.147	13.0		15.7		
Jan-00	0.138	18.0		23.0		
Feb-00	0.142	12.6		18.4		
Mar-00	0.099	20.0		20.2		
Apr-00	0.094	8.3		12.7		
May-00	0.122	9.3		2.4		
Jun-00	0.110	9.0		4.8		
Jul-00	0.119	9.0		6.0		
Aug-00	0.134	8.0		3.0		
Sep-00	0.110	5.0		5.0		
Oct-00	0.125	4.0		5.0		
Nov-00	0.110	14.6		8.2		
Dec-00	0.068	27.0		29.0		
Jan-01	0.132	24.0		13.0		
Feb-01	0.150	13.0		6.9		
Mar-01	0.131	17.0		5.0		
Apr-01	0.152	5.0		6.0		
May-01	0.200	14.0		8.0		
Jun-01	0.187	14.0		4.0		
Jul-01	0.146	10.0		6.0		
Aug-01	0.128	14.0		3.0		
Sep-01	0.120	10.0		4.0		
Oct-01	0.091	14.0		9.0		
Nov-01	0.091	19.0		13.0		
Dec-01	0.107	17.0		16.0		
Jan-02	0.102	20.0		21.0		

Month	Monthly average parameters Flow (MGD)	BOD5 (mg/L)	CBOD5 (mg/L)	TSS (mg/L)	NH3-N (mg/L)	Inst. min. DO (mg/L)
Feb-02	0.093	16.0		12.0		
Mar-02	0.129	16.0		17.0		
Apr-02	0.142	16.0		22.0		
May-02	0.148	5.0		8.0		
Jun-02	0.140	9.0		3.0		
Jul-02	0.159	11.0		5.0		
Aug-02	0.159	8.0		4.0		
Sep-02	0.145	10.0		9.0		
Oct-02	0.151	8.0		5.0		
Nov-02	0.133	8.0		5.0		
Dec-02	0.131	16.0		23.0		
Jan-03	0.137	24.0		31.0		
Feb-03	0.128	9.0		33.0		
Mar-03	0.126	13.0		14.0		
Apr-03	0.132	4.0		8.0		
May-03	0.160	3.0		2.0		
Jun-03	0.171	2.0		1.0		
Jul-03	0.125	2.0		3.0		
Aug-03	0.137	2.0		10.0		
Sep-03	0.156	3.0		3.0		
Oct-03	0.164	8.0		7.0		
Nov-03	0.199	20.0		11.0		
Dec-03	0.194	18.0		11.0		
Jan-04	0.209	19.0		25.0		
Feb-04	0.187	13.0		30.0		
Mar-04	0.155	11.0		20.0		
Apr-04	0.143	6.0		33.0		
May-04	0.178	6.0		13.0		
Jun-04	0.209	24.0		6.0		
Jul-04	0.216					
Aug-04	0.207	12.0		7.0		
Sep-04	0.200	8.0		18.0		
Oct-04	0.200	0.9		8.0		
Nov-04	0.205	5.0		19.0		
Dec-04						
Jan-05	0.184	13.3		10.6		
Feb-05	0.203	5.5		14.6		
Mar-05	0.196	9.8		11.7		
Apr-05	0.217	6.2		22.7		
May-05	0.240	3.2		17.7		
Jun-05	0.250	5.1		8.0		
Jul-05	0.212	3.3		6.7		
Aug-05	0.213	3.7		4.0		
Sep-05	0.213	2.2		2.7		
Oct-05	0.195	4.4		8.7		
Nov-05	0.176	10.4		5.3		
Dec-05	0.179	10.0		12.3		
Jan-06	0.192	16.0		9.7		
Feb-06	0.171	8.5		9.3		

EFFLUENT DATA FOR NEWCASTLE WWTP

Month	Monthly average parameters					Inst. min.
	Flow (MGD)	BOD5 (mg/L)	CBOD5 (mg/L)	TSS (mg/L)	NH3-N (mg/L)	DO (mg/L)
Mar-06	0.185	5.6		7.7		
Apr-06	0.177	5.5		8.0		
May-06	0.198	2.2		5.3		
Jun-06	0.184	3.5		11.7		
Jul-06	0.179	2.2		5.7		
Aug-06	0.196	2.5		11.0		
Sep-06	0.192	2.4		6.7		
Oct-06	0.178	2.6		10.0		
Nov-06	0.177	7.4		8.0		
Dec-06	0.169	4.2		5.0		
Jan-07	0.185	3.6		4.0		
Feb-07	0.170	13.2		18.7		
Mar-07	0.204	3.7		7.7		
Apr-07	0.181	14.7		13.7		
May-07	0.269	2.2		7.3		
Jun-07	0.372	2.2		8.3		
Jul-07	0.419	2.2		6.7		
Aug-07	0.337	2.3		6.3		
Sep-07	0.282	2.2		8.3		
Oct-07	0.246	2.7		7.3		
Nov-07	0.229	2.9		7.7		
Dec-07	0.234	5.0		11.3		
Jan-08	0.215	6.4		17.7		
Feb-08	0.229	6.2		7.0		
Mar-08	0.251	3.5		6.7		
Apr-08	0.304	3.8		9.5		
May-08	0.219	5.3		5.0		
Jun-08	0.340	2.3		3.7		
Jul-08						
Aug-08						
Sep-08						

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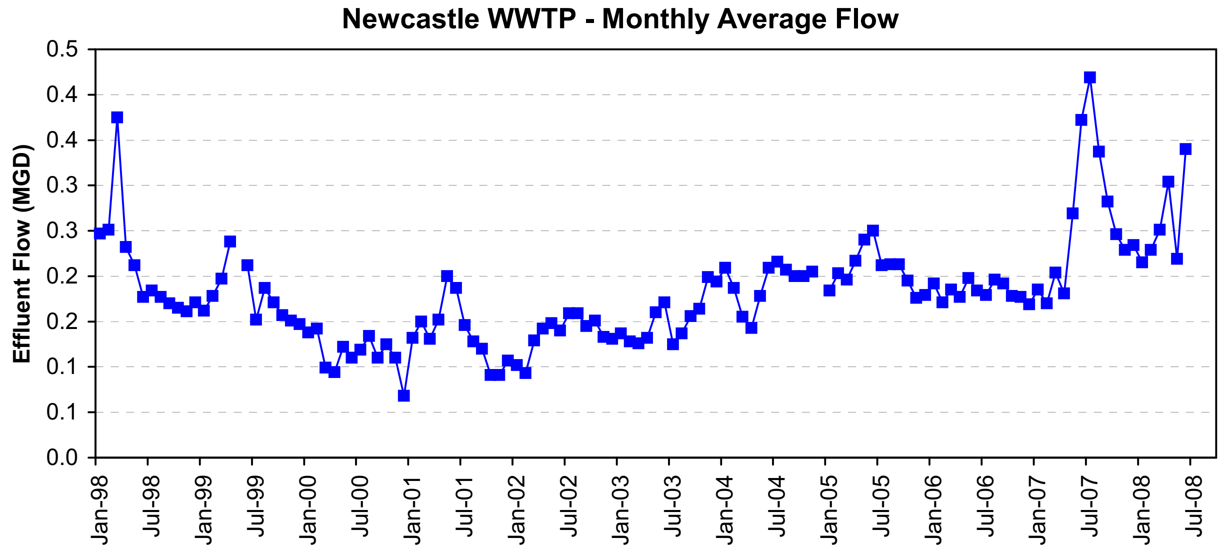

Newcastle WWTP - Monthly Average Flow
Effluent Flow (MGD)
0.0
0.1
0.1
0.2
0.2
0.3
0.3
0.4
0.4
0.5
Jan-98
Jul-98
Jan-99
Jul-99
Jan-00
Jul-00
Jan-01
Jul-01
Jan-02
Jul-02
Jan-03
Jul-03
Jan-04
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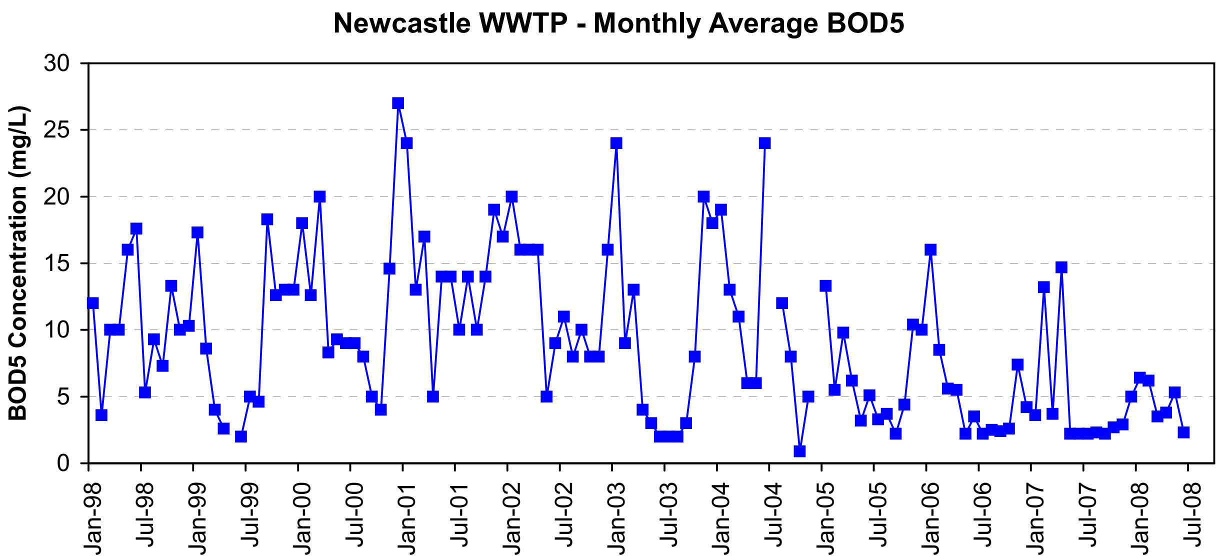
Jul-07
Jan-08
Jul-08



Newcastle WWTP - Monthly Average BOD5
BOD5 Concentration (mg/L)
0
5
10
15
20
25
30
Jan-98
Jul-98
Jan-99
Jul-99
Jan-00
Jul-00
Jan-01
Jul-01
Jan-02
Jul-02
Jan-03
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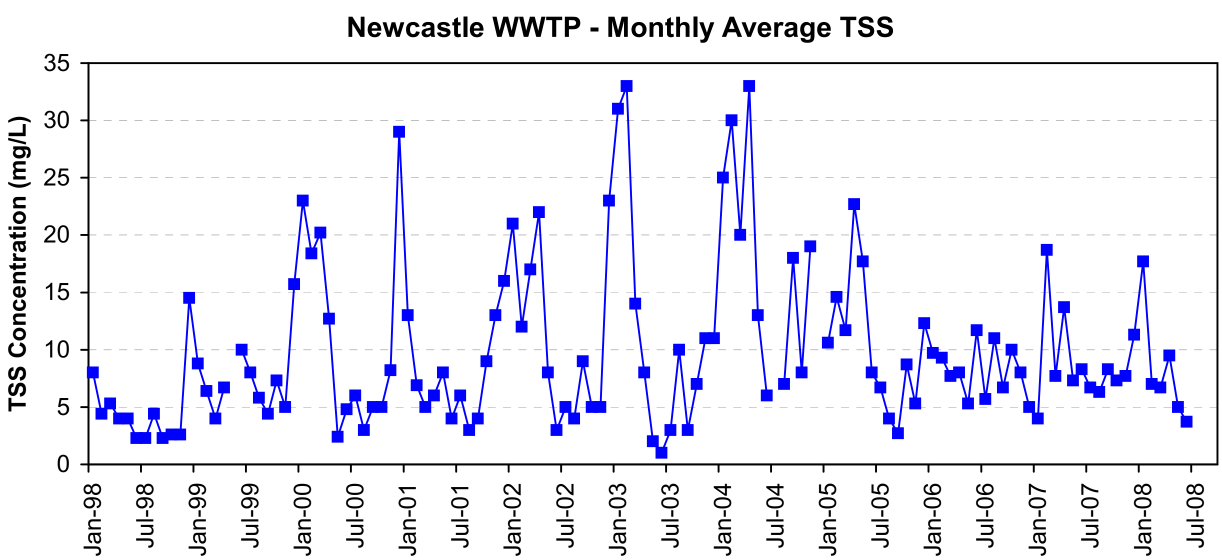
Jul-07
Jan-08
Jul-08



Newcastle WWTP - Monthly Average TSS
TSS Concentration (mg/L)
0
5
10
15
20
25
30
35
Jan-98
Jul-98
Jan-99
Jul-99
Jan-00
Jul-00
Jan-01
Jul-01
Jan-02
Jul-02
Jan-03
Jul-03
Jan-04
Jul-04
Jan-05
Jul-05
Jan-06
Jul-06
Jan-07
Jul-07
Jan-08
Jul-08

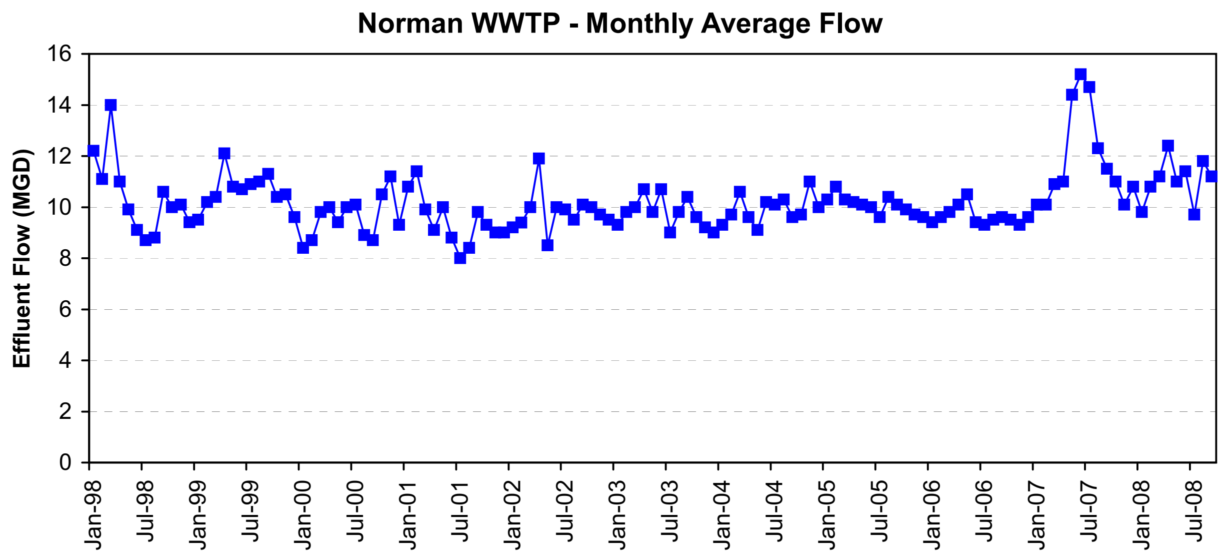
EFFLUENT DATA FOR NORMAN WWTP

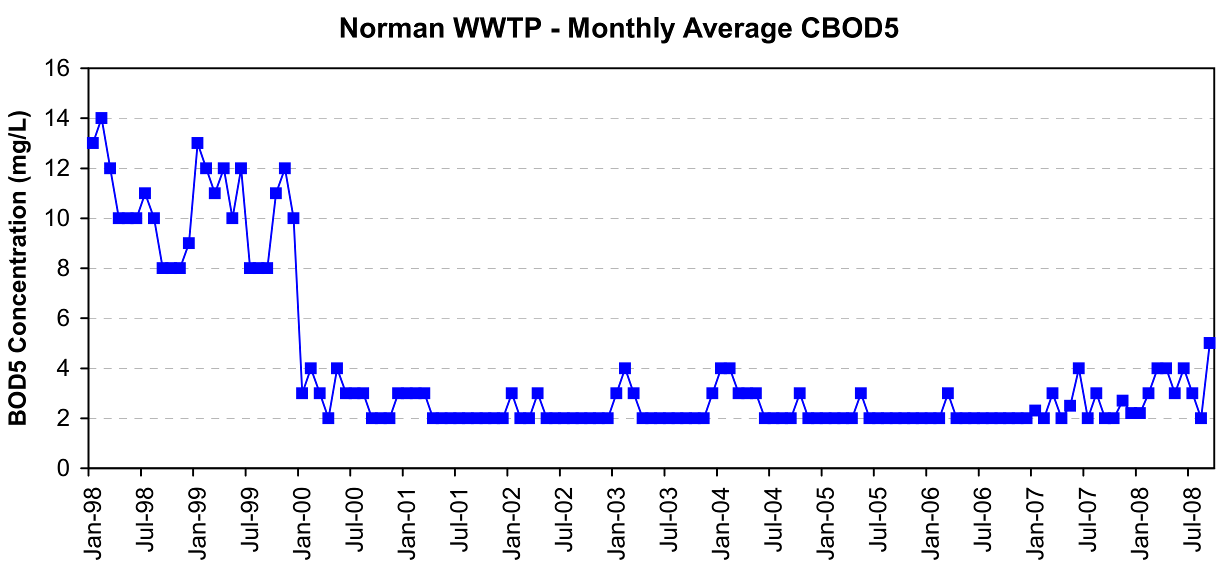
Month	Monthly average parameters					Inst. min.
	Flow (MGD)	BOD5 (mg/L)	CBOD5 (mg/L)	TSS (mg/L)	NH3-N (mg/L)	DO (mg/L)
Jan-98	12.200		13.0	8.0		6.4
Feb-98	11.100		14.0	8.0		5.8
Mar-98	14.000		12.0	10.0		5.9
Apr-98	11.000		10.0	7.0		6.0
May-98	9.900		10.0	7.0		5.9
Jun-98	9.100		10.0	6.0	4.3	5.5
Jul-98	8.700		11.0	7.0	7.8	5.3
Aug-98	8.800		10.0	7.0	8.1	5.2
Sep-98	10.600		8.0	6.0	6.2	5.0
Oct-98	10.000		8.0	7.0		5.8
Nov-98	10.100		8.0	7.0		5.2
Dec-98	9.400		9.0	8.0		6.0
Jan-99	9.500		13.0	10.0		5.5
Feb-99	10.200		12.0	9.0		6.0
Mar-99	10.400		11.0	7.0		5.8
Apr-99	12.100		12.0	9.0		5.0
May-99	10.800		10.0	7.0		5.6
Jun-99	10.700		12.0	8.0	6.7	5.4
Jul-99	10.900		8.0	8.0	3.8	6.0
Aug-99	11.000		8.0	7.0	5.5	5.3
Sep-99	11.300		8.0	7.0	5.2	5.4
Oct-99	10.400		11.0	9.0		5.1
Nov-99	10.500		12.0	9.0		5.1
Dec-99	9.600		10.0	9.0		5.7
Jan-00	8.400		3.0	6.0	0.8	6.4
Feb-00	8.700		4.0	8.0	0.4	6.4
Mar-00	9.800		3.0	6.0	0.9	6.3
Apr-00	10.000		2.0	3.0	0.3	5.9
May-00	9.400		4.0	7.0	0.3	5.7
Jun-00	10.000		3.0	5.0	0.3	5.6
Jul-00	10.100		3.0	3.0	0.4	5.7
Aug-00	8.900		3.0	3.0	0.4	5.5
Sep-00	8.700		2.0	2.0	3.3	5.6
Oct-00	10.500		2.0	3.0	0.3	6.1
Nov-00	11.200		2.0	2.0	0.2	6.5
Dec-00	9.300		3.0	5.0	0.4	6.4
Jan-01	10.800		3.0	5.0	0.9	6.2
Feb-01	11.400		3.0	10.0	1.3	6.0
Mar-01	9.900		3.0	4.0	0.2	6.2
Apr-01	9.100		2.0	2.0	0.3	6.3
May-01	10.000		2.0	3.0	0.7	6.0
Jun-01	8.800		2.0	2.0	0.5	5.7
Jul-01	8.000		2.0	2.0	0.3	5.8
Aug-01	8.400		2.0	3.0	0.2	5.5
Sep-01	9.800		2.0	3.0	0.2	5.4
Oct-01	9.300		2.0	3.0	0.2	5.9
Nov-01	9.000		2.0	6.0	1.0	5.7
Dec-01	9.000		2.0	3.0	0.9	5.8
Jan-02	9.200		3.0	5.0	2.0	6.2

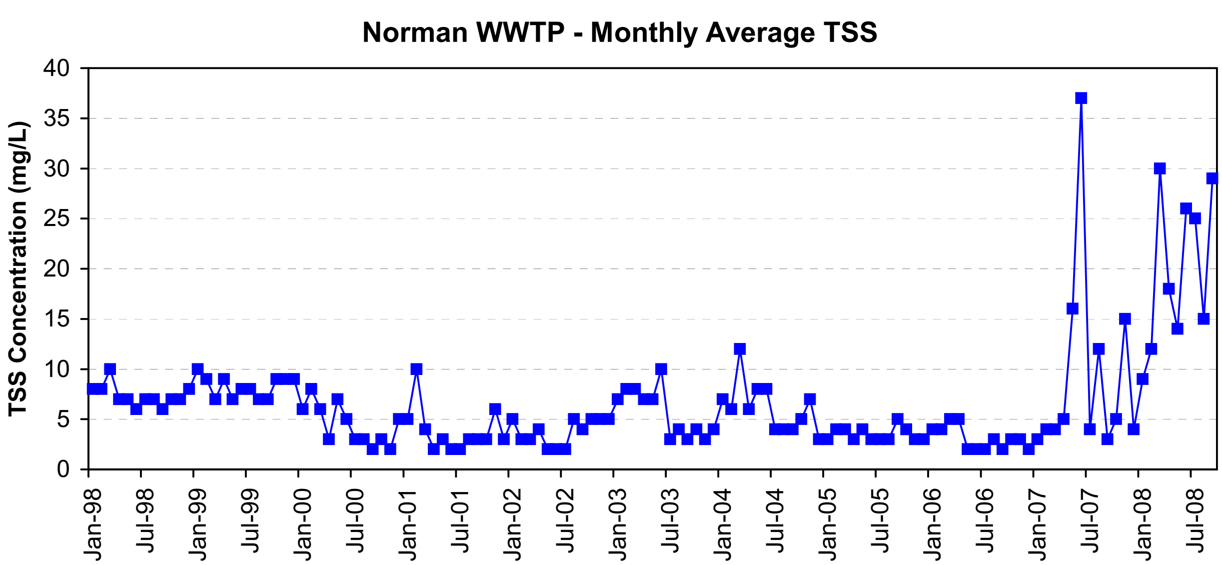
Month	Monthly average parameters Flow (MGD)	BOD5 (mg/L)	CBOD5 (mg/L)	TSS (mg/L)	NH3-N (mg/L)	Inst. min. DO (mg/L)
Feb-02	9.390		2.0	3.0	1.5	6.2
Mar-02	10.000		2.0	3.0	0.7	6.2
Apr-02	11.900		3.0	4.0	1.1	5.9
May-02	8.500		2.0	2.0	0.6	5.5
Jun-02	10.000		2.0	2.0	0.5	5.3
Jul-02	9.900		2.0	2.0	0.4	5.1
Aug-02	9.500		2.0	5.0	0.4	5.0
Sep-02	10.100		2.0	4.0	0.3	5.1
Oct-02	10.000		2.0	5.0	0.2	5.2
Nov-02	9.700		2.0	5.0	0.2	5.4
Dec-02	9.500		2.0	5.0	0.1	5.7
Jan-03	9.300		3.0	7.0	0.3	5.6
Feb-03	9.800		4.0	8.0	1.2	5.6
Mar-03	10.000		3.0	8.0	3.7	5.4
Apr-03	10.700		2.0	7.0	0.4	5.6
May-03	9.800		2.0	7.0	0.3	5.6
Jun-03	10.700		2.0	10.0	1.4	5.2
Jul-03	9.000		2.0	3.0	0.2	5.3
Aug-03	9.800		2.0	4.0	0.3	5.1
Sep-03	10.400		2.0	3.0	0.4	5.1
Oct-03	9.600		2.0	4.0	1.1	5.2
Nov-03	9.200		2.0	3.0	0.8	5.0
Dec-03	9.000		3.0	4.0	2.7	5.1
Jan-04	9.300		4.0	7.0	3.0	5.5
Feb-04	9.700		4.0	6.0	3.8	5.7
Mar-04	10.600		3.0	12.0	1.5	5.6
Apr-04	9.600		3.0	6.0	1.7	5.7
May-04	9.100		3.0	8.0	0.8	5.2
Jun-04	10.200		2.0	8.0	0.4	5.1
Jul-04	10.100		2.0	4.0	0.7	5.1
Aug-04	10.300		2.0	4.0	0.4	5.0
Sep-04	9.600		2.0	4.0	0.4	5.2
Oct-04	9.700		3.0	5.0	0.2	5.1
Nov-04	11.000		2.0	7.0	0.2	5.3
Dec-04	10.000		2.0	3.0	0.2	5.9
Jan-05	10.300		2.0	3.0	1.5	6.0
Feb-05	10.800		2.0	4.0	1.9	5.9
Mar-05	10.300		2.0	4.0	0.4	5.7
Apr-05	10.200		2.0	3.0	0.5	5.5
May-05	10.100		3.0	4.0	0.4	5.6
Jun-05	10.000		2.0	3.0	0.3	5.3
Jul-05	9.600		2.0	3.0	0.8	5.0
Aug-05	10.400		2.0	3.0	0.6	5.3
Sep-05	10.100		2.0	5.0	0.3	5.3
Oct-05	9.900		2.0	4.0	0.1	5.0
Nov-05	9.700		2.0	3.0	0.5	5.4
Dec-05	9.600		2.0	3.0	0.6	6.0
Jan-06	9.400		2.0	4.0	0.7	6.0
Feb-06	9.600		2.0	4.0	3.2	5.8

