Water Quality Assessment

FINAL REPORT TASK 4
WATER QUALITY DATA FOR THE ARKANSAS RIVER CORRIDOR PROJECT, TULSA, OKLAHOMA
W912BV-06-P-0303

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Acronyms

ARC	Arkansas River Corridor
ASL	Above Sea Level
AVG	Average
BUMP	Beneficial Use Monitoring Program
C	Celsius
Colif	Coliform
CWA	Clean Water Act
F	Fahrenheit
FIPS	Federal Information Processing Standard
GIS	Geographical Information System
GPD	Gallons Per Day
HUC	Hydrologic Unit Code
HRDNSS	Hardness
INCOG	Indian Nations Council of Governments
MGD	Million gallons per day
MG/L	milligrams per liter
N	Nitrogen
NAD83	North American Horizontal Datum
NAVD88	North American Vertical Datum
NPDES	National Pollutant Discharge Elimination System
NTU	Nephelometric Turbidity Units
ODEQ	Oklahoma Department of Environmental Quality
OK	Oklahoma
OPDES	Oklahoma Pollutant Discharge Elimination System
OWRB	Oklahoma Water Resources Board
PCS	Permit Compliance System
S	Sulfate
SDSFIE	Spatial Data Standards for Facilities, Infrastructure, and the Environment
TMDL	Total Maximum Daily Load
UG/L	micrograms per liter
USAP	Use Support Assessment Protocols
USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey
USACE	United States Army Corps of Engineers
WQS	Water Quality Standards

Abstract

The Arkansas River's natural water quality has caused it to be largely abandoned as a source of municipal/industrial and public water supply. In general, the river's water quality is greatly influenced by the mineral and salt concentrations of the Salt Fork, Cimarron and Canadian tributaries draining into it from across western Oklahoma. However, within the 42-mile long study area from the Keystone Dam to the Tulsa/Wagoner County line certain physical and chemical constituents of the river are typical of other streams' water quality within the United States. This would include pH, temperature, alkalinity, hardness, chloride, sulfate, total dissolved solids, heavy metal concentrations and others. In addition, the Oklahoma Water Resources Board's beneficial use determinations and the US Environmental Protection Agency's Water Quality Standards for the river are being supported and/or met, respectively. This is substantiated by three Oklahoma Water Resources Board's monitoring stations, five City of Tulsa monitoring stations, and seven years of recent water quality data. Throughout most of the study area, the river is supported for the Oklahoma Water Resources Board's designated beneficial uses that include; Emergency Water Supply, Warm Water Aquatic Community, Agriculture, and Aesthetic Quality. This also includes the river not being Nutrient Threatened. The water quality of the river is also influenced by anthropogenic (manmade) sources of pollution mostly in the form of biological constituents. Thus, the Oklahoma Water Resources Board's beneficial use for Primary Body Contact—Recreation is variously impaired or not impaired throughout most of the study area because of fecal coliform, E. Coli and Enterococci bacteriological concentrations and number of occurrences. The industrial facilities located along the river within the study area includes; nine (9) wastewater treatment plants, three (3) public electricity generation utilities, nine (9) sand & gravel operations or concrete batch operations, two (2) petroleum refineries, one (1) petroleum pipeline, one (1) paper product manufacturer, and three (3) chemical product manufacturers or processors. These industrial facilities are permitted under the US Environmental Protection Agency's National Pollutant Discharge Elimination System or the Oklahoma Pollutant Discharge Elimination System. In general, because of the long-standing success of the state's permitting program, the Oklahoma Water Resources Board's beneficial use criteria and the US Environmental Protection Agency's Water Quality Standards (where applicable) are still being met within the 42-mile study area.

Arkansas River Corridor (ARC) Water Quality Data Report

Purpose of Study

The Greater Tulsa Area communities recognize the Arkansas River Corridor (ARC) is an important natural resource that could be developed to stimulate immense private investment and greatly improve the quality of life for current and future generations. A Tulsa County, one-penny, 13-year sales tax was approved to support this vision (Vision 2025) with a portion of the tax devoted to studies and improvements along the ARC. The Indian Nations Council of Governments (INCOG) directed and oversaw the development of an ARC Master Plan/Phase I Vision Plan that was completed in August 2004. The US Army Corps of Engineers (USACE), Tulsa District and INCOG developed a Phase II Master Plan and Pre-Reconnaissance Study in October of 2005. Some of the objectives of the Phase II Plan involved addressing potential environmental issues. This led to a letter agreement between Tulsa County, the Oklahoma Water Resources Board (OWRB) and the USACE Tulsa District to inventory, assess and evaluate environmental data for the Arkansas River from the Keystone Dam to the Tulsa/Wagoner County line, a 42-mile long corridor. The environmental initiatives included a: 1) faunal and floral inventory; 2) fish community structure and composition assessment; 3) aquatic macro-invertebrate structure and composition; 4) water quality data assessment; 5) and cultural resource evaluation. This report is specific to the water quality data assessment.

This ARC water quality data assessment was conducted in 2006/07 and included the compilation, analysis and synopsis of existing water quality data. The water quality data was compiled from available published reports and scientific literature produced by municipal agencies, county agencies, state agencies, federal agencies, and private industry. A thorough analysis of the existing water quality data produced this synopsis (report) of the current water quality conditions within the study area. The study area was defined as the 42-mile long corridor of the Arkansas River within Tulsa County from the Keystone Dam to the Tulsa/Wagoner County line **(Figure 1)**. In addition to the analysis and synopsis of the water quality data, this study included a supporting GIS database for mapping. The GIS database and mapping format was designed to be compatible with the USACE and county agency mapping formats. The GIS database and mapping format used for this study was based on state of Oklahoma's FIPS 3501 (feet), NAD83 horizontal datum plane and NAVD88 vertical datum plane coordinate system. The GIS database format also included all of the appropriate features that support the USACE's Spatial Data Standards for Facilities, Infrastructure, and the Environment (SDSFIE) Release 2.5 requirements.

Introduction

In order to adequately assess the ARC (42-mile study area) one must first understand the basics of water quality measurements as well as the natural chemistry of surface water. It is also important to understand the basic characteristics of the Arkansas River as a whole. Secondly, it is important to understand the specific characteristics of the river within the study area. These specific characteristics include the climate, physiography, geology, soils, natural vegetation, hydrology, and watersheds. Another characteristic to understand is the impact to the river by man (anthropogenic influences). So, it is important to identify the demographic characteristics within the study area. These demographic characteristics include the population distribution, municipalities, land use, water use, man-made structures, and environmental influences.

FIGURE 1

Arkansas River Corridor; 42-Mile Study Area & Watersheds

Tulsa County, Oklahoma

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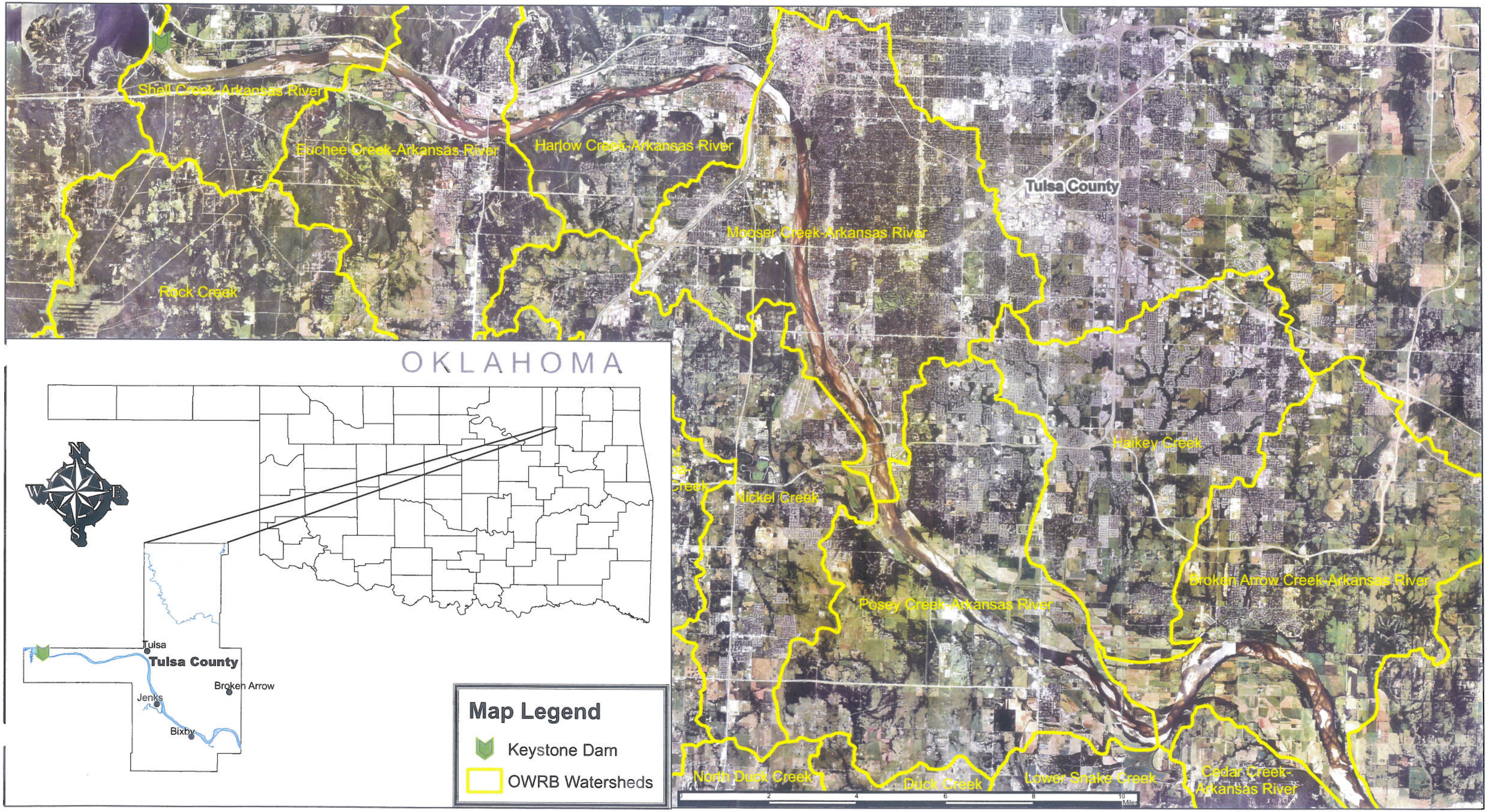

A final understanding necessary to assessing the water quality of the study area involves identifying the governing state and federal water quality standards and regulations. These state and federal standards and regulations dictate how a water body must be protected, the frequency of monitoring, and the required types of physical, biological and chemical analysis. The governing agencies include the OWRB and the United States Environmental Protection Agency (USEPA). The USEPA and the Oklahoma Department of Environmental Quality (ODEQ) also regulate what type of discharges are allowed into a river and who must be permitted to discharge into a river **(USEPA, Permit Compliance System [PCS], 2007)**. Finally, the surface water data must be assessed to establish a current and relevant baseline of the water quality.

Water Quality Measurements

Water quality is a term used to describe the physical, biological, chemical characteristics and general composition of water. These characteristics affect the ability of a water body to sustain life and determine the suitability for human consumption. They can be naturally occurring or have an anthropogenic (manmade) source. The complexity of water quality as a subject is reflected by the many types of measurements of water. These measurements can be simple to complex. Most of the simple measurements can be made on-site in the field, in direct contact with the water. The more complex measurements have to be measured in a laboratory setting. These require a water sample to be collected, preserved, and analyzed. The physical, chemical and biological measurements include, but are not limited to; temperature, color, taste/odor, pH, alkalinity, conductivity, dissolved oxygen, turbidity, total suspended solids, chemical oxygen demand, biochemical oxygen demand, microorganisms, nutrients, dissolved metals/metalloids, dissolved organics, pesticides and heavy metals **(Hem, 1986)**.

Surface water analysis is intended to reflect the actual composition of the water whether it is a physical, biological or chemical characteristic and whether it is measured directly or indirectly. The physical characteristics can be measured or observed directly such as stream width, stream depth, stream flow, sample depth, temperature, color, canopy cover, odor, and other similar observations. Likewise, the measurement of the biological characteristics (e.g., fecal coliform, E. coli, Enterococci) would be a direct and/or physical measurement of the number of colonies per a given water volume. On the other hand, the chemical characteristics of surface water are more complex and require measurements made by more indirect methods and sophisticated instrumentation. For example, dissolved oxygen uses an electrode to measure the partial pressure of oxygen in the water and a similar measurement for its percent saturation takes temperature into account. In addition, while some inorganic compounds exist in solution as uncharged molecules (silica, SiO_2) others dissociate into cations (e.g., ammonium ion, NH_4^{+1}) and anions (e.g., nitrate ion, NO_3^{-1}). Another example would be hardness and alkalinity titrations which are usually measured as an equivalent quantity of calcium carbonate. And, the quantity of calcium carbonate (hardness & alkalinity) affects the reportable concentrations of trace heavy metals (arsenic, barium, chromium, etc.).

Chemical Characteristics of Natural Surface Water

Typically, temperature varies with surface water depending on the source, location, depth and width of the water body. However, temperature is important because of its influence on the water chemistry. The rate of chemical reactions generally increases at higher temperature, which in turn affects the biological activity. The pH of pure water at 25° Celsius is 7.00. Surface waters not influenced by pollution generally have a pH in the range of 6.5 to 8.5. The pH of water determines the solubility and biological availability of chemical constituents such as nutrients (phosphorus, nitrogen, carbon) and heavy metals. The dissolved oxygen in water is expressed in mg/l and as a percent saturation. Other associated measurements include the biochemical oxygen demand, chemical oxygen demand and oxidation/reduction potential. Dissolved oxygen concentrations around 2-3 mg/l or less pose a threat to aquatic life. Turbidity is a measurement of the fine suspended matter in water. The turbidity is measured in units that measure the light-scattering and absorbing properties of the suspended matter **(Hem, 1986)**. The Oklahoma Water Quality Standard for turbidity is 50 Nephelometric Turbidity Units (NTU) for streams and 25 NTU for lakes, and both only apply to base flow conditions.

The specific conductance (conductivity) of surface water or its ability to conduct an electrical current is dependent upon the concentration of cations (e.g., hydrogen, sodium, calcium, magnesium) and anions (e.g., hydroxide, chloride, sulfate, bicarbonate, carbonate, phosphate) in solution. Natural waters have specific conductances that are much less than one mmho/cm (mS/cm) so the values are expressed in umho/cm (uS/cm). The measurement of total dissolved solids is a measure of the ions plus the dissolved solids (e.g., inorganic acids, bases and salts). The United States Geological Survey (USGS) classifies fresh water as having 500 mg/l or less of total dissolved solids which is also the preferable concentrations for domestic use and many industrial processes **(Hem, 1986)**.

The occurrence of ions in surface waters also predicates the degree of salinity which is usually measured as sodium chloride. Chloride (anion) occurs in all natural waters but typically is low. Chloride concentrations of 10 mg/l are commonly found in natural waters in humid regions. The USEPA secondary drinking water standard for chloride is 250 mg/l as a comparative number. Another anion (sulfate) is found in natural waters as oxidized sulfides, sulfites and thiosulfates or in organic matter. It also can occur as industrial pollution (detergents, tanneries). The USEPA secondary drinking water standard for sulfate is 250 mg/l **(Hem, 1986)**.

Alkalinity is almost entirely a measurement of bicarbonate and carbonate anions expressed as an equivalent amount of calcium carbonate. It has the capacity to neutralize acid or maintain the pH at a certain level. Alkalinity values ranging from 5 to 125 mg/l are expected to be found in surface waters. Hardness is also expressed as an equivalent of calcium carbonate, but is a measurement of calcium and magnesium cations in the water. Concentrations from 0 to 50 mg/l are considered soft, 50 to 150 mg/l are moderately hard, 150 to 300 mg/l are hard, and above 330 mg/l are very hard. The degree of hardness can adversely impact industry processes and build up deposits in piping **(Hem, 1986)**.

The chemical and biological processes that transfer nitrogen to form the lithosphere, atmosphere, hydrosphere and biosphere are referred to as the nitrogen cycle. Nitrogen is an essential nutrient for plant growth. Man's influence on the nitrogen cycle includes the production of synthetic fertilizers such as ammonia and other nitrogen compounds. It can be measured as total nitrogen, Kjeldahl nitrogen, nitrate, nitrite, or ammonia. Excessive concentrations of nitrate in drinking water, greater than 10 mg/l, can cause health problems especially in small children **(Hem, 1986)**.

Phosphorous in its elemental form is insoluble in water and soils. It is found in detergents, animal waste, sewage and commercial fertilizers. In its anionic form, it is called phosphate and in water occurs as orthophosphate, polyphosphate and organically bound phosphate. Total phosphate is a measurement of all three forms. Orthophosphate is the most likely to occur in natural water **(Hem, 1986)**. When phosphates are present in the water they are capable of supporting excessive growth and high densities of plants and algae. The state of Oklahoma has a numerical criteria limit value for phosphates of 0.037 mg/l for scenic rivers.

Trace metals and/or heavy metals in surface water occur naturally and have anthropogenic sources. Anthropogenic sources can include agricultural runoff, industrial operations, electroplating, leachate from landfills, chemicals, galvanizing operations and others. As a minor constituent in surface water, concentrations for arsenic, cadmium, lead, nickel, and zinc range from 0.0001 to 0.1 mg/l or parts per million. Also as minor constituents in surface water, other concentration values and ranges are; mercury (0.5 ug/l in 32% of surface waters sampled), thallium (1.0 ug/l), silver (0.1 to 4 ug/l), selenium (less than 10 ug/l), copper (less than 20 ug/l), and chromium (1 to 100 ug/l) **(Hem, 1986)**. A microgram per liter (ug/l) equivalent expression is parts per billion.

The biological characteristics include fecal coliform, Escherichia coli (E. coli) and Enterococci. All three forms are bacteria and are present in the intestine and/or feces of warm-blooded animals. Fecal coliform generally do not pose a danger to people or animals but they indicate the potential presence of other disease-causing bacteria, such as those that cause typhoid, dysentery, hepatitis A, and cholera. Unlike fecal coliform, disease-causing bacteria generally do not survive long enough in the water or outside the body of animals to be detected. This makes their direct monitoring difficult. So, scientists and public health officials consider the presence of fecal coliform as an indicator that disease causing bacteria may be present in the water. The presence of fecal coliform, E. coli and Enterococci bacteria in water can be an indication of recent sewage or animal waste contamination and in general terms only are limited to 200 colonies/100ml, 126 colonies/100 ml and 33 colonies /100 ml, respectively for recreational use **(OWRB, 2004)**.

Arkansas River

The headwaters of the Arkansas River begin near Leadville, central Colorado. The river flows 1,450 miles across Colorado, Kansas, north-central Oklahoma, east-central Oklahoma and through Arkansas before it reaches the confluence with the Mississippi River. It is the fourth longest river in the United States. With a drainage basin of nearly 195,000 square miles, the Arkansas River is the largest tributary of the Mississippi-Missouri River System. It enters Oklahoma near Arkansas City on the Kansas border above Kaw Lake (Kay County, Oklahoma), then flows generally southeast through Tulsa and Muskogee before turning east and flowing across the Arkansas State Line into Fort Smith. In Oklahoma, the Arkansas River is fed by the Salt Fork, Black Bear, Cimarron, Illinois, Verdigris and Canadian Rivers along with several other smaller rivers, creeks and streams. Numerous dams including the Keystone Dam west of Tulsa have created very large lakes on the Arkansas River **(McCord, 2007)**.

The natural water quality of the Arkansas River has caused it to be largely abandoned as a source of municipal/industrial and public water supply. In general, the water quality is greatly influenced by the mineral and salt concentrations of tributaries draining into it from across western Oklahoma. These rivers include the Salt Fork, Black Bear, Cimarron and Canadian. Above Keystone Dam (beginning of the study area) is the tributary inflow from the Salt Fork, Black Bear and Cimarron Rivers. The mineral and salt concentrations from these rivers greatly influence the Arkansas River's natural water quality throughout the 42-mile study area and to the confluence of the Verdigris, Neosho, Illinois and Arkansas Rivers some 30 miles below the study area. These eastern Oklahoma Rivers are significantly less mineralized and provide a large volume of water to dilute the mineralized (total dissolved solids) concentrations transported by the Arkansas River. It is not until the tributary inflow of the Canadian River another 30 miles further downstream of the eastern Oklahoma rivers' confluence that the dissolved solids concentrations increase again because of the western Oklahoma tributary influence.

Climate

The climate of Tulsa County is temperate. The normal annual temperature is 60.3 degrees Fahrenheit (F). The average annual maximum and minimum temperatures are 71° and 49° F, respectively. The highest recorded temperature was 115° F and the lowest recorded temperature was -15° F. On the average, the relative humidity ranges between 47% and 92%. The normal annual precipitation is 41.91 inches and there are approximately 83 days per year with precipitation. The majority of the annual rainfall (64%) occurs between April and September. Thunderstorms occur predominantly in the spring and summer for about 50 days out of the year. The prevailing winds across Tulsa County are predominantly from the south to southeast and the wind speeds average nearly seven miles per hour on an annual basis **(Bennison, Knight, Creath, Dott, Hayes, 1972)**. The mean annual pan evaporation rate for Tulsa County is between 70 and 80 inches **(Watson & Burnett, 1993)**.

Physiography

There are two geomorphic provinces identified in Tulsa County. They are called the Eastern Sandstone Cuesta Plain and the Claremore Cuesta Plain. The Eastern Sandstone Cuesta Plain forms rugged hills with one steep face (cuesta) on top of broad shale plains (river floodplain) in the most western arm of the county. The Claremore Cuesta Plain produces less pronounced and less frequent hills, but is composed of sandstone and limestone on top of the broad shale plains. The Claremore Cuesta Plain occurs throughout the rest of the county **(Johnson, et al., 1979)**. These hills form the topographic highs (elevations) while the Arkansas River itself forms the topographic lows. These topographic highs and lows define the watersheds and drainage basin boundaries for the Arkansas River within the study area. The relief (elevation differences) ranges from 180 to 300 feet when the cuestas are in close proximity to the river and 20 to 60 feet when the floodplains dominate the landscape.

Geology

Some of the hills (cuestas) that outcrop next to the river are Pennsylvanian age, rock formations. The hills along the upper reaches of the study area are composed of the Dewey Limestone and Nellie Bly Formation. Progressing downriver these rock formations become older and include the Coffeyville, Checkerboard Limestone, Seminole, Holdenville, and Nowata Shale. These formations represent ancient river and sea deposits: delta; prodelta; subtidal clastics & marine shell banks; shallow marine banks; platform shallow marine; and marine basinal shales **(Bennison, et al., 1972; Marcher & Bingham, 1988)**.