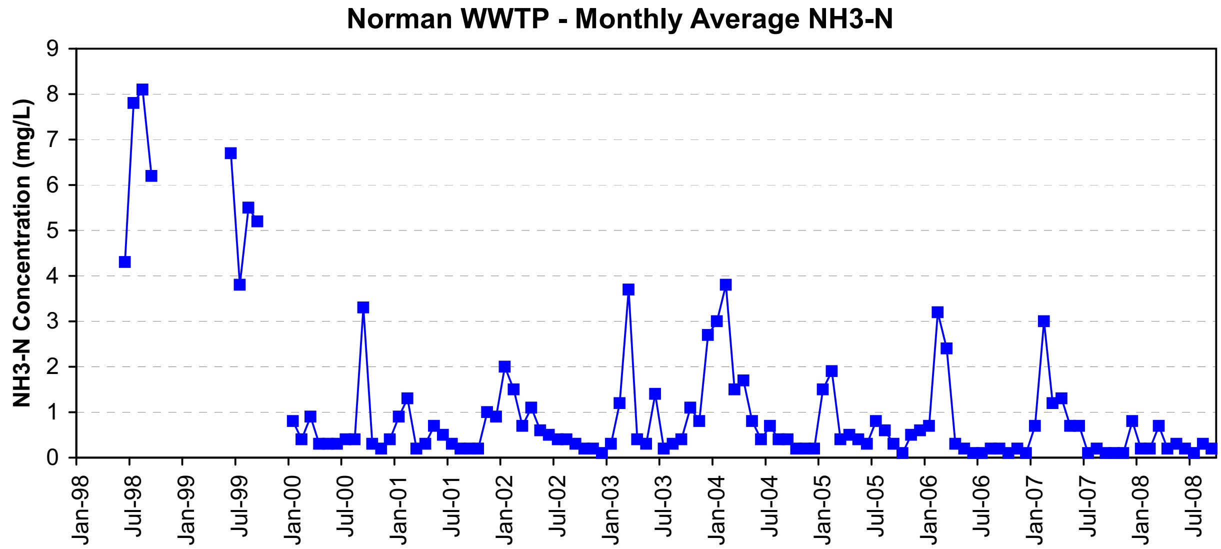
	Monthly average parameters					Inst. min.
Month	Flow (MGD)	BOD5 (mg/L)	CBOD5 (mg/L)	TSS (mg/L)	NH3-N (mg/L)	DO (mg/L)
Mar-06	9.800		3.0	5.0	2.4	5.6
Apr-06	10.100		2.0	5.0	0.3	5.6
May-06	10.500		2.0	2.0	0.2	5.4
Jun-06	9.400		2.0	2.0	0.1	5.6
Jul-06	9.300		2.0	2.0	0.1	5.4
Aug-06	9.500		2.0	3.0	0.2	5.1
Sep-06	9.600		2.0	2.0	0.2	5.0
Oct-06	9.500		2.0	3.0	0.1	5.5
Nov-06	9.300		2.0	3.0	0.2	5.7
Dec-06	9.600		2.0	2.0	0.1	5.8
Jan-07	10.100		2.3	3.0	0.7	5.2
Feb-07	10.100		2.0	4.0	3.0	6.2
Mar-07	10.900		3.0	4.0	1.2	5.2
Apr-07	11.000		2.0	5.0	1.3	5.6
May-07	14.400		2.5	16.0	0.7	5.0
Jun-07	15.200		4.0	37.0	0.7	5.0
Jul-07	14.700		2.0	4.0	0.1	5.0
Aug-07	12.300		3.0	12.0	0.2	5.0
Sep-07	11.500		2.0	3.0	0.1	5.2
Oct-07	11.000		2.0	5.0	0.1	5.1
Nov-07	10.100		2.7	15.0	0.1	5.2
Dec-07	10.800		2.2	4.0	0.8	5.5
Jan-08	9.800		2.2	9.0	0.2	5.8
Feb-08	10.800		3.0	12.0	0.2	5.8
Mar-08	11.200		4.0	30.0	0.7	5.5
Apr-08	12.400		4.0	18.0	0.2	5.7
May-08	11.000		3.0	14.0	0.3	5.5
Jun-08	11.400		4.0	26.0	0.2	1.5
Jul-08	9.700		3.0	25.0	0.1	5.0
Aug-08	11.800		2.0	15.0	0.3	5.0
Sep-08	11.200		5.0	29.0	0.2	4.8

FILE: R:\PROJECTS\5238-030\TECH\NPDES\DMR DATA FOR POINT SOURCES.XLS


Norman WWTP - Monthly Average Flow
Effluent Flow (MGD)
0 2 4 6 8 10 12 14 16
Jan-98 Jul-98 Jan-99 Jul-99 Jan-00 Jul-00 Jan-01 Jul-01 Jan-02 Jul-02 Jan-03 Jul-03 Jan-04 Jul-04 Jan-05 Jul-05 Jan-06 Jul-06 Jan-07 Jul-07 Jan-08 Jul-08


Norman WWTP - Monthly Average CBOD5
BOD5 Concentration (mg/L)
0 2 4 6 8 10 12 14 16
Jan-98 Jul-98 Jan-99 Jul-99 Jan-00 Jul-00 Jan-01 Jul-01 Jan-02 Jul-02 Jan-03 Jul-03 Jan-04 Jul-04 Jan-05 Jul-05 Jan-06 Jul-06 Jan-07 Jul-07 Jan-08 Jul-08


Norman WWTP - Monthly Average TSS
TSS Concentration (mg/L)
0 5 10 15 20 25 30 35 40
Jan-98 Jul-98 Jan-99 Jul-99 Jan-00 Jul-00 Jan-01 Jul-01 Jan-02 Jul-02 Jan-03 Jul-03 Jan-04 Jul-04 Jan-05 Jul-05 Jan-06 Jul-06 Jan-07 Jul-07 Jan-08 Jul-08


Norman WWTP - Monthly Average NH3-N
NH3-N Concentration (mg/L)
0
1
2
3
4
5
6
7
8
9
Jan-98
Jul-98
Jan-99
Jul-99
Jan-00
Jul-00
Jan-01
Jul-01
Jan-02
Jul-02
Jan-03
Jul-03
Jan-04
Jul-04
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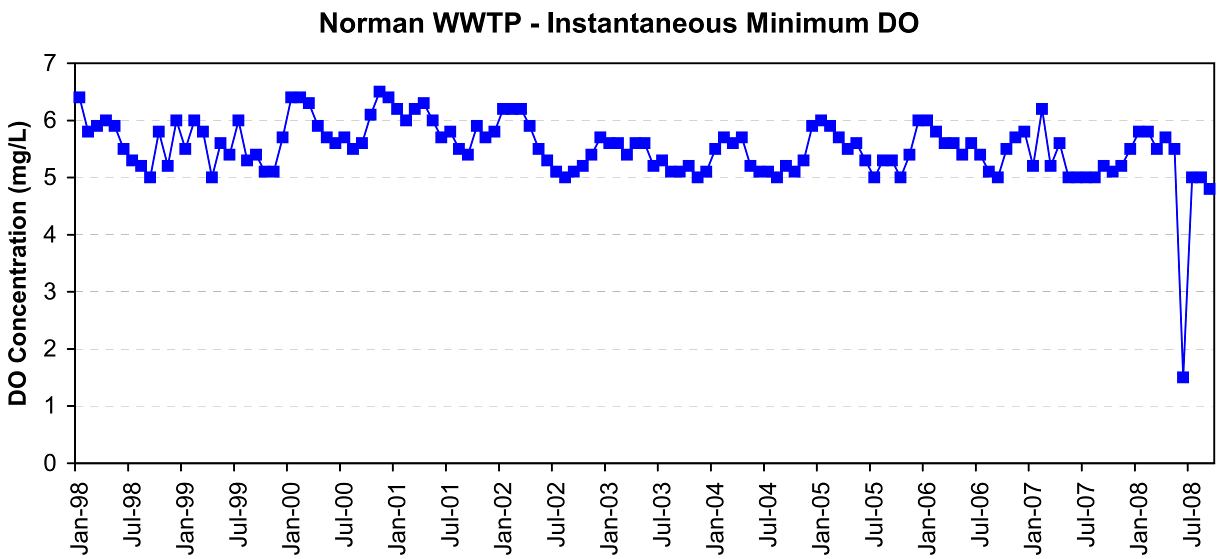
Jan-06
Jul-06
Jan-07
Jul-07
Jan-08
Jul-08


Norman WWTP - Instantaneous Minimum DO
DO Concentration (mg/L)
0
1
2
3
4
5
6
7
Jan-98
Jul-98
Jan-99
Jul-99
Jan-00
Jul-00
Jan-01
Jul-01
Jan-02
Jul-02
Jan-03
Jul-03
Jan-04
Jul-04
Jan-05
Jul-05
Jan-06
Jul-06
Jan-07
Jul-07
Jan-08
Jul-08

Month	Monthly average parameters					Inst. min.
	Flow (MGD)	BOD5 (mg/L)	CBOD5 (mg/L)	TSS (mg/L)	NH3-N (mg/L)	DO (mg/L)
Jan-98	1.000	4.7		26.5		
Feb-98	0.800	4.8		14.4		
Mar-98	1.240	3.7		9.1		
Apr-98	0.900	4.9		7.4		
May-98	0.630	6.4		10.0		
Jun-98	0.430	2.4		9.2		
Jul-98	0.340	1.9		8.0		
Aug-98	0.390	3.0		17.7		
Sep-98	0.430	2.6		11.0		
Oct-98	0.430	3.3		17.0		
Nov-98	0.410	2.9		12.0		
Dec-98	0.440	3.2		21.0		
Jan-99	0.430	5.8		14.0		
Feb-99	0.460	4.1		21.2		
Mar-99	0.550	3.6		18.5		
Apr-99	0.700	4.1		11.0		
May-99	0.680	3.7		8.9		
Jun-99	0.580	4.8		25.0		
Jul-99	0.460	4.1		6.3		
Aug-99	0.420	2.8		8.3		
Sep-99	0.470	2.9		6.3		
Oct-99	0.420	2.5		9.1		
Nov-99	0.430	8.9		12.3		
Dec-99	0.480	13.4		10.3		
Jan-00	0.460	18.9		25.0		
Feb-00	0.570	16.5		17.0		
Mar-00	0.630	16.1		25.5		
Apr-00	0.600	15.0		17.7		
May-00	0.530	10.9		8.1		
Jun-00	0.720	14.0		14.0		
Jul-00	0.690	11.6		7.9		
Aug-00	0.430	11.1		7.1		
Sep-00	0.420	12.5		7.1		
Oct-00	0.560	14.0		7.0		
Nov-00	0.910	13.0		10.0		
Dec-00	0.750	13.7		14.0		
Jan-01	1.100	13.6		9.6		
Feb-01	1.180	20.0		20.2		
Mar-01	0.930	18.8		9.1		
Apr-01	0.720	15.9		6.7		
May-01	0.730	14.8		6.7		
Jun-01	0.610	14.2		6.5		
Jul-01	0.380	13.8		5.1		
Aug-01	0.430	13.3		5.7		
Sep-01	0.470	13.0		3.5		
Oct-01	0.450	18.5		8.1		
Nov-01	0.470	15.3		10.5		
Dec-01	0.500	17.8		16.6		
Jan-02	0.500	17.3		14.3		

Month	Monthly average parameters Flow (MGD)	BOD5 (mg/L)	CBOD5 (mg/L)	TSS (mg/L)	NH3-N (mg/L)	Inst. min. DO (mg/L)
Feb-02	0.500	16.2		10.3		
Mar-02	0.580	18.3		15.5		
Apr-02	0.870	18.3		18.9		
May-02	0.520	17.6		10.3		
Jun-02	0.500	14.4		7.3		
Jul-02	0.570	13.8		7.9		
Aug-02	0.470	13.5		11.9		
Sep-02	0.450	14.3		10.2		
Oct-02	0.520	13.2		7.3		
Nov-02	0.530	15.6		8.9		
Dec-02	0.590	17.7		12.3		
Jan-03	0.480	19.5		19.3		
Feb-03	0.460	19.2		17.8		
Mar-03	0.610	18.2		17.9		
Apr-03	0.670	14.0		14.5		
May-03	0.510	15.8		16.9		
Jun-03	0.590	13.2		10.3		
Jul-03	0.430	14.3		9.1		
Aug-03	0.440	13.0		9.5		
Sep-03	0.460	11.8		4.3		
Oct-03	0.380	12.6		8.3		
Nov-03	0.350	15.7		13.1		
Dec-03	0.310	13.0		5.3		
Jan-04	0.340	14.5		4.9		
Feb-04	0.370	17.5		10.5		
Mar-04	0.460	11.8		5.7		
Apr-04	0.410	14.3		10.7		
May-04	0.360	15.0		11.4		
Jun-04	0.420	11.9		8.2		
Jul-04	0.480	13.5		7.7		
Aug-04	0.420	16.7		8.9		
Sep-04	0.380	16.5		9.1		
Oct-04	0.350	14.1		4.4		
Nov-04	0.540	15.8		19.6		
Dec-04	0.500	15.8		10.4		
Jan-05	0.580	18.6		7.7		
Feb-05	0.560	15.5		7.7		
Mar-05	0.490	15.3		13.1		
Apr-05	0.420	13.0		10.4		
May-05	0.390	13.2		8.6		
Jun-05	0.370	10.9		2.8		
Jul-05	0.350	11.1		3.1		
Aug-05	0.360	11.8		10.3		
Sep-05	0.350	12.0		5.7		
Oct-05	0.330	13.5		9.6		
Nov-05	0.340	3.0		8.0		
Dec-05	no data	no data		no data		
Jan-06	0.300	4.3		13.6		
Feb-06	0.270	3.5		7.0		

EFFLUENT DATA FOR NOBLE WWTP

Month	Monthly average parameters Flow (MGD)	BOD5 (mg/L)	CBOD5 (mg/L)	TSS (mg/L)	NH3-N (mg/L)	Inst. min. DO (mg/L)
Mar-06	0.320	3.7		8.2		
Apr-06	0.330	4.4		7.5		
May-06	0.380	3.6		7.6		
Jun-06	0.370	3.6		10.2		
Jul-06	0.350	2.9		4.2		
Aug-06	0.350	3.0		5.5		
Sep-06	0.340	2.0		6.8		
Oct-06	0.350	2.9		6.7		
Nov-06	0.290	2.7		7.7		
Dec-06	0.390	2.7		22.3		
Jan-07	0.300	2.9		7.7		
Feb-07	0.360	3.1		10.0		
Mar-07	0.470	3.8		6.0		
Apr-07	0.530	3.3		7.5		
May-07	1.040	3.2		5.2		
Jun-07	1.070	2.9		3.8		
Jul-07	1.170	5.4		6.2		
Aug-07	0.660	2.1		6.0		
Sep-07	0.510	3.6		7.0		
Oct-07	0.590	2.8		8.8		
Nov-07	0.470	3.9		8.0		
Dec-07	0.650	4.2		3.5		
Jan-08	0.520	5.1		10.7		
Feb-08	0.520	4.9		6.8		
Mar-08	0.700	4.9		18.5		
Apr-08	0.910	4.9		14.7		
May-08	0.740	4.5		16.8		
Jun-08	0.850	4.1		13.8		
Jul-08	0.470	5.0		9.2		
Aug-08	0.510	5.4		10.2		
Sep-08	0.420	4.2		13.7		

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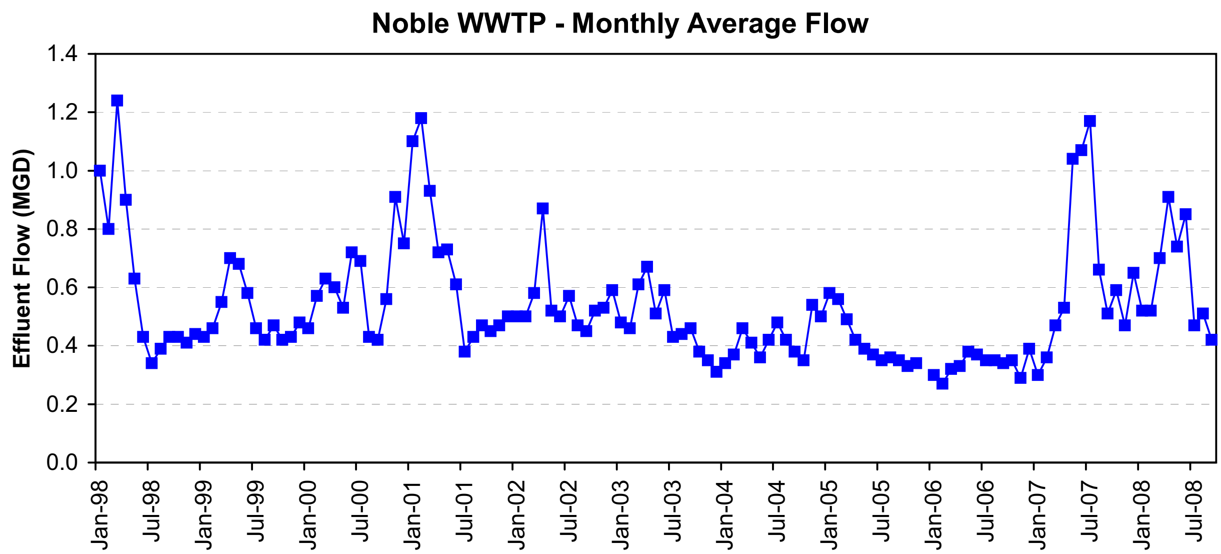
Noble WWTP - Monthly Average Flow
Effluent Flow (MGD)
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
Jan-98
Jul-98
Jan-99
Jul-99
Jan-00
Jul-00
Jan-01
Jul-01
Jan-02
Jul-02
Jan-03
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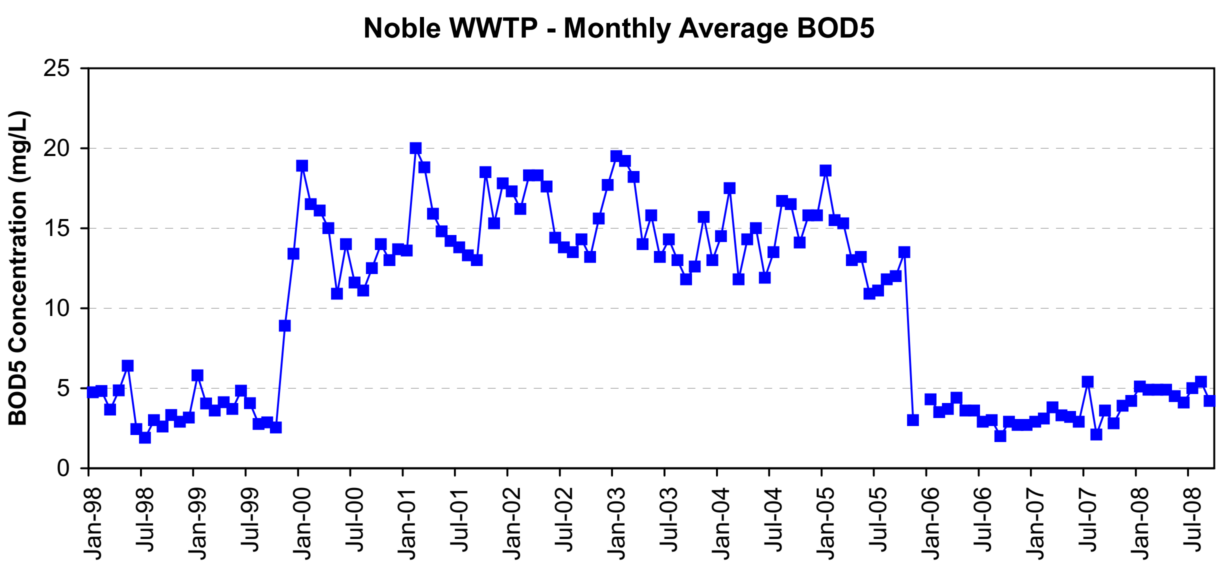
Jul-07
Jan-08
Jul-08


Noble WWTP - Monthly Average BOD5
BOD5 Concentration (mg/L)
0
5
10
15
20
25
Jan-98
Jul-98
Jan-99
Jul-99
Jan-00
Jul-00
Jan-01
Jul-01
Jan-02
Jul-02
Jan-03
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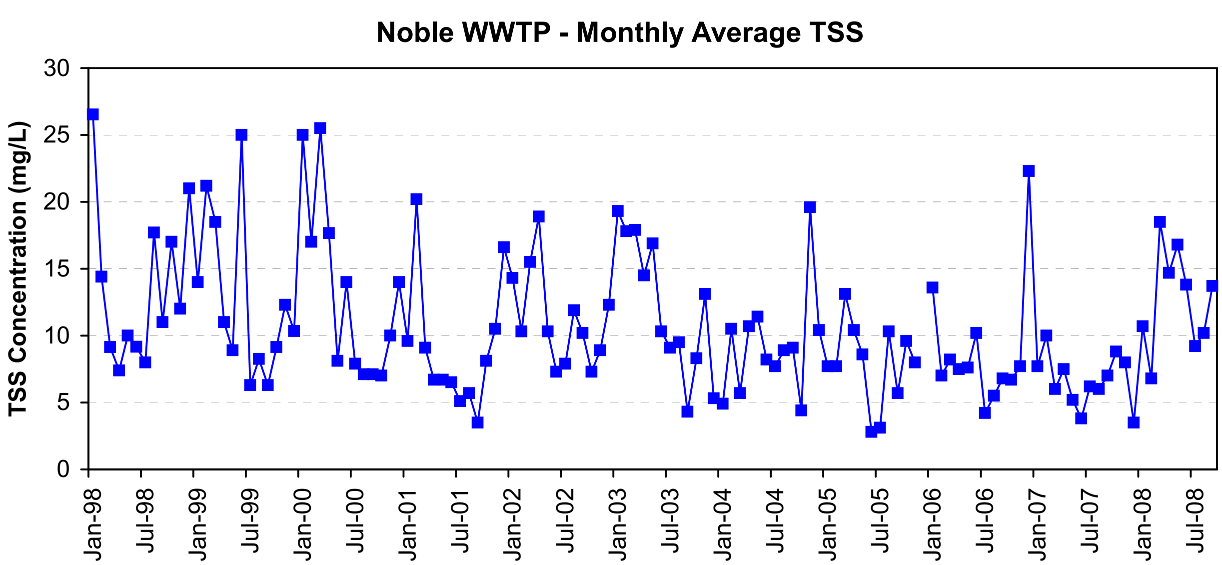
Jul-07
Jan-08
Jul-08


Noble WWTP - Monthly Average TSS
TSS Concentration (mg/L)
0
5
10
15
20
25
30
Jan-98
Jul-98
Jan-99
Jul-99
Jan-00
Jul-00
Jan-01
Jul-01
Jan-02
Jul-02
Jan-03
Jul-03
Jan-04
Jul-04
Jan-05
Jul-05
Jan-06
Jul-06
Jan-07
Jul-07
Jan-08
Jul-08

EFFLUENT DATA FOR LEXINGTON WWTP

Month	Monthly average parameters Flow (MGD)	BOD5 (mg/L)	CBOD5 (mg/L)	TSS (mg/L)	NH3-N (mg/L)	Inst. min. DO (mg/L)
Jan-98	0.160	6.2		6.0		
Feb-98	0.129	21.0		18.0		
Mar-98	0.160	21.0		26.0		
Apr-98	0.174	14.0		21.0		
May-98	0.128	15.8		24.0		
Jun-98	0.159	15.0		18.0		
Jul-98	0.160	9.9		17.0		
Aug-98	0.134	12.8		15.0		
Sep-98	0.111	15.0		18.0		
Oct-98	0.168	16.6		17.0		
Nov-98	0.146	17.5		22.0		
Dec-98	0.160	21.0		20.0		
Jan-99	0.104	31.0		6.0		
Feb-99	0.152	21.2		10.0		
Mar-99	0.109	23.8		1.0		
Apr-99	0.175	28.0		12.0		
May-99	0.162	11.9		17.0		
Jun-99	0.175	8.6		11.0		
Jul-99	0.150	20.3		17.0		
Aug-99	0.151	21.3		21.0		
Sep-99	0.157	17.6		17.0		
Oct-99	0.127	15.6		12.0		
Nov-99	0.143	17.6		14.0		
Dec-99	0.167	22.0		20.0		
Jan-00	0.149	42.0		17.0		
Feb-00	0.147	28.0		18.0		
Mar-00	0.144	not meas.		not meas.		
Apr-00	0	no discharge		no discharge		
May-00	0.157	not meas.		not meas.		
Jun-00	0.177	14.2		24.0		
Jul-00	0.159	17.1		14.0		
Aug-00	0.150	8.7		25.0		
Sep-00	0.159	14.2		16.0		
Oct-00	0.160	167.0		8.0		
Nov-00	0.168	14.0		6.0		
Dec-00	0.160	6.0		4.0		
Jan-01	0.168	6.0		8.0		
Feb-01	0.185	9.0		1.0		
Mar-01	0.218	11.4		6.0		
Apr-01	0.210	6.0		6.0		
May-01	0.222	16.0		28.0		
Jun-01	0.154	10.0		4.0		
Jul-01	0.134	6.0		6.0		
Aug-01	0.144	6.0		60.0		
Sep-01	0.188	14.0		4.0		
Oct-01	0.178	10.0		25.0		
Nov-01	0.168	8.0		50.0		
Dec-01	0.157	6.6		13.0		
Jan-02	no data	no data		no data		

Month	Monthly average parameters Flow (MGD)	BOD5 (mg/L)	CBOD5 (mg/L)	TSS (mg/L)	NH3-N (mg/L)	Inst. min. DO (mg/L)
Feb-02	0.168	8.0		2.0		
Mar-02	0.158	6.0		15.0		
Apr-02	0.194	8.0		10.0		
May-02	0.176	6.0		16.0		
Jun-02	0.173	18.0		7.0		
Jul-02	0.168	7.0		2.0		
Aug-02	0.176	22.0		8.0		
Sep-02	0.174	13.0		4.0		
Oct-02	0.185	6.0		2.0		
Nov-02	0.177	14.0		8.0		
Dec-02	no data	16.0		14.0		
Jan-03	0.184	27.0		12.0		
Feb-03	0.184	17.0		1.0		
Mar-03	no data	16.0		3.0		
Apr-03	0.184	6.0		13.0		
May-03	0.188	13.0		11.0		
Jun-03	0.195	4.0		24.0		
Jul-03	0.165	10.0		5.0		
Aug-03	0.194	10.0		14.0		
Sep-03	0.177	8.0		13.0		
Oct-03	0.178	2.0		9.0		
Nov-03	0.171	26.0		8.0		
Dec-03	0.167	19.0		9.0		
Jan-04	0.170	11.0		13.0		
Feb-04	0.187	41.0		44.0		
Mar-04	0.195	12.0		17.0		
Apr-04	0.179	19.0		4.0		
May-04	0.177	29.0		1.0		
Jun-04	0.204	9.0		2.0		
Jul-04	0.129	37.0		6.0		
Aug-04	0.186	8.0		6.0		
Sep-04	0.146	3.0		4.0		
Oct-04	0.192	2.0		9.0		
Nov-04	0.216	12.0		11.0		
Dec-04	0.186	20.0		14.0		
Jan-05	0.123	11.0		1.0		
Feb-05	0.177	16.0		15.0		
Mar-05	0.174	12.0		1.0		
Apr-05	0.176	3.0		9.0		
May-05	0.181	8.0		15.0		
Jun-05	0.182	21.5		9.0		
Jul-05	0.175	5.0		7.0		
Aug-05	0.185	14.0		12.0		
Sep-05	0.176	6.0		13.0		
Oct-05	0.176	7.0		7.0		
Nov-05	0.188	16.0		11.0		
Dec-05	0.174	12.0		16.0		
Jan-06	0.175	21.0		22.0		
Feb-06	no data	14.0		6.0		

EFFLUENT DATA FOR LEXINGTON WWTP

Month	Monthly average parameters Flow (MGD)	BOD5 (mg/L)	CBOD5 (mg/L)	TSS (mg/L)	NH3-N (mg/L)	Inst. min. DO (mg/L)
Mar-06	0.184	14.0		9.0		
Apr-06	0.178	7.0		9.0		
May-06	0.177	12.0		11.0		
Jun-06	0.175	2.0		6.0		
Jul-06	0.166	13.0		7.0		
Aug-06	0.175	2.0		10.0		
Sep-06	0.181	20.0		10.0		
Oct-06	0.191	2.0		7.0		
Nov-06	0.179	19.0		21.0		
Dec-06	0.176	18.0		14.0		
Jan-07	0.180	11.0		14.0		
Feb-07	0.168	22.0		16.0		
Mar-07	0.190	8.0		16.0		
Apr-07	0.190	12.0		29.0		
May-07	0.201	26.0		4.0		
Jun-07	0.207	11.0		47.0		
Jul-07	0.174	8.0		8.0		
Aug-07	0.183	6.0		13.0		
Sep-07	0.175	2.0		7.0		
Oct-07	0.173	5.5		11.5		
Nov-07	0.173	8.5		12.0		
Dec-07	0.180	11.0		16.5		
Jan-08	0.179	4.0		20.0		
Feb-08	0.182	5.0		21.0		
Mar-08	0.177	28.0		35.0		
Apr-08	0.188	19.5		7.5		
May-08	0.172	6.0		17.0		
Jun-08	0.174	10.0		9.0		
Jul-08	0.163	14.0		4.0		
Aug-08	0.187	7.5		11.0		
Sep-08	0.177	13.0		16.0		

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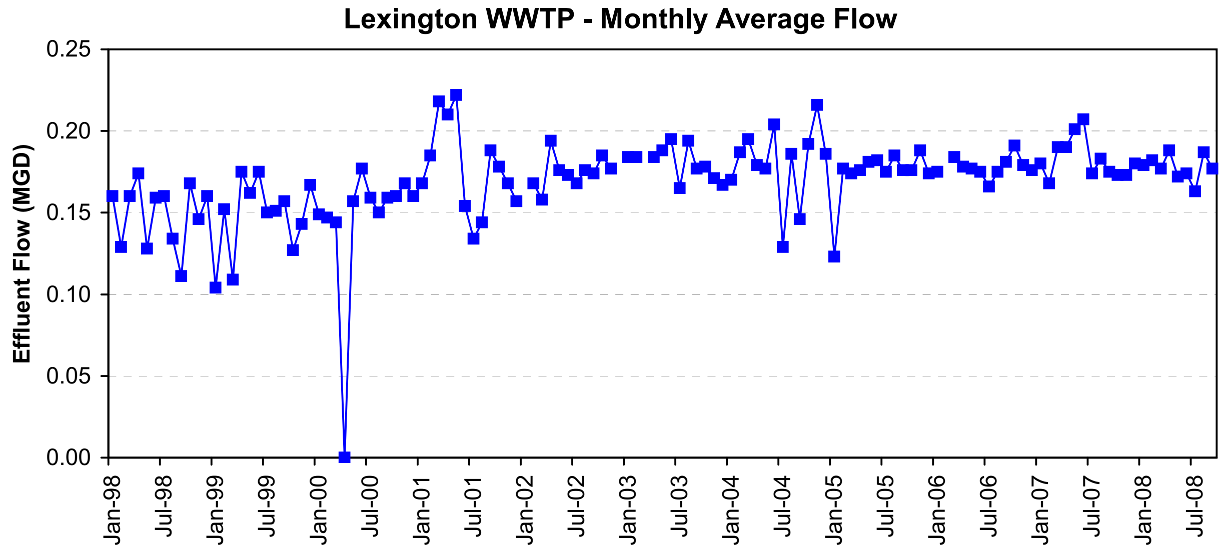
Lexington WWTP - Monthly Average Flow
Effluent Flow (MGD)
0.25
0.20
0.15
0.10
0.05
0.00
Jan-98
Jul-98
Jan-99
Jul-99
Jan-00
Jul-00
Jan-01
Jul-01
Jan-02
Jul-02
Jan-03
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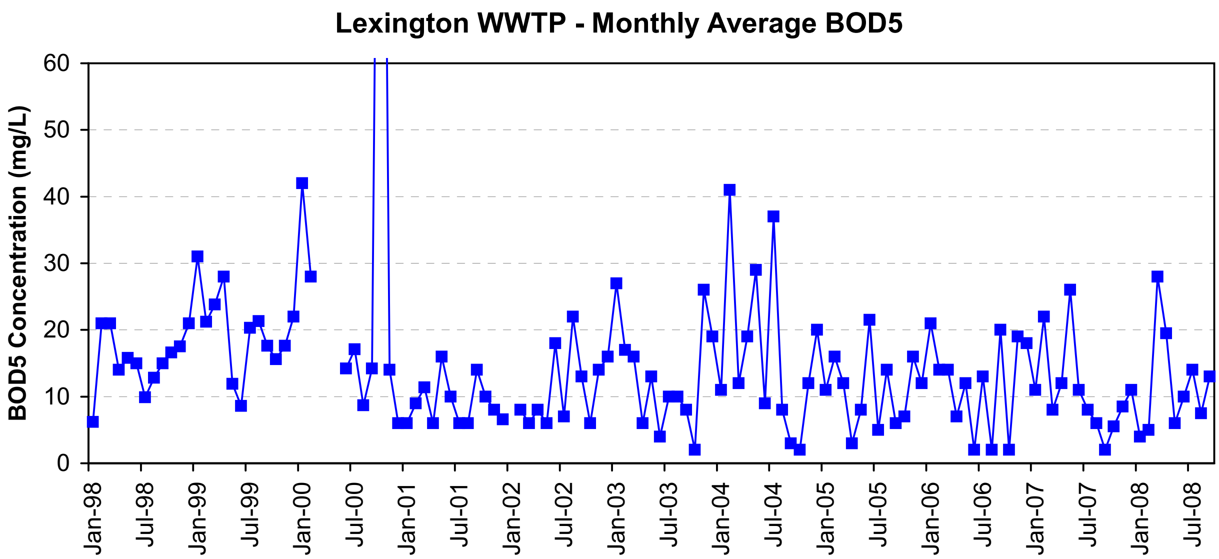
Jul-07
Jan-08
Jul-08


Lexington WWTP - Monthly Average BOD5
BOD5 Concentration (mg/L)
60
50
40
30
20
10
0
Jan-98
Jul-98
Jan-99
Jul-99
Jan-00
Jul-00
Jan-01
Jul-01
Jan-02
Jul-02
Jan-03
Jul-03
Jan-04
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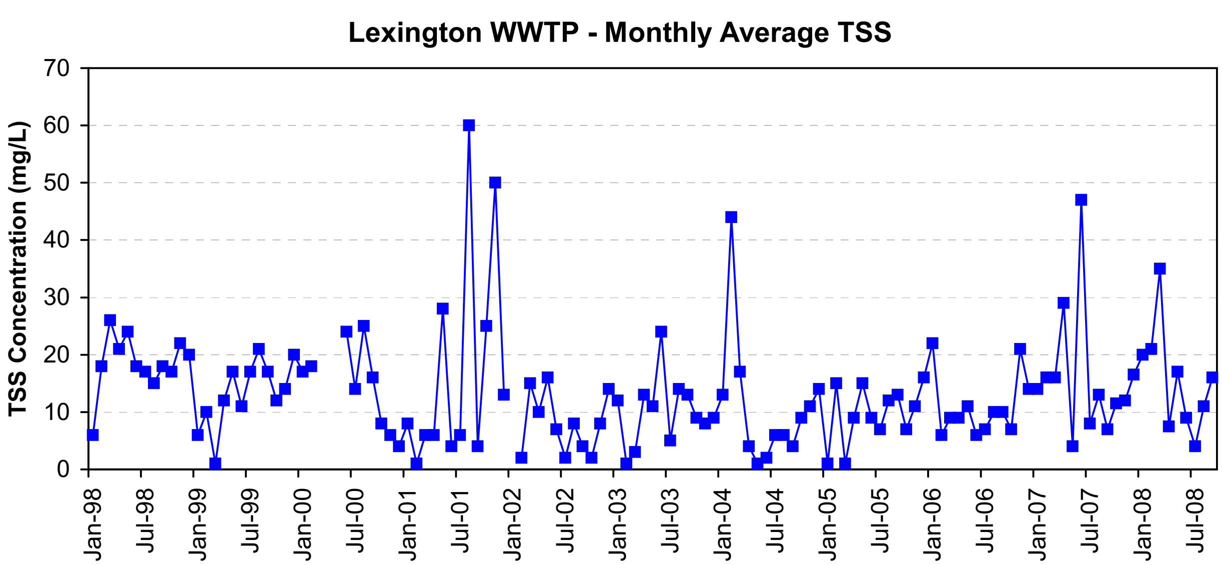
Jul-07
Jan-08
Jul-08


Lexington WWTP - Monthly Average TSS
TSS Concentration (mg/L)
70
60
50
40
30
20
10
0
Jan-98
Jul-98
Jan-99
Jul-99
Jan-00
Jul-00
Jan-01
Jul-01
Jan-02
Jul-02
Jan-03
Jul-03
Jan-04
Jul-04
Jan-05
Jul-05
Jan-06
Jul-06
Jan-07
Jul-07
Jan-08
Jul-08

EFFLUENT DATA FOR PURCELL WWTP

Month	Monthly average parameters					Inst. min.
	Flow (MGD)	BOD5 (mg/L)	CBOD5 (mg/L)	TSS (mg/L)	NH3-N (mg/L)	DO (mg/L)
Jan-98	0.900	18.5		8.0		
Feb-98	0.820	22.6		10.2		
Mar-98	1.060	20.2		9.5		
Apr-98	0.950	19.0		16.1		
May-98	0.870	20.2		13.2		
Jun-98	0.640	20.2		30.5		
Jul-98	0.570	22.7		18.4		
Aug-98	0.600	18.6		24.4		
Sep-98	0.630	14.1		13.7		
Oct-98	0.630	11.7		13.8		
Nov-98	0.600	13.4		13.8		
Dec-98	0.620	11.4		8.9		
Jan-99	0.620	29.0		10.5		
Feb-99	0.650	21.0		13.8		
Mar-99	0.690	13.8		9.1		
Apr-99	0.730	19.3		15.5		
May-99	0.770	22.3		17.1		
Jun-99	0.740	19.5		29.0		
Jul-99	0.630	18.9		32.8		
Aug-99	0.560	22.6		28.1		
Sep-99	0.580	25.8		23.8		
Oct-99	0.540	15.7		17.8		
Nov-99	0.550	22.7		15.3		
Dec-99	0.600	14.8		9.0		
Jan-00	0.540	17.2		13.5		
Feb-00	0.590	18.6		14.1		
Mar-00	0.610	20.6		13.6		
Apr-00	0.650	18.2		19.0		
May-00	no data	20.5		22.5		
Jun-00	0.590	18.8		19.1		
Jul-00	0.610	18.8		28.2		
Aug-00	0.550	25.2		40.2		
Sep-00	0.520	16.2		30.0		
Oct-00	0.630	11.7		10.2		
Nov-00	0.750	12.9		11.7		
Dec-00	0.750	16.1		16.1		
Jan-01	0.717	20.0		18.0		
Feb-01	0.816	21.0		9.4		
Mar-01	0.859	24.0		6.7		
Apr-01	0.764	30.0		14.0		
May-01	0.679	29.4		20.8		
Jun-01	0.596	16.0		14.0		
Jul-01	0.356	28.0		25.0		
Aug-01	0.439	18.0		28.0		
Sep-01	0.632	11.0		18.0		
Oct-01	0.555	11.0		11.0		
Nov-01	0.587	16.0		11.0		
Dec-01	0.671	22.0		8.0		
Jan-02	0.576	29.0		15.0		

Month	Monthly average parameters: Flow (MGD)	BOD5 (mg/L)	CBOD5 (mg/L)	TSS (mg/L)	NH3-N (mg/L)	Inst. min. DO (mg/L)
Feb-02	0.639	26.0		25.0		
Mar-02	0.619	18.0		15.0		
Apr-02	0.750	22.0		17.0		
May-02	0.675	15.0		13.0		
Jun-02	0.610	21.0		27.0		
Jul-02	0.537	15.0		15.0		
Aug-02	0.531	20.0		29.0		
Sep-02	0.504	22.0		28.0		
Oct-02	0.299	10.0		7.0		
Nov-02	0.591	21.0		12.0		
Dec-02	0.593	24.0		17.0		
Jan-03	0.386	20.0		14.0		
Feb-03	0.517	25.0		20.0		
Mar-03	0.629	25.0		15.0		
Apr-03	0.574	27.0		23.0		
May-03	0.469	16.0		15.0		
Jun-03	0.554	22.0		18.0		
Jul-03	0.432	25.0		29.0		
Aug-03	0.497	28.0		21.0		
Sep-03	0.518	23.0		14.0		
Oct-03	0.442	9.8		6.3		
Nov-03	0.516	18.6		11.8		
Dec-03	0.466	23.2		19.3		
Jan-04	0.323	17.7		11.5		
Feb-04	0.422	20.3		15.6		
Mar-04	0.578	18.0		54.8		
Apr-04	0.572	14.0		11.2		
May-04	0.529	20.2		18.7		
Jun-04	0.607	10.5		8.7		
Jul-04	0.623	18.9		22.8		
Aug-04	0.571	26.0		25.0		
Sep-04	0.519	18.8		17.8		
Oct-04	0.575	12.0		2.7		
Nov-04	0.689	11.2		6.1		
Dec-04	0.643	22.5		14.8		
Jan-05	0.714	20.1		12.5		
Feb-05	0.687	18.0		16.3		
Mar-05	0.645	22.1		10.8		
Apr-05	0.505	20.2		25.8		
May-05	0.525	22.1		25.3		
Jun-05	0.531	17.3		28.8		
Jul-05	0.557	11.7		17.3		
Aug-05	0.567	15.2		13.8		
Sep-05	0.524	15.7		11.3		
Oct-05	0.525	19.2		10.5		
Nov-05	0.454	20.4		10.3		
Dec-05	0.408	26.9		14.7		
Jan-06	0.381	16.7		8.1		
Feb-06	0.427	17.5		25.8		

Month	Monthly average parameters					Inst. min.
	Flow (MGD)	BOD5 (mg/L)	CBOD5 (mg/L)	TSS (mg/L)	NH3-N (mg/L)	DO (mg/L)
Mar-06	0.461	26.1		23.8		
Apr-06	0.505	23.7		20.0		
May-06	0.532	20.4		20.5		
Jun-06	0.465	16.8		19.7		
Jul-06	0.450	18.2		16.8		
Aug-06	0.499	18.5		25.5		
Sep-06	0.519	23.4		7.8		
Oct-06	0.274	18.3		11.0		
Nov-06	0.483	16.1		12.5		
Dec-06	0.530	23.6		9.1		
Jan-07	0.538	23.9		11.9		
Feb-07	0.561	25.1		20.2		
Mar-07	0.583	22.3		9.2		
Apr-07	0.607	22.4		21.0		
May-07	0.933	13.1		11.8		
Jun-07	0.882	16.9		12.3		
Jul-07	1.060	16.1		7.0		
Aug-07	0.870	14.9		2.3		
Sep-07	0.720	20.7		2.5		
Oct-07	0.720	20.0		5.0		
Nov-07	0.600	20.5		8.3		
Dec-07	0.570	22.0		11.3		
Jan-08	0.640	30.4		10.0		
Feb-08	0.560	25.0		5.0		
Mar-08	0.640	32.6		10.0		
Apr-08	0.680	28.0		17.7		
May-08	0.770	21.6		9.0		
Jun-08	0.860	10.9		3.2		
Jul-08	0.620	21.0		13.0		
Aug-08	0.630	17.1		11.5		
Sep-08	0.560	18.0		9.0		

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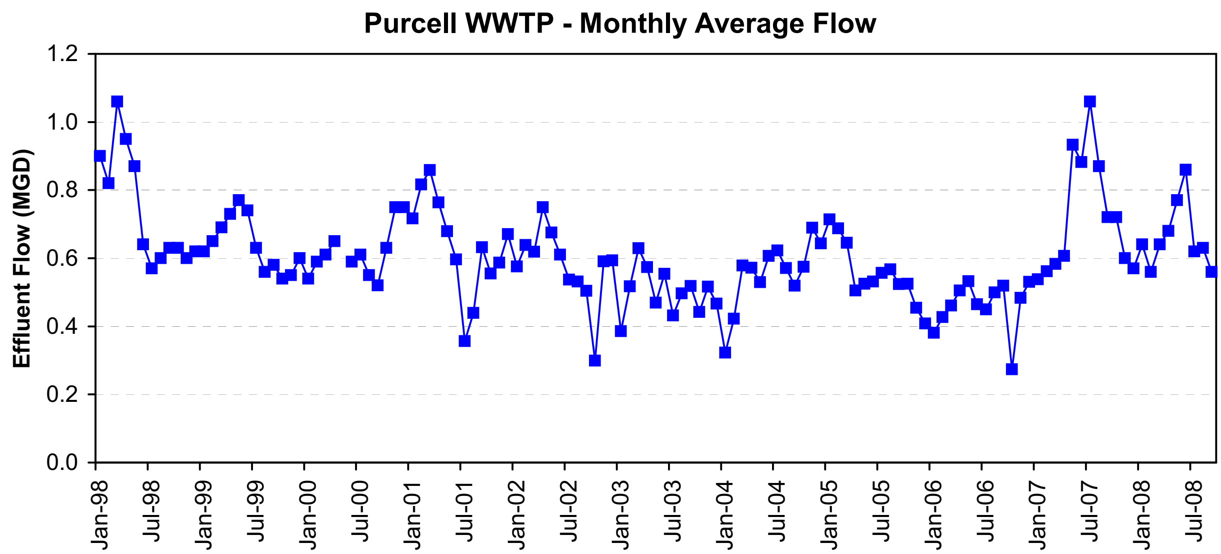
Purcell WWTP - Monthly Average Flow
Effluent Flow (MGD)
0.0
0.2
0.4
0.6
0.8
1.0
1.2
Jan-98
Jul-98
Jan-99
Jul-99
Jan-00
Jul-00
Jan-01
Jul-01
Jan-02
Jul-02
Jan-03
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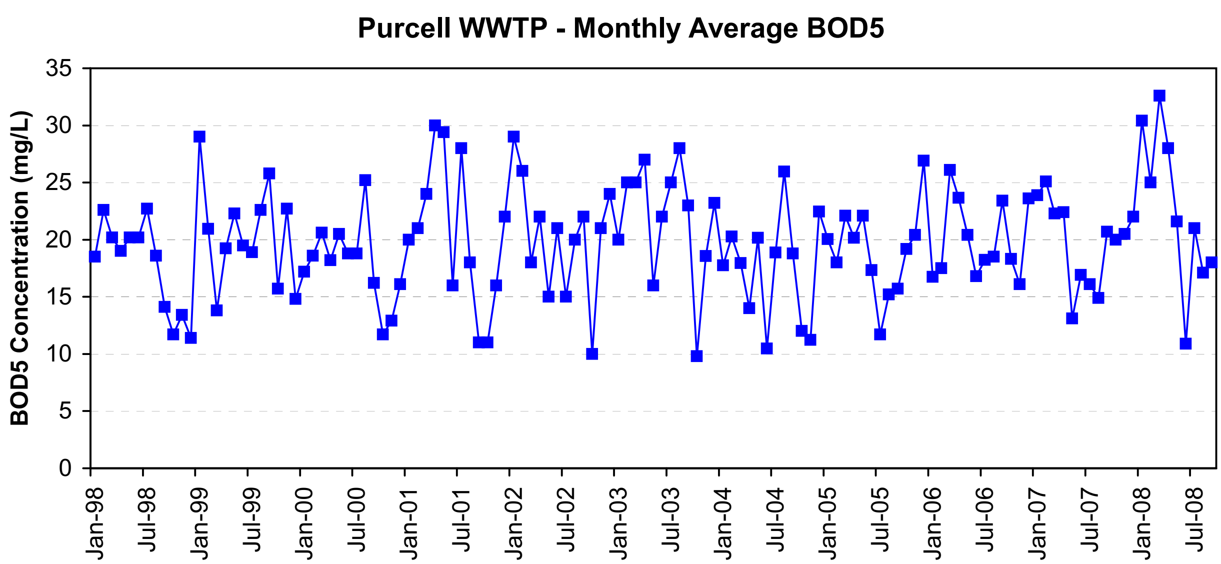
Jul-07
Jan-08
Jul-08