Quaternary river deposits cover the younger Pennsylvanian formations on the broad floodplains when the hills are not encountered next to the river. These river deposits predominate along the river and study area. The younger Holocene deposits represent modern floodplain alluvium that overlie older Pleistocoene terrace deposits. The deposits consist of unconsolidated gravels, sands, silts and clays **(Bennison, et al., 1972; Marcher & Bingham, 1988)**.

Soils

The Choska-Severn Association is the predominate soil along the Arkansas River within the study area. These soils are deep, nearly level, well drained, loamy to gravelly soils overlying loamy and sandy materials on the floodplains. There are four basic horizons with alternating colors of dark reddish brown and yellowish red. The depth to groundwater is typically six feet. The depth to bedrock is greater than 60 inches **(Cole, Bartolina & Swafford, 1977)**.

Natural Vegetation

The natural vegetation of Tulsa County is dependent upon climatic factors, physiographic features, geology (parent material) and soils. Typically there are three main types of vegetation. The rugged hills to the west and south of Tulsa are dominated by scrub-oak woodland. The plains north and east of Tulsa are underlain by limestone and grasslands are dominant. The floodplains along the Arkansas River, other rivers, and the streams in the county are dominated by mixed forest of tall trees and dense undergrowth. The three main vegetation types are generally not well defined and areas between them are characteristically transitional **(Bennison, et al., 1972)**.

Hydrology

Throughout Oklahoma and certainly within the study area, the Arkansas River is considered to be a mature, late stage river. A late stage river is characterized by the formation of a broad floodplain with large meanders, natural levees, oxbow lakes, point bars, back swamp areas and some Yazoo streams. The river's drainage system is identified by a characteristic dendritic pattern which is the most common form of drainage in the world. It consists of a main river with tributaries and sub-tributaries. It's stream order is also classified as a large sixth to seventh stream. The dendritic drainage system looks like a tree from an aerial viewpoint. The pattern has v-shaped junctions, similar to a leaf with its veins representing the tributaries, and the stem representing the main channel. Rivers that flow in a dendritic drainage system usually are on a gentle slope. The Arkansas River has characteristics of a braided stream throughout the study area with the exception of the low-water dam area (Zinc Lake). A braided stream is characterized by alternating flood-stage scouring and the subsequent filling of multiple interconnecting channels within the confines of the river banks. The braids or anastomosing channels are subject to widely fluctuating water discharge and intermittently abundant sediment supply.

The elevation of the Arkansas River is 650 feet above sea level (ASL) at the Keystone Dam or upper most reach of the study area and 577 feet (ASL) at the lower reach of the study area or at the Tulsa/Wagoner County line. This relief difference produces a stream slope of approximately 1.74 feet per mile along the 42-mile long study area.

The Arkansas River is impounded by the Keystone Dam and it dramatically influences the volume of flow and sediment supply downstream. For the last ten years, the average, annual discharge rate at the Tulsa gage has been 9,892 cubic feet per second **(USGS, 2007)**. Over the past 25 years, the Arkansas River has eroded increasing its channel storage and capacity for Base Flood Flow to 205,000 cubic feet second **(C. H. Guernsey & Company, 2005)**. Prior to the dam completion in 1964, the average annual sediment load passing the Tulsa, Oklahoma gage was approximately 22,100,000 tons. There have not been any recent sediment loading studies for the Tulsa vicinity **(Bennison, et al., 1972)**.

Watersheds

There are five USGS, eight-digit Hydrologic Unit Codes (HUC) for the Arkansas River Basin in Oklahoma. One of these HUC is located in the Lower Arkansas River Basin and is called the Polecat-Snake (11110101) Watershed. The Polecat-Snake Watershed extends throughout southern Tulsa County and northeastern Muskogee County. The Arkansas River and approximately twenty-one tributaries make up the Polecat-Snake watershed (OK 11110101) which has a drainage area of 280 square miles.

There are four, State of Oklahoma watershed basins identified for the 42-mile study area. They include portions of Tulsa, Creek, Muskogee, Okmulgee, Osage, Rogers and Wagoner Counties. The Oklahoma Water Body Identification System identifies these eight-digit watersheds as OK120410-01, OK120410-03, OK120420-01, and OK120420-02.

The Arkansas River tributaries from the upper reach to the lower reach of the study area (42-miles long) and in sequential order, include; Brush Creek (north side of river), Little Sand Creek (north), Sand Creek (north), Mud Creek (south side of river), Shell Creek (north), Fisher Creek (south), Euchee Creek (north), Anderson Creek (south), Big Heart Creek (north), Berryhill Creek (south), Harlow Creek (north), Crow Creek (north, 31st), Cherry Creek (south), Mooser Creek (south), Joe Creek (north), Fred Creek (north), Polecat Creek (south), Posey Creek (south), Haikey Creek (north), Snake Creek (south), and Broken Arrow Creek (north) **(Figure 1A)**.

Demographics

Tulsa County has a total population of 563,299 people. The population density is 988 persons per square mile**(US Census Bureau, 2006)**. As a contrast, the state of Oklahoma has a population density of 50 persons per square mile **(University of Oklahoma Urban Design Studio [OUUDS], 2003)**. The cities and towns along the Arkansas River from the upper reaches to the lower reaches of the study area include Sand Springs, Tulsa, Jenks, Bixby and Broken Arrow and they have a total population of 518,047 persons. The specific populations are Sand Springs (17,667), Tulsa (382,457), Jenks (13,095), Bixby (18,600) and Broken Arrow (86,228) **(US Census Bureau, 2006)**. There are some smaller communities along the river such as Lotsee, Wekiwa, Fisher, Bend, Prattville, Shirk, Gray, Price, Kengle, and Garden City all of which are located within the study area and are included in the census population.

Land Use

One method for identifying land use within the ARC study area involves measuring the percentage of urbanized development verses non-urbanized along the north and south banks. Urbanization is defined as developed land that is used for residential, commercial, industrial and other non-agricultural uses with a population density typically greater than 500 persons per square mile and/or possessing significant civic infrastructure **(OUUDS, 2003).** The non-urbanization would be defined as all other land uses. In these terms, the river corridor (42-miles long by one mile wide) is approximately 62.5% urbanized along the north and east banks verses 37.5% which is non-urbanized. And, 51% is urbanized along the south and west banks verses 49% which is non-urbanized.

FIGURE 1A

Arkansas River Tributaries (ARC Study Area)

Tulsa County, Oklahoma

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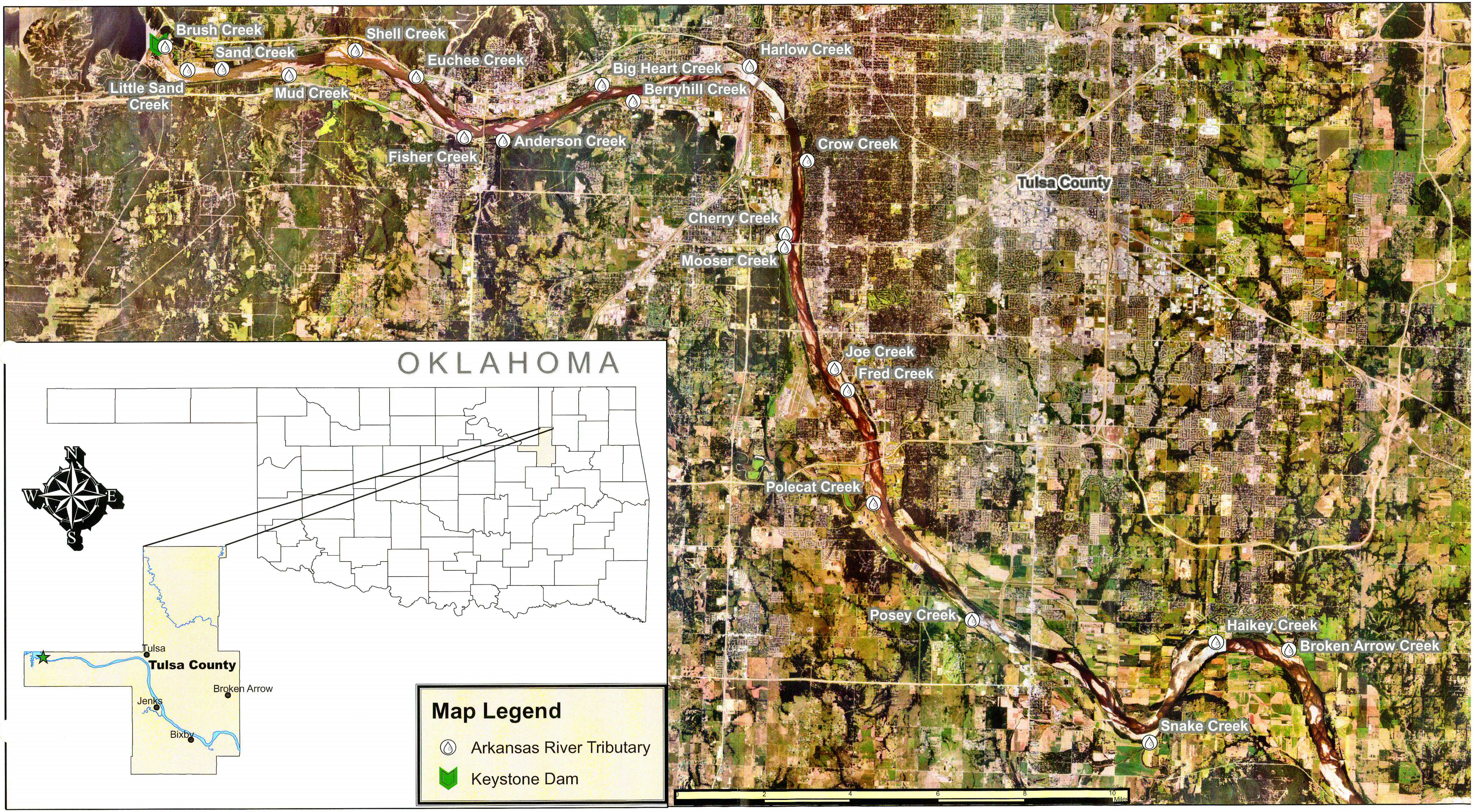


Another method for identifying land use within the ARC study area is to look at the percentage of urbanization verses agricultural development and non-urbanization along the 42-mile length and one mile width area (slightly less than 26,880 acres). The urbanization definition is expanded to include developed lands used for residential, commercial, industrial, transportation/communication utilities, strip mines/quarries/gravel pits and other built-up areas. The agricultural development definition includes cropland/pasture, and orchards/groves/vineyards/nurseries/horticultural areas. The non-urbanized definition includes deciduous forest land, streams/canals, reservoirs, beaches, other sandy areas, and transitional areas **(C.H. Guernsey & Company, 2005).** In these terms, the urbanized development percentage is 22.9%, the agricultural development percentage is 35.6% and the non-urbanized percentage is 41.6%. The deciduous forest lands comprise 14.5% of the total study area acreage and 34.9% of the non-urbanized area.

Water Use

The urban/suburban, industrial and agricultural/horticulture development in Tulsa County and along the ARC has led to anthropogenic (manmade) uses for the river and sources of discharge into the river. Uses have included recreation (boating, fishing & hunting), industrial, utility, municipal, agriculture/horticulture and structure building along the river.

There are significant recreational areas (parkways) located along the east bank of Tulsa from 11th Street to 101st Street. Industrial areas are concentrated along the north bank of Sand Springs, the north & west bank of Tulsa, and sporadically south of Tulsa on either bank of the river. There are five major municipalities with significant commercial and residential areas developed along the center two-thirds of the study area. In the southern portion of the study area (Bixby & Broken Arrow), there is significant agriculture/horticulture development along both banks of the river. There is a major dam (Keystone), a low-water dam (Zink Lake), and fifteen bridges spanning the Arkansas River within the study area.

USEPA Water Quality Regulations

The Water Quality Standards (WQS) are the foundation of the Water Quality-Based Pollution Control Program mandated by the federal Clean Water Act (CWA). The WQS define the goals for a water body by: 1) designating its uses (e.g., recreation, water supply, aquatic life, agriculture, etc.); 2) setting water quality criteria (e.g., numeric pollutant concentrations & narrative requirements); 3) establishing anti-degradation policies to maintain and protect existing uses and high quality waters; and 4) establishing general policies (e.g., low flows, variances, mixing zones, etc.) **(USEPA, WQS, 2007)**.

The WQS regulations require the states to specify appropriate water uses to be achieved and protected. The appropriate uses are identified by taking into consideration the use and value of the water body for: public water supply; for protection of fish, shellfish, and wildlife; and for recreational, agricultural, industrial, and navigational purposes. In designating the uses for a water body, states examine the suitability of a water body for the uses based on: the physical, chemical, and biological characteristics of the water body; its geographical setting and scenic qualities; and economic considerations **(USEPA, WQS, 2007)**.

The CWA also provides the statutory basis for regulating the discharge of pollutants from point sources into waters of the United States. The CWA gives the USEPA the authority to set effluent limits on an industry-wide (technology-based) basis and on a water-quality basis to ensure the protection of the receiving water. This was done through the National Pollutant Discharge Elimination System (NPDES) Permit Program. The CWA also allows the USEPA to delegate the NPDES Permit Program to state governments, enabling states like Oklahoma to perform many of the permitting, administrative, and enforcement aspects for the federal program through its own permit program, the Oklahoma Pollutant Discharge Elimination System (OPDES). The USEPA still retains oversight responsibilities in the states that have been authorized to implement the CWA programs **(USEPA, WQS, 2007)**.

The key sections of the CWA that directly relate to the NPDES Permit Program include Titles I, II, III and IV. Title I is research and related programs and Title II is grants for construction of treatment works. Title III is the standards and enforcement which includes effluent standards (§301), water quality-related effluent limitations (§302), water quality standards and implementation plan (§303), information and guidelines (§304), water quality inventory (§305), and the toxic and pretreatment effluent standards (§307). Title IV is the permitting and licensing, specifically the NPDES (§402) **(USEPA, Permit Compliance System [PCS], 2007)**.

Oklahoma Water Quality Regulations

The Oklahoma WQS are set forth under statutory authority of the OWRB which is authorized under 82 O.S. § 1085.30 **(OWRB, Rules, 2007)**. The rules adopted by the state of Oklahoma are in accordance with the federal CWA, applicable federal regulations, and state pollution control and administrative procedure statutes. The WQS serve a dual role: 1) they establish water quality benchmarks; and 2) provide a basis for developing water-quality based pollution control programs **(Oklahoma Department of Environmental Quality [ODEQ], 2004)**.

The state's surface waters receive broad and explicit protection through the WQS. Furthermore, the implementation rules contain Use Support Assessment Protocols (USAP) for Oklahoma's water bodies and are developed in coordination with all of the state's environmental agencies. The USAP establish a consistent and scientific decision methodology for determining whether a water body's beneficial uses are being supported, and they outline the minimum data requirements for the decision methodology **(OWRB, 2004)**. This scientific decision methodology or USAP involves collecting and analyzing the physical, chemical and biological characteristics of a particular water body in various numeric criteria and narrative assessment combinations.

Created in 1998, the Beneficial Use Monitoring Program (BUMP) is a comprehensive statewide compilation of water quality data. The BUMP main goals are to document beneficial use impairments, identify impairment sources, detect water quality trends, provide needed information for the Oklahoma WQS, and provide critical information for the prioritization of pollution control activities by state and local entities. The current recognized beneficial uses for some or all of the waters in Oklahoma include public and private water supply, fish and wildlife propagation, agriculture, hydropower, municipal and industrial process and cooling water, primary body contact recreation (such as swimming), secondary body contact recreation (such as boating or fishing), navigation, and aesthetics. **(OWRB, 2004)**. The Arkansas River within the 42-mile study area does have identified beneficial use impairments.

The ODEQ also has statutory authority under Title 27A O.S., § 2.6.101 et. seq. for water quality in the state. The state statutes allow the ODEQ to: issue permits; conduct water quality assessments, listings, and reports; manage point source and non-point sources of pollution; establish Total Maximum Daily Load (TMDL) restrictions and modeling for streams; conduct toxicity & biomonitoring; and implement a water quality management plan (208 Plan).

The ODEQ issues municipal point source discharge permits (OKG58), municipal stormwater MS4 permits (Tulsa), small municipal stormwater MS4 permits (Sand Springs, Jenks, Bixby, Broken Arrow), industry specific point source discharge permits, industrial stormwater permits (multi-sector general permit, OKR05, MSGP), and construction stormwater discharge permits (OKR10).

The CWA 303(d) regulations require states to develop lists of water bodies that do not meet the water quality standards and submit an updated list to the USEPA every two years. For water bodies on the 303(d) list, the CWA requires that a pollutant load reduction plan or TMDL be developed to correct each impairment. TMDLs must document the nature of the water quality impairment, determine the maximum amount of a pollutant which can be discharged and still meet the standard requirements, and identify allowable loads from the contributing sources **(ODEQ, 2004)**. Currently, there are no TMDL requirements for the Arkansas River within the 42-mile study area.

The CWA 305(b) regulations require a state to develop an inventory of the water quality of all state water bodies and submit an updated report to the USEPA every two years. The 305(b) report includes: 1) analysis and compliance of the water bodies "fishable/swimmable" goal; 2) analysis and elimination process of pollutant discharges and the water quality related to the "fishable/swimmable" goal; 3) the environmental impact; 4) economic and social cost/benefit analysis; 5) and the estimated date of such achievement. It also entails a description of the nature and extent of non-point sources of pollutants, recommendations of programs needed to control them, and an estimate of the costs of implementing such programs **(ODEQ, 2004)**. The ODEQ now consolidates both the 303(d) and 305(b) biannual reports into a single document, the Oklahoma Water Quality Integrated Report.

Water Quality Reports & Data

Most of the available water quality data for Oklahoma has been generated by local, county, regional, state and federal agencies. These agencies have included the City of Tulsa, Tulsa County Health Department, Oklahoma Conservation Commission, ODEQ, Department of Agriculture Food and Forestry, OWRB, USACE, USGS and INCOG.

There are older water quality data reports and studies that have been conducted for the Arkansas River in general, near the study area, and within the study area. There are also former and existing USGS and USACE gauging stations that have water quality data for the Arkansas River in or near the identified study area. While some of these studies and gauging stations do provide data with some insight on the water quality of the Arkansas River, they are either too general in nature, temporally (time) non-relevant or spatially (distance) non-relevant for the goals of this report. The general, temporal and spatial non-relevant studies and data included, but were not limited to:

- Dover, T.B. (1957). Water Quality- A Factor in Arkansas River Development. USGS. Presented before the Tulsa Chamber of Commerce, July 22, 1957.
- Cox, W. R., Wright, M. D., & Woodruff, G. D. (1981). The Importance of Intense Trend Bacteriological Monitoring for Evaluating a Recreational Water Quality Enhancement Program. Water Quality Control Section, Office of Planning & Research, Tulsa City-County Health Department. Oklahoma Academy Science, Volume 61: 58-61.

- USACE. (2001). Water Quality Report; Keystone Lake Oklahoma 1996. Southwestern Division, Tulsa District.
- USGS. (2005). Water Resources Data, Oklahoma Water Year 2005. Volume 1. Arkansas River Basin. Water-Data Report OK-05-1.
- USGS. (1978). Water Type And Suitability of Oklahoma Surface Waters For Public Supply And Irrigation, Part 1: Arkansas River Mainstem and Verdigris, Neosho, and Illinois River Basins Through 1978. Water-Resources Investigations 81-83.

Two reports that begin to relate to the ARC study area in terms of specific, temporal and spatial terms include a five year period from 1976-1980, and a twelve year period from 1989-2000. While they are relevant to the study area they do not represent the most recent data. However, for the purposes of this report, they were used to support the most recent data and water quality trends within the study area. The Zink Lake Water Quality Assessment is referenced in Appendix A and the Arkansas River Water Quality Reports are included as part of Appendix D. The two reports are:

- Tulsa County Health Department. (1989-2000). Arkansas River Water Quality Reports.
- Woodruff, Gary D. (1983). Zink Lake Water Quality Assessment. Office of Planning and Research and Water Quality Section. Tulsa City-County Health Department.

The more recent reports and data which were used to establish the water quality baseline for the study area reflect a seven year period from 2000-2006. The reports are:

- City of Tulsa, Department of Public Works. (2005). 1992-2004 Stream Monitoring Sampling Plan and Data. Tulsa, Oklahoma.
- City of Tulsa, Department of Public Works. (2006). 2005/06 Stream Monitoring Sampling Plan and Data. Tulsa, Oklahoma.
- INCOG, Arkansas River Heavy Metals Study. (November 2001).
- Oklahoma Water Resources Board. (2004). Beneficial Use Monitoring Program (BUMP) Streams Report. State of Oklahoma.
- Oklahoma Water Resources Board. (2008). 2006 Validated Water Quality Data for Arkansas River; Stations 120410010080-001AT, 120420010010-001AT & 120420010130-001AT.
- USEPA. (2007, May 17). Permit Compliance System (PCS). Water Discharge Permits. http://www.epa.gov/enviro/html/pcs/index.html

Water Quality Data Monitoring Stations

There are three fixed, OWRB, BUMP monitoring stations that are used to characterize the beneficial use impairments for the Arkansas River (Polecat-Snake Watershed, Hydrologic Unit Code [HUC] 11110101) and the 42-mile study area **(Figure 2)**. These monitoring stations are used to collect the physical, biological and chemical data. The first two locations are in Tulsa County near Sand Springs (S.H. 97 Bridge) and Bixby (S.H. 64 Bridge). A third station is in northeastern Muskogee County east of Haskell (S.H. 104 Bridge). The USAP and the CWA 305 (b) guidelines limit the spatial coverage of a BUMP monitoring station(s) to 25 stream miles on a non-wadable stream like the Arkansas River. In addition, the spatial coverage for a monitoring station(s) cannot extend outside the eight-digit HUC watershed unless it is determined reasonable to do so.

The Sand Springs BUMP station is representative of the Arkansas River from Keystone Reservoir (36.1504, -96.2528) downstream west of Tulsa (36.1392, -96.0569). Within this segment the water enters the river system from Keystone Lake and from several tributaries including; Shell Creek, Fisher Creek, Euchee Creek, Anderson Creek, Big Heart Creek, and Berryhill Creek. The Bixby BUMP station is representative of the Arkansas River from west of Tulsa (36.1392, -96.0569) downstream to the confluence of the Arkansas River and Snake Creek (35.9305, -95.8344). Within this segment tributary waters enter the river system from Harlow Creek, Crow Creek, Cherry Creek, Mooser Creek, Joe Creek, Fred Creek, Polecat Creek, Posey Creek, Haikey Creek, and Snake Creek. The Haskell BUMP station is representative of the Arkansas River from the confluence of Snake Creek (35.9305, -95.8344) downstream to the confluence of the Arkansas River and Pecan Creek (35.7990, -95.4348). Within this segment the tributary water entering the river system is from Broken Arrow Creek.