Purcell WWTP - Monthly Average BOD5
BOD5 Concentration (mg/L)
0
5
10
15
20
25
30
35
Jan-98
Jul-98
Jan-99
Jul-99
Jan-00
Jul-00
Jan-01
Jul-01
Jan-02
Jul-02
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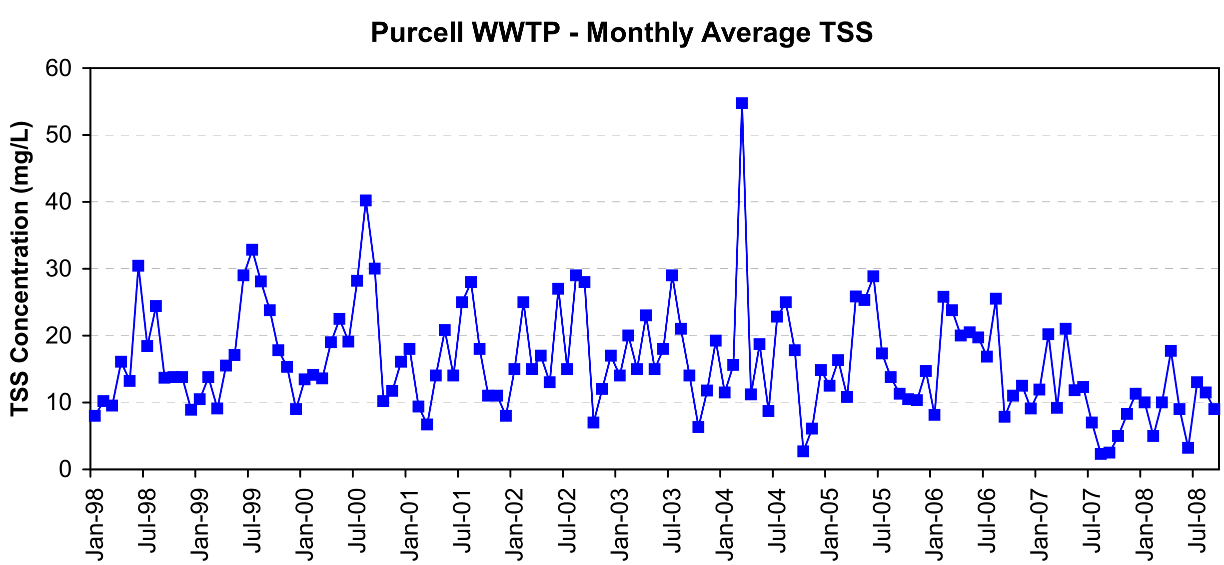
Jul-07
Jan-08
Jul-08


Purcell WWTP - Monthly Average TSS
TSS Concentration (mg/L)
0
10
20
30
40
50
60
Jan-98
Jul-98
Jan-99
Jul-99
Jan-00
Jul-00
Jan-01
Jul-01
Jan-02
Jul-02
Jan-03
Jul-03
Jan-04
Jul-04
Jan-05
Jul-05
Jan-06
Jul-06
Jan-07
Jul-07
Jan-08
Jul-08

APPENDIX B

OWRB WATER QUALITY DATA FOR

CANADIAN RIVER AT

PURCELL AND NORMAN

OWRB WATER QUALITY DATA FOR CANADIAN RIVER AT PURCELL
STATION 520610010010-001AT

Sample Date	DO (mg/L)	DO Percent Saturation (%)	Ammonia Nitrogen, laboratory (mg/L)	Ammonia Nitrogen, Hach (mg/L)	Total Kjeldahl Nitrogen (mg/L)	Nitrate Nitrogen (mg/L)	Nitrite + Nitrate Nitrogen (mg/L)	Ortho Phos-phorus (mg/L)	Total Phos-phorus (mg/L)	Corrected Chloro-phyll a (ug/L)
2/24/99	11.9	103%	0.38		0.57	0.95		0.186	0.191	
2/24/99	11.9									
4/21/99	7.8	96%	< 0.05		< 0.05	0.44		0.166	0.333	
4/21/99	7.8									
5/11/99	6.7	80%	0.37		1.82	0.05		0.167	0.507	
6/16/99	8.2	102%	0.36		1.33	< 0.05		0.097	0.236	
7/13/99									0.013	
7/13/99									0.011	
7/19/99	9.4	133%	0.95		2.36	< 0.05		0.046	0.111	
8/11/99	10.7	157%	0.13		1.92	0.13		0.219	0.282	
9/21/99			< 0.05		3.12	2.66		0.403	1.024	
10/12/99	12.6	158%	< 0.05		< 0.05	0.13		< 0.005	< 0.005	
10/12/99			< 0.05		0.83	1.32		0.054	1.631	
11/09/99			1.14		2.21	0.51		0.530	0.634	
12/08/99	9.7	90%	1.40		1.94	0.92		0.195	0.330	
12/08/99			1.38		2.11	0.88		0.207	0.324	
12/08/99									0.353	
12/08/99									0.499	
12/08/99									0.409	
12/08/99									0.481	
1/25/00	15.5	129%	< 0.05		0.46	0.88		0.220	0.410	
1/25/00			< 0.05		0.50	0.90		0.218	0.356	
2/14/00			< 0.05		0.58	0.79		0.153	0.217	
2/14/00			< 0.05		0.61	0.75		0.152	0.245	
3/15/00	9.9	107%				0.43			0.247	
4/12/00	12.5	123%	0.09		0.83	0.48		0.141	0.380	
5/09/00	16.3	186%	0.39		1.40	< 0.05		0.063	0.391	
5/09/00			0.34		1.40	< 0.05		0.063	0.414	
6/19/00	5.2	64%	0.17		1.28	0.41		0.350	0.480	
7/19/00	13.6	191%	< 0.05		1.84	0.05		0.068	0.323	
7/19/00			< 0.05		1.52	< 0.05		0.050	0.290	
8/16/00	14.8	200%	0.05		2.20	0.38		0.316	0.989	
8/16/00			0.08		2.08	0.37		0.310	1.023	
9/13/00	13.5	193%	0.12		1.56	2.34		0.572	1.019	
9/13/00			0.11		1.70	2.34		0.607	0.949	
10/11/00	11.9	121%	< 0.05		1.55	8.30		1.680	2.457	
10/11/00			0.06		1.55	8.59		1.650	2.190	
11/07/00	10.9	94%	0.34		1.22	0.91		0.253	1.007	
2/14/01	10.1	95%	0.25		1.24	0.83		0.137	0.421	
3/14/01	12.0	118%	0.11		1.18	< 0.05		0.261	0.391	
4/11/01	10.5	118%	< 0.05		1.96	< 0.05		0.097	0.446	
6/13/01	9.0	116%	< 0.05		1.53	< 0.05		0.129	0.434	
7/18/01	12.0	180%			1.87	< 0.05		0.029	0.222	
8/15/01					1.89	< 0.05		0.027	0.225	
9/05/01	13.7	175%			2.37	0.91		0.187	0.618	
10/17/01	9.2	98%			1.70	1.98		0.288	0.580	
11/28/01	9.5	72%			0.94	2.71		0.803	2.765	
2/27/02	12.3	97%	0.10		0.96	1.31		0.129	0.222	
2/27/02			0.08		1.19	1.31		0.127	0.290	
3/19/02	8.4	78%	0.14		1.34	0.87		0.095	0.339	
3/19/02			0.17		1.22	0.87		0.095	0.343	
4/17/02	7.6	84%	0.21		1.73	0.92		0.144	0.329	
4/17/02			0.24		1.55	1.02		0.147	0.334	
5/20/02	7.8	84%	0.59		2.88	0.73		0.050	0.570	

Sample Date	DO (mg/L)	DO Percent Saturation (%)	Ammonia Nitrogen, laboratory (mg/L)	Ammonia Nitrogen, Hach (mg/L)	Total Kjeldahl Nitrogen (mg/L)	Nitrate Nitrogen (mg/L)	Nitrite + Nitrate Nitrogen (mg/L)	Ortho Phos-phorus (mg/L)	Total Phos-phorus (mg/L)	Corrected Chloro-phyll a (ug/L)
5/20/02	7.8	84%	0.56		2.86	0.75		0.050	0.600	
6/11/02	9.5	126%	< 0.05		2.13	< 0.05		0.052	0.269	
6/11/02	9.5	126%	0.05		1.25	< 0.05		0.055	0.276	
7/16/02	15.6	191%	0.24		1.49	0.37		0.019	0.225	
7/16/02			0.18		1.30	0.37		0.019	0.225	
8/14/02	10.9	141%	0.33		1.72	2.16		0.685	1.020	
8/14/02	10.9	141%	0.19		1.65	1.95		0.684	0.985	
9/17/02	13.7	166%	0.08		2.90	< 0.05		0.233	0.650	
9/17/02			0.08		2.81	< 0.05		0.235	0.630	
10/14/02	7.4	70%								
11/20/02	10.0	93%	< 0.05		0.68	0.94		0.063	0.169	
11/20/02	10.0	93%	< 0.05		0.72	0.92		0.068	0.172	
1/07/03	12.3	102%	0.19		0.64	0.99		0.144	0.199	
1/07/03	12.3	102%	0.20		0.67	1.00		0.145	0.201	
2/11/03	10.5	78%	0.23		0.49	0.90		0.132	0.205	
2/11/03	10.5	78%	0.24		0.77	0.91		0.132	0.218	
3/19/03	11.1	112%	< 0.05		0.93	0.06		0.062	0.230	
3/19/03	11.1	112%	< 0.05		1.25	0.05		0.062	0.230	
4/29/03	10.2	112%	< 0.05		1.39	0.43		0.054	0.212	
4/29/03	10.2	112%	< 0.05		1.34	0.44		0.055	0.214	
6/30/03	7.8	93%	< 0.05		0.85	0.17		0.093	0.260	
6/30/03	7.8	93%	< 0.05		1.39	0.18		0.093	0.257	
8/05/03	7.7	94%	0.12		2.41	4.23		1.100	1.360	51.6
8/05/03	7.7	94%	0.13		2.14	4.17		1.090	1.340	47.3
9/10/03	11.0	133%	0.09		1.58	3.95		0.484	0.580	42.6
9/10/03			0.26		1.01	3.95		0.487	0.565	36.0
10/13/03	11.5	133%	0.41		1.91	0.82		0.274	0.545	
10/13/03			0.43		1.85	0.83		0.269	0.535	
12/02/03	7.9	67%	< 0.05		2.43	2.36		0.018	0.635	
12/02/03			< 0.05		2.45	2.35		0.019	0.570	
1/05/04	12.5	84%	0.08		0.93	1.00		0.073	0.176	
1/05/04	12.5	84%	0.07		1.01	1.00		0.069	0.180	
2/09/04	9.4	71%	0.44		1.08	1.05		0.088	0.180	
2/09/04	9.4	71%	0.43		1.05	1.05		0.087	0.175	
3/22/04	11.1	103%	0.05		1.42	< 0.05		< 0.005	0.326	
3/22/04	11.1	103%	0.06		1.41	< 0.05		0.038	0.321	
4/19/04	10.5	116%	0.06		1.26	< 0.05		0.026	0.214	
4/19/04	10.5	116%	0.06		1.23	< 0.05		0.021	0.216	
6/01/04	10.6	141%	0.05		1.34	< 0.05		0.022	0.237	
6/01/04	10.6	141%	< 0.05		1.34	< 0.05		0.022	0.241	
6/02/04										48.3
7/07/04	4.2	53%	0.30		2.36	0.22		0.213	0.760	
7/07/04	4.2	53%	0.24		2.47	0.23		0.223	0.750	
8/10/04	8.5	103%	0.06		2.14	0.27		0.228	0.488	
8/10/04	8.5	103%	0.06		1.39	0.26		0.226	0.479	
9/13/04	13.3	164%	0.07		2.67	0.07		0.035	0.316	
9/13/04	13.3	164%	0.07		2.53	0.07		0.034	0.305	
10/19/04	12.4	138%	0.17		1.66	< 0.05		0.030	0.235	103.8
10/19/04	12.4	138%	0.18		1.96	< 0.05		0.030	0.251	99.6
11/12/04										22.1
11/12/04										17.6
11/21/04	5.5	51%	0.28		2.08	0.45		0.081	0.580	
11/21/04	5.5	51%	0.27		2.09	0.45		0.080	0.585	
1/11/05	9.5	78%	0.32		2.02	0.68		0.295	0.391	9.4
1/11/05	9.5	78%	0.35		1.89	0.67		0.305	0.416	8.3
2/09/05	18.8	146%	0.11		0.99	0.77		0.144	0.383	5.7
2/09/05										0.5

Sample Date	DO (mg/L)	DO Percent Saturation (%)	Ammonia Nitrogen, laboratory (mg/L)	Ammonia Nitrogen, Hach (mg/L)	Total Kjeldahl Nitrogen (mg/L)	Nitrate Nitrogen (mg/L)	Nitrite + Nitrate Nitrogen (mg/L)	Ortho Phos-phorus (mg/L)	Total Phos-phorus (mg/L)	Corrected Chloro-phyll a (ug/L)
3/15/05	10.2	91%	0.06		1.15		0.74	0.024	0.159	46.6
3/15/05	10.2	91%	< 0.05		1.07		0.73	0.023	0.160	48.3
5/23/05	7.8	93%	< 0.05		1.23		0.44	0.244	0.394	
5/23/05	7.8	93%	< 0.05		1.11		0.44	0.242	0.382	
7/11/05	7.5	93%	0.14		1.76		0.08	0.044	0.329	46.1
7/11/05	7.5	93%	0.08		1.59		0.07	0.050	0.285	46.1
8/09/05	7.0	84%	0.13		2.43		1.17	0.460	0.620	48.5
8/09/05	7.0	84%	0.14		2.53		1.17	0.455	0.610	48.1
9/06/05	8.5	95%	< 0.05		2.97		0.21	0.030	0.460	136.0
9/06/05	8.5	95%	< 0.05		2.83		0.21	0.030	0.461	141.0
10/10/05	7.2	73%	0.58		4.43		1.29	0.133	0.980	11.0
10/10/05	7.2	73%	0.67		4.50		1.27	0.135	1.000	7.0
11/15/05	10.7	99%	< 0.05		1.42		1.39	0.064	0.329	56.0
11/15/05	10.7	99%	< 0.05		1.33		1.41	0.065	0.325	44.0
1/09/06	12.0	96%	0.05		0.83		1.53	0.172	0.326	24.0
1/09/06	11.5	96%	0.05		0.88		1.52	0.171	0.282	24.0
2/13/06	9.5	65%	0.14		0.85		1.27	0.170	0.256	7.1
2/13/06	9.5	65%	0.14		0.83		1.28	0.166	0.226	6.8
3/20/06	9.7	84%	0.39		2.19		1.17	0.091	0.513	48.9
3/20/06	9.7	84%	0.38		2.04		0.98	0.095	0.522	43.9
4/24/06	7.9	89%	< 0.05		1.72		< 0.05	0.044	0.422	
4/24/06	7.9	89%	< 0.05		1.73		< 0.05	0.045	0.422	
5/31/06	7.8	106%	< 0.05		2.75		1.27	0.831	0.330	104.0
5/31/06	7.8	106%	< 0.05		2.84		1.26	0.825	1.180	107.0
8/08/06	13.1	163%	< 0.05		1.99		1.60	0.206	0.340	
8/08/06	13.1	163%	< 0.05		2.01		1.61	0.206	0.338	
9/19/06	7.1	74%	0.63		3.43		1.24	0.404	1.022	
9/19/06	7.1	74%	0.64		3.45		1.23	0.421	1.040	
10/16/06	8.4	88%	0.18		1.45		1.26	0.263	0.424	16.2
10/16/06	8.4	88%	0.18		1.48		1.25	0.256	0.411	14.7
12/04/06			0.40		1.28		3.34	0.604	0.608	
12/04/06			0.41		1.26		3.35	0.616	0.630	
1/09/07	12.4	94%	0.44		1.72		1.03	0.248	0.405	
1/09/07	12.4	94%	0.45		1.79		1.03	0.251	0.382	
2/26/07	12.7	106%	< 0.05		1.01		1.04	0.123	0.215	43.3
3/26/07	5.9	62%	0.58		4.12		0.64	0.444	1.050	
4/30/07	8.8	98%	0.12		2.03		0.18	0.138	0.348	124.0
5/29/07	7.8	87%	0.32		2.05		0.52	0.151	0.481	46.7
7/02/07	7.1	84%	0.12		2.07		0.52	0.141	0.805	5.9
8/06/07	13.7	184%		0.04	2.08		< 0.05		0.277	
8/08/07										113.2
9/10/07	6.0	74%		0.99	3.06		0.60		0.840	119.0
10/15/07	9.1	98%		0.22	2.68		0.81		0.610	179.5
11/26/07	12.6	100%			1.22		1.73		0.459	8.9
1/22/08	14.3	99%		0.47	1.07		1.67		0.225	5.0
2/25/08		91%		0.70	1.56		1.08		0.283	
3/31/08	8.7	93%		0.09	1.43		0.91		0.443	
5/19/08	9.7	109%			1.55		< 0.05		0.258	

No. of values =	124	123	131	6	144	98	47	136	151	44
Minimum =	4.2	51%	< 0.05	0.04	< 0.05	< 0.05	< 0.05	< 0.005	< 0.005	0.5
Median =	9.8	96%	0.11	0.35	1.55	0.59	1.08	0.141	0.382	45.1
Maximum =	18.8	200%	1.40	0.99	4.50	8.59	3.35	1.680	2.765	179.5

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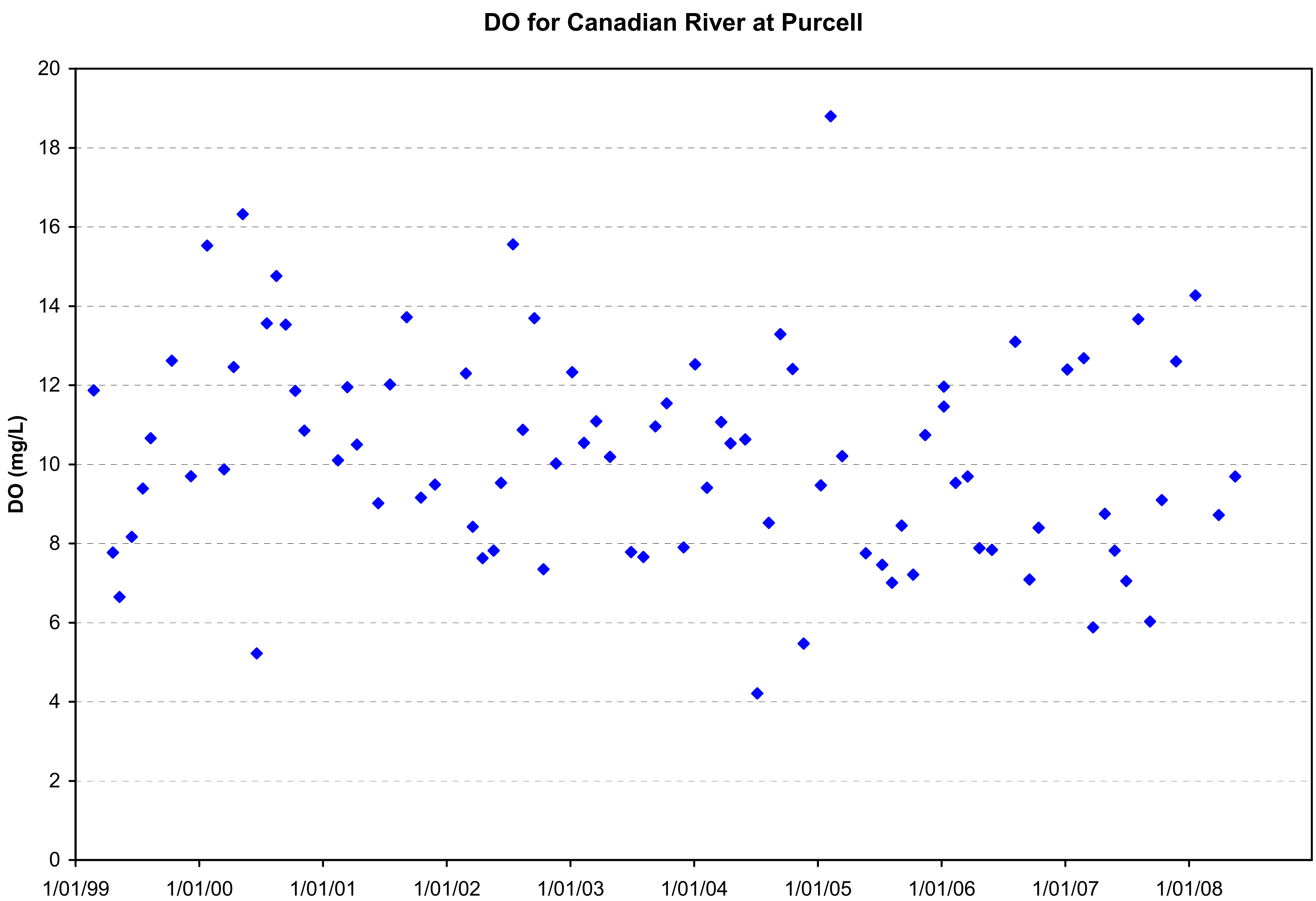
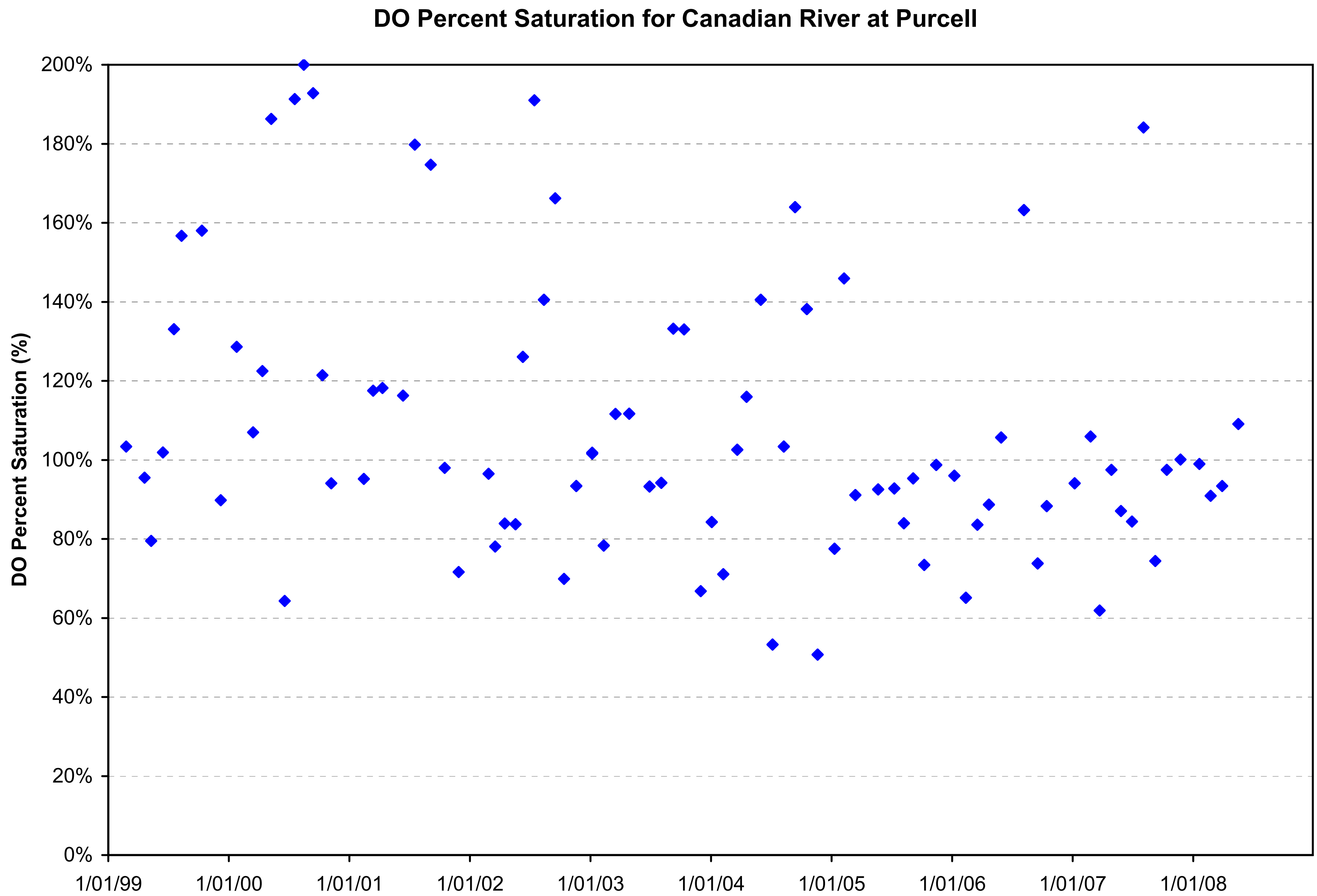
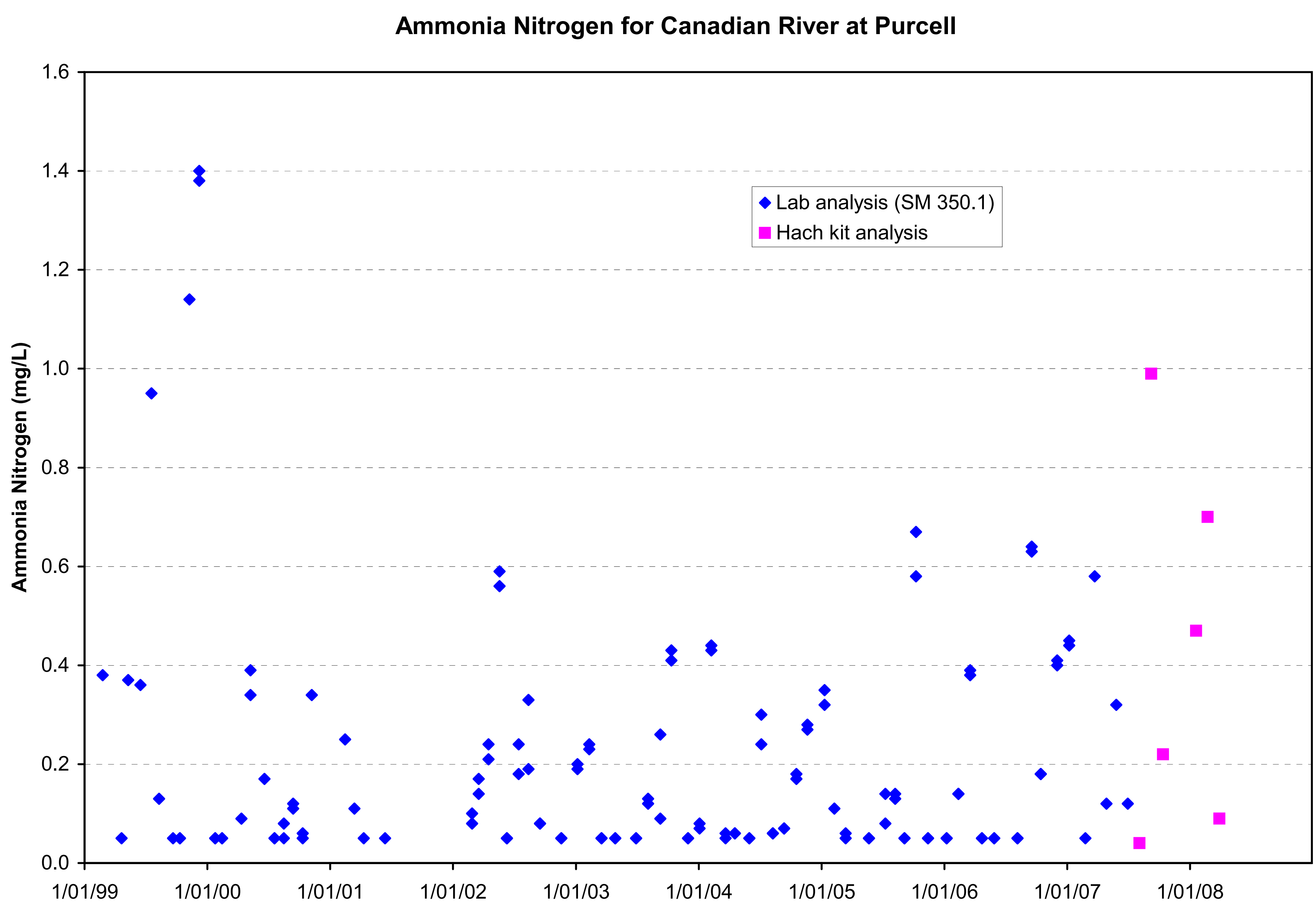
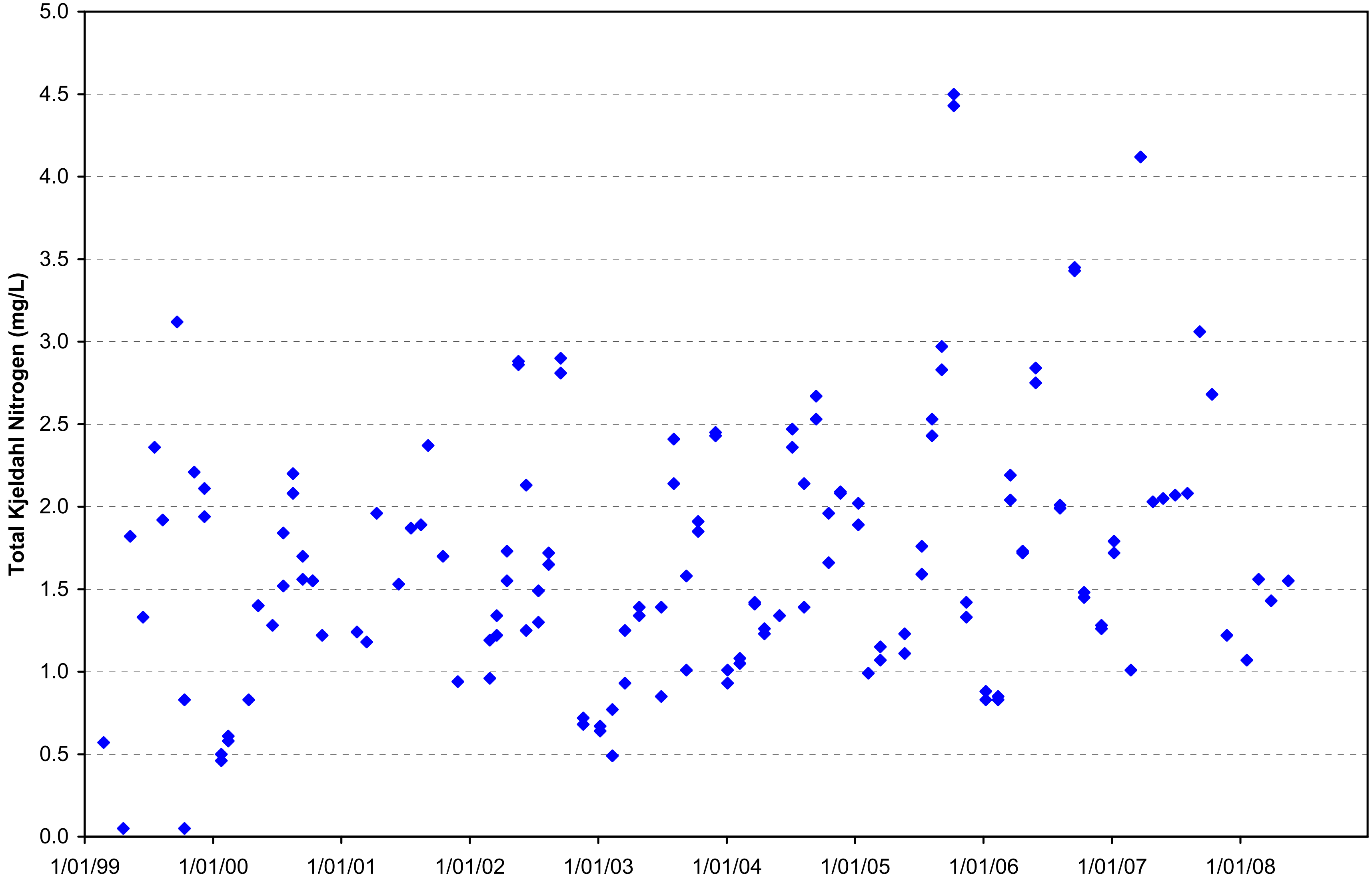

DO for Canadian River at Purcell
DO (mg/L)
20
18
16
14
12
10
8
6
4
2
0
1/01/99
1/01/00
1/01/01
1/01/02
1/01/03
1/01/04
1/01/05
1/01/06
1/01/07
1/01/08

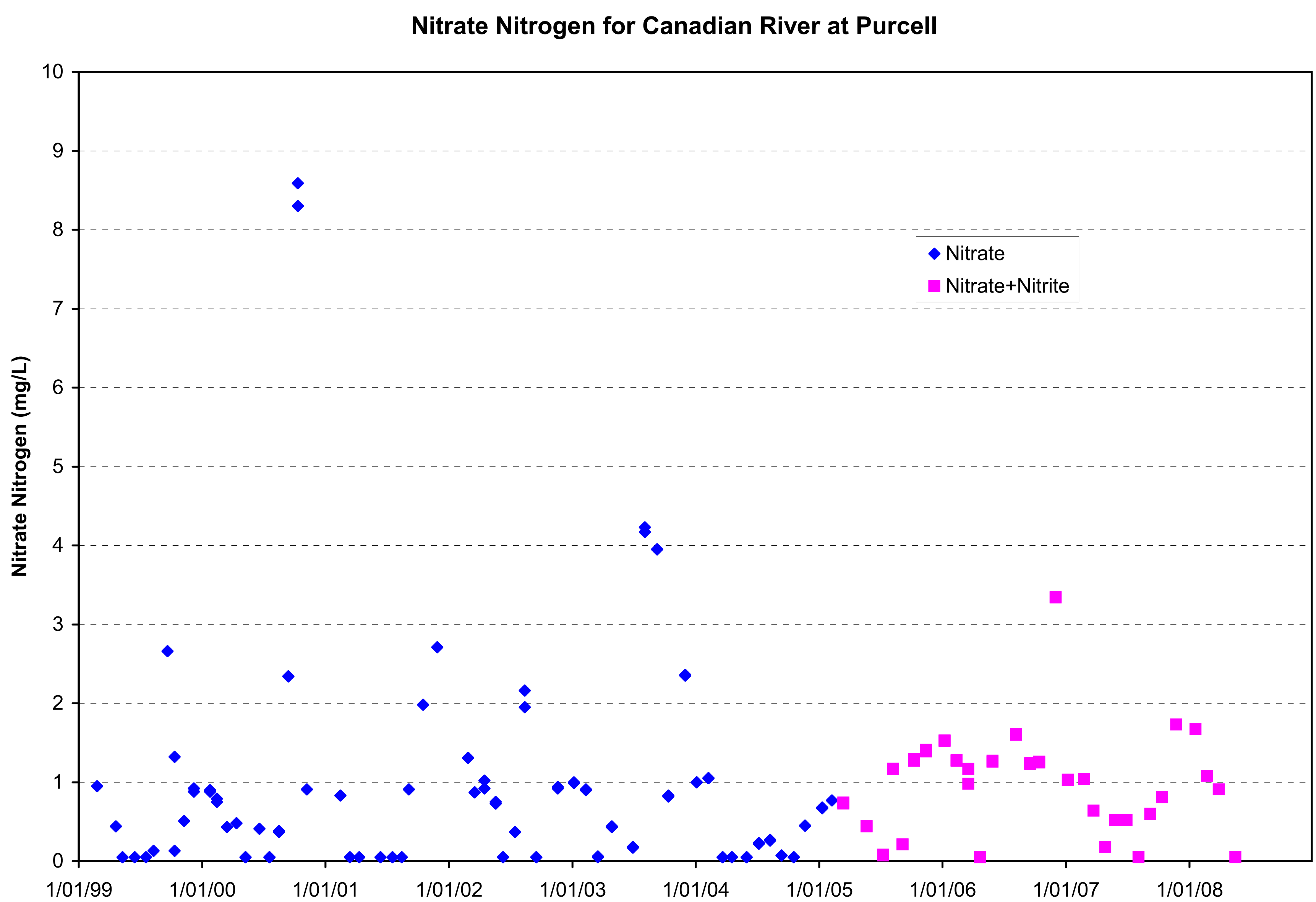


DO Percent Saturation for Canadian River at Purcell
DO Percent Saturation (%)
200%
180%
160%
140%
120%
100%
80%
60%
40%
20%
0%
1/01/99
1/01/00
1/01/01
1/01/02
1/01/03
1/01/04
1/01/05
1/01/06
1/01/07
1/01/08


Ammonia Nitrogen for Canadian River at Purcell
Ammonia Nitrogen (mg/L)
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
1/01/99
1/01/00
1/01/01
1/01/02
1/01/03
1/01/04
1/01/05
1/01/06
1/01/07
1/01/08
Lab analysis (SM 350.1)
Hach kit analysis

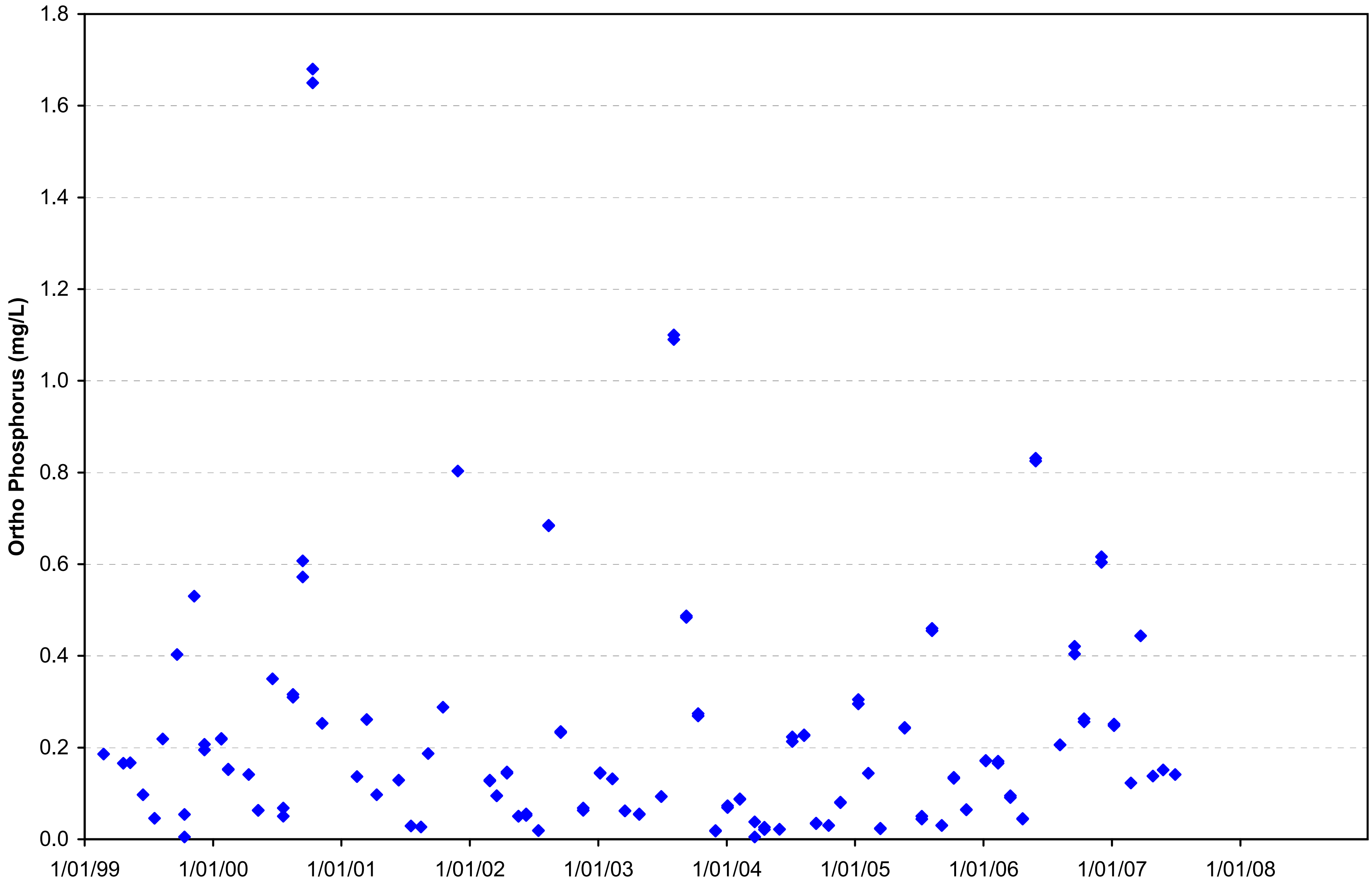
Total Kjeldahl Nitrogen for Canadian River at Purcell

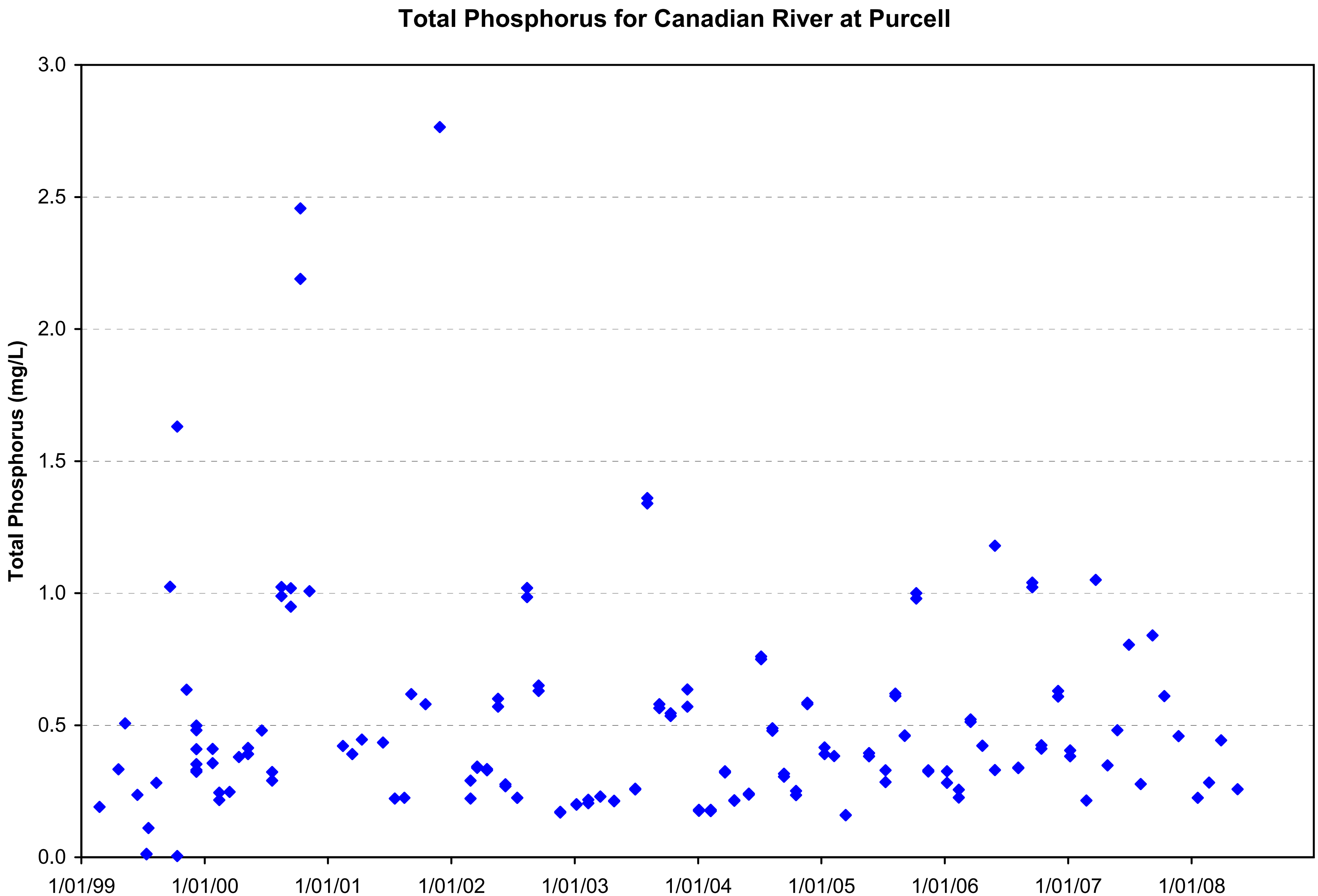


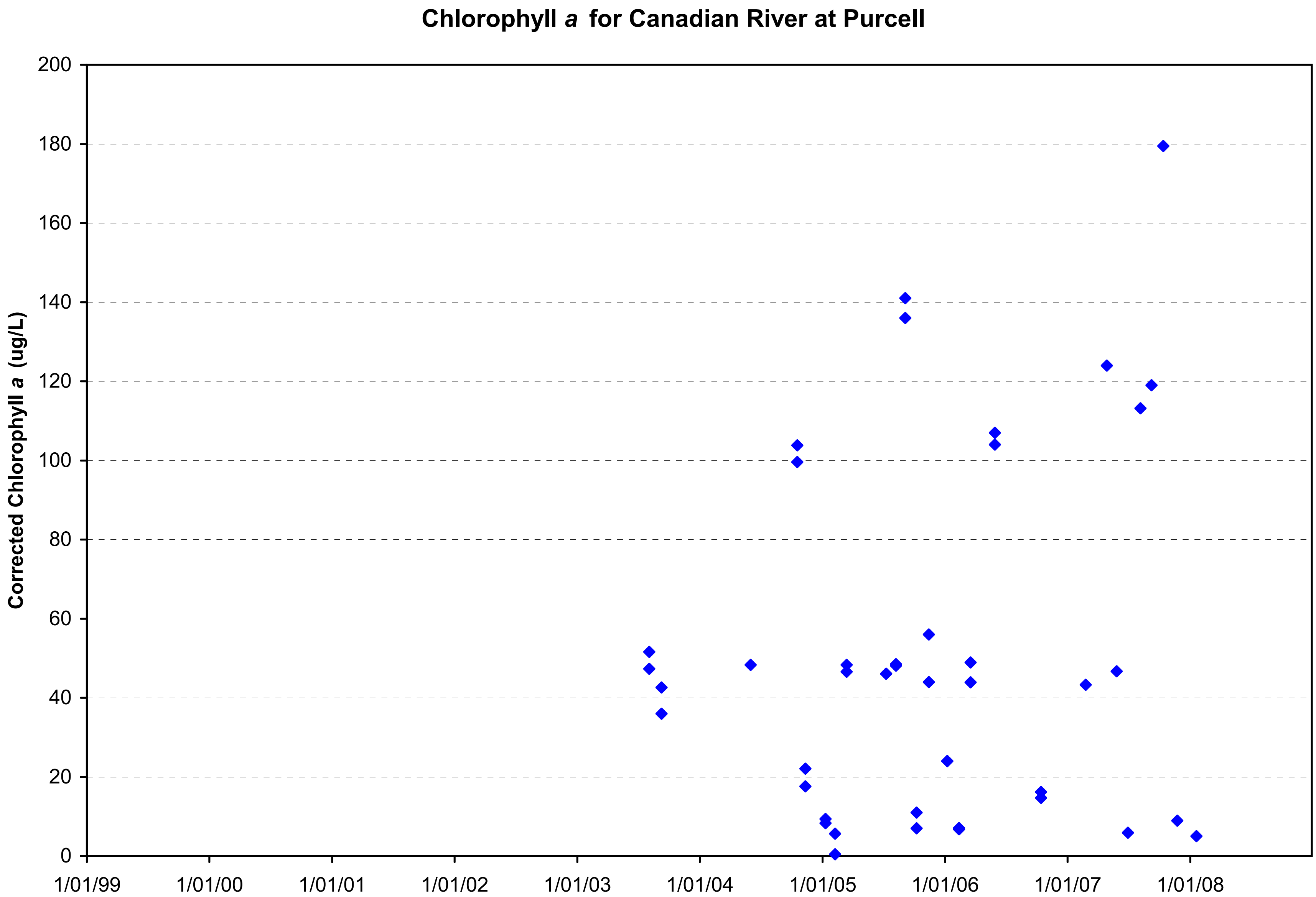


Nitrate Nitrogen for Canadian River at Purcell
Nitrate Nitrogen (mg/L)
10
9
8
7
6
5
4
3
2
1
0
1/01/99
1/01/00
1/01/01
1/01/02
1/01/03
1/01/04
1/01/05
1/01/06
1/01/07
1/01/08
Nitrate
Nitrate+Nitrite

Ortho Phosphorus for Canadian River at Purcell




Total Phosphorus for Canadian River at Purcell
Total Phosphorus (mg/L)
3.0
2.5
2.0
1.5
1.0
0.5
0.0
1/01/99
1/01/00
1/01/01
1/01/02
1/01/03
1/01/04
1/01/05
1/01/06
1/01/07
1/01/08



Chlorophyll *a* for Canadian River at Purcell
Corrected Chlorophyll *a* (ug/L)
0
20
40
60
80
100
120
140
160
180
200
1/01/99
1/01/00
1/01/01
1/01/02
1/01/03
1/01/04
1/01/05
1/01/06
1/01/07
1/01/08