There are five City of Tulsa surface water monitoring stations on the Arkansas River and within the 42-mile study area. In downstream order, they are AR-1, 11th Street Bridge at Tulsa (36.1434, -96.9870), AR-3, I-44 Bridge at Tulsa (36.0968, -95.9854), AR-4, 68th & Riverside at Tulsa (36.0640, -95.9796), AR-6, Highway 64 Bridge at Bixby (35.9587, -95.8869), and AR-8, Indian Springs Sports Complex at Broken Arrow (35.9620, -95.8080) **(Figure 2)**. These monitoring stations are used to collect the physical, biological and chemical data throughout the year to meet, support and supplement the ODEQ Permit reporting requirements. These permits include the City of Tulsa's Municipal Point Source Discharges (OKG58) and Municipal Separate Storm Sewer System Discharges (MS4).

There are four USGS surface water stations for the Arkansas River (Polecat-Snake Watershed, HUC 11110101). In downstream order, they are the Arkansas River at Tulsa (36.1406, -96.0061), Joe Creek at 61st Street at Tulsa (36.0756, -95.9603), Haikey Creek at 101stst Street South at Tulsa (36.0170, -95.8486), and Little Haikey Creek at 101st Street at Tulsa (36.0175, -95.8606). These stations measure the stage height of the river. Since the BUMP stations measure discharge (flow) and temperature at all of their locations, the USGS stations were identified for the purposes of this report, but will not be used in the evaluation of the water quality. In addition, all of the BUMP stations are located on the Arkansas River itself and not on tributaries that feed into the river.

Water Quality Data (OWRB) & Conclusions

The CWA 305(b) and USAP limit the spatial coverage of the state's BUMP monitoring locations to 25 stream miles on non-wadable streams. In addition, the spatial coverage for the monitoring locations cannot extend outside the eight-digit HUC watershed unless it is determined reasonable to do so. The USAP establishes two temporal coverage limitations. First, the collected data cannot be biased towards critical-flow, base-flow or high-flow conditions. Second, stream data that is more than five years old cannot be used to assess support unless no other data exists or a scientifically defensible reason can be used to justify using the older data. The 2004 BUMP Report uses data collected during all of the seasons and does not use data collected before November of 1998 **(OWRB, 2004)**.

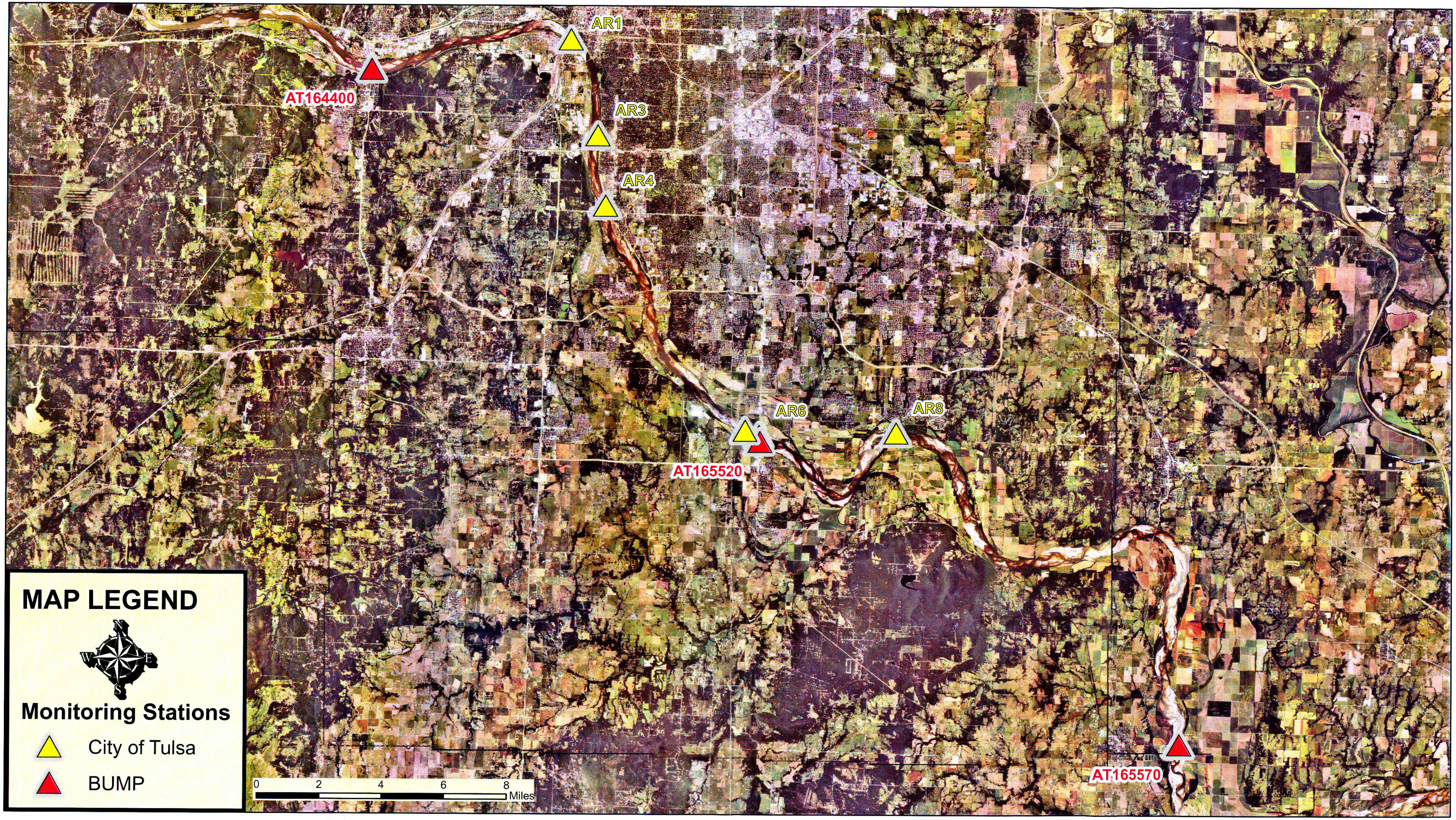
The minimum number of samples required to assess the use support for all general water quality variables is ten (10). The BUMP program collects at least ten samples per year on all general water quality parameters with the exception of bacteria, organics and metals. Toxicants (metals and organics) require a minimum of five (5) samples to determine use support, however, less than five (5) samples can be used to determine if a use is partially supported or not supported. The metals are sampled on an as needed basis. Typically, the samples collected from a monitoring station for the

Oklahoma Water Resources Board & City of Tulsa Monitoring Stations

Tulsa County, Oklahoma

FIGURE 2

JUNE 2007



beneficial use determinations are averaged over one year which produce geometric mean values. These values are in turn compared to a screening level value, long-term averaging values, and/or average sample standards for all of the monitoring stations in a specific watershed. The percentage of exceedences determines the beneficial use status. For many USAP determinations, the prescribed percent exceedences are: 1) less than or equal to ten percent are supporting; 2) greater than ten percent (10%), but less than twenty-five percent (25%) are partially supporting; 3) and greater than or equal to twenty-five percent (25%) are not supporting **(OWRB, 2004)**. There are different determination criteria depending on the specific USAP as identified in the Oklahoma Administrative Code (OAC), Title 785, Chapter 46.

The following table **(Table 1)** identifies the numerical criteria used by the OWRB's USAP for determining whether or not a particular beneficial use is supported, partially supported, not supported or threatened. Most of the values in Table 1 that are used in USAP determinations come from OAC 785:45, Appendix G, Table 2. The OAC 785:46-15 specifies how these values should be used for making beneficial use attainment determinations under USAP. The USAP has a number of parameter or parameter category (e.g., metals) determination methods specific to certain beneficial use types. The USAP also has "default protocols" that allow beneficial use determinations to be made for those methods not specified in Chapter 46-15. For example, the beneficial use determinations can be based on the percentage of samples exceeding an average sample standard or geometric mean or a certain percent of samples in a data set that exceed the numerical criterion in Chapter 45, Appendix G, Table 2. Certain heavy metals criteria in Chapter 45, Appendix G, Table 2 utilize hardness-dependent equations to determine the numerical criteria for those metals that are hardness dependent. However, the average sample standards, geometric means and mg/l concentrations identified in Table 1 do provide invaluable information in a simplified format for the baseline comparison. Table 1 also includes typical stream water quality mean and range values and the USEPA Water Quality Standard values for comparative purposes only **(OWRB, 2008)**.

The OWRB 2006 water quality data identified in **Tables 2, 3 & 4** are tabulated as yearly mean and range of values for the physical, chemical and biological water constituents and measurements collected within the ARC **(Appendix B)**. This water quality data represent the most recent, full year of validated data. It is intended to augment the City of Tulsa's water quality data **(Tables 5, 6, 7, 8 & 9)** which provide full year data for years 2000, 2001, 2002, 2003, 2004 and 2005. Thus, seven years of recent data have been provided to establish a baseline for the water quality within the ARC. For comparative purposes, both the OWRB and City of Tulsa have similar physical, chemical and biological constituents or parameters presented in these tables. Some of the City of Tulsa's sampling locations may not be entirely representative of the entire cross-channel water column. For example, the AR-1 and AR-4 locations are sampled as single points in the water column from the middle of the bridge and AR-3, AR-6 and AR-8 are collected from a stream bank. However, low flows in the Arkansas River create pooling and braided stream conditions across a transect (bank to bank).

The Sand Springs monitoring station has been active for all of the water quality variables since September of 1999. The following assessment of beneficial uses is based on data collected from October of 1999 through October of 2004. The following designated beneficial uses for this segment are: 1) Emergency Water Supply; 2) Fish and Wildlife Propagation, Warm Water Aquatic Community; 3) Agriculture—Class I Irrigation; 4) Secondary Body Contact— Recreation; 5) and Aesthetic. All of the listed beneficial uses are supported and/or not threatened based upon the most recent USEPA approved 303(d) list (2006). The Aesthetic beneficial use is not threatened. The Public & Private Water Supply does not apply to this water body segment. And, this segment of the river is not nutrient-threatened **(OWRB, 2004)**.

Table 1
***Applicable OWRB Criteria & Standards, and USGS & USEPA Comparative Data**

Constituent/Measurement	USGS Water-Supply Paper 2254 Typical Streams	OWRB USAP Values	OWRB USAP Values	USEPA Water Quality Standards
Temperature C°	---	18-32	---	---
pH	6.5-8.5	6.5-9.0	---	6.5-8.5 (Secondary)
Dissolved Oxygen, mg/l	---	4.0-5.0	---	---
Total Alkalinity, mg/l	5-125 mg/l	---	---	---
Total Hardness, as $CaCO_3$, mg/l	---	---	---	---
Total Dissolved Solids (TDS), mg/l	---	1,868 (Sand Springs/Bixby) 1,782 (Haskell) sample standard	1,496 (Sand Springs/Bixby) 1,419 (Haskell) yearly mean standard	500 (Secondary)
Turbidity, NTU	---	50	---	---
Chloride, mg/l	10	925 (Sand Springs/Bixby) 810 (Haskell) sample standard	719 (Sand Springs/Bixby) 629 (Haskell) yearly mean standard	250 (Secondary)
Sulfate, mg/l	---	178 (Sand Springs/Bixby) 172 (Haskell) sample standard	147 (Sand Springs/Bixby) 140 (Haskell) yearly mean standard	250 (Secondary)
Fecal Coliform, count/100 ml	---	406 geometric mean	---	---
E. Coli, Quanti-Tray, count/100 ml	---	126 geometric mean	---	---
Enterococci, count/100 ml	---	33 geometric mean	---	---

***The OWRB USAP values have been simplified to provide a general understanding and format in order to compare them to the USGS typical stream values found across the United States and the USEPA Water Quality Standards. The USGS typical stream values and USEPA Water Quality Standards are for comparative purposes only.**

Table 1
* Applicable OWRB Criteria & Standards, and USGS & USEPA Comparative Data

Constituent/Measurement	USGS Water-Supply Paper 2254 Typical Streams	OWRB USAP Values	OWRB USAP Values	USEPA Water Quality Standards
Nitrogen, Nitrate/Nitrite as N, mg/l	---	5.0	---	10.000 (Primary)
Nitrogen, Nitrite, mg/l	---	---	---	1.0 (Primary)
Phosphorous, Total, mg/l	---	0.36	---	---
Arsenic, mg/l	0.0001-0.10	0.04	---	0.010 (Primary)
Barium, mg/l	---	1.00	---	2.0 (Primary)
Cadmium, mg/l	0.0001-0.10	0.020	---	0.005 (Primary)
Chromium, mg/l	0.001-0.10	0.050	---	0.1 (Primary)
Copper, mg/l	<0.020	1.000	---	1.0 (Secondary)
Cyanide, mg/l	---	0.200	---	0.2 (Primary)
Fluoride (@ 90° C), mg/l	---	4.0	---	4.0 (Primary), 2.0 (Secondary)
Lead, mg/l	0.0001-0.10	0.100	---	0.015 action level
Mercury, mg/l	0.00050	0.002	---	0.002 (Primary)
Nickel, mg/l	0.0001-0.10	---	---	---
Selenium, mg/l	< 0.010	0.010	---	0.05 (Primary)
Silver, mg/l	0.0001-0.0040	0.050	---	0.10 (Secondary)
Thallium, mg/l	0.0010	---	---	0.002 (Primary)
Zinc, mg/l	0.0001-0.10	5.000	---	5.0 (Secondary)

***The OWRB USAP values have been simplified to provide a general understanding and format in order to compare them to the USGS typical stream values found across the United States and the USEPA Water Quality Standards. The USGS typical stream values and USEPA Water Quality Standards are for comparative purposes only.**

The Sand Springs monitoring station and the 1999 through 2004 data indicate the Warm Water Aquatic Community beneficial use is supported because the dissolved oxygen, pH, turbidity and toxicant samples met the criteria prescribed for this beneficial use. The Agriculture beneficial use is supported for total dissolved solids, chlorides, and sulfates even though twelve percent (12%) of the sulfate concentrations exceeded the sample standard of 178.0 mg/l. The sulfate concentration values are also below the prescribed minimum standard of 250 mg/l. The Primary Body Contact—Recreation beneficial use is supported for fecal coliform, Enterococci and E. coli concentrations. This particular segment of the Arkansas River is not nutrient-threatened because the total phosphorus and nitrate/nitrite median values were below the threshold medians of 0.36 mg/l and 5.0 mg/l, respectively **(OWRB, 2004)**.

The Sand Springs monitoring station and the 2006 data values **(Table 2)** are trending very similar to the 1999 through 2004 data. This suggests this segment of the river will have similar results for its beneficial use determinations. In addition, the physical and chemical mean and range values generally reflect typical conditions found in other streams in the United States **(Hem, 1986)**.

The Bixby monitoring station has been active for all water quality variables since November of 1998. The following assessment of beneficial uses is based on data collected from October of 1999 through October of 2004. The following designated beneficial uses for this segment are: 1) Emergency Water Supply; 2) Fish & Wildlife Propagation, Warm Water Aquatic Community; 3) Agriculture—Class I Irrigation; 4) Secondary Body Contact—Recreation; 5) and Aesthetic. All of the listed beneficial uses are supported with one exception. The exception is the Secondary Body Contact—Recreation beneficial use which is not supported because the fecal coliform and Enterococci concentrations exceeded the USAP thresholds. The Aesthetic beneficial use is not threatened. The Public & Private Water Supply does not apply to this water body segment. And, this segment of the river is not nutrient-threatened **(OWRB, 2004)**.

The Bixby monitoring station and the 1999 through 2004 data indicate the Warm Water Aquatic Community beneficial use is supported because the dissolved oxygen, pH, turbidity, and toxicant samples met the criteria prescribed for this beneficial use. The Agriculture beneficial use is supported for total dissolved solids, chlorides, and sulfates even though eleven percent (11%) of the sulfate concentrations exceeded the sample standard of 178.0 mg/l. The sulfate concentration values are also below the prescribed minimum standard of 250 mg/l. The Primary Body Contact—Recreation beneficial use is not supported. Of the seventeen (17) fecal coliform concentrations, seven (7) samples or forty-one percent (41%) exceeded the prescribed screening level of 400 cfu/ml, and the geometric mean of 884.8 cfu/ml exceeded the prescribed mean standard of 400 cfu/ml. Of the seventeen (17) E. coli concentrations, three (3) samples exceeded the prescribed screening level of 406 cfu/ml, and the geometric mean of 141.8 cfu/ml exceeded the prescribed mean standard of 126 cfu/ml. Finally, of the seventeen (17) Enterococci concentrations, three (3) samples exceeded the prescribed screening level of 406 cfu/ml, and the geometric mean of 415 cfu/ml exceeded the prescribed mean standard of 33 cfu/ml. This particular segment of the Arkansas River is not nutrient-threatened because the total phosphorus and nitrate/nitrite median values were below the threshold medians of 0.36 mg/l and 5.0 mg/l, respectively **(OWRB, 2004)**.

Table 2
OWRB, Beneficial Use Monitoring Program (BUMP), River Segment (120420), AT164400 (Sand Springs) State Highway 97, 36.12393866/-96.115783427

2006 Mean & Range Data

Constituent/Measurement	Mean	Range
Temperature C°	17.20	4.42 – 27.33
Oxidation/Reduction Potential, MV	---	---
Specific Conductance, umhos/cm (uS/cm)	2,201	1,430 – 3,306
Dissolved Oxygen, mg/l	8.29	4.61 – 12.87
Dissolved Oxygen Saturation, %	85.9	57.7 – 121.5
pH (actual pH values were averaged to determine mean)	7.95	7.48 – 8.32
Total Alkalinity, mg/l	---	---
P-Alkalinity, mg/l	---	---
Total Hardness, as $CaCO_3$, mg/l	271	168 – 384
Total Dissolved Solids (TDS), mg/l	1,409	915 – 2,116
Salinity, g/l	---	---
Turbidity, NTU	11.7	5.0 – 34.0
Chloride, mg/l	572	313 – 1100
Sulfate, mg/l	119.4	43.4 – 195.0
Fecal Coliform, count/100 ml	109	10 – 380
E. Coli, Quanti-Tray, count/100 ml	39	10 – 119
Enterococci, count/100 ml	47	10 – 109
Nitrogen, Ammonia, mg/l	0.07	0.05 – 0.18
Nitrogen, Kjeldahl, mg/l	0.58	0.47 – 0.69
Nitrogen, Nitrate/Nitrite as N, mg/l	0.19	0.05 – 0.44
Phosphorous, Total, mg/l	0.110	0.070 – 0.221
Phosphorous, Ortho, mg/l	0.070	0.044 – 0.175

The Bixby monitoring station and the 2006 data values **(Table 3)** are trending very similar to the 1999 through 2004 water quality data suggesting this segment of the river will have similar results for its beneficial use determinations. This would include the biological mean and range values which currently will not support the Primary Body Contact—Recreation beneficial use for this segment of the river. The physical and chemical mean and range values generally reflect typical conditions found in other streams in the United States **(Hem, 1986)**.

The Haskell monitoring station has been active for all water quality variables since November of 1998. The following assessment of beneficial uses is based on data collected from October of 1999 through September of 2004. The following designated beneficial uses for this segment are: 1) Emergency Water Supply; 2) Fish & Wildlife Propagation, Warm Water Aquatic Community; 3) Agriculture—Class I Irrigation; 4) Secondary Body Contact—Recreation; 5) and Aesthetic. The Fish & Wildlife Propagation, Warm Water Aquatic Community beneficial use is supported. The Agriculture—Class I Irrigation beneficial use is partially supported. The Secondary Body Contact—Recreation beneficial use is not supported. The Aesthetic beneficial use is not threatened. The Public & Private Water Supply does not apply to this water body segment. And, this segment of the river is not nutrient-threatened **(OWRB, 2004)**.

The Haskell monitoring station and the 1999 through 2004 data indicate the Warm Water Aquatic Community beneficial use is supported because the dissolved oxygen, pH, turbidity, and toxicant samples met the criteria prescribed for this beneficial use. The Agriculture beneficial use is partially supported. Of the forty-five (45) total dissolved solids concentrations, nine (9) of the samples or twenty percent (20%) exceeded the minimum sample standard of 1,782 mg/l. The chlorides and sulfates are within the prescribed sample standards and yearly means. The Primary Body Contact—Recreation beneficial use is not supported. Of the twenty-two (22) Enterococci concentrations, one (1) sample exceeded the prescribed screening level of 406 cfu/100 ml, and the geometric mean of 36.0 cfu/ 100 ml. This particular segment of the Arkansas River is not nutrient-threatened because the total phosphorus and nitrate/nitrite median values were below the threshold medians of 0.36 mg/l and 5.0 mg/l, respectively **(OWRB, 2004)**.

The Haskell monitoring station and the 2006 data values **(Table 4)** are trending very similar to the 1999 through 2004 water quality data suggesting this segment of the river will have similar results for its beneficial use determinations. This would include the biological mean and range values which currently will not support the Primary Body Contact—Recreation beneficial use for this segment of the river. The physical and chemical mean and range values generally reflect typical conditions found in other streams in the United States **(Hem, 1986)**.

Table 3
OWRB, Beneficial Use Monitoring Program (BUMP), River Segment (120420), AT165520 (Bixby) State Highway 64, 35.955853074/-95.886225622

2006 Mean & Range Data

Constituent/Measurement	Mean	Range
Temperature C°	18.98	6.66 – 32.11
Oxidation/Reduction Potential, MV	---	---
Specific Conductance, umhos/cm (uS/cm)	1,928	1,361 – 3,031
Dissolved Oxygen, mg/l	10.94	5.93 – 17.37
Dissolved Oxygen Saturation, %	116.9	75.3 – 194.8
pH (actual pH values were averaged to determine mean)	8.35	7.89 – 9.15
Total Alkalinity, mg/l	---	---
P-Alkalinity, mg/l	---	---
Total Hardness, as $CaCO_3$, mg/l	245	182 – 368
Total Dissolved Solids (TDS), mg/l	1,243	871 – 1,940
Salinity, g/l	---	---
Turbidity, NTU	16.1	5.0 – 58.0
Chloride, mg/l	467	249 – 840
Sulfate, mg/l	118.7	69.5 – 164.0
Fecal Coliform, count/100 ml	1,074	30 – 4,500
E. Coli, Quanti-Tray, count/100 ml	89	10 – 235
Enterococci, count/100 ml	155	10 – 471
Nitrogen, Ammonia, mg/l	0.09	0.05 – 0.33
Nitrogen, Kjeldahl, mg/l	0.99	0.66 – 1.83
Nitrogen, Nitrate/Nitrite as N, mg/l	0.62	0.05 – 1.72
Phosphorous, Total, mg/l	0.320	0.203 – 0.835
Phosphorous, Ortho, mg/l	0.220	0.107 – 0.646

Table 4
OWRB, Beneficial Use Monitoring Program (BUMP), River Segment (120410), AT165570 (Haskell) State Highway 104 35.820955487/-95.639952643

2006 Mean & Range Data

Constituent/Measurement	Mean	Range
Temperature C°	19.52	7.55 – 32.04
Oxidation/Reduction Potential, MV	---	---
Specific Conductance, umhos/cm (uS/cm)	1,896	856 – 2,918
Dissolved Oxygen, mg/l	9.61	6.26 – 12.84
Dissolved Oxygen Saturation, %	105.8	58.0 – 167.8
pH (actual pH values were averaged to determine mean)	8.36	7.83 – 8.88
Total Alkalinity, mg/l	---	---
P-Alkalinity, mg/l	---	---
Total Hardness, as $CaCO_3$, mg/l	234	164 – 304
Total Dissolved Solids (TDS), mg/l	1,214	548 – 1,867
Salinity, g/l	---	---
Turbidity, NTU	23.3	5.0 – 76.0
Chloride, mg/l	466	218 – 815
Sulfate, mg/l	119.4	69.1 – 158.0
Fecal Coliform, count/100 ml	606	10 – 4,900
E. Coli, Quanti-Tray, count/100 ml	237	10 –1,515
Enterococci, count/100 ml	312	10 –1,989
Nitrogen, Ammonia, mg/l	0.10	0.05 – 0.32
Nitrogen, Kjeldahl, mg/l	1.08	0.66 – 2.17
Nitrogen, Nitrate/Nitrite as N, mg/l	0.39	0.05 – 1.09
Phosphorous, Total, mg/l	0.290	0.158 – 0.62
Phosphorous, Ortho, mg/l	0.150	0.036 – 0.365

Water Quality Data (City of Tulsa) & Conclusions

The water quality data provided in **Tables 5, 6, 7, 8 & 9** are the City of Tulsa's 2000-05 water quality data which are used to supplement their Stormwater Management Plan requirements **(Appendix C)**. Also, they are used in accordance with the ODEQ 252: 605-7-31(e) regulations to support the City's NPDES/OPDES Waste Water Treatment Plant Permits. The City of Tulsa's water quality data are used because: 1) there were five additional monitoring stations within the study area to obtain information; 2) four of the five City of Tulsa monitoring stations represent different sampling points in the study area; 3) water quality data are available for multiple years and is current; 4) and the City of Tulsa's water quality data are similar to the constituents sampled by the OWRB. The City's water quality data comes from five monitoring stations **(Figure 2)** and involves six years of monitoring data, 2000, 2001, 2002, 2003, 2004 and 2005. Some of the City of Tulsa's sampling locations may not be entirely representative of the entire cross-channel water column. For example, the AR-1 and AR-4 locations are sampled as single points in the water column from the middle of the bridge and AR-3, AR-6 and AR-8 are collected from a stream bank. However, low flows in the Arkansas River create pooling and braided stream conditions across a transect (bank to bank). A geometric mean is calculated for each of the monitoring stations and the water year's physical, chemical and biological constituents. The geometric mean is calculated to allow for a comparative analysis to the OWRB's 2006 water quality data. The most comprehensive data are represented by monitoring station AR-1 (11th St. Bridge, Tulsa) and monitoring station AR-6 (U.S. Highway 64 Bridge, Bixby).

All of the monitoring station's physical and chemical constituents sampled over the six year period reflect water quality typical of that found in other streams in the United States. It should be noted that the water is generally found to be hard because the hardness concentrations, as mg/l calcium carbonate, are between 250 and 330 mg/l. The majority of the physical, chemical and biological constituents supports the OWRB's 2004 BUMP Report findings for the particular beneficial use and also supports the OWRB's 2006 data identified in **Tables 2, 3 & 4**. This would include the Warm Water Aquatic Community, Primary Body Contact—Recreation, and Nutrient-Threatened beneficial use determinations.

The fecal coliform, geometric mean concentration values for all five of the monitoring stations and most of the monitoring years reflect concentrations that would make them not-supported for the OWRB Primary Body Contact—Recreation beneficial use. The City of Tulsa fecal coliform values are similar to the OWRB monitoring station fecal coliform results in that higher concentrations are occurring downstream from Tulsa's central business district through south Tulsa. The OWRB's Sand Springs monitoring station is located at the State Highway 97 Bridge and the segment it represents is from the Keystone Dam to just west of downtown Tulsa. This segment of the river does support the Primary Body Contact—Recreation Beneficial Use. However, the City of Tulsa's monitoring stations begin at AR-1 (11th St. Bridge, Tulsa) and are all located downstream as are the two remaining OWRB monitoring stations. Thus, the City of Tulsa and the two other OWRB monitoring stations reflect relatively high levels for fecal coliform.

Only four of the five City of Tulsa monitoring stations included metals analysis. Most of the metals analysis from these four monitoring stations (AR-1, AR-3, AR-6 & AR-8) reflect concentrations that meet the OWRB requirements with the exception of arsenic, mercury and selenium. At AR-1 (11th St. Bridge, Tulsa), arsenic concentrations were approximately 1.5 times the OWRB criteria limit of 0.04 mg/l in 2000 and 2001(Table 5). At AR-3 (East Bank, Near I-44 Bridge, Tulsa), arsenic concentrations were slightly above the OWRB criteria limit in years 2000 and at the criteria limit in 2001 (Table 6). At AR-6 (North Bank, Under U.S. Highway 64 Bridge, Bixby), the arsenic concentration in 2001 was at the OWRB criteria limit (Table 8). In 2002, the mercury concentration of 0.0041 mg/l was twice the OWRB criteria limit of 0.002 mg/l. In 2001, the selenium concentration was approximately twice the OWRB criteria limit of 0.01 mg/l (Table 8). At AR-8 (North Bank Indian Springs Sports Complex, Broken Arrow), the arsenic concentrations were 1.5 times the OWRB criteria limit of 0.04 mg/l in 2000 and slightly over the limit in 2001.

Water Quality (Tulsa City—County Health Department) & Conclusions

The Tulsa County Health Department conducted water quality assessments from 1976-1980 (**Woodruff, 1983**) and 1989-2000 (**Tulsa County Health Department, 1989-2000**). The monitoring locations were the 11th Street Bridge (middle of bridge), 21st Street Bridge (middle of bridge) and Pedestrian Bridge (middle of bridge), and at the 11th Street Storm Drain, Indian Avenue Sanitary Drain, 21st Street Storm Drain and 26th Street Sanitary Drain. The monitoring included the collection of physical and chemical parameters 1976-1980 and 1991-95 (**Appendix D, Table 1 & Reports**). The monitoring also included the collection of biological parameters 1976-1980 and 1989-2000 (**Appendix D, Tables 2 & 3 & Water Quality Reports**). For comparison, the monitoring would include all of the Tulsa County Health Department locations, the City of Tulsa's 11th Street location and the OWRB's Bixby location. As a caveat, the Bixby location represents water quality to the confluence of Cherry Creek, just upstream of the of the 51Street bridge in Tulsa.

There are similarities or trends when the earlier Tulsa County Health Department data are compared to the more recent OWRB and City of Tulsa data. In general, the physical parameter monitoring was similar to the OWRB and City of Tulsa data with little difference. Again, the physical mean and range values reflect typical conditions found in other streams in the United States **(Hem, 1986)**.

The chemical (heavy metal) parameters, specifically cadmium, chromium, lead and mercury showed a decrease in concentration from the earlier data to the more recent data. The decreases ranged from two to four times lower for cadmium, four to eight times lower for chromium, four to 10 times lower for lead, and one order of magnitude lower for mercury. The other chemical parameters were similar to the OWRB and City of Tulsa data with little to no variation. The chemical mean and range values reflect typical conditions found in other streams in the United States **(Hem, 1986)**.

The Tulsa County Health Department biological parameters (fecal coliform) were sampled in-stream at the bridges or from the direct measurement of the discharge from each of the storm drains. These results, data years (1991-1996), continue to confirm the OWRB and City of Tulsa sampling results. The direct effluent concentrations for fecal coliform ranged from 10,000 cfu/100 ml to 1,100,000 cfu/100 ml at the storm drains. (**Appendix D, Tables 2 & 3 & Water Quality Reports**).

Water Quality (NPDES Permitted Industrial Facilities) & Conclusions

There are 38 issued NPDES/OPDES permits throughout the 42-mile study area **(Appendix E)**. Of the 38 issued permits, there are 28 active discharge points for 25 different facilities **(Figure 3)**. There are six (6) wastewater treatment plants, three (3) public electricity generation utilities, nine (9) sand & gravel operations or concrete batch operations, two (2) petroleum refineries, one (1) petroleum pipeline, one (1) paper product manufacturer, and three (3) chemical product manufacturers or processors. These facilities are permitted by the ODEQ under the OPDES permit program. Permits are issued under the Industrial (specific) Point Source Discharge categories and the Storm Water Discharge (OKR05) if applicable (**USEPA, PCS, 2007**).

The most common, measured constituents for the permitted facilities are flow (MGD), pH, biochemical oxygen demand (BOD), total suspended solids (TSS) and oil and grease. The least measured constituents are chemical oxygen demand (COD), total dissolved solids (TDS), total chloride, total chlorine residual, total fluoride, total sulfate, total sulfide, total antimony, total tin, total mercury, total hexavalent chromium, total chromium, total ammonia, fecal coliform and total phenolics **(Table 10)**. Some of these constituents have USEPA specified effluent limits, and others have no applicable water quality standards **(USEPA, NPDES, 2007)**.

The effluent limits for each type of industry have established numeric criteria and narrative (qualitative) standards. The effluent limits are established to meet the water quality standards of the state and not degrade (antidegradation policy) the water quality. In addition, the effluent limits and other requirements are specific to the type of industry. If a particular stream/river's water quality is threatened by an industrial facility's discharge a limit is set on the concentration and amount of discharge. This is known as a water quality based wasteload allocation which can be set by either a wasteload allocation study or TMDL study. Currently there are no TMDLs established within the Arkansas River along the 42-mile study area **(USEPA, NPDES, 2007)**. However, INCOG and the ODEQ have a draft bacteria TMDL for most of the study area that should received EPA approval in 2009.

In general, the physical, chemical and biological constituents identified in Table 10 fall within the typical stream characteristics of other streams in the United States, meet the Oklahoma WQS criteria. There are no USEPA Primary and/or Secondary Water Quality Standards established for the biochemical oxygen demand, chemical oxygen demand, total suspended solids, total organic carbon, phenolics and/or oil and grease.

Table 5
City of Tulsa; Arkansas River Water Quality Monitoring
To Support
Storm Water Management Plan & Waste Water Treatment Plant Permits

Constituent	**AR-1 11th Street Bridge (Tulsa) 36.143417/-96.987056**					
Year	**2000 mean**	**2001 mean**	**2002 mean**	**2003 mean**	**2004 mean**	**2005 mean**
Temperature C°	18.47	17.68	17.74	16.47	16.54	14.42
pH (actual pH values were averaged to determine mean)	7.99	8.00	8.02	7.92	7.97	8.03
Dissolved Oxygen, mg/l	9.06	8.29	8.42	8.35	7.97	9.27
Biochemical Oxygen Demand, mg/l	2.99	2.23	2.07	2.06	2.08	2.00
Ammonia, mg/l	0.10	0.17	0.11	0.11	0.17	0.098
Nitrate, mg/l	0.69	0.75	0.83	0.62	0.78	----
Nitrite, mg/l	0.02	0.04	0.03	0.12	0.02	----
Nitrate + Nitrite, mg/l	0.71	0.77	0.86	0.72	0.75	0.62
Kjeldahl, ug/l	----	----	0.83	0.86	0.71	0.68
Hardness, mg/l	261.66	263.42	227.58	256.67	231.33	283.00
Fecal Coliform, count/100 ml	251	204	129	752	392	506
Phosphorous, mg/l	----	----	----	0.13	0.16	0.14
Arsenic, mg/l	0.0594	0.0590	----	----	----	----
Cadmium, mg/l	<0.0040	<0.0040	0.0043	0.00123	0.00168	0.0013

Table 5
City of Tulsa; Arkansas River Water Quality Monitoring
To Support
Storm Water Management Plan & Waste Water Treatment Plant Permits

Constituent	AR-1 11th Street Bridge (Tulsa) 36.143417/-96.987056					
Year	2000 mean	2001 mean	2002 mean	2003 mean	2004 mean	2005 Mean
Chromium, mg/l	<0.010	<0.010	----	----	----	----
Copper, mg/l	0.010	0.0148	0.00670	0.00560	0.00670	0.0059
Lead, mg/l	0.00150	0.0056	0.00226	0.00204	0.00236	0.00221
Mercury, mg/l	<0.00020	0.00006	----	<0.00020	----	----
Selenium, mg/l	<0.0020	0.0044	----	----	----	----
Silver, mg/l	<0.0010	<0.0030	----	----	----	----
Zinc, mg/l	0.05590	0.05013	0.03910	0.11281	0.0648	0.01671

Table 6
City of Tulsa; Arkansas River Water Quality Monitoring
To Support
Storm Water Management Plan & Waste Water Treatment Plant Permits

Constituent	AR-3 East Bank, Near I-44 Bridge (Tulsa) 36.096778/-95.985389					
Year	2000 mean	2001 mean	2002 mean	2003 mean	2004 mean	2005 mean
Temperature C°	18.84	17.74	19.08	18.23	17.64	16.56
pH (actual pH values were averaged to determine mean)	7.93	7.98	8.16	7.98	7.91	7.89
Dissolved Oxygen, mg/l	9.43	9.44	10.71	9.23	8.48	10.28
Biochemical Oxygen Demand, mg/l	----	----	----	1.00	----	----
Ammonia, mg/l	----	----	----	----	----	----
Nitrate, mg/l	----	----	----	----	----	----
Nitrite, mg/l	----	----	----	----	----	----
Nitrate + Nitrite, mg/l	----	----	----	----	----	----
Kjeldahl, ug/l	----	----	----	----	----	----
Hardness, mg/l	----	258.00	205.00	993.78	----	----
Fecal Coliform, count/100 ml	2,119	3,276	1,089	5,221	1,399	1,192
Phosphorous, mg/l	----	----	----	0.16	----	----
Phenol, mg/l	<10	----	----	5.00	----	----

Table 6
City of Tulsa; Arkansas River Water Quality Monitoring
To Support
Storm Water Management Plan & Waste Water Treatment Plant Permits

Constituent	AR-3 East Bank, Near I-44 Bridge (Tulsa) 36.096778/-95.985389					
Year	**2000 mean**	**2001 mean**	**2002 mean**	**2003 mean**	**2004 mean**	**2005 mean**
Arsenic, mg/l	<0.050	<0.040	<0.002	----	----	----
Cadmium, mg/l	<0.004	<0.004	<0.004	<0.001	----	----
Chromium, mg/l	<0.010	<0.010	----	----	----	----
Copper, mg/l	0.011	<0.010	<0.0078	0.0067	----	----
Lead, mg/l	0.0011	<0.0020	<0.0020	<0.0020	----	----
Mercury, mg/l	<0.00020	<0.00020	<0.00020	<0.00020	----	----
Selenium, mg/l	<0.0020	0.0035	<0.0020	<0.0020	----	----
Silver, mg/l	<0.001	<.0030	<0.0028	<0.0020	----	----
Zinc, mg/l	0.0160	0.0164	0.0320	0.160	----	----

Table 7
City of Tulsa; Arkansas River Water Quality Monitoring
To Support
Storm Water Management Plan & Waste Water Treatment Plant Permits

Constituent	**AR-4 71st Street Bridge (Tulsa) 36.064000/-95.979583**					
Year	**2000 Mean**	**2001 mean**	**2002 mean**	**2003 mean**	**2004 mean**	**2005 mean**
Temperature C°	18.53	17.74	18.25	18.00	16.55	16.55
pH (actual pH values were averaged to determine mean)	7.97	8.05	8.00	8.06	7.95	7.97
Dissolved Oxygen, mg/l	9.21	8.58	9.42	8.85	8.70	9.72
Hardness, mg/l	----	243.00	----	----	----	----
Fecal Coliform, count/100 ml	641	924	1,087	1,637	307	2,342
Phosphorous, mg/l	----	----	----	0.17	----	----

Table 8
City of Tulsa; Arkansas River Water Quality Monitoring
To Support
Storm Water Management Plan & Waste Water Treatment Plant Permits

Constituent	AR-6 North Bank, Under U.S. Highway 64 Bridge (Bixby) 35.958667/-95.886889					
Year	2000 mean	2001 mean	2002 mean	2003 mean	2004 mean	2005 mean
Temperature C°	18.42	17.97	18.48	18.20	17.29	17.3
pH (actual pH values were averaged to determine mean)	8.06	8.09	8.05	8.04	8.02	8.02
Dissolved Oxygen, mg/l	9.06	8.25	8.89	8.29	8.09	9.20
Biochemical Oxygen Demand, mg/l	----	11.44	2.72	2.10	2.63	2.75
Ammonia, mg/l	----	0.10	0.21	0.10	0.08	0.16
Nitrate, mg/l	----	0.57	0.56	0.69	0.71	----
Nitrite, mg/l	----	0.02	0.02	0.03	0.04	----
Nitrate + Nitrite, mg/l	----	0.58	0.59	0.67	0.61	0.62
Kjeldahl, ug/l	----	----	1.04	0.82	0.67	1.18
Hardness, mg/l	----	251.00	212.50	256.67	204.00	240
Fecal Coliform, count/100 ml	724	1,423	796	2,322	449	1,483
Phosphorous, mg/l	----	----	----	0.17	0.19	0.25
Arsenic, mg/l	----	<0.040	----	----	----	----
Cadmium, mg/l	----	<0.0040	0.0041	0.000981	0.0014	0.0012

Table 8
City of Tulsa; Arkansas River Water Quality Monitoring
To Support
Storm Water Management Plan & Waste Water Treatment Plant Permits

Constituent	AR-6 North Bank, Under U.S. Highway 64 Bridge (Bixby) 35.958667/-95.886889					
Year	2000 mean	2001 mean	2002 Mean	2003 Mean	2004 mean	2005 Mean
Chromium, mg/l	----	<0.0100	----	----	----	----
Copper, mg/l	----	0.0135	0.00733	0.0073	0.00725	0.01212
Lead, mg/l	----	0.0047	0.00372	0.00279	0.00278	0.00204
Mercury, mg/l	----	<0.0002	0.0041	<0.0002	----	----
Selenium, mg/l	----	0.0220	----	----	----	----
Silver, mg/l	----	<0.0030	----	----	----	----
Zinc, mg/l	----	0.0255	----	----	----	0.01642

Table 9
City of Tulsa; Arkansas River Water Quality Monitoring
To Support
Storm Water Management Plan & Waste Water Treatment Plant Permits

Constituent	AR-8 North Bank, Indian Springs Sports Complex (Broken Arrow) 35.961972/-95.807972					
Year	**2000 mean**	**2001 mean**	**2002 mean**	**2003 mean**	**2004 mean**	**2005 Mean**
Temperature C°	18.69	17.98	18.92	19.05	16.80	16.95
pH (actual pH values were averaged to determine mean)	8.04	8.11	7.86	8.13	7.93	8.01
Dissolved Oxygen, mg/l	9.06	8.99	8.88	8.41	8.23	9.55
Biochemical Oxygen Demand, mg/l	4.12	4.05	----	----	----	----
Ammonia, mg/l	0.09	0.22	----	----	----	----
Nitrate, mg/l	0.63	0.71	----	----	----	----
Nitrite, mg/l	0.03	0.03	----	----	----	----
Nitrate + Nitrite, mg/l	0.64	0.73	----	----	----	----
Kjeldahl, ug/l	----	----	----	----	----	----
Hardness, mg/l	248.25	256.19	----	----	----	----
Fecal Coliform, count/100 ml	1,007	656	1,484	2,837	227	1,198
Phosphorous, mg/l	----	----	----	0.22	----	----
Arsenic, mg/l	0.064	0.0465	----	----	----	----

Table 9
City of Tulsa; Arkansas River Water Quality Monitoring
To Support
Storm Water Management Plan & Waste Water Treatment Plant Permits

Constituent	AR-8 North Bank, Indian Springs Sports Complex (Broken Arrow) 35.961972/-95.807972					
Year	2000 mean	2001 Mean	2002 mean	2003 mean	2004 mean	2005 Mean
Cadmium, mg/l	0.0040	0.0041	----	----	----	----
Chromium, mg/l	<0.0100	<0.0100	----	----	----	----
Copper, mg/l	0.011	0.0139	----	----	----	----
Lead, mg/l	0.00125	0.0047	----	----	----	----
Mercury, mg/l	<0.00020	0.00003	----	----	----	----
Selenium, mg/l	<0.0020	0.0020	----	----	----	----
Silver, mg/l	<0.001	<0.003	----	----	----	----
Zinc, mg/l	0.0425	0.0304	----	----	----	----

Table 10
(NPDES) & (OPDES) Permitted Facilities
Arkansas River Corridor, 42-Mile Study Area

CONSTITUENT (mg/l & GPD)	Paper Products	Chemical Processing	Petroleum Refineries & Pipeline	Sand, Gravel & Concrete Operations	Public Utilities (Electrical Power)	Municipal Wastewater Treatment Plants
	Range of Values For Each Facility Classification (Individual Facility Mean Values Based On 2006 & 2007 Data)					
	1 Facility	3 Facilities	3 Facilities	10 Facilities	3 Facilities	9 Facilities
Flow (GPD)	54,357—2,095,000	3,987—3,735,556	2,936—1,985,214	121,682—2,166,667	0.331—361,428	349,607—21,309,333
pH	6.64—7.84	7.27—8.43	7.10—8.74	7.53—8.26	7.48—7.89	6.98—7.99
Biochemical Oxygen Demand	3.008	3.43	6.12—6.32	---	---	4.71—21.34
Chemical Oxygen Demand	12.43—24.70	---	51—55.1	---	---	---
Total Suspended Solids	3.95—9.42	<5.7—9.66	6.19—17.21	9.0—36.77	4.62—21.34	6.8—15.16
Total Dissolved Solids	---	665	---	---	---	491
Total Organic Carbon	---	0.5	5.25	---	---	---
Oil & Grease	5.167	5.144	4.16—5.0	<6.0	<5.0	---
Total Chloride	---	187.2	---	---	---	---
Total Chlorine Residual	---	---	---	---	<0.09	.025—0.058
Total Fluoride	---	1.196	---	---	---	---
Total Sulfate	---	245.6	---	---	---	---
Total Sulfide as (S)	---	---	0.021—0.055	---	---	---
Total Antimony	---	0.0185	---	---	---	---
Total Tin	---	0.036	---	---	---	---

Table 10
(NPDES) & (OPDES) Permitted Facilities
Arkansas River Corridor, 42-Mile Study Area