OWRB WATER QUALITY DATA FOR CANADIAN RIVER AT NORMAN
STATION 520610010010-002RS

Sample Date	DO (mg/L)	DO Percent Saturation (%)	Ammonia Nitrogen (mg/L)	Total Kjeldahl Nitrogen (mg/L)	Nitrate Nitrogen (mg/L)	Ortho Phosphorus (mg/L)	Total Phosphorus (mg/L)
3/19/02	8.9	83%	0.12	1.04	0.44	0.094	0.201
4/16/02	8.3	94%	0.17	1.70	0.58	0.104	0.302
5/20/02	8.1	86%	0.59	2.55	0.53	0.051	0.655
6/11/02	7.6	107%	< 0.05	1.55	< 0.05	0.067	0.244
7/16/02	11.2	136%	0.06	0.83	< 0.05	0.025	0.220
8/14/02	9.2	129%	0.07	1.02	0.10	0.660	0.765
9/18/02	4.2	49%	0.11	2.93	< 0.05	0.113	0.447
10/15/02	7.8	78%	< 0.05	0.62	< 0.05	0.027	0.212
1/07/03	11.9	100%	0.23	0.61	0.71	0.136	1.250
3/19/03	9.5	95%	< 0.05	0.69	< 0.05	0.052	0.218
9/10/03	8.5	98%	0.05	1.17	0.17	1.070	1.090

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OWRB WATER QUALITY DATA FOR CANADIAN RIVER AT BRIDGEPORT
STATION 520610020150-001AT

Sample Date	DO (mg/L)	DO Percent Saturation (%)	Ammonia Nitrogen, laboratory (mg/L)	Total Kjeldahl Nitrogen (mg/L)	Nitrate Nitrogen (mg/L)	Nitrite + Nitrate Nitrogen (mg/L)	Ortho Phos-phorus (mg/L)	Total Phos-phorus (mg/L)	Corrected Chloro-phyll a (ug/L)
2/10/99	9.6	90%	0.09	0.43	0.53		0.043	0.103	
2/10/99	9.6								
3/30/99	9.7	97%	< 0.05	0.53	0.57		0.014	0.279	
3/30/99	9.7								
6/16/99		5%	0.15	0.48	< 0.05		0.029	0.094	
6/16/99									
7/12/99	9.9	118%	0.06	0.78	0.15		0.121	0.325	
7/12/99	9.9								
8/18/99	8.6	102%	< 0.05	0.44	0.06		0.011	0.010	
8/18/99	8.6								
9/15/99	9.9	110%	< 0.05	0.45	0.52		0.053	0.074	
9/15/99	9.9								
10/11/99	10.3	105%	< 0.05	0.36	0.29		0.009	0.035	
11/08/99	8.1	82%	< 0.05	0.44	0.38		0.026	0.115	
12/06/99	11.7	85%	0.19	1.16	0.77		0.114	0.143	
1/18/00	16.2	132%	< 0.05	0.48	1.26		0.014	0.048	
2/14/00	19.8	150%	0.07	0.24	0.65		0.015	0.059	
3/14/00	10.4	100%			0.28			0.021	
4/11/00	9.0	94%	< 0.05	0.61	0.42		0.061	0.141	
4/11/00			< 0.05	0.61	0.42		0.058	0.150	
5/08/00	8.1	104%	0.05	0.59	< 0.05		0.011	0.278	
5/08/00			0.06	0.63	< 0.05		0.010	0.291	
6/12/00	5.4	69%	< 0.05	0.59	0.06		0.012	0.139	
6/12/00			< 0.05	0.54	0.07		0.015	0.137	
7/18/00	7.8	98%	0.05	0.50	< 0.05		0.025	0.107	
7/18/00			0.06	0.56	< 0.05		0.031	0.114	
8/15/00	8.3	97%	< 0.05	0.33	< 0.05		0.014	0.064	
8/15/00			< 0.05	0.33	< 0.05		0.015	0.062	
9/11/00	8.1	96%	< 0.05	0.43	< 0.05		0.009	0.065	
9/11/00			< 0.05	0.41	< 0.05		0.007	0.070	
10/09/00	11.5	90%	< 0.05	0.38	0.50		< 0.005	0.034	
11/06/00	7.9	77%	0.10	0.80	0.56		0.046	0.555	
11/06/00			< 0.05	< 0.05	< 0.05		< 0.005	< 0.005	
2/27/01	7.4	65%	0.16	1.62	0.35		0.146	0.472	
3/20/01	11.2	91%	< 0.05	0.83	0.51		0.041	0.219	
4/17/01	9.8	88%	< 0.05	0.67	0.10		0.022	0.141	
5/21/01	6.4	67%	0.07	1.19	0.21		0.092	0.405	
6/27/01	8.9	118%	< 0.05	0.82	< 0.05		0.012	0.075	
7/23/01	7.7	94%		0.55	< 0.05		0.018	0.065	
8/20/01	5.7	68%		0.50	< 0.05		0.014	0.059	
9/17/01	8.1	92%		0.44	0.25		0.015	0.027	
10/22/01	9.2	98%		0.34	0.27		0.011	0.023	
11/13/01	10.0	102%		0.51	0.75		0.012	0.060	
2/13/02	10.6	90%	0.07	0.90	0.69		0.029	0.130	
2/13/02			0.08	0.88	0.68		0.027	0.122	
3/20/02	10.8	109%	0.08	0.43	0.55		0.015	0.096	
3/20/02			0.08	0.43	0.55		0.015	0.097	
4/17/02	10.1	125%	0.08	1.14	< 0.05		0.018	0.132	
4/17/02	10.1	125%	0.06	1.13	< 0.05		0.018	0.135	
5/14/02	9.6	97%							
5/14/02	9.6	97%							
6/12/02	9.5	125%	< 0.05	0.72	< 0.05		0.022	0.126	
6/12/02	9.5	125%	< 0.05	0.80	< 0.05		0.025	0.129	
7/17/02	7.4	103%	< 0.05	0.79	< 0.05		0.009	0.073	

Sample Date	DO (mg/L)	DO Percent Saturation (%)	Ammonia Nitrogen, laboratory (mg/L)	Total Kjeldahl Nitrogen (mg/L)	Nitrate Nitrogen (mg/L)	Nitrite + Nitrate Nitrogen (mg/L)	Ortho Phos-phorus (mg/L)	Total Phos-phorus (mg/L)	Corrected Chloro-phyll a (ug/L)
7/17/02	7.4	103%	< 0.05	0.64	< 0.05		0.009	0.071	
8/14/02	8.4	103%	< 0.05	0.45	< 0.05		0.014	0.100	
8/14/02	8.4	103%	< 0.05	0.47	< 0.05		0.014	0.098	
10/23/02	8.8	83%	0.07	0.57	0.20		0.017	0.224	
11/18/02	10.5	92%	< 0.05	0.78	0.44		0.021	0.109	
1/06/03	13.0	96%	0.05	0.43	0.51		0.028	0.063	
1/06/03	13.0	96%	0.05	0.45	0.53		0.025	0.061	
2/11/03	9.2	77%	0.05	0.18	0.57		0.033	0.058	
2/11/03	9.2	77%	0.06	0.54	0.55		0.032	0.064	
3/17/03	7.9	89%	< 0.05	0.34	0.17		0.013	0.070	
3/17/03	7.9	89%	< 0.05	0.40	0.17		0.014	0.053	
5/27/03	9.6	112%	< 0.05	0.84	0.05		0.011	0.086	
5/27/03	9.6	112%	< 0.05	0.92	0.06		0.011	0.089	
6/30/03	8.5	106%	< 0.05	0.67	< 0.05		0.015	0.107	18.1
6/30/03	8.5	106%	< 0.05	0.71	< 0.05		0.015	0.102	
8/05/03									5.5
8/06/03	9.5	60%	< 0.05	0.53	< 0.05		0.009	0.040	
8/06/03	9.5	60%	< 0.05	0.50	< 0.05		0.009	0.041	
9/08/03	8.0	92%	< 0.05	0.46	< 0.05		0.008	0.035	
9/08/03	8.0	92%	< 0.05	0.50	< 0.05		0.008	0.039	
10/15/03	9.7	102%	< 0.05	0.65	0.50		0.017	0.062	
10/15/03	9.7	102%	< 0.05	0.55	0.50		0.017	0.059	
11/24/03	8.5	59%	< 0.05	0.33	0.77		0.017	0.043	
1/28/04	17.5	139%	< 0.05	0.85	0.71		0.038	0.103	
1/28/04	17.5	139%	< 0.05	0.84	0.70		0.039	0.104	
2/09/04	11.3	87%	0.07	0.45	0.79		0.022	0.087	
2/09/04	11.3	87%	< 0.05	0.57	0.79		0.023	0.078	
3/15/04	9.9	92%	0.09	0.77	0.46		0.058	0.113	
3/15/04	9.9	92%	0.10	0.78	0.47		0.059	0.105	
4/26/04	9.6	111%	0.06	0.78	0.14		0.022	0.130	
4/26/04	9.6	111%	0.07	0.74	0.13		0.021	0.130	
6/01/04	8.8	10%	0.06	1.21	< 0.05		0.038	0.171	75.0
6/01/04	8.8	100%	0.07	1.20	< 0.05		0.034	0.169	84.4
7/06/04	7.3	87%	0.07	1.09	< 0.05		0.050	0.265	24.2
7/06/04	7.3	87%	0.07	1.11	< 0.05		0.059	0.281	25.0
8/10/04	7.0	83%	< 0.05	0.66	< 0.05		0.014	0.063	13.0
8/10/04	7.0	83%	< 0.05	0.71	< 0.05		0.014	0.062	
9/14/04	6.8	78%	0.05	0.52	< 0.05		0.006	0.048	20.6
9/14/04	6.8	78%	0.05	0.56	< 0.05		0.006	0.049	21.3
10/18/04	9.6	94%	0.08	0.67	0.20		0.025	0.111	17.2
10/18/04	9.6	94%	0.07	0.65	0.21		0.026	0.099	15.4
12/06/04	10.2	86%	0.12	0.83	0.58		0.054	0.159	3.6
12/06/04	10.2	86%	0.12	0.96	0.59		0.053	0.164	
3/16/05	8.1	67%	< 0.05	0.44		0.41	0.015	0.096	7.9
3/16/05	8.1	67%	< 0.05	0.33		0.42	0.015	0.087	7.9
5/31/05	8.4	96%	< 0.05	0.59		0.09	0.013	0.083	
5/31/05	8.4	96%	< 0.05	0.69		0.07	0.013	0.079	
7/06/05	7.6	98%	0.16	0.70		< 0.05	0.017	0.106	26.5
7/06/05	7.6	98%	< 0.05	0.75		< 0.05	0.016	0.091	26.3
8/10/05	9.1	129%	< 0.05	0.67		< 0.05	0.009	0.073	14.8
8/10/05	9.1	129%	< 0.05	0.82		< 0.05	0.009	0.072	14.9
9/07/05	10.5	126%	< 0.05	1.04		< 0.05	0.017	0.138	18.0
9/07/05	10.5	126%	< 0.05	1.08		< 0.05	0.017	0.143	41.5
10/12/05	9.1	91%	0.33	1.52		0.84	0.117	0.276	12.0
10/12/05	9.1	91%	0.36	1.22		0.84	0.117	0.288	12.0
11/16/05	12.8	105%	< 0.05	0.32		0.62	0.033	0.068	4.2
11/16/05	12.8	105%	< 0.05	0.33		0.62	0.030	0.067	5.4

Sample Date	DO (mg/L)	DO Percent Saturation (%)	Ammonia Nitrogen, laboratory (mg/L)	Total Kjeldahl Nitrogen (mg/L)	Nitrate Nitrogen (mg/L)	Nitrite + Nitrate Nitrogen (mg/L)	Ortho Phos-phorus (mg/L)	Total Phos-phorus (mg/L)	Corrected Chloro-phyll a (ug/L)
1/11/06	11.8	99%	< 0.05	0.49		0.84	0.031	0.072	4.5
1/11/06	11.8	99%	< 0.05	0.45		0.84	0.031	0.072	5.3
2/15/06	10.3	81%	< 0.05	0.54		0.82	0.030	0.074	12.1
2/15/06	10.3	81%	< 0.05	0.58		0.82	0.031	0.070	4.0
3/29/06	7.7	74%	< 0.05	0.66		0.40	0.034	0.127	8.8
3/29/06	7.7	74%	< 0.05	0.66		0.40	0.035	0.119	9.0
4/24/06	8.1	106%	< 0.05	0.91		0.14	0.017	0.103	22.9
4/24/06									24.5
4/25/06	9.1	106%	0.05	0.73		0.17	0.016	0.101	
5/30/06	4.9	62%	0.37	3.05		0.33	0.113	0.855	18.1
5/30/06	4.9	62%	0.37	3.02		0.36	0.121	0.860	22.5
7/12/06	6.0	79%	< 0.05	0.90		< 0.05	0.018	0.097	
7/12/06	6.0	79%	< 0.05	0.88		< 0.05	0.018	0.097	
8/08/06	7.9	124%	< 0.05	0.94		< 0.05	0.038	0.072	
8/08/06	7.9	124%	< 0.05	0.97		0.06	0.007	0.070	
9/13/06	9.7	114%	< 0.05	0.80		0.34	0.072	0.181	34.9
9/13/06	9.7	114%	< 0.05	0.73		0.52	0.072	0.179	37.2
10/25/06	10.8	117%	< 0.05	0.47		1.75	0.075	0.118	
10/25/06	10.8	117%	< 0.05	0.39		1.74	0.075	0.110	
1/10/07	12.3	95%	< 0.05	0.93		0.53	0.065	0.104	
1/10/07	12.3	95%	0.14	0.88		0.53	0.067	0.100	
2/28/07	11.5	120%	< 0.05	0.56		0.46	0.020	0.098	
3/28/07	7.9	85%	0.18	2.10		0.19	0.125	0.905	
5/02/07	8.8	102%	< 0.05	1.17		0.13	0.073	0.220	
6/06/07	9.3	117%	< 0.05	1.69		< 0.05	0.029	0.218	
7/11/07	10.1	128%	0.09	1.51		0.15		0.225	
8/08/07			0.05	1.27		0.12		0.104	
9/12/07	8.0	96%		0.83		0.63		0.177	
10/17/07	9.7	102%		1.20		0.71		0.223	
1/30/08	13.0	105%	0.25	0.58		1.01		0.086	
2/27/08	12.4	104%	0.16	0.80		0.87		0.138	
3/31/08	7.4	76%				0.70			
5/07/08	10.0	112%		0.95		0.52		0.146	
7/14/08				1.53		0.48		0.351	

No. of values =	130	126	124	133	88	47	125	134	36
Minimum =	4.9	5%	< 0.05	< 0.05	< 0.05	< 0.05	< 0.005	< 0.005	3.6
Median =	9.5	96%	0.05	0.66	0.16	0.40	0.020	0.101	16.3
Maximum =	19.8	150%	0.37	3.05	1.26	1.75	0.146	0.905	84.4

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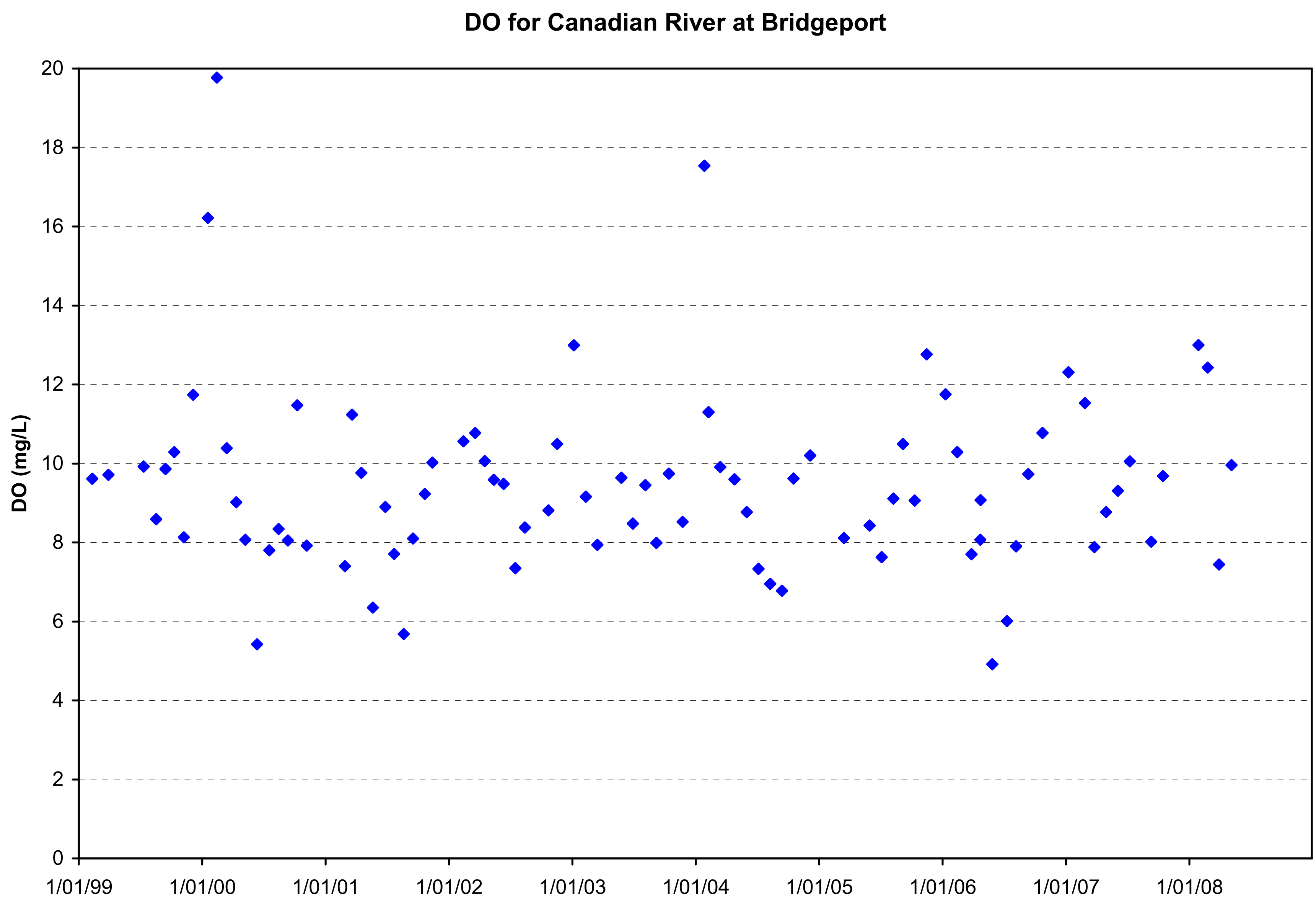
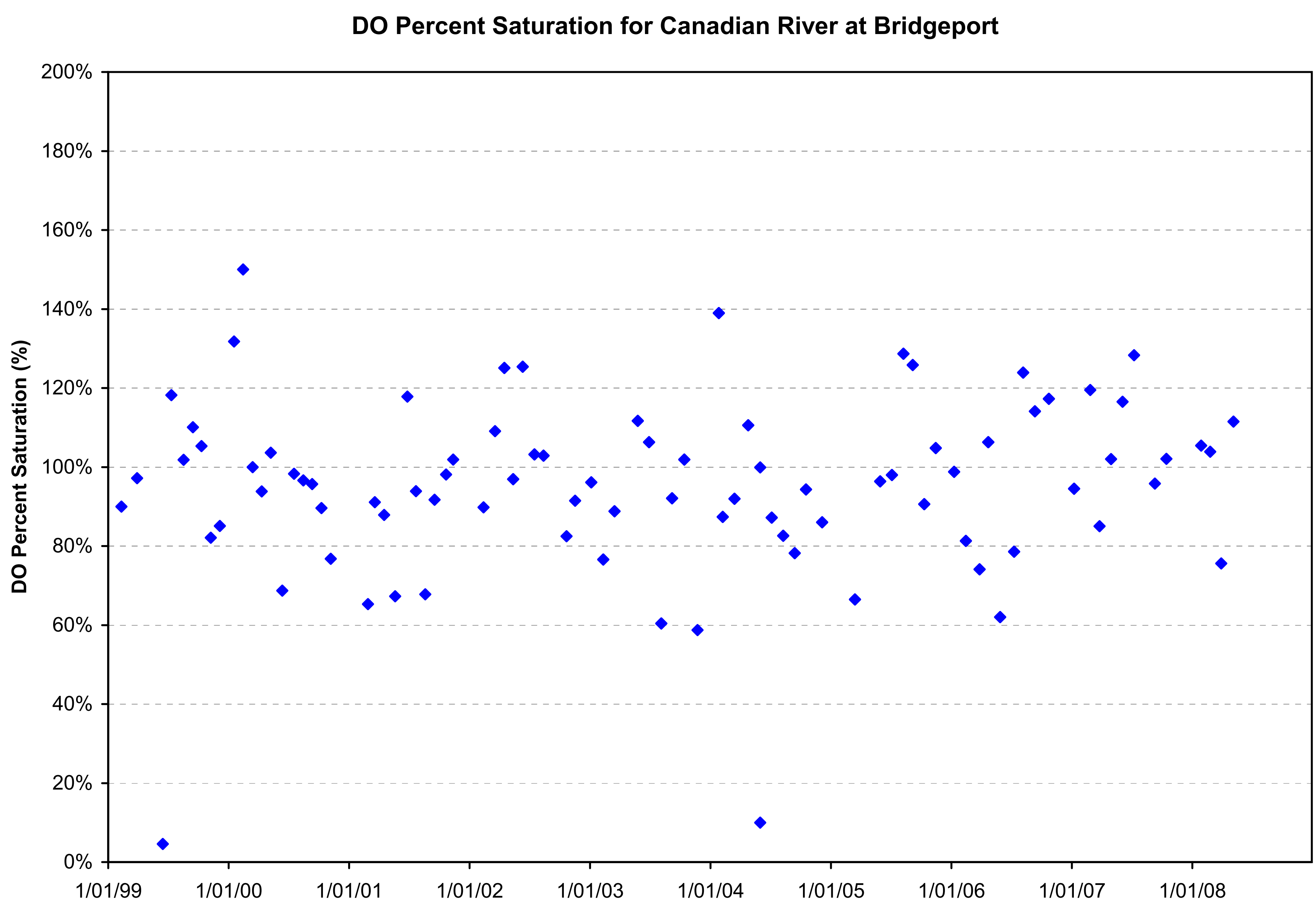
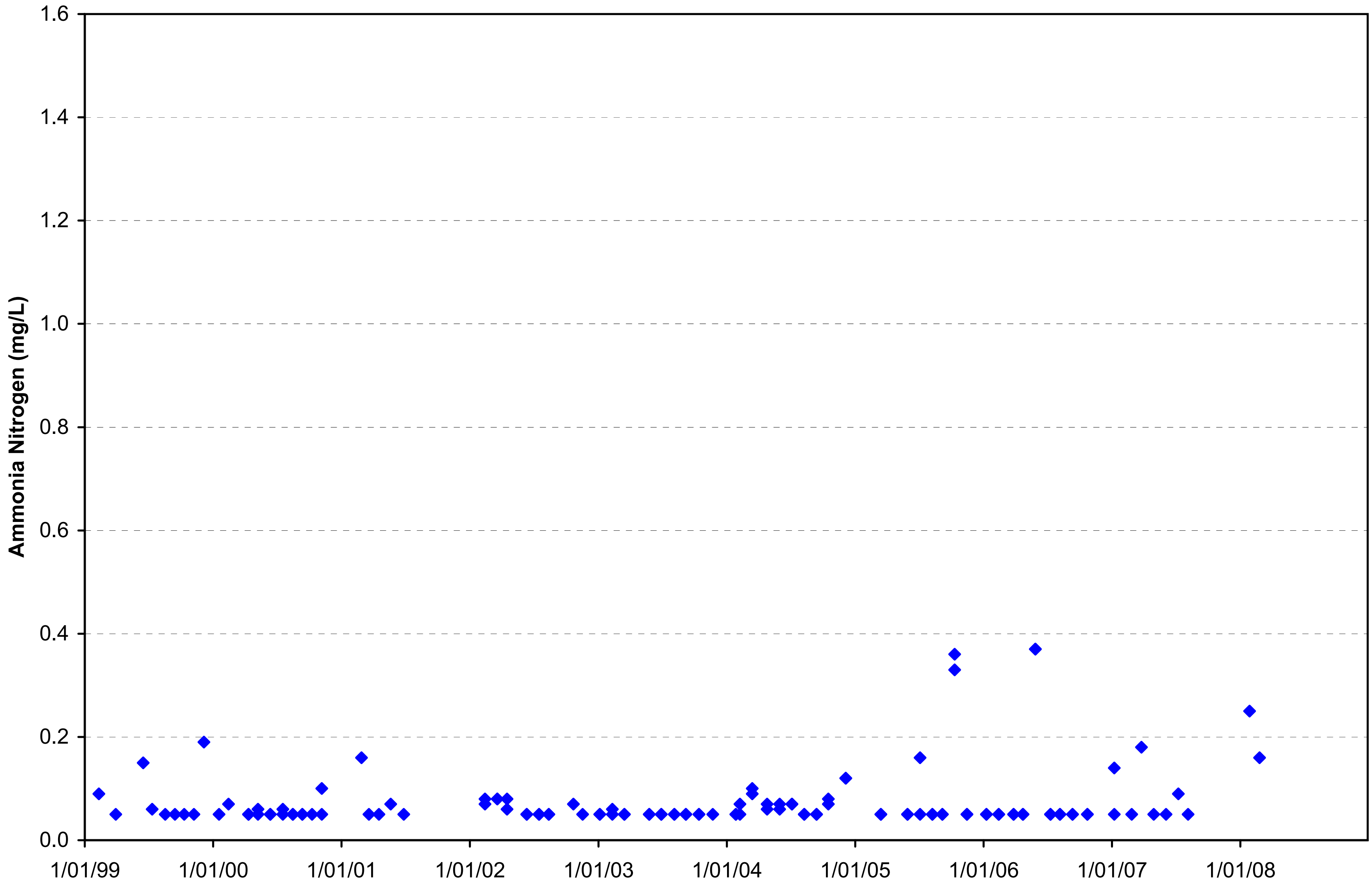
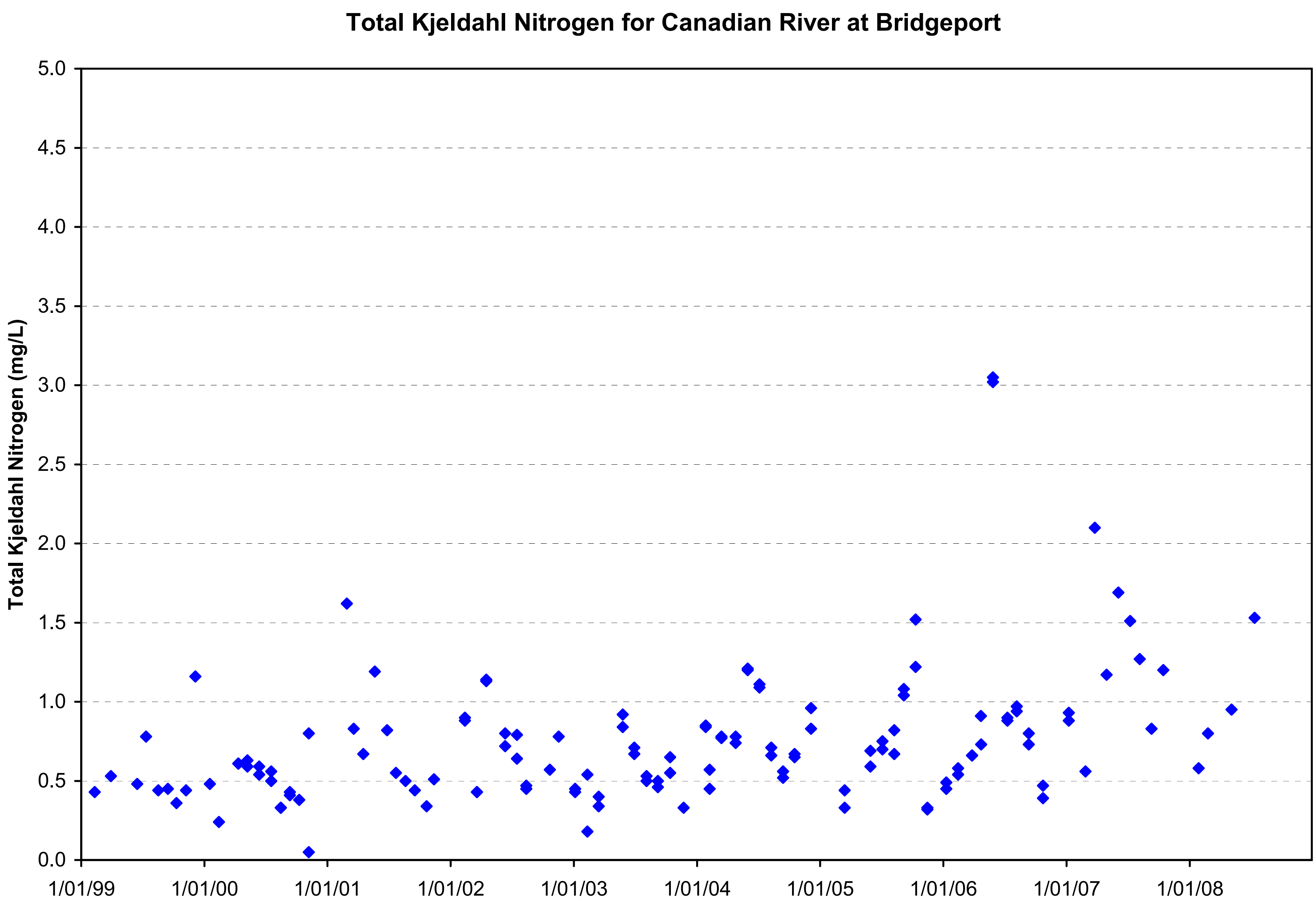