CONSTITUENT (mg/l & GPD)	Paper Products	Chemical Processing	Petroleum Refineries & Pipeline	Sand, Gravel & Concrete Operations	Public Utilities (Electrical Power)	Municipal Wastewater Treatment Plants
	Range of Values For Each Facility Classification (Individual Facility Mean Values Based On 2006 & 2007 Data)					
	1 Facility	3 Facilities	3 Facilities	10 Facilities	3 Facilities	9 Facilities
Total Mercury	---	---	---	---	---	0.0001
Total Hexavalent Chromium	---	---	0.011—0.016	---	---	---
Total Chromium	---	---	0.01—0.014	---	---	---
Total Ammonia As (N)	---	---	0.88—2.01	---	---	---
Fecal Coliform	---	---	---	---	---	8.1—351.32
Total Phenolics (Recoverable)	---	---	0.031—0.05	---	---	---

See Figure 3 PDF file

NPDES/OPDES Facility Discharges

Tulsa County, Oklahoma

FIGURE 3

JUNE 2007

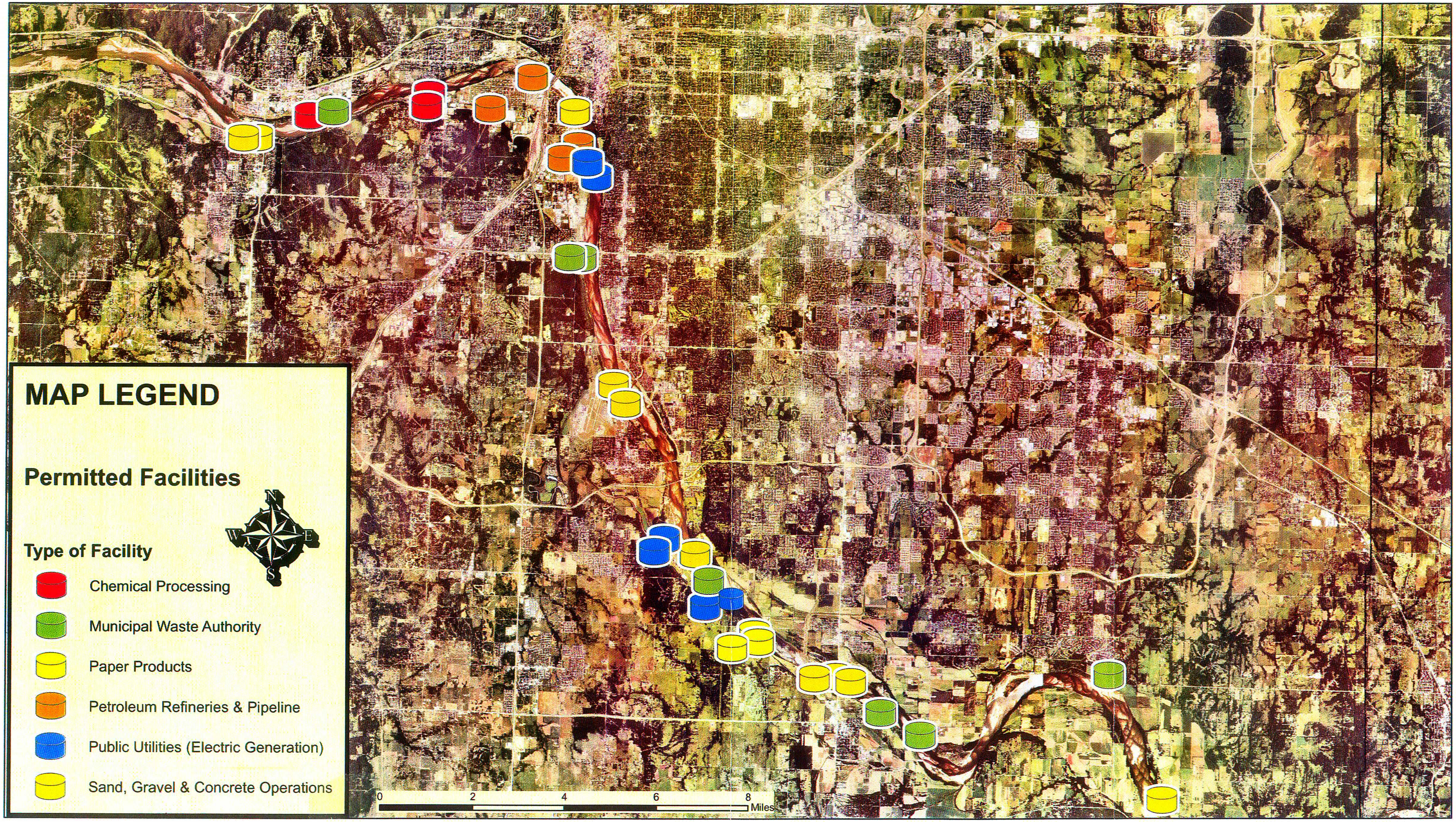


Table 10
(NPDES) & (OPDES) Permitted Facilities
Arkansas River Corridor, 42-Mile Study Area

CONSTITUENT (mg/l & GPD)	Paper Products	Chemical Processing	Petroleum Refineries & Pipeline	Sand, Gravel & Concrete Operations	Public Utilities (Electrical Power)	Municipal Wastewater Treatment Plants
	Range of Values For Each Facility Classification (Individual Facility Mean Values Based On 2006 & 2007 Data)					
	1 Facility	3 Facilities	3 Facilities	10 Facilities	3 Facilities	6 Facilities
Total Mercury	---	---	---	---	---	0.0001
Total Hexavalent Chromium	---	---	0.011—0.016	---	---	---
Total Chromium	---	---	0.01—0.014	---	---	---
Total Ammonia As (N)	---	---	0.88—2.01	---	---	---
Fecal Coliform	---	---	---	---	---	8.1—351.32
Total Phenolics (Recoverable)	---	---	0.031—0.05	---	---	---

Table 10
(NPDES) & (OPDES) Permitted Facilities
Arkansas River Corridor, 42-Mile Study Area

CONSTITUENT (mg/l & GPD)	Paper Products	Chemical Processing	Petroleum Refineries & Pipeline	Sand, Gravel & Concrete Operations	Public Utilities (Electrical Power)	Municipal Wastewater Treatment Plants
	Range of Values For Each Facility Classification (Individual Facility Mean Values Based On 2006 & 2007 Data)					
	1 Facility	3 Facilities	3 Facilities	10 Facilities	3 Facilities	6 Facilities
Flow (GPD)	54,357—2,095,000	3,987—3,735,556	2,936—1,985,214	121,682—2,166,667	0.331—361,428	349,607—21,309,333
pH	6.64—7.84	7.27—8.43	7.10—8.74	7.53—8.26	7.48—7.89	6.98—7.99
Biological Oxygen Demand	3.008	3.43	6.12—6.32	---	---	4.71—21.34
Chemical Oxygen Demand	12.43—24.70	---	51—55.1	---	---	---
Total Suspended Solids	3.95—9.42	<5.7—9.66	6.19—17.21	9.0—36.77	4.62—21.34	6.8—15.16
Total Dissolved Solids	---	665	---	---	---	491
Total Organic Carbon	---	0.5	5.25	---	---	---
Oil & Grease	5.167	5.144	4.16—5.0	<6.0	<5.0	---
Total Chloride	---	187.2	---	---	---	---
Total Chlorine Residual	---	---	---	---	<0.09	.025—0.058
Total Fluoride	---	1.196	---	---	---	---
Total Sulfate	---	245.6	---	---	---	---
Total Sulfide As (S)	---	---	0.021—0.055	---	---	---
Total Antimony	---	0.0185	---	---	---	---
Total Tin	---	0.036	---	---	---	---

Table 9
City of Tulsa; Arkansas River Water Quality Monitoring
To Support
Storm Water Management Plan & Waste Water Treatment Plant Permits

Constituent	AR8 North Bank, Indian Springs Sports Complex (Broken Arrow) 35.961972/-95.807972					
Year	**2000 mean**	**2001 mean**	**2002 mean**	**2003 mean**	**2004 mean**	**2005 mean**
Cadmium, mg/l	0.0040	0.0040	----	----	----	----
Chromium, mg/l	0.0100	0.0100	----	----	----	----
Copper, mg/l	0.0178	0.0116	----	----	----	----
Lead, mg/l	0.0018	0.0024	----	----	----	----
Mercury, mg/l	0.00020	0.00016	----	----	----	----
Selenium, mg/l	0.0020	0.0020	----	----	----	----
Silver, mg/l	0.00050	0.0007	----	----	----	----
Zinc, mg/l	0.0242	0.0201	----	----	----	----

Table 9
City of Tulsa; Arkansas River Water Quality Monitoring
To Support
Storm Water Management Plan & Waste Water Treatment Plant Permits

Constituent	AR8 North Bank, Indian Springs Sports Complex (Broken Arrow) 35.961972/-95.807972					
Year	2000 mean	2001 mean	2002 mean	2003 mean	2004 mean	2005 mean
Temperature C°	18.69	17.98	18.92	19.05	16.80	16.95
pH	8.04	8.11	7.86	8.13	7.93	8.01
Dissolved Oxygen, mg/l	9.06	8.99	8.88	8.41	8.23	9.55
Biological Oxygen Demand, mg/l	4.12	4.05	----	----	----	----
Ammonia, mg/l	0.09	0.22	----	----	----	----
Nitrate, mg/l	0.63	0.71	----	----	----	----
Nitrite, mg/l	0.03	0.03	----	----	----	----
Nitrate + Nitrite, mg/l	0.64	0.73	----	----	----	----
Kjaldahl, ug/l	----	----	----	----	----	----
Hardness, mg/l	248.25	256.19	----	----	----	----
Fecal Coliform, count/100 ml	1.007	656	1.483.92	2.836.59	227.22	1.197.90
Phosphorous, mg/l	----	----	----	0.22	----	----
Arsenic, mg/l	0.0525	0.0418	----	----	----	----

Table 8 City of Tulsa; Arkansas River Water Quality Monitoring To Support Storm Water Management Plan & Waste Water Treatment Plant Permits						
Constituent	AR6 U.S. Highway 64 Bridge (Bixby) 35.958667/-95.886889					
Year	**2000 mean**	**2001 mean**	**2002 mean**	**2003 mean**	**2004 mean**	**2005 mean**
Chromium, mg/l	----	0.0100	----	----	----	----
Copper, mg/l	----	0.0109	0.0082	0.0056	0.0058	0.0101
Lead, mg/l	----	0.0034	0.0032	0.0022	0.0023	0.0019
Mercury, mg/l	----	0.0002	0.0040	0.0002	----	----
Selenium, mg/l	----	0.0220	----	----	----	----
Silver, mg/l	----	0.0030	----	----	----	----
Zinc, mg/l	----	0.0216	----	----	----	0.0137

Table 8
City of Tulsa; Arkansas River Water Quality Monitoring
To Support
Storm Water Management Plan & Waste Water Treatment Plant Permits

Constituent	AR6 U.S. Highway 64 Bridge (Bixby) 35.958667/-95.886889					
Year	**2000 mean**	**2001 mean**	**2002 mean**	**2003 mean**	**2004 mean**	**2005 mean**
Temperature C°	18.42	17.97	18.48	18.20	17.29	17.3
pH	8.06	8.09	8.05	8.04	8.02	8.02
Dissolved Oxygen, mg/l	9.06	8.25	8.89	8.29	8.09	9.20
Biological Oxygen Demand, mg/l	----	11.44	2.72	2.10	2.63	2.71
Ammonia, mg/l	----	0.10	0.21	0.10	0.08	0.11
Nitrate, mg/l	----	0.57	0.56	0.69	0.71	----
Nitrite, mg/l	----	0.02	0.02	0.03	0.04	----
Nitrate + Nitrite, mg/l	----	0.58	0.59	0.67	0.61	0.62
Kjaldahl, ug/l	----	----	1.04	0.82	0.67	1.09
Hardness, mg/l	----	251.00	212.50	256.67	204.00	240
Fecal Coliform, count/100 ml	724	1.423	796.13	2.321.86	448.79	1.482.58
Phosphorous, mg/l	----	----	----	0.17	0.19	0.25
Arsenic, mg/l	----	0.040	----	----	----	----
Cadmium, mg/l	----	0.0040	0.0040	0.0010	0.0014	0.0012

Table 7
City of Tulsa; Arkansas River Water Quality Monitoring
To Support
Storm Water Management Plan & Waste Water Treatment Plant Permits

Constituent	**AR4 East Bank, 68th & South Riverside (Tulsa) 36.064000/-95.979583**					
Year	**2000 mean**	**2001 mean**	**2002 mean**	**2003 mean**	**2004 mean**	**2005 mean**
Temperature C°	18.53	17.74	18.25	18.00	16.55	16.55
pH	7.97	8.05	8.00	8.06	7.95	7.97
Dissolved Oxygen, mg/l	9.21	8.58	9.42	8.85	8.70	9.72
Hardness, mg/l	----	243.00	----	----	----	----
Fecal Coliform, count/100 ml	726.07	923.86	1.086.74	1.637.05	306.82	2.342.33
Phosphorous, mg/l	----	----	----	0.17	----	----

Table 6
City of Tulsa; Arkansas River Water Quality Monitoring
To Support
Storm Water Management Plan & Waste Water Treatment Plant Permits

Constituent	AR3 I-44 Bridge (Tulsa) 36.096778/-95.985389					
Year	2000 mean	2001 mean	2002 mean	2003 mean	2004 mean	2005 mean
Arsenic, mg/l	0.040	0.040	0.002	----	----	----
Cadmium, mg/l	0.004	0.004	0.004	0.001	----	----
Chromium, mg/l	0.010	0.010	----	----	----	----
Copper, mg/l	0.015	0.010	0.0078	0.0058	----	----
Lead, mg/l	0.0016	0.0020	0.0020	0.0020	0.0020	----
Mercury, mg/l	0.00020	0.00020	0.00020	0.00020	----	----
Selenium, mg/l	0.0020	0.0025	0.0020	0.0020	----	----
Silver, mg/l	0.0008	.0030	0.0028	0.0020	----	----
Zinc, mg/l	0.0190	0.0132	0.0320	0.0850	----	----

Table 6
City of Tulsa; Arkansas River Water Quality Monitoring
To Support
Storm Water Management Plan & Waste Water Treatment Plant Permits

Constituent	AR3 I-44 Bridge (Tulsa) 36.096778/-95.985389					
Year	2000 mean	2001 mean	2002 mean	2003 mean	2004 mean	2005 mean
Temperature C°	18.84	17.74	19.08	18.23	17.64	16.56
pH	7.93	7.98	8.16	7.98	7.91	7.89
Dissolved Oxygen, mg/l	9.43	9.44	10.71	9.23	8.48	10.28
Biological Oxygen Demand, mg/l	----	----	----	1.00	----	----
Ammonia, mg/l	----	----	----	----	----	----
Nitrate, mg/l	----	----	----	----	----	----
Nitrite, mg/l	----	----	----	----	----	----
Nitrate + Nitrite, mg/l	----	----	----	----	----	----
Kjaldahl, ug/l	----	----	----	----	----	----
Hardness, mg/l	----	258.00	205.00	993.78	----	----
Fecal Coliform, count/100 ml	2,119.33	3,276.38	1,089.1	5,221.33	1,398.64	1,192.45
Phosphorous, mg/l	----	----	----	0.16	----	----
Phenol, mg/l	8.75	----	----	5.00	----	----

Table 5
City of Tulsa; Arkansas River Water Quality Monitoring
To Support
Storm Water Management Plan & Waste Water Treatment Plant Permits

Constituent	**AR1 11th Street Bridge (Tulsa) 36.143417/-96.987056**					
Year	**2000 mean**	**2001 mean**	**2002 mean**	**2003 mean**	**2004 mean**	**2005 mean**
Chromium, mg/l	0.010	0.010	----	----	----	----
Copper, mg/l	0.016	0.0109	0.00612	0.00544	0.00671	0.00545
Lead, mg/l	0.00167	0.00224	0.00202	0.00202	0.00236	0.00206
Mercury, mg/l	0.00020	0.00018	----	0.00020	----	----
Selenium, mg/l	----	----	----	----	----	----
Silver, mg/l	----	----	----	----	----	----
Zinc, mg/l	0.0436	0.0392	0.0342	0.0957	0.0648	0.0172

Table 5
City of Tulsa; Arkansas River Water Quality Monitoring
To Support
Storm Water Management Plan & Waste Water Treatment Plant Permits

Constituent	AR1 11th Street Bridge (Tulsa) 36.143417/-96.987056					
Year	2000 mean	2001 mean	2002 mean	2003 mean	2004 mean	2005 mean
Temperature C°	18.47	17.68	17.74	16.47	16.54	14.42
pH	7.99	8.00	8.02	7.92	7.97	8.03
Dissolved Oxygen, mg/l	9.06	8.29	8.42	8.35	7.97	9.27
Biological Oxygen Demand, mg/l	2.99	2.23	2.07	2.06	2.08	2.80
Ammonia, mg/l	0.10	0.17	0.11	0.11	0.17	0.09
Nitrate, mg/l	0.69	0.75	0.83	0.62	0.78	----
Nitrite, mg/l	0.02	0.04	0.03	0.12	0.02	----
Nitrate + Nitrite, mg/l	0.71	0.77	0.86	0.72	0.75	0.62
Kjaldahl, ug/l	----	----	0.83	0.88	0.71	0.68
Hardness, mg/l	261.66	263.42	227.58	256.67	231.33	283.00
Fecal Coliform, count/100 ml	251.21	204.29	129.17	752.17	391.58	506.09
Phosphorous, mg/l	----	----	----	0.13	0.16	0.14
Arsenic, mg/l	0.0494	0.0411	----	----	----	----
Cadmium, mg/l	0.0040	0.0040	0.0040	0.0011	0.0017	0.0013

Appendix A

References

Two (2) pages

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Appendix B

Oklahoma Water Resources Board
BUMP Monitoring Station Data

Sand Springs (120420010130-001AT)
16 pages

Bixby (120420010010-001AT)
19 pages

Haskell (120410010080-001AT)
39 pages

	A	B	C	D	E	F	G	H
1	**Sand Springs Biological & Field Data**							
2	**STATION_ID**	**SAMPLE_ID**	**SAMPLE_DATE**	**PARAMETER_TYPE**	**PARAMETER**	**VALUE**	**UNITS**	**METHOD**
3	120420010130-001AT	A00750	5/23/2006	Biological	COLIFORM, FECAL	30	NM/100ML	9222D
4	120420010130-001AT	A00750	5/23/2006	Biological	E. COLI QUANTI TRAY	41	MPN/100ML	9223
5	120420010130-001AT	A00750	5/23/2006	Biological	ENTEROCOCCI	10	CFU/100ML	9230C
6	120420010130-001AT	A00951	6/12/2006	Biological	COLIFORM, FECAL	30	NM/100ML	9222D
7	120420010130-001AT	A00951	6/12/2006	Biological	E. COLI QUANTI TRAY	20	MPN/100ML	9223
8	120420010130-001AT	A00951	6/12/2006	Biological	ENTEROCOCCI	10	CFU/100ML	9230C
9	120420010130-001AT	A01038	6/26/2006	Biological	COLIFORM, FECAL	10	NM/100ML	9222D
10	120420010130-001AT	A01038	6/26/2006	Biological	E. COLI QUANTI TRAY	10	MPN/100ML	9223
11	120420010130-001AT	A01038	6/26/2006	Biological	ENTEROCOCCI	31	CFU/100ML	9230C
12	120420010130-001AT	A01329	7/24/2006	Biological	COLIFORM, FECAL	10	NM/100ML	9222D
13	120420010130-001AT	A01329	7/24/2006	Biological	E. COLI QUANTI TRAY	31	MPN/100ML	9223
14	120420010130-001AT	A01329	7/24/2006	Biological	ENTEROCOCCI	63	CFU/100ML	9230C
15								
16								
17	**STATION_ID**	**SAMPLE_ID**	**SAMPLE_DATE**	**PARAMETER_TYPE**	**PARAMETER**	**VALUE**	**UNITS**	**METHOD**
18	120420010130-001AT	391006	1/23/2006	Field	Water Temperature	4.42	DEG CELS	2550B
19	120420010130-001AT	391006	1/23/2006	Field	AIR TEMPERATURE	-1.1	DEG C	2550B
20	120420010130-001AT	391006	1/23/2006	Field	BARROMETRIC PRESSURE	769	MM HG	
21	120420010130-001AT	391006	1/23/2006	Field	CLOUD COVER	5	PERCENT	
22	120420010130-001AT	391006	1/23/2006	Field	WIND VELOCITY	2	MPH	
23	120420010130-001AT	391006	1/23/2006	Field	WIND DIRECTION	270	AZIMUTH	
24	120420010130-001AT	391006	1/23/2006	Field	STREAM STAGE	2.01	feet	
25	120420010130-001AT	391006	1/23/2006	Field	OXIDATION/REDUCTION POT. (FIELD)	406	MV	
26	120420010130-001AT	391006	1/23/2006	Field	Specific Conductance	3205	UMHOS/CM	120.1
27	120420010130-001AT	391006	1/23/2006	Field	DISSOLVED OXYGEN, analysis by probe	7.39	MG/L	
28	120420010130-001AT	391006	1/23/2006	Field	DISS OXY SATURATION	57.7	PERCENT	
29	120420010130-001AT	391006	1/23/2006	Field	PH (FIELD)	7.88	STD UNIT	150.1
30	120420010130-001AT	391006	1/23/2006	Field	TOT ALK FIELD CACO3	151	MG/L	
31	120420010130-001AT	391006	1/23/2006	Field	Hardness, Total (as CaCO3)	384	MG/L	

	A	B	C	D	E	F	G	H
1	Sand Springs Biological & Field Data							
2	STATION_ID	SAMPLE_ID	SAMPLE_DATE	PARAMETER_TYPE	PARAMETER	VALUE	UNITS	METHOD
32	120420010130-001AT	391006	1/23/2006	Field	Oil and Grease, Severity (1=none, 2=light, 3=moderate, 4=heavy, 5=total)	1	code	
33	120420010130-001AT	391006	1/23/2006	Field	Odor, Atmospheric, Severity (1=none, 2=light, 3=moderate, 4=heavy, 5=severe)	1	code	
34	120420010130-001AT	391006	1/23/2006	Field	Debris, Floating, Severity (1=none, 2=light, 3=moderate, 4=heavy, 5=total)	1	code	
35	120420010130-001AT	391006	1/23/2006	Field	Foaming, Severity (1=none, 2=light, 3=moderate, 4=heavy, 5=total)	1	code	
36	120420010130-001AT	391006	1/23/2006	Field	Scum, Severity (1=none, 2=light, 3=moderate, 4=heavy, 5=total)	1	code	
37	120420010130-001AT	391006	1/23/2006	Field	Turbidity, Type (1=inorganic, 2=organic, 3=mix)	1	code	
38	120420010130-001AT	391006	1/23/2006	Field	STREAM FLOW, SEVERITY (1=none, 2=light, 3=moderate, 4=heavy, 5=stormwater)	1	CODE	
39	120420010130-001AT	391006	1/23/2006	Field	TOTAL DISSOLVED SOLIDS (FIELD)	2051	MG/L	
40	120420010130-001AT	391006	1/23/2006	Field	SALINITY (FIELD)	7.73	G/L	
41	120420010130-001AT	391006	1/23/2006	Field	Periphyton, Severity (% of streambed; 1=0%, 2=25%, 3=50%, 4=75%, 5=100%)	1	code	
42	120420010130-001AT	391006	1/23/2006	Field	Periphyton Line, Visible (1=yes, 2=no)	2	code	
43	120420010130-001AT	391006	1/23/2006	Field	Flow, Instantaneous	12.75	CFS	
44	120420010130-001AT	391006	1/23/2006	Field	Turbidity, Field	5	NTU	180.1
45	120420010130-001AT	391006	1/23/2006	Field	P-ALKALINITY (FIELD)	0	MG/L	
46	120420010130-001AT	391006	1/23/2006	Field	STREAM WIDTH	125	METERS	
47	120420010130-001AT	391006	1/23/2006	Field	STREAM TYPE	2	CODE	

	A	B	C	D	E	F	G	H
1	Sand Springs Biological & Field Data							
2	STATION_ID	SAMPLE_ID	SAMPLE_DATE	PARAMETER_TYPE	PARAMETER	VALUE	UNITS	METHOD
48	120420010130-001AT	391006	1/23/2006	Field	Flow Measurement Tech (1=composite average, 2=rated, 3=DCP)	2	code	
49	120420010130-001AT	391006	1/23/2006	Field	DEPTH, MAXIMUM OF SAMPLE	0.2	METERS	
50	120420010130-001AT	391006	1/23/2006	Field	COLOR, BORGER COLOR SYSTEM	93	CODE	
51	120420010130-001AT	393460	2/27/2006	Field	Water Temperature	8.2	DEG CELS	2550B
52	120420010130-001AT	393460	2/27/2006	Field	AIR TEMPERATURE	20	DEG C	2550B
53	120420010130-001AT	393460	2/27/2006	Field	BAROMETRIC PRESSURE	765	MM HG	
54	120420010130-001AT	393460	2/27/2006	Field	CLOUD COVER	1	PERCENT	
55	120420010130-001AT	393460	2/27/2006	Field	WIND VELOCITY	28	MPH	
56	120420010130-001AT	393460	2/27/2006	Field	WIND DIRECTION	180	AZIMUTH	
57	120420010130-001AT	393460	2/27/2006	Field	STREAM STAGE	5.57	feet	
58	120420010130-001AT	393460	2/27/2006	Field	OXIDATION/REDUCTION POT. (FIELD)	449	MV	
59	120420010130-001AT	393460	2/27/2006	Field	Specific Conductance	2987	UMHOS/CM	120.1
60	120420010130-001AT	393460	2/27/2006	Field	DISSOLVED OXYGEN, analysis by probe	12.87	MG/L	
61	120420010130-001AT	393460	2/27/2006	Field	DISS OXY SATURATION	121.46	PERCENT	
62	120420010130-001AT	393460	2/27/2006	Field	PH (FIELD)	8.32	STD UNIT	150.1
63	120420010130-001AT	393460	2/27/2006	Field	TOT ALK FIELD CACO3	151	MG/L	
64	120420010130-001AT	393460	2/27/2006	Field	Hardness, Total (as CaCO3)	320	MG/L	
65	120420010130-001AT	393460	2/27/2006	Field	Oil and Grease, Severity (1=none, 2=light, 3=moderate, 4=heavy, 5=total)	2	code	
66	120420010130-001AT	393460	2/27/2006	Field	Odor, Atmospheric, Severity (1=none, 2=light, 3=moderate, 4=heavy, 5=severe)	2	code	
67	120420010130-001AT	393460	2/27/2006	Field	Debris, Floating, Severity (1=none, 2=light, 3=moderate, 4=heavy, 5=total)	2	code	

	A	B	C	D	E	F	G	H
1	**Sand Springs Biological & Field Data**							
2	**STATION_ID**	**SAMPLE_ID**	**SAMPLE_DATE**	**PARAMETER_TYPE**	**PARAMETER**	**VALUE**	**UNITS**	**METHOD**
68	120420010130-001AT	393460	2/27/2006	Field	Foaming, Severity (1=none, 2=light, 3=moderate, 4=heavy, 5=total)	3	code	
69	120420010130-001AT	393460	2/27/2006	Field	Debris, Floating, Size (1=small, 2=medium, 3= large)	1	code	
70	120420010130-001AT	393460	2/27/2006	Field	Scum, Severity (1=none, 2=light, 3=moderate, 4=heavy, 5=total)	3	code	
71	120420010130-001AT	393460	2/27/2006	Field	Turbidity, Type (1=inorganic, 2=organic, 3=mix)	3	code	
72	120420010130-001AT	393460	2/27/2006	Field	STREAM FLOW, SEVERITY (1=none, 2=light, 3=moderate, 4=heavy, 5=stormwater)	3	CODE	
73	120420010130-001AT	393460	2/27/2006	Field	TOTAL DISSOLVED SOLIDS (FIELD)	1887	MG/L	
74	120420010130-001AT	393460	2/27/2006	Field	SALINITY (FIELD)	1.4	G/L	
75	120420010130-001AT	393460	2/27/2006	Field	Periphyton, Severity (% of streambed; 1=0%, 2=25%, 3=50%, 4=75%, 5=100%)	1	code	
76	120420010130-001AT	393460	2/27/2006	Field	Periphyton Line, Visible (1=yes, 2=no)	2	code	
77	120420010130-001AT	393460	2/27/2006	Field	Flow, Instantaneous	2765.1	CFS	
78	120420010130-001AT	393460	2/27/2006	Field	Turbidity, Field	8	NTU	180.1
79	120420010130-001AT	393460	2/27/2006	Field	P-ALKALINITY (FIELD)	0	MG/L	
80	120420010130-001AT	393460	2/27/2006	Field	STREAM WIDTH	1150	METERS	
81	120420010130-001AT	393460	2/27/2006	Field	STREAM TYPE	2	CODE	
82	120420010130-001AT	393460	2/27/2006	Field	Flow Measurement Tech (1=composite average, 2=rated, 3=DCP)	2	code	
83	120420010130-001AT	393460	2/27/2006	Field	DEPTH, MAXIMUM OF SAMPLE	0.5	METERS	
84	120420010130-001AT	393460	2/27/2006	Field	COLOR, BORGER COLOR SYSTEM	31	CODE	
85	120420010130-001AT	395292	4/3/2006	Field	Water Temperature	16.98	DEG CELS	2550B

	A	B	C	D	E	F	G	H
1	Sand Springs Biological & Field Data							
2	STATION_ID	SAMPLE_ID	SAMPLE_DATE	PARAMETER_TYPE	PARAMETER	VALUE	UNITS	METHOD
86	120420010130-001AT	395292	4/3/2006	Field	AIR TEMPERATURE	21.5	DEG C	2550B
87	120420010130-001AT	395292	4/3/2006	Field	BAROMETRIC PRESSURE	766.8	MM HG	
88	120420010130-001AT	395292	4/3/2006	Field	CLOUD COVER	2	PERCENT	
89	120420010130-001AT	395292	4/3/2006	Field	WIND VELOCITY	2	MPH	
90	120420010130-001AT	395292	4/3/2006	Field	WIND DIRECTION	0	AZIMUTH	
91	120420010130-001AT	395292	4/3/2006	Field	STREAM STAGE	4.94	feet	
92	120420010130-001AT	395292	4/3/2006	Field	OXIDATION/REDUCTION POT. (FIELD)	396	MV	
93	120420010130-001AT	395292	4/3/2006	Field	Specific Conductance	3306	UMHOS/CM	120.1
94	120420010130-001AT	395292	4/3/2006	Field	DISSOLVED OXYGEN, analysis by probe	11.32	MG/L	
95	120420010130-001AT	395292	4/3/2006	Field	DISS OXY SATURATION	116.2	PERCENT	
96	120420010130-001AT	395292	4/3/2006	Field	PH (FIELD)	8.06	STD UNIT	150.1
97	120420010130-001AT	395292	4/3/2006	Field	TOT ALK FIELD CACO3	164	MG/L	
98	120420010130-001AT	395292	4/3/2006	Field	Hardness, Total (as CaCO3)	355	MG/L	
99	120420010130-001AT	395292	4/3/2006	Field	Oil and Grease, Severity (1=none, 2=light, 3=moderate, 4=heavy, 5=total)	1	code	
100	120420010130-001AT	395292	4/3/2006	Field	Odor, Atmospheric, Severity (1=none, 2=light, 3=moderate, 4=heavy, 5=severe)	1	code	
101	120420010130-001AT	395292	4/3/2006	Field	Debris, Floating, Severity (1=none, 2=light, 3=moderate, 4=heavy, 5=total)	1	code	
102	120420010130-001AT	395292	4/3/2006	Field	Foaming, Severity (1=none, 2=light, 3=moderate, 4=heavy, 5=total)	1	code	
103	120420010130-001AT	395292	4/3/2006	Field	Scum, Severity (1=none, 2=light, 3=moderate, 4=heavy, 5=total)	1	code	
104	120420010130-001AT	395292	4/3/2006	Field	Turbidity, Type (1=inorganic, 2=organic, 3=mix)	1	code	

	A	B	C	D	E	F	G	H
1	**Sand Springs Biological & Field Data**							
2	**STATION_ID**	**SAMPLE_ID**	**SAMPLE_DATE**	**PARAMETER_TYPE**	**PARAMETER**	**VALUE**	**UNITS**	**METHOD**
105	120420010130-001AT	395292	4/3/2006	Field	STREAM FLOW, SEVERITY (1=none, 2=light, 3=moderate, 4=heavy, 5=stormwater)	3	CODE	
106	120420010130-001AT	395292	4/3/2006	Field	TOTAL DISSOLVED SOLIDS (FIELD)	2116	MG/L	
107	120420010130-001AT	395292	4/3/2006	Field	SALINITY (FIELD)	1.79	G/L	
108	120420010130-001AT	395292	4/3/2006	Field	Periphyton, Severity (% of streambed; 1=0%, 2=25%, 3=50%, 4=75%, 5=100%)	1	code	
109	120420010130-001AT	395292	4/3/2006	Field	Periphyton Line, Visible (1=yes, 2=no)	2	code	
110	120420010130-001AT	395292	4/3/2006	Field	Flow, Instantaneous	1527.2	CFS	
111	120420010130-001AT	395292	4/3/2006	Field	Turbidity, Field	6	NTU	180.1
112	120420010130-001AT	395292	4/3/2006	Field	P-ALKALINITY (FIELD)	0	MG/L	
113	120420010130-001AT	395292	4/3/2006	Field	STREAM WIDTH	700	METERS	
114	120420010130-001AT	395292	4/3/2006	Field	STREAM TYPE	2	CODE	
115	120420010130-001AT	395292	4/3/2006	Field	Flow Measurement Tech (1=composite average, 2=rated, 3=DCP)	2	code	
116	120420010130-001AT	395292	4/3/2006	Field	DEPTH, MAXIMUM OF SAMPLE	0.8	METERS	
117	120420010130-001AT	395292	4/3/2006	Field	COLOR, BORGER COLOR SYSTEM	36	CODE	
118	120420010130-001AT	397258	5/9/2006	Field	Water Temperature	21.24	DEG CELS	2550B
119	120420010130-001AT	397258	5/9/2006	Field	AIR TEMPERATURE	24	DEG C	2550B
120	120420010130-001AT	397258	5/9/2006	Field	BARROMETRIC PRESSURE	761.5	MM HG	
121	120420010130-001AT	397258	5/9/2006	Field	CLOUD COVER	100	PERCENT	
122	120420010130-001AT	397258	5/9/2006	Field	WIND VELOCITY	2.5	MPH	
123	120420010130-001AT	397258	5/9/2006	Field	WIND DIRECTION	180	AZIMUTH	
124	120420010130-001AT	397258	5/9/2006	Field	STREAM STAGE	9.33	feet	
125	120420010130-001AT	397258	5/9/2006	Field	OXIDATION/REDUCTION POT. (FIELD)	253	MV	
126	120420010130-001AT	397258	5/9/2006	Field	Specific Conductance	2170	UMHOS/CM	120.1

	A	B	C	D	E	F	G	H
1	**Sand Springs Biological & Field Data**							
2	**STATION_ID**	**SAMPLE_ID**	**SAMPLE_DATE**	**PARAMETER_TYPE**	**PARAMETER**	**VALUE**	**UNITS**	**METHOD**
127	120420010130-001AT	397258	5/9/2006	Field	DISSOLVED OXYGEN, analysis by probe	7.86	MG/L	
128	120420010130-001AT	397258	5/9/2006	Field	DISS OXY SATURATION	89.1	PERCENT	
129	120420010130-001AT	397258	5/9/2006	Field	PH (FIELD)	8.2	STD UNIT	150.1
130	120420010130-001AT	397258	5/9/2006	Field	TOT ALK FIELD CACO3	127	MG/L	
131	120420010130-001AT	397258	5/9/2006	Field	Hardness, Total (as CaCO3)	239	MG/L	
132	120420010130-001AT	397258	5/9/2006	Field	Oil and Grease, Severity (1=none, 2=light, 3=moderate, 4=heavy, 5=total)	2	code	
133	120420010130-001AT	397258	5/9/2006	Field	Odor, Atmospheric, Severity (1=none, 2=light, 3=moderate, 4=heavy, 5=severe)	2	code	
134	120420010130-001AT	397258	5/9/2006	Field	Debris, Floating, Severity (1=none, 2=light, 3=moderate, 4=heavy, 5=total)	1	code	
135	120420010130-001AT	397258	5/9/2006	Field	Foaming, Severity (1=none, 2=light, 3=moderate, 4=heavy, 5=total)	3	code	
136	120420010130-001AT	397258	5/9/2006	Field	Debris, Floating, Size (1=small, 2=medium, 3= large)	1	code	
137	120420010130-001AT	397258	5/9/2006	Field	Scum, Severity (1=none, 2=light, 3=moderate, 4=heavy, 5=total)	3	code	
138	120420010130-001AT	397258	5/9/2006	Field	Turbidity, Type (1=inorganic, 2=organic, 3=mix)	3	code	
139	120420010130-001AT	397258	5/9/2006	Field	STREAM FLOW, SEVERITY (1=none, 2=light, 3=moderate, 4=heavy, 5=stormwater)	4	CODE	
140	120420010130-001AT	397258	5/9/2006	Field	Precipitation	0	inches	
141	120420010130-001AT	397258	5/9/2006	Field	Precipitation Type (1=fog, 2=rain, 3=sleet, 4=snow, 5=mix)	0	code	
142	120420010130-001AT	397258	5/9/2006	Field	TOTAL DISSOLVED SOLIDS (FIELD)	1389	MG/L	
143	120420010130-001AT	397258	5/9/2006	Field	SALINITY (FIELD)	1.2	G/L	

	A	B	C	D	E	F	G	H
1	Sand Springs Biological & Field Data							
2	STATION_ID	SAMPLE_ID	SAMPLE_DATE	PARAMETER_TYPE	PARAMETER	VALUE	UNITS	METHOD
144	120420010130-001AT	397258	5/9/2006	Field	Periphyton, Severity (% of streambed; 1=0%, 2=25%, 3=50%, 4=75%, 5=100%)	1	code	
145	120420010130-001AT	397258	5/9/2006	Field	Periphyton Line, Visible (1=yes, 2=no)	2	code	
146	120420010130-001AT	397258	5/9/2006	Field	Flow, Instantaneous	33309	CFS	
147	120420010130-001AT	397258	5/9/2006	Field	Turbidity, Field	28	NTU	180.1
148	120420010130-001AT	397258	5/9/2006	Field	P-ALKALINITY (FIELD)	0	MG/L	
149	120420010130-001AT	397258	5/9/2006	Field	STREAM WIDTH	1680	METERS	
150	120420010130-001AT	397258	5/9/2006	Field	STREAM TYPE	2	CODE	
151	120420010130-001AT	397258	5/9/2006	Field	Flow Measurement Tech (1=composite average, 2=rated, 3=DCP)	2	code	
152	120420010130-001AT	397258	5/9/2006	Field	DEPTH, MAXIMUM OF SAMPLE	0.3	METERS	
153	120420010130-001AT	397258	5/9/2006	Field	COLOR, BORGER COLOR SYSTEM	29	CODE	
154	120420010130-001AT	398904	6/12/2006	Field	Water Temperature	24.95	DEG CELS	2550B
155	120420010130-001AT	398904	6/12/2006	Field	AIR TEMPERATURE	23.4	DEG C	2550B
156	120420010130-001AT	398904	6/12/2006	Field	BARROMETRIC PRESSURE	746.8	MM HG	
157	120420010130-001AT	398904	6/12/2006	Field	CLOUD COVER	100	PERCENT	
158	120420010130-001AT	398904	6/12/2006	Field	WIND VELOCITY	5	MPH	
159	120420010130-001AT	398904	6/12/2006	Field	WIND DIRECTION	0	AZIMUTH	
160	120420010130-001AT	398904	6/12/2006	Field	STREAM STAGE	45.22	feet	
161	120420010130-001AT	398904	6/12/2006	Field	OXIDATION/REDUCTION POT. (FIELD)	478	MV	
162	120420010130-001AT	398904	6/12/2006	Field	Specific Conductance	1430	UMHOS/CM	120.1
163	120420010130-001AT	398904	6/12/2006	Field	DISSOLVED OXYGEN, analysis by probe	6.74	MG/L	
164	120420010130-001AT	398904	6/12/2006	Field	DISS OXY SATURATION	85.2	PERCENT	
165	120420010130-001AT	398904	6/12/2006	Field	PH (FIELD)	7.85	STD UNIT	150.1
166	120420010130-001AT	398904	6/12/2006	Field	TOT ALK FIELD CACO3	130	MG/L	
167	120420010130-001AT	398904	6/12/2006	Field	Hardness, Total (as CaCO3)	202	MG/L	

	A	B	C	D	E	F	G	H
1	Sand Springs Biological & Field Data							
2	STATION_ID	SAMPLE_ID	SAMPLE_DATE	PARAMETER_TYPE	PARAMETER	VALUE	UNITS	METHOD
168	120420010130-001AT	398904	6/12/2006	Field	Oil and Grease, Severity (1=none, 2=light, 3=moderate, 4=heavy, 5=total)	1	code	
169	120420010130-001AT	398904	6/12/2006	Field	Odor, Atmospheric, Severity (1=none, 2=light, 3=moderate, 4=heavy, 5=severe)	1	code	
170	120420010130-001AT	398904	6/12/2006	Field	Debris, Floating, Severity (1=none, 2=light, 3=moderate, 4=heavy, 5=total)	1	code	
171	120420010130-001AT	398904	6/12/2006	Field	Foaming, Severity (1=none, 2=light, 3=moderate, 4=heavy, 5=total)	1	code	
172	120420010130-001AT	398904	6/12/2006	Field	Scum, Severity (1=none, 2=light, 3=moderate, 4=heavy, 5=total)	1	code	
173	120420010130-001AT	398904	6/12/2006	Field	Turbidity, Type (1=inorganic, 2=organic, 3=mix)	1	code	
174	120420010130-001AT	398904	6/12/2006	Field	STREAM FLOW, SEVERITY (1=none, 2=light, 3=moderate, 4=heavy, 5=stormwater)	2	CODE	
175	120420010130-001AT	398904	6/12/2006	Field	Precipitation	0	inches	
176	120420010130-001AT	398904	6/12/2006	Field	Precipitation Type (1=fog, 2=rain, 3=sleet, 4=snow, 5=mix)	2	code	
177	120420010130-001AT	398904	6/12/2006	Field	TOTAL DISSOLVED SOLIDS (FIELD)	915.3	MG/L	
178	120420010130-001AT	398904	6/12/2006	Field	SALINITY (FIELD)	0.76	G/L	
179	120420010130-001AT	398904	6/12/2006	Field	Periphyton, Severity (% of streambed; 1=0%, 2=25%, 3=50%, 4=75%, 5=100%)	1	code	
180	120420010130-001AT	398904	6/12/2006	Field	Periphyton Line, Visible (1=yes, 2=no)	2	code	
181	120420010130-001AT	398904	6/12/2006	Field	Turbidity, Field	5	NTU	180.1
182	120420010130-001AT	398904	6/12/2006	Field	P-ALKALINITY (FIELD)	0	MG/L	
183	120420010130-001AT	398904	6/12/2006	Field	STREAM WIDTH	60	METERS	

	A	B	C	D	E	F	G	H
1	Sand Springs Biological & Field Data							
2	STATION_ID	SAMPLE_ID	SAMPLE_DATE	PARAMETER_TYPE	PARAMETER	VALUE	UNITS	METHOD
184	120420010130-001AT	398904	6/12/2006	Field	STREAM TYPE	2	CODE	
185	120420010130-001AT	398904	6/12/2006	Field	Flow Measurement Tech (1=composite average, 2=rated, 3=DCP)	2	code	
186	120420010130-001AT	398904	6/12/2006	Field	DEPTH, MAXIMUM OF SAMPLE	0.5	METERS	
187	120420010130-001AT	398904	6/12/2006	Field	COLOR, BORGER COLOR SYSTEM	36	CODE	
188	120420010130-001AT	400975	7/17/2006	Field	Water Temperature	27.33	DEG CELS	2550B
189	120420010130-001AT	400975	7/17/2006	Field	AIR TEMPERATURE	30	DEG C	2550B
190	120420010130-001AT	400975	7/17/2006	Field	BARROMETRIC PRESSURE	744.5	MM HG	
191	120420010130-001AT	400975	7/17/2006	Field	CLOUD COVER	0	PERCENT	
192	120420010130-001AT	400975	7/17/2006	Field	WIND VELOCITY	5	MPH	
193	120420010130-001AT	400975	7/17/2006	Field	WIND DIRECTION	180	AZIMUTH	
194	120420010130-001AT	400975	7/17/2006	Field	STREAM STAGE	44.19	feet	
195	120420010130-001AT	400975	7/17/2006	Field	OXIDATION/REDUCTION POT. (FIELD)	441	MV	
196	120420010130-001AT	400975	7/17/2006	Field	Specific Conductance	1930	UMHOS/CM	120.1
197	120420010130-001AT	400975	7/17/2006	Field	DISSOLVED OXYGEN, analysis by probe	4.61	MG/L	
198	120420010130-001AT	400975	7/17/2006	Field	DISS OXY SATURATION	59.7	PERCENT	
199	120420010130-001AT	400975	7/17/2006	Field	PH (FIELD)	7.48	STD UNIT	150.1
200	120420010130-001AT	400975	7/17/2006	Field	TOT ALK FIELD CACO3	127	MG/L	
201	120420010130-001AT	400975	7/17/2006	Field	Hardness, Total (as CaCO3)	168	MG/L	
202	120420010130-001AT	400975	7/17/2006	Field	Oil and Grease, Severity (1=none, 2=light, 3=moderate, 4=heavy, 5=total)	1	code	
203	120420010130-001AT	400975	7/17/2006	Field	Odor, Atmospheric, Severity (1=none, 2=light, 3=moderate, 4=heavy, 5=severe)	1	code	
204	120420010130-001AT	400975	7/17/2006	Field	Debris, Floating, Severity (1=none, 2=light, 3=moderate, 4=heavy, 5=total)	1	code	