DO for Canadian River at Bridgeport
DO (mg/L)
0
2
4
6
8
10
12
14
16
18
20
1/01/99
1/01/00
1/01/01
1/01/02
1/01/03
1/01/04
1/01/05
1/01/06
1/01/07
1/01/08

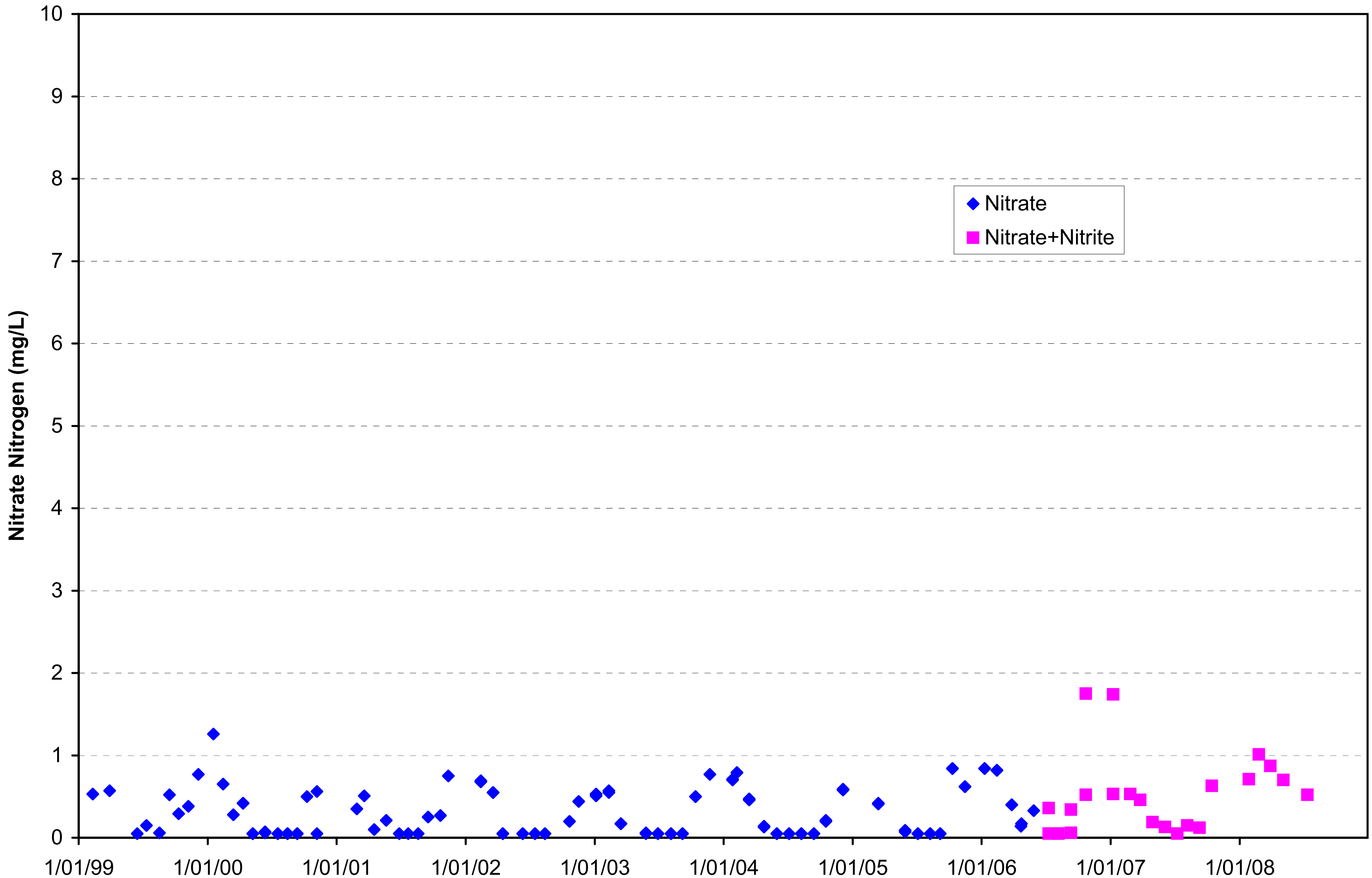

DO Percent Saturation for Canadian River at Bridgeport
DO Percent Saturation (%)
200%
180%
160%
140%
120%
100%
80%
60%
40%
20%
0%
1/01/99
1/01/00
1/01/01
1/01/02
1/01/03
1/01/04
1/01/05
1/01/06
1/01/07
1/01/08

Ammonia Nitrogen for Canadian River at Bridgeport

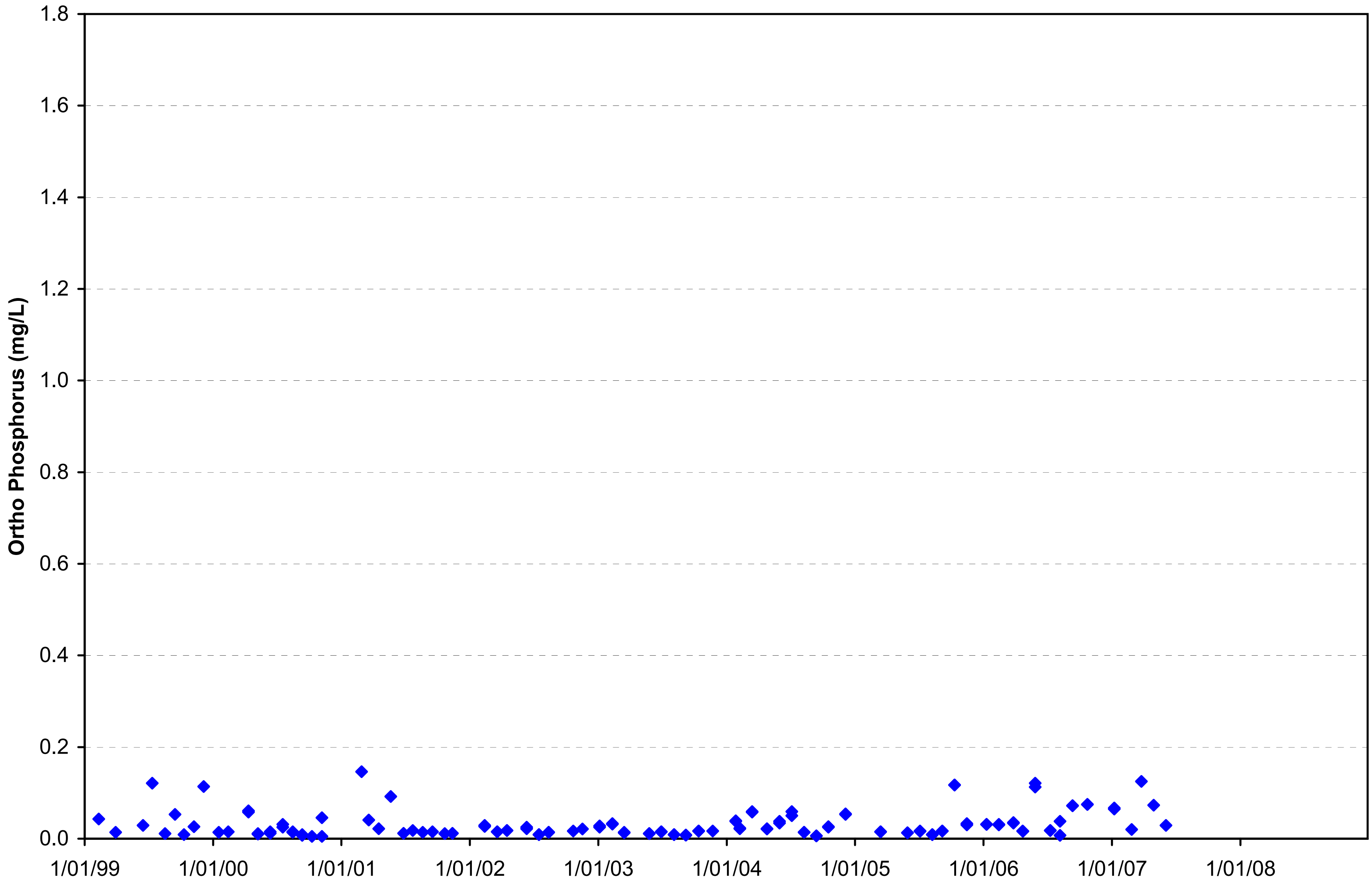



Total Kjeldahl Nitrogen for Canadian River at Bridgeport
Total Kjeldahl Nitrogen (mg/L)
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
1/01/99
1/01/00
1/01/01
1/01/02
1/01/03
1/01/04
1/01/05
1/01/06
1/01/07
1/01/08

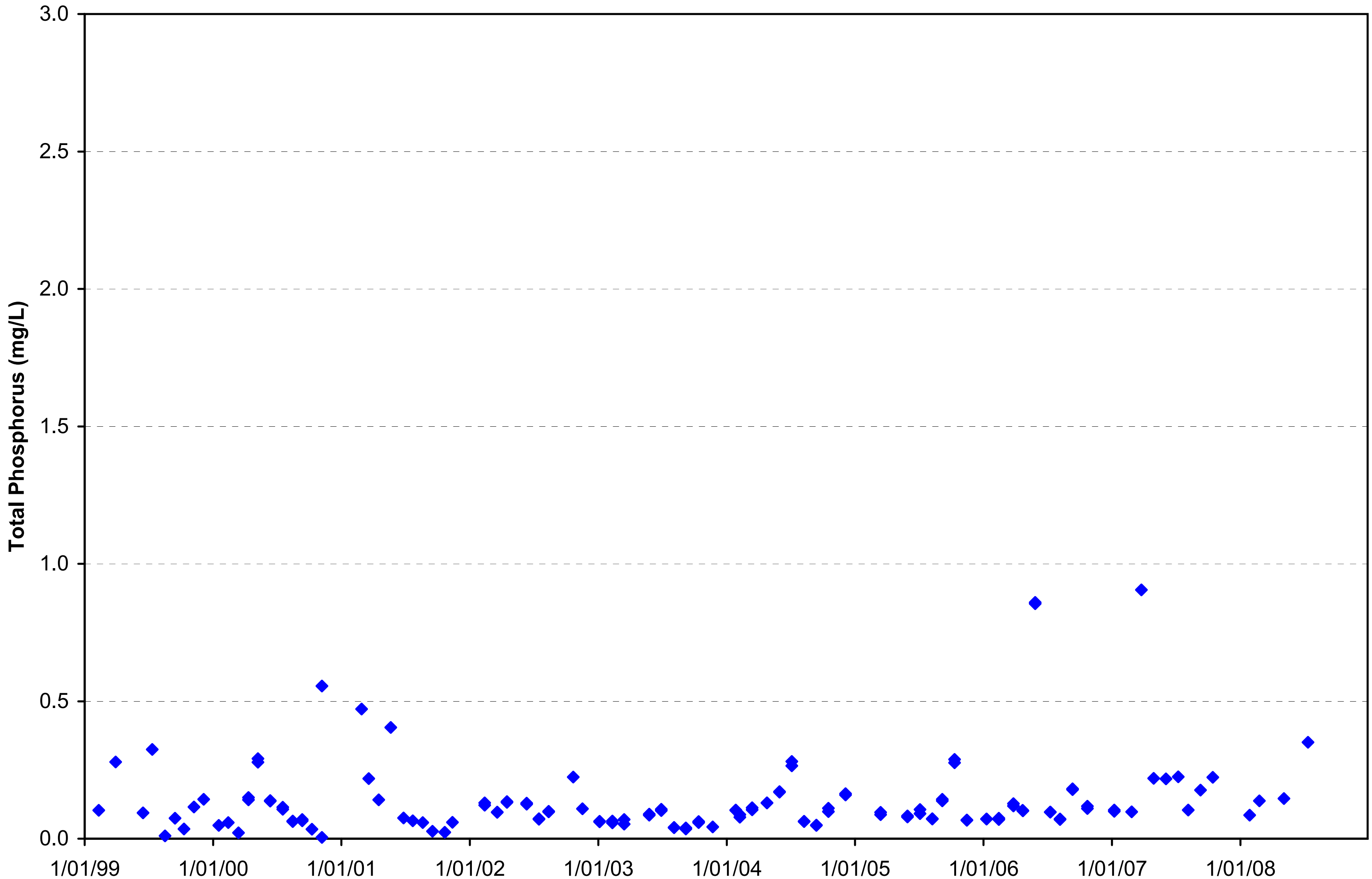
Nitrate Nitrogen for Canadian River at Bridgeport

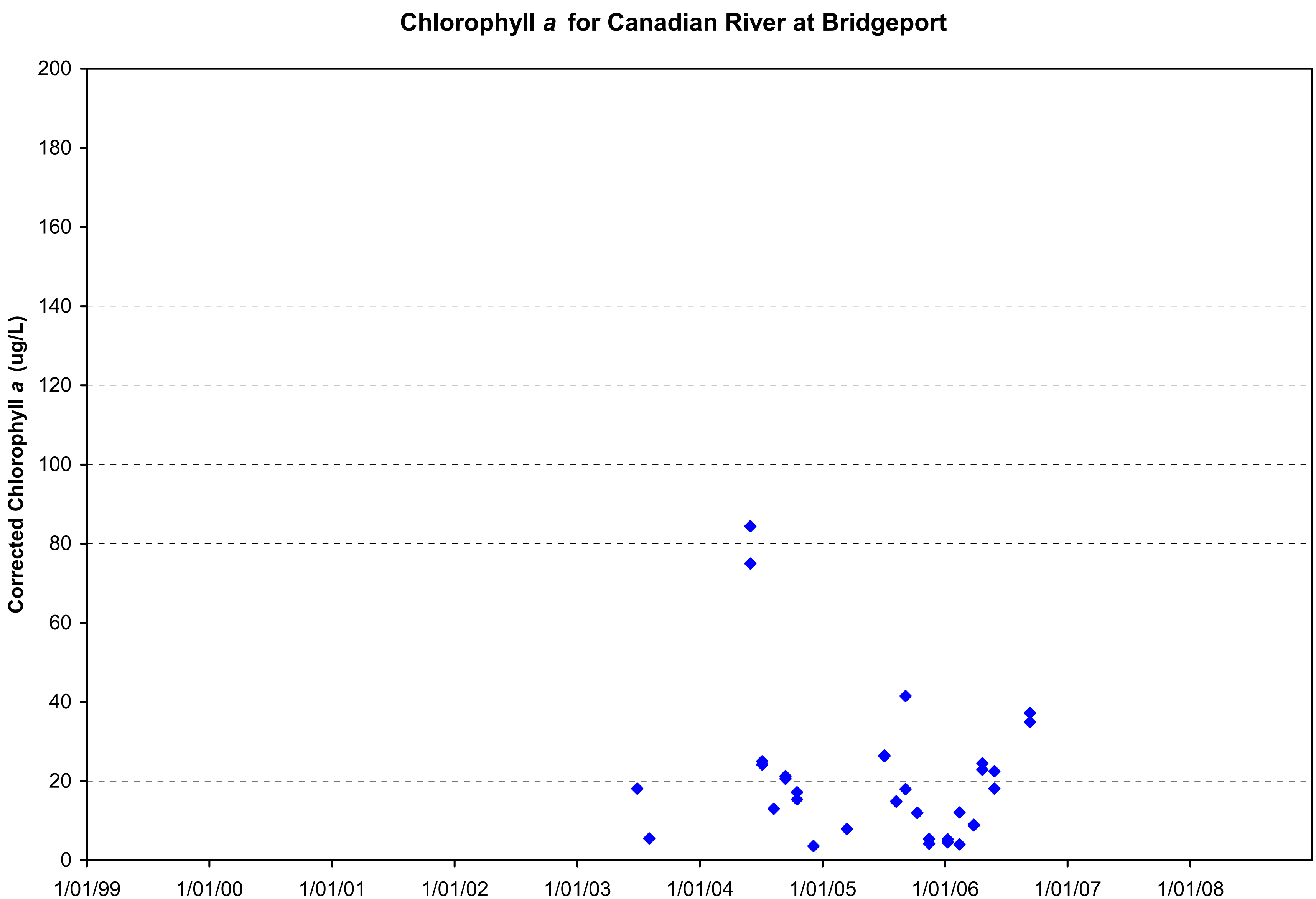


Ortho Phosphorus for Canadian River at Bridgeport



Total Phosphorus for Canadian River at Bridgeport



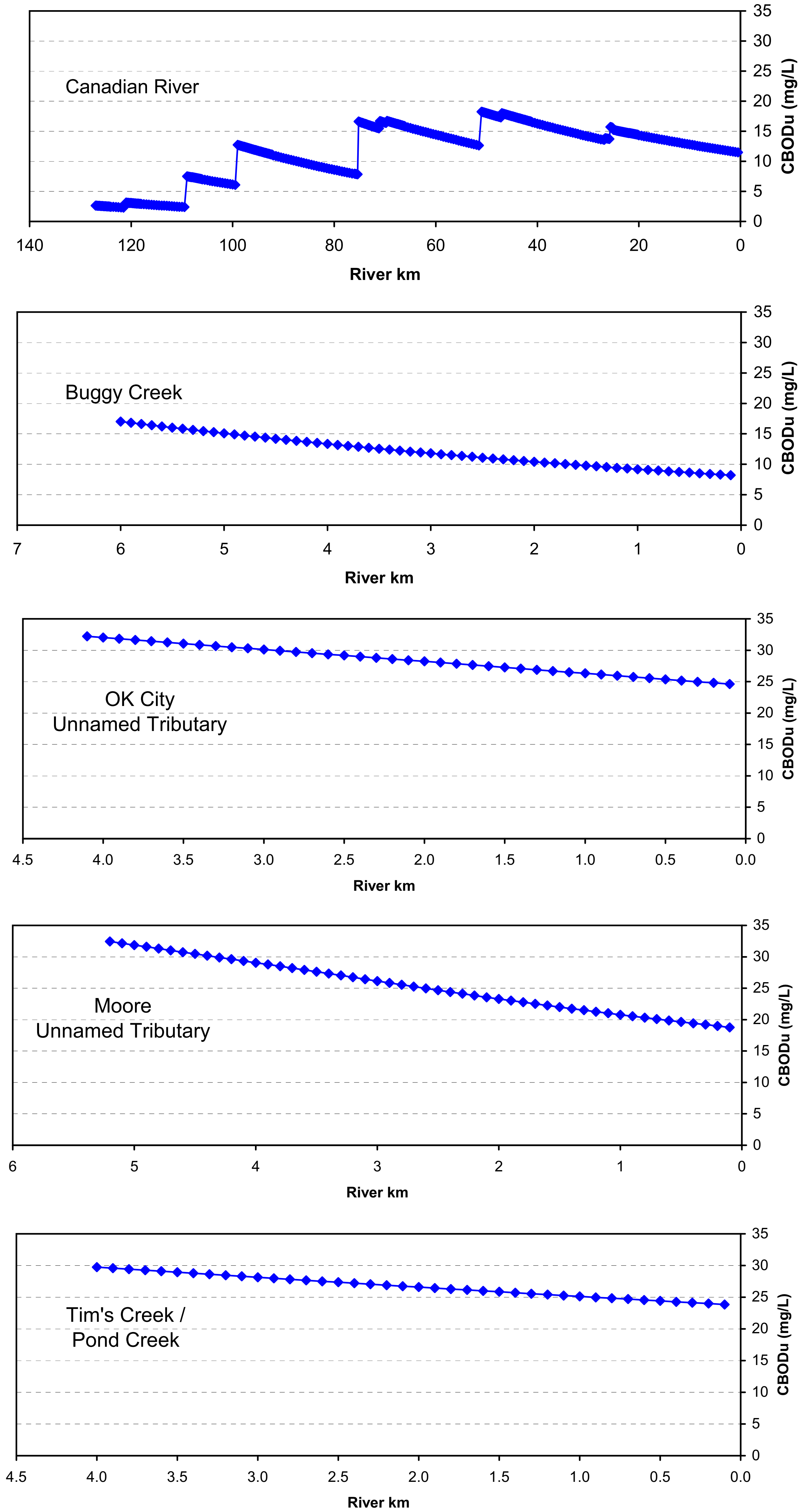


Chlorophyll *a* for Canadian River at Bridgeport
Corrected Chlorophyll *a* (ug/L)
200
180
160
140
120
100
80
60
40
20
0
1/01/99
1/01/00
1/01/01
1/01/02
1/01/03
1/01/04
1/01/05
1/01/06
1/01/07
1/01/08