	A	B	C	D	E	F	G	H
1	Sand Springs Biological & Field Data							
2	STATION_ID	SAMPLE_ID	SAMPLE_DATE	PARAMETER_TYPE	PARAMETER	VALUE	UNITS	METHOD
205	120420010130-001AT	400975	7/17/2006	Field	Foaming, Severity (1=none, 2=light, 3=moderate, 4=heavy, 5=total)	1	code	
206	120420010130-001AT	400975	7/17/2006	Field	Scum, Severity (1=none, 2=light, 3=moderate, 4=heavy, 5=total)	1	code	
207	120420010130-001AT	400975	7/17/2006	Field	Turbidity, Type (1=inorganic, 2=organic, 3=mix)	1	code	
208	120420010130-001AT	400975	7/17/2006	Field	STREAM FLOW, SEVERITY (1=none, 2=light, 3=moderate, 4=heavy, 5=stormwater)	2	CODE	
209	120420010130-001AT	400975	7/17/2006	Field	Precipitation	0	inches	
210	120420010130-001AT	400975	7/17/2006	Field	Precipitation Type (1=fog, 2=rain, 3=sleet, 4=snow, 5=mix)	0	code	
211	120420010130-001AT	400975	7/17/2006	Field	TOTAL DISSOLVED SOLIDS (FIELD)	1240	MG/L	
212	120420010130-001AT	400975	7/17/2006	Field	SALINITY (FIELD)	1.02	G/L	
213	120420010130-001AT	400975	7/17/2006	Field	Periphyton, Severity (% of streambed; 1=0%, 2=25%, 3=50%, 4=75%, 5=100%)	1	code	
214	120420010130-001AT	400975	7/17/2006	Field	Periphyton Line, Visible (1=yes, 2=no)	2	code	
215	120420010130-001AT	400975	7/17/2006	Field	Turbidity, Field	5	NTU	180.1
216	120420010130-001AT	400975	7/17/2006	Field	P-ALKALINITY (FIELD)	0	MG/L	
217	120420010130-001AT	400975	7/17/2006	Field	STREAM WIDTH	150	METERS	
218	120420010130-001AT	400975	7/17/2006	Field	STREAM TYPE	2	CODE	
219	120420010130-001AT	400975	7/17/2006	Field	Flow Measurement Tech (1=composite average, 2=rated, 3=DCP)	2	code	
220	120420010130-001AT	400975	7/17/2006	Field	DEPTH, MAXIMUM OF SAMPLE	0.1	METERS	
221	120420010130-001AT	400975	7/17/2006	Field	COLOR, BORGER COLOR SYSTEM	36	CODE	
222	120420010130-001AT	403479	8/22/2006	Field	Water Temperature	25.56	DEG CELS	2550B

	A	B	C	D	E	F	G	H
1	Sand Springs Biological & Field Data							
2	STATION_ID	SAMPLE_ID	SAMPLE_DATE	PARAMETER_TYPE	PARAMETER	VALUE	UNITS	METHOD
223	120420010130-001AT	403479	8/22/2006	Field	AIR TEMPERATURE	24	DEG C	2550B
224	120420010130-001AT	403479	8/22/2006	Field	BARROMETRIC PRESSURE	764	MM HG	
225	120420010130-001AT	403479	8/22/2006	Field	CLOUD COVER	100	PERCENT	
226	120420010130-001AT	403479	8/22/2006	Field	WIND VELOCITY	0	MPH	
227	120420010130-001AT	403479	8/22/2006	Field	WIND DIRECTION	0	AZIMUTH	
228	120420010130-001AT	403479	8/22/2006	Field	STREAM STAGE	3.14	feet	
229	120420010130-001AT	403479	8/22/2006	Field	OXIDATION/REDUCTION POT. (FIELD)	456	MV	
230	120420010130-001AT	403479	8/22/2006	Field	Specific Conductance	1502	UMHOS/CM	120.1
231	120420010130-001AT	403479	8/22/2006	Field	DISSOLVED OXYGEN, analysis by probe	4.98	MG/L	
232	120420010130-001AT	403479	8/22/2006	Field	DISS OXY SATURATION	60.9	PERCENT	
233	120420010130-001AT	403479	8/22/2006	Field	PH (FIELD)	7.9	STD UNIT	150.1
234	120420010130-001AT	403479	8/22/2006	Field	TOT ALK FIELD CACO3	125	MG/L	
235	120420010130-001AT	403479	8/22/2006	Field	Hardness, Total (as CaCO3)	180	MG/L	
236	120420010130-001AT	403479	8/22/2006	Field	Oil and Grease, Severity (1=none, 2=light, 3=moderate, 4=heavy, 5=total)	2	code	
237	120420010130-001AT	403479	8/22/2006	Field	Odor, Atmospheric, Severity (1=none, 2=light, 3=moderate, 4=heavy, 5=severe)	2	code	
238	120420010130-001AT	403479	8/22/2006	Field	Debris, Floating, Severity (1=none, 2=light, 3=moderate, 4=heavy, 5=total)	2	code	
239	120420010130-001AT	403479	8/22/2006	Field	Foaming, Severity (1=none, 2=light, 3=moderate, 4=heavy, 5=total)	3	code	
240	120420010130-001AT	403479	8/22/2006	Field	Debris, Floating, Size (1=small, 2=medium, 3= large)	1	code	
241	120420010130-001AT	403479	8/22/2006	Field	Scum, Severity (1=none, 2=light, 3=moderate, 4=heavy, 5=total)	3	code	
242	120420010130-001AT	403479	8/22/2006	Field	Turbidity, Type (1=inorganic, 2=organic, 3=mix)	3	code	

	A	B	C	D	E	F	G	H
1	Sand Springs Biological & Field Data							
2	STATION_ID	SAMPLE_ID	SAMPLE_DATE	PARAMETER_TYPE	PARAMETER	VALUE	UNITS	METHOD
243	120420010130-001AT	403479	8/22/2006	Field	STREAM FLOW, SEVERITY (1=none, 2=light, 3=moderate, 4=heavy, 5=stormwater)	2	CODE	
244	120420010130-001AT	403479	8/22/2006	Field	Precipitation	0	inches	
245	120420010130-001AT	403479	8/22/2006	Field	Precipitation Type (1=fog, 2=rain, 3=sleet, 4=snow, 5=mix)	0	code	
246	120420010130-001AT	403479	8/22/2006	Field	TOTAL DISSOLVED SOLIDS (FIELD)	961	MG/L	
247	120420010130-001AT	403479	8/22/2006	Field	SALINITY (FIELD)	0.8	G/L	
248	120420010130-001AT	403479	8/22/2006	Field	Periphyton, Severity (% of streambed; 1=0%, 2=25%, 3=50%, 4=75%, 5=100%)	2	code	
249	120420010130-001AT	403479	8/22/2006	Field	Periphyton Line, Visible (1=yes, 2=no)	1	code	
250	120420010130-001AT	403479	8/22/2006	Field	Periphyton Color (1=brown, 2=green, 3=red/orange, 4=yellow, 5=other)	5	code	
251	120420010130-001AT	403479	8/22/2006	Field	Flow, Instantaneous	150.45	CFS	
252	120420010130-001AT	403479	8/22/2006	Field	Turbidity, Field	34	NTU	180.1
253	120420010130-001AT	403479	8/22/2006	Field	P-ALKALINITY (FIELD)	0	MG/L	
254	120420010130-001AT	403479	8/22/2006	Field	STREAM WIDTH	750	METERS	
255	120420010130-001AT	403479	8/22/2006	Field	STREAM TYPE	2	CODE	
256	120420010130-001AT	403479	8/22/2006	Field	Flow Measurement Tech (1=composite average, 2=rated, 3=DCP)	2	code	
257	120420010130-001AT	403479	8/22/2006	Field	DEPTH, MAXIMUM OF SAMPLE	0.3	METERS	
258	120420010130-001AT	403479	8/22/2006	Field	COLOR, BORGER COLOR SYSTEM	30	CODE	
259								
260	Inorganics							
261	STATION_ID	SAMPLE_ID	SAMPLE_DATE	PARAMETER	REMARK	VALUE	UNITS	METHOD
262	120420010130-001AT	391006	1/23/2006	Nitrogen, Ammonia	<	0.05	mg/L	350.1

	A	B	C	D	E	F	G	H
1	Sand Springs Biological & Field Data							
2	STATION_ID	SAMPLE_ID	SAMPLE_DATE	PARAMETER_TYPE	PARAMETER	VALUE	UNITS	METHOD
263	120420010130-001AT	391006	1/23/2006	Nitrogen, Kjeldahl		0.55	mg/L	351.3
264	120420010130-001AT	391006	1/23/2006	Nitrogen, Nitrate/Nitrite as N		0.44	mg/L	
265	120420010130-001AT	391006	1/23/2006	Phosphorous, Total		0.07	mg/L	365.3
266	120420010130-001AT	391006	1/23/2006	Chloride		955	mg/L	325.2
267	120420010130-001AT	391006	1/23/2006	Sulfate		161	mg/L	375.4
268	120420010130-001AT	391006	1/23/2006	Phosphorous, Ortho		0.044	mg/L	365.1
269	120420010130-001AT	393460	2/27/2006	Nitrogen, Ammonia	<	0.05	mg/L	350.1
270	120420010130-001AT	393460	2/27/2006	Nitrogen, Kjeldahl		0.61	mg/L	351.3
271	120420010130-001AT	393460	2/27/2006	Nitrogen, Nitrate/Nitrite as N		0.16	mg/L	
272	120420010130-001AT	393460	2/27/2006	Phosphorous, Total		0.075	mg/L	365.3
273	120420010130-001AT	393460	2/27/2006	Chloride		1100	mg/L	325.2
274	120420010130-001AT	393460	2/27/2006	Sulfate		195	mg/L	375.4
275	120420010130-001AT	393460	2/27/2006	Phosphorous, Ortho		0.019	mg/L	365.1
276	120420010130-001AT	395292	4/3/2006	Nitrogen, Ammonia	<	0.05	mg/L	350.1
277	120420010130-001AT	395292	4/3/2006	Nitrogen, Kjeldahl		0.56	mg/L	351.3
278	120420010130-001AT	395292	4/3/2006	Nitrogen, Nitrate/Nitrite as N		0.15	mg/L	
279	120420010130-001AT	395292	4/3/2006	Phosphorous, Total		0.078	mg/L	365.3
280	120420010130-001AT	395292	4/3/2006	Chloride		840	mg/L	325.2
281	120420010130-001AT	395292	4/3/2006	Sulfate		172	mg/L	375.4
282	120420010130-001AT	395292	4/3/2006	Phosphorous, Ortho		0.024	mg/L	365.1
283	120420010130-001AT	397258	5/9/2006	Nitrogen, Ammonia		0.07	mg/L	350.1
284	120420010130-001AT	397258	5/9/2006	Nitrogen, Kjeldahl		0.64	mg/L	351.3
285	120420010130-001AT	397258	5/9/2006	Nitrogen, Nitrate/Nitrite as N		0.22	mg/L	
286	120420010130-001AT	397258	5/9/2006	Phosphorous, Total		0.105	mg/L	365.3
287	120420010130-001AT	397258	5/9/2006	Chloride		497	mg/L	325.2
288	120420010130-001AT	397258	5/9/2006	Sulfate		122	mg/L	375.4
289	120420010130-001AT	397258	5/9/2006	Phosphorous, Ortho		0.068	mg/L	365.1
290	120420010130-001AT	398904	6/12/2006	Nitrogen, Ammonia	<	0.05	mg/L	350.1
291	120420010130-001AT	398904	6/12/2006	Nitrogen, Kjeldahl		0.58	mg/L	351.3

	A	B	C	D	E	F	G	H
1	Sand Springs Biological & Field Data							
2	STATION_ID	SAMPLE_ID	SAMPLE_DATE	PARAMETER_TYPE	PARAMETER	VALUE	UNITS	METHOD
292	120420010130-001AT	398904	6/12/2006	Nitrogen, Nitrate/Nitrite as N		0.21	mg/L	
293	120420010130-001AT	398904	6/12/2006	Phosphorous, Total		0.142	mg/L	365.3
294	120420010130-001AT	398904	6/12/2006	Chloride		313	mg/L	325.2
295	120420010130-001AT	398904	6/12/2006	Sulfate		94.5	mg/L	375.4
296	120420010130-001AT	398904	6/12/2006	Phosphorous, Ortho		0.093	mg/L	365.1
297	120420010130-001AT	400975	7/17/2006	Nitrogen, Ammonia		0.18	mg/L	350.1
298	120420010130-001AT	400975	7/17/2006	Nitrogen, Kjeldahl		0.69	mg/L	351.3
299	120420010130-001AT	400975	7/17/2006	Nitrogen, Nitrate/Nitrite as N		0.12	mg/L	
300	120420010130-001AT	400975	7/17/2006	Phosphorous, Total		0.221	mg/L	365.3
301	120420010130-001AT	400975	7/17/2006	Chloride		470	mg/L	325.2
302	120420010130-001AT	400975	7/17/2006	Sulfate		114	mg/L	375.4
303	120420010130-001AT	400975	7/17/2006	Phosphorous, Ortho		0.175	mg/L	365.1
304	120420010130-001AT	403479	8/22/2006	Nitrogen, Ammonia		0.09	mg/L	350.1
305	120420010130-001AT	403479	8/22/2006	Nitrogen, Kjeldahl		0.6	mg/L	351.3
306	120420010130-001AT	403479	8/22/2006	Nitrogen, Nitrate/Nitrite as N		0.12	mg/L	
307	120420010130-001AT	403479	8/22/2006	Phosphorous, Total		0.146	mg/L	365.3
308	120420010130-001AT	403479	8/22/2006	Chloride		372	mg/L	325.2
309	120420010130-001AT	403479	8/22/2006	Sulfate		92.9	mg/L	375.4
310	120420010130-001AT	403479	8/22/2006	Phosphorous, Ortho		0.109	mg/L	365.1
311	120420010130-001AT	406988	10/2/2006	Nitrogen, Ammonia	<	0.05	mg/L	350.1
312	120420010130-001AT	406988	10/2/2006	Nitrogen, Kjeldahl		0.54	mg/L	351.3
313	120420010130-001AT	406988	10/2/2006	Nitrogen, Nitrate/Nitrite as N		0.11	mg/L	
314	120420010130-001AT	406988	10/2/2006	Phosphorous, Total		0.087	mg/L	365.3
315	120420010130-001AT	406988	10/2/2006	Chloride		326	mg/L	325.2
316	120420010130-001AT	406988	10/2/2006	Sulfate		99.2	mg/L	375.4
317	120420010130-001AT	406988	10/2/2006	Phosphorous, Ortho		0.049	mg/L	365.1
318	120420010130-001AT	408925	11/8/2006	Nitrogen, Ammonia	<	0.05	mg/L	350.1
319	120420010130-001AT	408925	11/8/2006	Nitrogen, Kjeldahl		0.55	mg/L	351.3

	A	B	C	D	E	F	G	H
1	Sand Springs Biological & Field Data							
2	STATION_ID	SAMPLE_ID	SAMPLE_DATE	PARAMETER_TYPE	PARAMETER	VALUE	UNITS	METHOD
320	120420010130-001AT	408925	11/8/2006	Nitrogen, Nitrate/Nitrite as N	<	0.05	mg/L	
321	120420010130-001AT	408925	11/8/2006	Phosphorous, Total		0.07	mg/L	365.3
322	120420010130-001AT	408925	11/8/2006	Chloride		330	mg/L	325.2
323	120420010130-001AT	408925	11/8/2006	Sulfate		99.9	mg/L	375.4
324	120420010130-001AT	408925	11/8/2006	Phosphorous, Ortho		0.039	mg/L	365.1
325	120420010130-001AT	410315	12/6/2006	Nitrogen, Ammonia		0.09	mg/L	350.1
326	120420010130-001AT	410315	12/6/2006	Nitrogen, Kjeldahl		0.47	mg/L	351.3
327	120420010130-001AT	410315	12/6/2006	Nitrogen, Nitrate/Nitrite as N		0.27	mg/L	
328	120420010130-001AT	410315	12/6/2006	Phosphorous, Total		0.068	mg/L	365.3
329	120420010130-001AT	410315	12/6/2006	Chloride		522	mg/L	325.2
330	120420010130-001AT	410315	12/6/2006	Sulfate		43.4	mg/L	375.4
331	120420010130-001AT	410315	12/6/2006	Phosphorous, Ortho		0.052	mg/L	365.1

Bixby Biological & Field Data

STATION_ID	SAMPLE_ID	SAMPLE_DATE	PARAMETER_TYPE	PARAMETER	REMARK	VALUE	UNITS	METHOD
12042001010-001AT	A00751	5/23/2006	Biological	COLIFORM, FECAL		200	NM/100ML	9222D
12042001010-001AT	A00751	5/23/2006	Biological	E. COLI QUANTI TRAY		107	MPN/100ML	9223
12042001010-001AT	A00751	5/23/2006	Biological	ENTEROCOCCI		31	CFU/100ML	9230C
12042001010-001AT	A00957	6/12/2006	Biological	COLIFORM, FECAL		410	NM/100ML	9222D
12042001010-001AT	A00957	6/12/2006	Biological	E. COLI QUANTI TRAY		85	MPN/100ML	9223
12042001010-001AT	A00957	6/12/2006	Biological	ENTEROCOCCI		10	CFU/100ML	9230C
12042001010-001AT	A01042	6/26/2006	Biological	COLIFORM, FECAL		1190	NM/100ML	9222D
12042001010-001AT	A01042	6/26/2006	Biological	E. COLI QUANTI TRAY		235	MPN/100ML	9223
12042001010-001AT	A01042	6/26/2006	Biological	ENTEROCOCCI		471	CFU/100ML	9230C
12042001010-001AT	A01099	7/5/2006	Biological	COLIFORM, FECAL		720	NM/100ML	9222D
12042001010-001AT	A01099	7/5/2006	Biological	E. COLI QUANTI TRAY		41	MPN/100ML	9223
12042001010-001AT	A01099	7/5/2006	Biological	ENTEROCOCCI		323	CFU/100ML	9230C
12042001010-001AT	A01335	7/24/2006	Biological	COLIFORM, FECAL		210	NM/100ML	9222D
12042001010-001AT	A01335	7/24/2006	Biological	E. COLI QUANTI TRAY		10	MPN/100ML	9223
12042001010-001AT	A01335	7/24/2006	Biological	ENTEROCOCCI		243	CFU/100ML	9230C

STATION_ID	SAMPLE_ID	SAMPLE_DATE	PARAMETER_TYPE	PARAMETER	REMARK	VALUE	UNITS	METHOD
12042001010-001AT	391007	1/23/2006	Field	Water Temperature		6.66	DEG CELS	2550B
12042001010-001AT	391007	1/23/2006	Field	AIR TEMPERATURE		4.2	DEG C	2550B
12042001010-001AT	391007	1/23/2006	Field	BARROMETRIC PRESSURE		769	MM HG	
12042001010-001AT	391007	1/23/2006	Field	CLOUD COVER		1	PERCENT	
12042001010-001AT	391007	1/23/2006	Field	WIND VELOCITY		5	MPH	
12042001010-001AT	391007	1/23/2006	Field	WIND DIRECTION		315	AZIMUTH	
12042001010-001AT	391007	1/23/2006	Field	STREAM STAGE		5.69	feet	
12042001010-001AT	391007	1/23/2006	Field	OXIDATION/REDUCTION POT. (FIELD)		371	MV	
12042001010-001AT	391007	1/23/2006	Field	Specific Conductance		2885	UMHOS/CM	120.1
12042001010-001AT	391007	1/23/2006	Field	DISSOLVED OXYGEN, analysis by probe		9.71	MG/L	
12042001010-001AT	391007	1/23/2006	Field	DISS OXY SATURATION		79.3	PERCENT	

120420010010-001AT	A00751	5/23/2006	Biological	ENTEROCOCCI		31	CFU/100ML	9230C
120420010010-001AT	A00957	6/12/2006	Biological	COLIFORM, FECAL		410	NM/100ML	9222D
120420010010-001AT	391007	1/23/2006	Field	PH (FIELD)		8.34	STD UNIT	150.1
120420010010-001AT	391007	1/23/2006	Field	TOT ALK FIELD CACO3		170	MG/L	
120420010010-001AT	391007	1/23/2006	Field	Hardness, Total (as CaCO3)		368	MG/L	
120420010010-001AT	391007	1/23/2006	Field	Oil and Grease, Severity (1=none, 2=light, 3=moderate, 4=heavy, 5=total)		1	code	
120420010010-001AT	391007	1/23/2006	Field	Odor, Atmospheric, Severity (1=none, 2=light, 3=moderate, 4=heavy, 5=severe)		3	code	
120420010010-001AT	391007	1/23/2006	Field	Debris, Floating, Severity (1=none, 2=light, 3=moderate, 4=heavy, 5=total)		1	code	
120420010010-001AT	391007	1/23/2006	Field	Foaming, Severity (1=none, 2=light, 3=moderate, 4=heavy, 5=total)		2	code	
120420010010-001AT	391007	1/23/2006	Field	Scum, Severity (1=none, 2=light, 3=moderate, 4=heavy, 5=total)		1	code	
120420010010-001AT	391007	1/23/2006	Field	Turbidity, Type (1=inorganic, 2=organic, 3=mix)		3	code	
120420010010-001AT	391007	1/23/2006	Field	STREAM FLOW, SEVERITY (1=none, 2=light, 3=moderate, 4=heavy, 5=stormwater)		3	CODE	
120420010010-001AT	391007	1/23/2006	Field	TOTAL DISSOLVED SOLIDS (FIELD)		1847	MG/L	