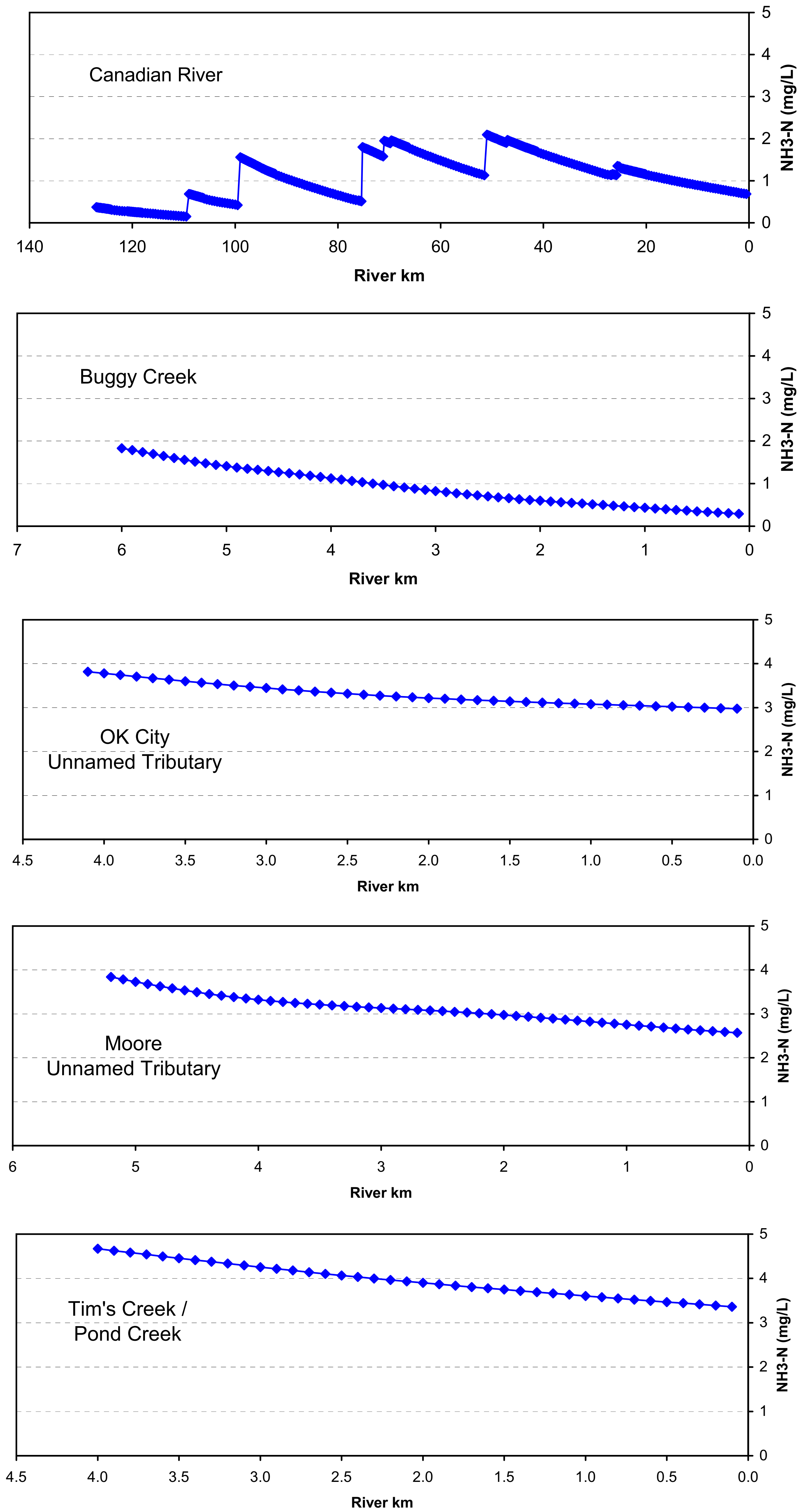
APPENDIX C

GRAPHS OF PREDICTED CONCENTRATIONS FROM THE WASP MODEL

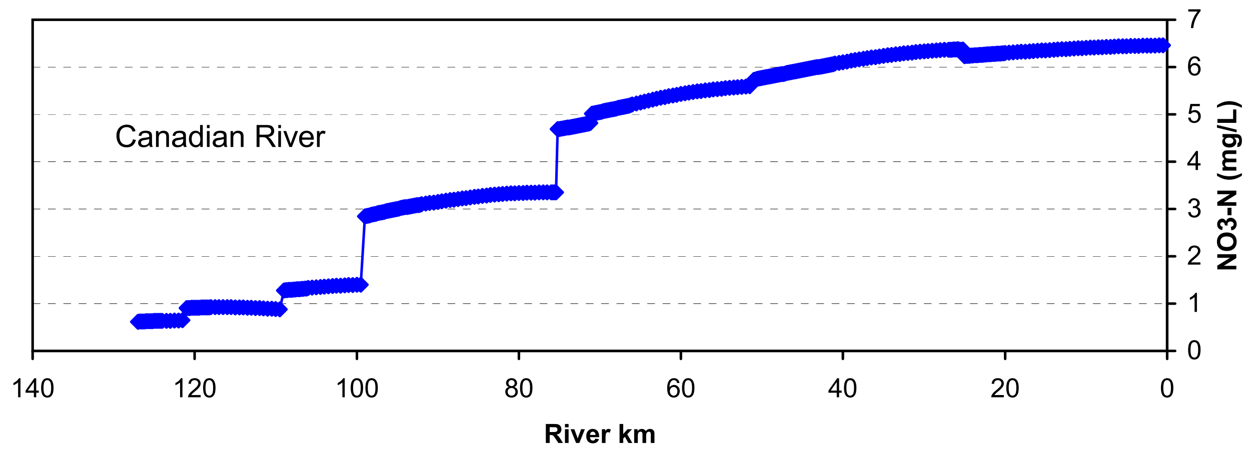
Effluent CBODu from Desktop WASP Model

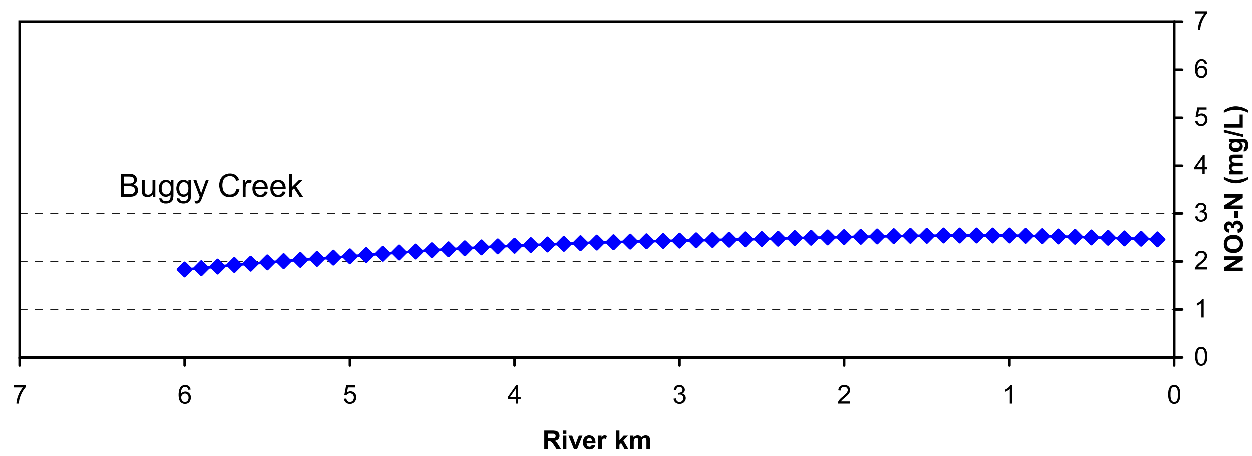


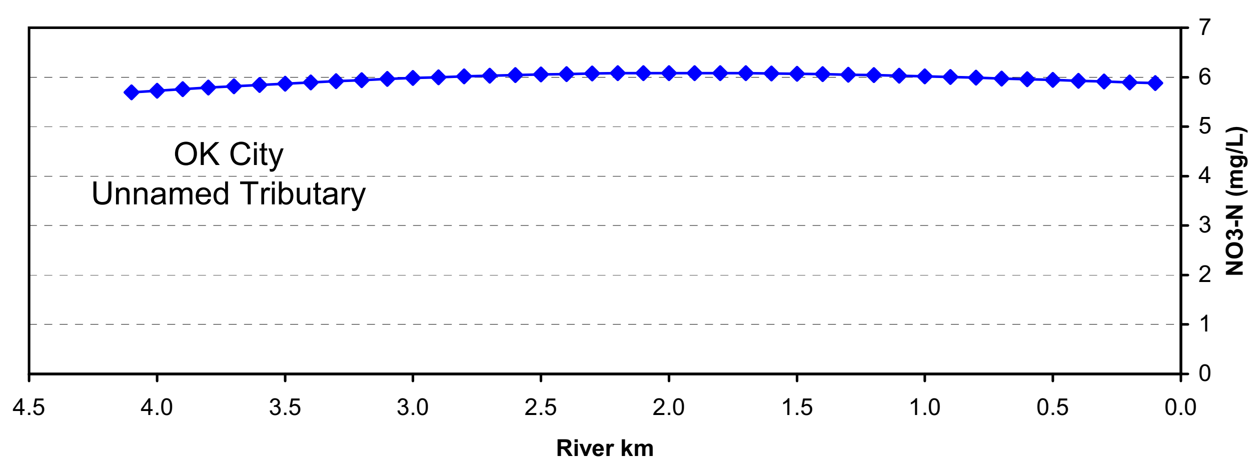
Ammonia Nitrogen from Desktop WASP Model

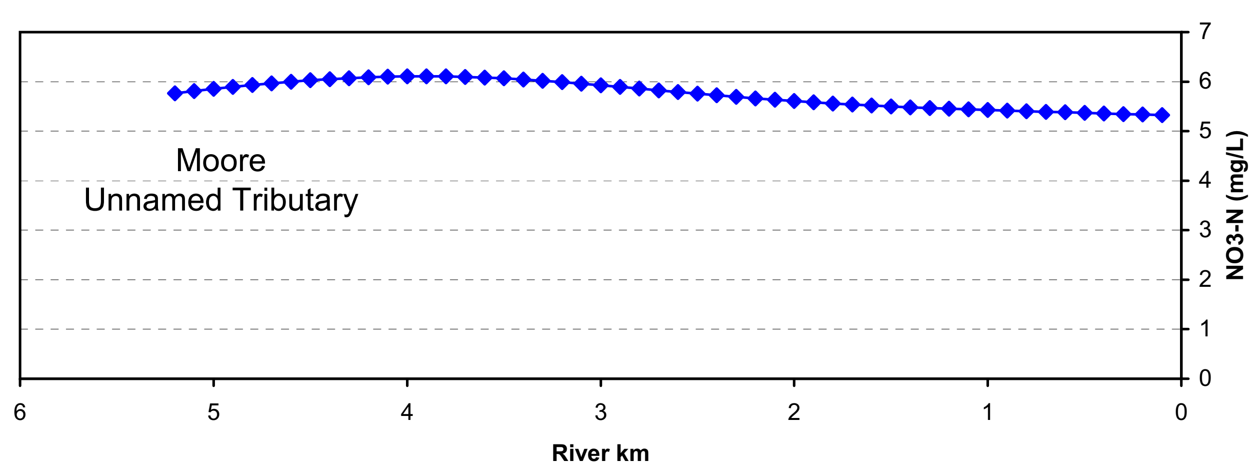


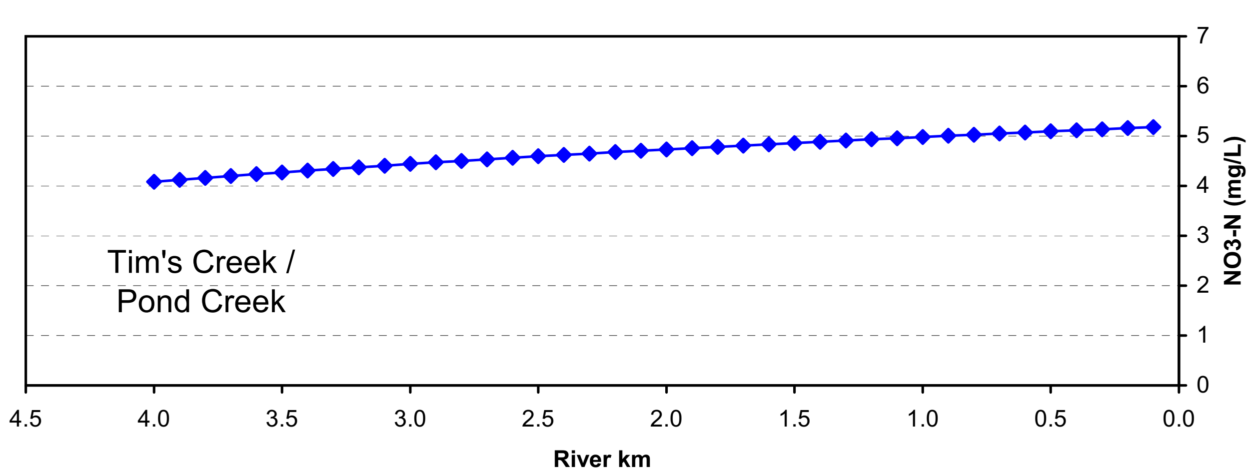
Nitrate Nitrogen from Desktop WASP Model



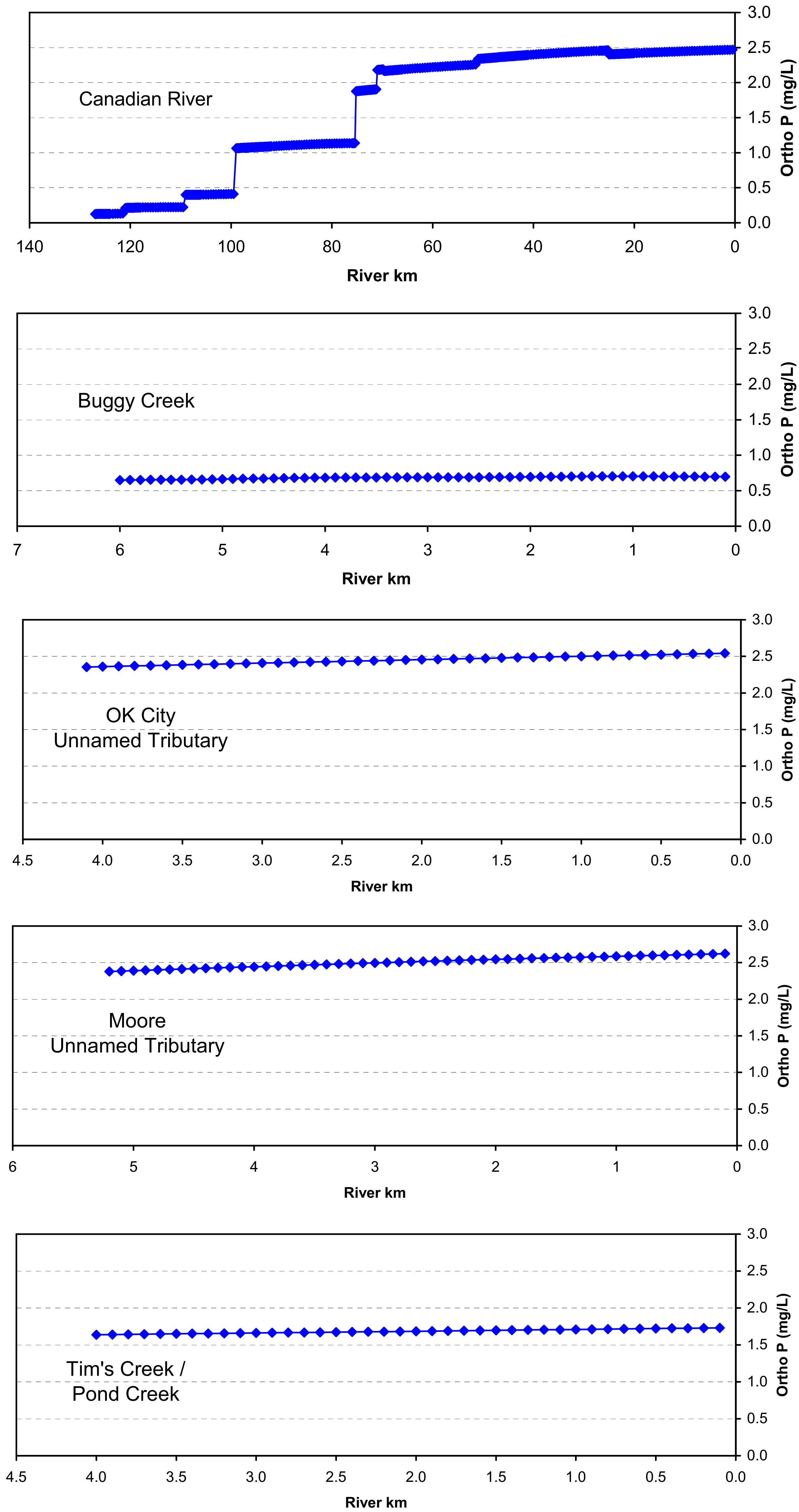




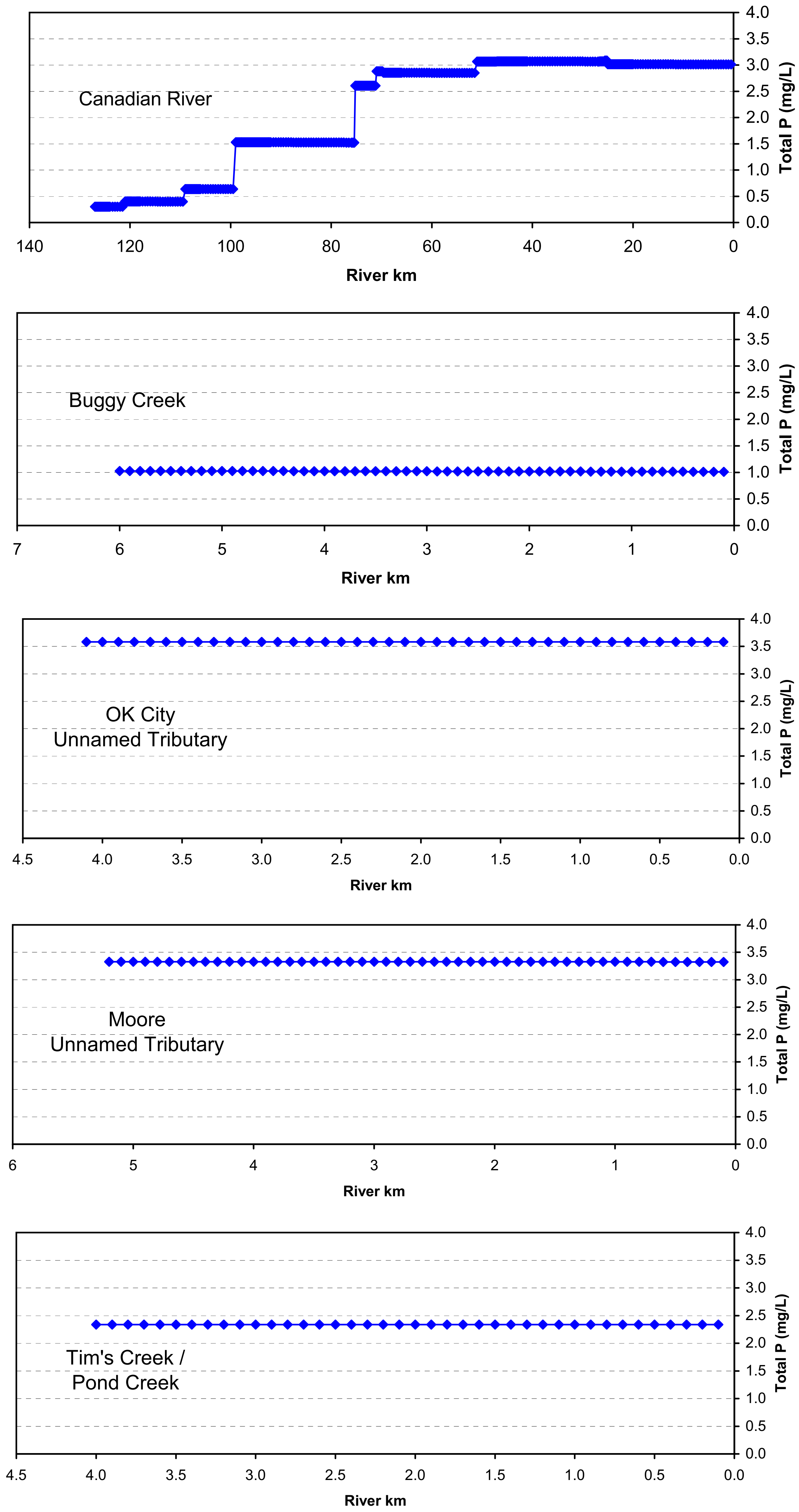




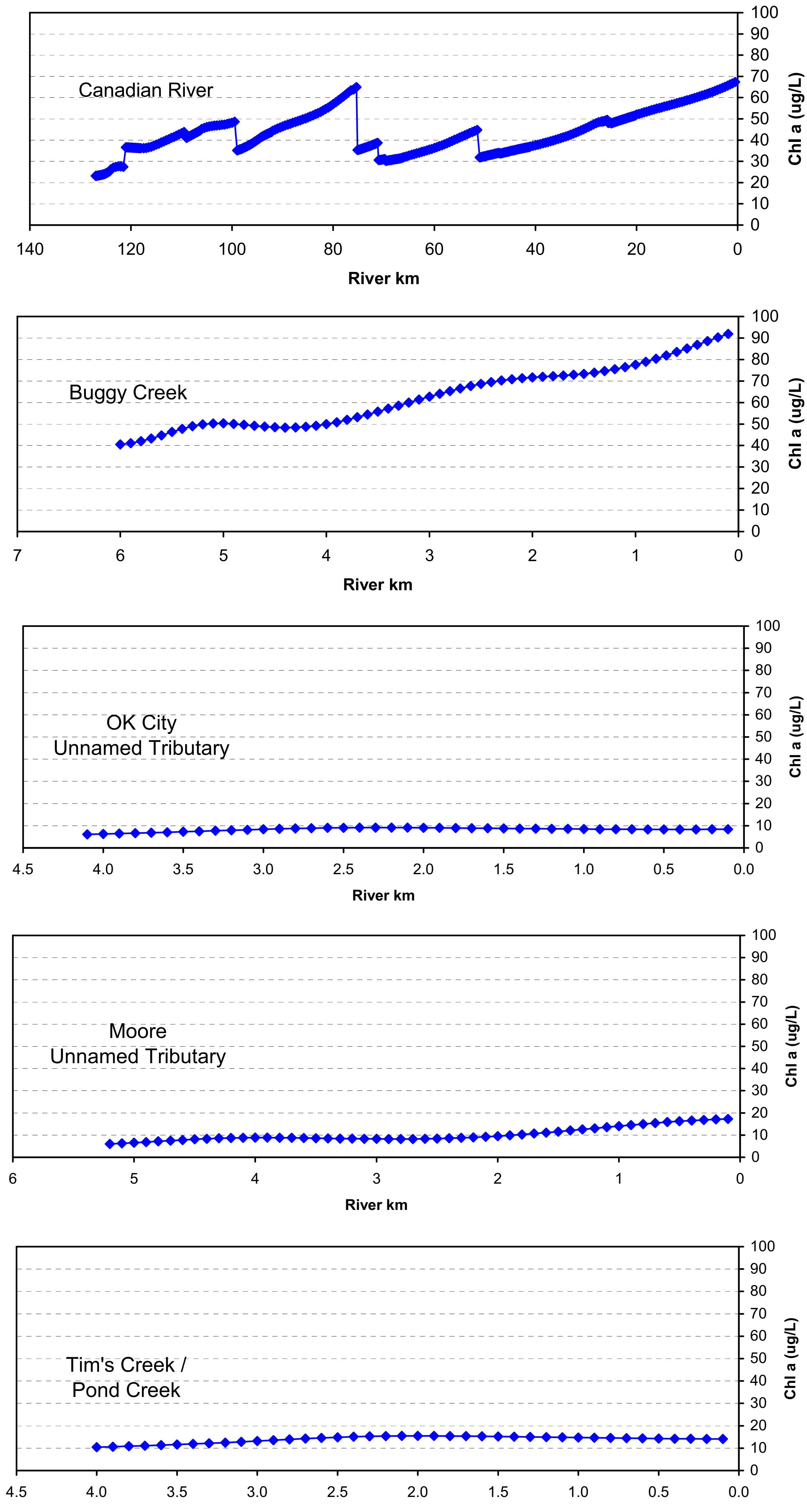
Ortho Phosphorus from Desktop WASP Model



Total Phosphorus from Desktop WASP Model



Chlorophyll *a* from Desktop WASP Model



DO from Desktop WASP Model