120420010010-001AT	A00751	5/23/2006	Biological	ENTEROCOCCI		31	CFU/100ML	9230C
120420010010-001AT	A00957	6/12/2006	Biological	COLIFORM, FECAL		410	NM/100ML	9222D
120420010010-001AT	391007	1/23/2006	Field	SALINITY (FIELD)		1.56	G/L	
120420010010-001AT	391007	1/23/2006	Field	Periphyton, Severity (% of streambed; 1=0%, 2=25%, 3=50%, 4=75%, 5=100%)		3	code	
120420010010-001AT	391007	1/23/2006	Field	Periphyton Line, Visible (1=yes, 2=no)		1	code	
120420010010-001AT	391007	1/23/2006	Field	Periphyton Texture (1=filamentous, 2=gelatinous, 3=rough, 4=slimy, 5=other)		4	code	
120420010010-001AT	391007	1/23/2006	Field	Periphyton Color (1=brown, 2=green, 3=red/orange, 4=yellow, 5=other)		2	code	
120420010010-001AT	391007	1/23/2006	Field	Flow, Instantaneous		661.41	CFS	
120420010010-001AT	391007	1/23/2006	Field	Turbidity, Field		5	NTU	180.1
120420010010-001AT	391007	1/23/2006	Field	P-ALKALINITY (FIELD)		0	MG/L	
120420010010-001AT	391007	1/23/2006	Field	STREAM WIDTH		150	METERS	
120420010010-001AT	391007	1/23/2006	Field	STREAM TYPE		2	CODE	
120420010010-001AT	391007	1/23/2006	Field	Flow Measurement Tech (1=composite average, 2=rated, 3=DCP)		2	code	
120420010010-001AT	391007	1/23/2006	Field	DEPTH, MAXIMUM OF SAMPLE		0.9	METERS	
120420010010-001AT	391007	1/23/2006	Field	COLOR, BORGER COLOR SYSTEM		39	CODE	
120420010010-001AT	393461	2/27/2006	Field	Water Temperature		9.66	DEG CELS	2550B
120420010010-001AT	393461	2/27/2006	Field	AIR TEMPERATURE		16	DEG C	2550B
120420010010-001AT	393461	2/27/2006	Field	BARROMETRIC PRESSURE		765	MM HG	
120420010010-001AT	393461	2/27/2006	Field	CLOUD COVER		1	PERCENT	
120420010010-001AT	393461	2/27/2006	Field	WIND VELOCITY		28	MPH	

120420010010-001AT	A00751	5/23/2006	Biological	ENTEROCOCCI		31	CFU/100ML	9230C
120420010010-001AT	A00957	6/12/2006	Biological	COLIFORM, FECAL		410	NM/100ML	9222D
120420010010-001AT	393461	2/27/2006	Field	WIND DIRECTION		180	AZIMUTH	
120420010010-001AT	393461	2/27/2006	Field	STREAM STAGE		5.23	feet	
120420010010-001AT	393461	2/27/2006	Field	OXIDATION/REDUCTION POT. (FIELD)		419	MV	
120420010010-001AT	393461	2/27/2006	Field	Specific Conductance		3031	UMHOS/CM	120.1
120420010010-001AT	393461	2/27/2006	Field	DISSOLVED OXYGEN, analysis by probe		15.1	MG/L	
120420010010-001AT	393461	2/27/2006	Field	DISS OXY SATURATION		133.4	PERCENT	
120420010010-001AT	393461	2/27/2006	Field	PH (FIELD)		8.4	STD UNIT	150.1
120420010010-001AT	393461	2/27/2006	Field	TOT ALK FIELD CACO3		183	MG/L	
120420010010-001AT	393461	2/27/2006	Field	Hardness, Total (as CaCO3)		279	MG/L	
120420010010-001AT	393461	2/27/2006	Field	Oil and Grease, Severity (1=none, 2=light, 3=moderate, 4=heavy, 5=total)		2	code	
120420010010-001AT	393461	2/27/2006	Field	Odor, Atmospheric, Severity (1=none, 2=light, 3=moderate, 4=heavy, 5=severe)		3	code	
120420010010-001AT	393461	2/27/2006	Field	Debris, Floating, Severity (1=none, 2=light, 3=moderate, 4=heavy, 5=total)		2	code	
120420010010-001AT	393461	2/27/2006	Field	Foaming, Severity (1=none, 2=light, 3=moderate, 4=heavy, 5=total)		3	code	
120420010010-001AT	393461	2/27/2006	Field	Debris, Floating, Size (1=small, 2=medium, 3= large)		1	code	

120420010010-001AT	A00751	5/23/2006	Biological	ENTEROCOCCI		31	CFU/100ML	9230C
120420010010-001AT	A00957	6/12/2006	Biological	COLIFORM, FECAL		410	NM/100ML	9222D
120420010010-001AT	393461	2/27/2006	Field	Scum, Severity (1=none, 2=light, 3=moderate, 4=heavy, 5=total)		4	code	
120420010010-001AT	393461	2/27/2006	Field	Turbidity, Type (1=inorganic, 2=organic, 3=mix)		3	code	
120420010010-001AT	393461	2/27/2006	Field	STREAM FLOW, SEVERITY (1=none, 2=light, 3=moderate, 4=heavy, 5=stormwater)		2	CODE	
120420010010-001AT	393461	2/27/2006	Field	TOTAL DISSOLVED SOLIDS (FIELD)		1940	MG/L	
120420010010-001AT	393461	2/27/2006	Field	SALINITY (FIELD)		1.5	G/L	
120420010010-001AT	393461	2/27/2006	Field	Periphyton, Severity (% of streambed; 1=0%, 2=25%, 3=50%, 4=75%, 5=100%)		1	code	
120420010010-001AT	393461	2/27/2006	Field	Periphyton Line, Visible (1=yes, 2=no)		2	code	
120420010010-001AT	393461	2/27/2006	Field	Flow, Instantaneous		425.95	CFS	
120420010010-001AT	393461	2/27/2006	Field	Turbidity, Field		5	NTU	180.1
120420010010-001AT	393461	2/27/2006	Field	P-ALKALINITY (FIELD)		0	MG/L	
120420010010-001AT	393461	2/27/2006	Field	STREAM WIDTH		1020	METERS	
120420010010-001AT	393461	2/27/2006	Field	STREAM TYPE		2	CODE	
120420010010-001AT	393461	2/27/2006	Field	Flow Measurement Tech (1=composite average, 2=rated, 3=DCP)		2	code	
120420010010-001AT	393461	2/27/2006	Field	DEPTH, MAXIMUM OF SAMPLE		0.6	METERS	
120420010010-001AT	393461	2/27/2006	Field	COLOR, BORGER COLOR SYSTEM		31	CODE	

120420010010-001AT	A00751	5/23/2006	Biological	ENTEROCOCCI		31	CFU/100ML	9230C
120420010010-001AT	A00957	6/12/2006	Biological	COLIFORM, FECAL		410	NM/100ML	9222D
120420010010-001AT	395293	4/3/2006	Field	Water Temperature		15.17	DEG CELS	2550B
120420010010-001AT	395293	4/3/2006	Field	AIR TEMPERATURE		16	DEG C	2550B
120420010010-001AT	395293	4/3/2006	Field	BARROMETRIC PRESSURE		766.8	MM HG	
120420010010-001AT	395293	4/3/2006	Field	CLOUD COVER		5	PERCENT	
120420010010-001AT	395293	4/3/2006	Field	WIND VELOCITY		8	MPH	
120420010010-001AT	395293	4/3/2006	Field	WIND DIRECTION		315	AZIMUTH	
120420010010-001AT	395293	4/3/2006	Field	STREAM STAGE		4.94	feet	
120420010010-001AT	395293	4/3/2006	Field	OXIDATION/REDUCTION POT. (FIELD)		393	MV	
120420010010-001AT	395293	4/3/2006	Field	Specific Conductance		2224	UMHOS/CM	120.1
120420010010-001AT	395293	4/3/2006	Field	DISSOLVED OXYGEN, analysis by probe		16.7	MG/L	
120420010010-001AT	395293	4/3/2006	Field	DISS OXY SATURATION		166.1	PERCENT	
120420010010-001AT	395293	4/3/2006	Field	PH (FIELD)		8.39	STD UNIT	150.1
120420010010-001AT	395293	4/3/2006	Field	TOT ALK FIELD CACO3		157	MG/L	
120420010010-001AT	395293	4/3/2006	Field	Hardness, Total (as CaCO3)		260	MG/L	
120420010010-001AT	395293	4/3/2006	Field	Oil and Grease, Severity (1=none, 2=light, 3=moderate, 4=heavy, 5=total)		1	code	
120420010010-001AT	395293	4/3/2006	Field	Odor, Atmospheric, Severity (1=none, 2=light, 3=moderate, 4=heavy, 5=severe)		3	code	
120420010010-001AT	395293	4/3/2006	Field	Debris, Floating, Severity (1=none, 2=light, 3=moderate, 4=heavy, 5=total)		1	code	

120420010010-001AT	A00751	5/23/2006	Biological	ENTEROCOCCI		31	CFU/100ML	9230C
120420010010-001AT	A00957	6/12/2006	Biological	COLIFORM, FECAL		410	NM/100ML	9222D
120420010010-001AT	395293	4/3/2006	Field	Foaming, Severity (1=none, 2=light, 3=moderate, 4=heavy, 5=total)		1	code	
120420010010-001AT	395293	4/3/2006	Field	Scum, Severity (1=none, 2=light, 3=moderate, 4=heavy, 5=total)		1	code	
120420010010-001AT	395293	4/3/2006	Field	Turbidity, Type (1=inorganic, 2=organic, 3=mix)		3	code	
120420010010-001AT	395293	4/3/2006	Field	STREAM FLOW, SEVERITY (1=none, 2=light, 3=moderate, 4=heavy, 5=stormwater)		2	CODE	
120420010010-001AT	395293	4/3/2006	Field	TOTAL DISSOLVED SOLIDS (FIELD)		1423	MG/L	
120420010010-001AT	395293	4/3/2006	Field	SALINITY (FIELD)		1.19	G/L	
120420010010-001AT	395293	4/3/2006	Field	Periphyton, Severity (% of streambed; 1=0%, 2=25%, 3=50%, 4=75%, 5=100%)		2	code	
120420010010-001AT	395293	4/3/2006	Field	Periphyton Line, Visible (1=yes, 2=no)		1	code	
120420010010-001AT	395293	4/3/2006	Field	Periphyton Texture (1=filamentous, 2=gelatinous, 3=rough, 4=slimy, 5=other)		4	code	
120420010010-001AT	395293	4/3/2006	Field	Periphyton Color (1=brown, 2=green, 3=red/orange, 4=yellow, 5=other)		2	code	
120420010010-001AT	395293	4/3/2006	Field	Flow, Instantaneous		589	CFS	

120420010010-001AT	A00751	5/23/2006	Biological	ENTEROCOCCI		31	CFU/100ML	9230C
120420010010-001AT	A00957	6/12/2006	Biological	COLIFORM, FECAL		410	NM/100ML	9222D
120420010010-001AT	395293	4/3/2006	Field	Turbidity, Field		6	NTU	180.1
120420010010-001AT	395293	4/3/2006	Field	P-ALKALINITY (FIELD)		0	MG/L	
120420010010-001AT	395293	4/3/2006	Field	STREAM WIDTH		100	METERS	
120420010010-001AT	395293	4/3/2006	Field	STREAM TYPE		3	CODE	
120420010010-001AT	395293	4/3/2006	Field	Flow Measurement Tech (1=composite average, 2=rated, 3=DCP)		2	code	
120420010010-001AT	395293	4/3/2006	Field	DEPTH, MAXIMUM OF SAMPLE		0.3	METERS	
120420010010-001AT	395293	4/3/2006	Field	COLOR, BORGER COLOR SYSTEM		36	CODE	
120420010010-001AT	397259	5/8/2006	Field	Water Temperature		21.36	DEG CELS	2550B
120420010010-001AT	397259	5/8/2006	Field	AIR TEMPERATURE		25	DEG C	2550B
120420010010-001AT	397259	5/8/2006	Field	BARROMETRIC PRESSURE		760	MM HG	
120420010010-001AT	397259	5/8/2006	Field	CLOUD COVER		75	PERCENT	
120420010010-001AT	397259	5/8/2006	Field	WIND VELOCITY		2.5	MPH	
120420010010-001AT	397259	5/8/2006	Field	WIND DIRECTION		180	AZIMUTH	
120420010010-001AT	397259	5/8/2006	Field	STREAM STAGE		10.4	feet	
120420010010-001AT	397259	5/8/2006	Field	OXIDATION/REDUCTIO N POT. (FIELD)		275	MV	
120420010010-001AT	397259	5/8/2006	Field	Specific Conductance		2117	UMHOS/CM	120.1
120420010010-001AT	397259	5/8/2006	Field	DISSOLVED OXYGEN, analysis by probe		7.17	MG/L	
120420010010-001AT	397259	5/8/2006	Field	DISS OXY SATURATION		81.6	PERCENT	
120420010010-001AT	397259	5/8/2006	Field	PH (FIELD)		8.2	STD UNIT	150.1
120420010010-001AT	397259	5/8/2006	Field	TOT ALK FIELD CACO3		121	MG/L	
120420010010-001AT	397259	5/8/2006	Field	Hardness, Total (as CaCO3)		241	MG/L	

120420010010-001AT	A00751	5/23/2006	Biological	ENTEROCOCCI		31	CFU/100ML	9230C
120420010010-001AT	A00957	6/12/2006	Biological	COLIFORM, FECAL		410	NM/100ML	9222D
120420010010-001AT	397259	5/8/2006	Field	Oil and Grease, Severity (1=none, 2=light, 3=moderate, 4=heavy, 5=total)		2	code	
120420010010-001AT	397259	5/8/2006	Field	Odor, Atmospheric, Severity (1=none, 2=light, 3=moderate, 4=heavy, 5=severe)		2	code	
120420010010-001AT	397259	5/8/2006	Field	Debris, Floating, Severity (1=none, 2=light, 3=moderate, 4=heavy, 5=total)		2	code	
120420010010-001AT	397259	5/8/2006	Field	Foaming, Severity (1=none, 2=light, 3=moderate, 4=heavy, 5=total)		3	code	
120420010010-001AT	397259	5/8/2006	Field	Debris, Floating, Size (1=small, 2=medium, 3= large)		1	code	
120420010010-001AT	397259	5/8/2006	Field	Scum, Severity (1=none, 2=light, 3=moderate, 4=heavy, 5=total)		3	code	
120420010010-001AT	397259	5/8/2006	Field	Turbidity, Type (1=inorganic, 2=organic, 3=mix)		1	code	
120420010010-001AT	397259	5/8/2006	Field	STREAM FLOW, SEVERITY (1=none, 2=light, 3=moderate, 4=heavy, 5=stormwater)		4	CODE	
120420010010-001AT	397259	5/8/2006	Field	Precipitation		0	inches	
120420010010-001AT	397259	5/8/2006	Field	Precipitation Type (1=fog, 2=rain, 3=sleet, 4=snow, 5=mix)		0	code	

120420010010-001AT	A00751	5/23/2006	Biological	ENTEROCOCCI		31	CFU/100ML	9230C
120420010010-001AT	A00957	6/12/2006	Biological	COLIFORM, FECAL		410	NM/100ML	9222D
120420010010-001AT	397259	5/8/2006	Field	TOTAL DISSOLVED SOLIDS (FIELD)		1355	MG/L	
120420010010-001AT	397259	5/8/2006	Field	SALINITY (FIELD)		1.1	G/L	
120420010010-001AT	397259	5/8/2006	Field	Periphyton, Severity (% of streambed; 1=0%, 2=25%, 3=50%, 4=75%, 5=100%)		1	code	
120420010010-001AT	397259	5/8/2006	Field	Periphyton Line, Visible (1=yes, 2=no)		2	code	
120420010010-001AT	397259	5/8/2006	Field	Flow, Instantaneous		9568.7	CFS	
120420010010-001AT	397259	5/8/2006	Field	Turbidity, Field		58	NTU	180.1
120420010010-001AT	397259	5/8/2006	Field	P-ALKALINITY (FIELD)		0	MG/L	
120420010010-001AT	397259	5/8/2006	Field	STREAM WIDTH		1920	METERS	
120420010010-001AT	397259	5/8/2006	Field	STREAM TYPE		2	CODE	
120420010010-001AT	397259	5/8/2006	Field	Flow Measurement Tech (1=composite average, 2=rated, 3=DCP)		2	code	
120420010010-001AT	397259	5/8/2006	Field	DEPTH, MAXIMUM OF SAMPLE		0.2	METERS	
120420010010-001AT	397259	5/8/2006	Field	COLOR, BORGER COLOR SYSTEM		31	CODE	
120420010010-001AT	398905	6/12/2006	Field	Water Temperature		27.22	DEG CELS	2550B
120420010010-001AT	398905	6/12/2006	Field	AIR TEMPERATURE		30	DEG C	2550B
120420010010-001AT	398905	6/12/2006	Field	BARROMETRIC PRESSURE		746	MM HG	
120420010010-001AT	398905	6/12/2006	Field	CLOUD COVER		100	PERCENT	
120420010010-001AT	398905	6/12/2006	Field	WIND VELOCITY		3.5	MPH	
120420010010-001AT	398905	6/12/2006	Field	WIND DIRECTION		270	AZIMUTH	
120420010010-001AT	398905	6/12/2006	Field	STREAM STAGE		5.1	feet	
120420010010-001AT	398905	6/12/2006	Field	OXIDATION/REDUCTION POT. (FIELD)		465	MV	
120420010010-001AT	398905	6/12/2006	Field	Specific Conductance		1361	UMHOS/CM	120.1

120420010010-001AT	A00751	5/23/2006	Biological	ENTEROCOCCI		31	CFU/100ML	9230C
120420010010-001AT	A00957	6/12/2006	Biological	COLIFORM, FECAL		410	NM/100ML	9222D
120420010010-001AT	398905	6/12/2006	Field	DISSOLVED OXYGEN, analysis by probe		11.49	MG/L	
120420010010-001AT	398905	6/12/2006	Field	DISS OXY SATURATION		148.2	PERCENT	
120420010010-001AT	398905	6/12/2006	Field	PH (FIELD)		8.5	STD UNIT	150.1
120420010010-001AT	398905	6/12/2006	Field	TOT ALK FIELD CACO3		131	MG/L	
120420010010-001AT	398905	6/12/2006	Field	Hardness, Total (as CaCO3)		182	MG/L	
120420010010-001AT	398905	6/12/2006	Field	Oil and Grease, Severity (1=none, 2=light, 3=moderate, 4=heavy, 5=total)		1	code	
120420010010-001AT	398905	6/12/2006	Field	Odor, Atmospheric, Severity (1=none, 2=light, 3=moderate, 4=heavy, 5=severe)		1	code	
120420010010-001AT	398905	6/12/2006	Field	Debris, Floating, Severity (1=none, 2=light, 3=moderate, 4=heavy, 5=total)		1	code	
120420010010-001AT	398905	6/12/2006	Field	Foaming, Severity (1=none, 2=light, 3=moderate, 4=heavy, 5=total)		1	code	
120420010010-001AT	398905	6/12/2006	Field	Scum, Severity (1=none, 2=light, 3=moderate, 4=heavy, 5=total)		1	code	
120420010010-001AT	398905	6/12/2006	Field	Turbidity, Type (1=inorganic, 2=organic, 3=mix)		3	code	

120420010010-001AT	A00751	5/23/2006	Biological	ENTEROCOCCI		31	CFU/100ML	9230C
120420010010-001AT	A00957	6/12/2006	Biological	COLIFORM, FECAL		410	NM/100ML	9222D
120420010010-001AT	398905	6/12/2006	Field	STREAM FLOW, SEVERITY (1=none, 2=light, 3=moderate, 4=heavy, 5=stormwater)		3	CODE	
120420010010-001AT	398905	6/12/2006	Field	Precipitation		0	inches	
120420010010-001AT	398905	6/12/2006	Field	Precipitation Type (1=fog, 2=rain, 3=sleet, 4=snow, 5=mix)		0	code	
120420010010-001AT	398905	6/12/2006	Field	TOTAL DISSOLVED SOLIDS (FIELD)		871.1	MG/L	
120420010010-001AT	398905	6/12/2006	Field	SALINITY (FIELD)		0.72	G/L	
120420010010-001AT	398905	6/12/2006	Field	Periphyton, Severity (% of streambed; 1=0%, 2=25%, 3=50%, 4=75%, 5=100%)		1	code	
120420010010-001AT	398905	6/12/2006	Field	Periphyton Line, Visible (1=yes, 2=no)		2	code	
120420010010-001AT	398905	6/12/2006	Field	Flow, Instantaneous		379	CFS	
120420010010-001AT	398905	6/12/2006	Field	Turbidity, Field		12	NTU	180.1
120420010010-001AT	398905	6/12/2006	Field	P-ALKALINITY (FIELD)		0	MG/L	
120420010010-001AT	398905	6/12/2006	Field	STREAM WIDTH		110	METERS	
120420010010-001AT	398905	6/12/2006	Field	STREAM TYPE		2	CODE	
120420010010-001AT	398905	6/12/2006	Field	Flow Measurement Tech (1=composite average, 2=rated, 3=DCP)		1	code	
120420010010-001AT	398905	6/12/2006	Field	DEPTH, MAXIMUM OF SAMPLE		1.1	METERS	
120420010010-001AT	398905	6/12/2006	Field	COLOR, BORGER COLOR SYSTEM		36	CODE	
120420010010-001AT	400976	7/17/2006	Field	Water Temperature		32.11	DEG CELS	2550B
120420010010-001AT	400976	7/17/2006	Field	AIR TEMPERATURE		37	DEG C	2550B

120420010010-001AT	A00751	5/23/2006	Biological	ENTEROCOCCI		31	CFU/100ML	9230C
120420010010-001AT	A00957	6/12/2006	Biological	COLIFORM, FECAL		410	NM/100ML	9222D
120420010010-001AT	400976	7/17/2006	Field	BAROMETRIC PRESSURE		744.5	MM HG	
120420010010-001AT	400976	7/17/2006	Field	CLOUD COVER		0	PERCENT	
120420010010-001AT	400976	7/17/2006	Field	WIND VELOCITY		5	MPH	
120420010010-001AT	400976	7/17/2006	Field	WIND DIRECTION		180	AZIMUTH	
120420010010-001AT	400976	7/17/2006	Field	STREAM STAGE		7.64	feet	
120420010010-001AT	400976	7/17/2006	Field	OXIDATION/REDUCTION POT. (FIELD)		444	MV	
120420010010-001AT	400976	7/17/2006	Field	Specific Conductance		1870	UMHOS/CM	120.1
120420010010-001AT	400976	7/17/2006	Field	DISSOLVED OXYGEN, analysis by probe		8.9	MG/L	
120420010010-001AT	400976	7/17/2006	Field	DISS OXY SATURATION		125.6	PERCENT	
120420010010-001AT	400976	7/17/2006	Field	PH (FIELD)		8.25	STD UNIT	150.1
120420010010-001AT	400976	7/17/2006	Field	TOT ALK FIELD CACO3		138	MG/L	
120420010010-001AT	400976	7/17/2006	Field	Hardness, Total (as CaCO3)		208	MG/L	
120420010010-001AT	400976	7/17/2006	Field	Oil and Grease, Severity (1=none, 2=light, 3=moderate, 4=heavy, 5=total)		1	code	
120420010010-001AT	400976	7/17/2006	Field	Odor, Atmospheric, Severity (1=none, 2=light, 3=moderate, 4=heavy, 5=severe)		1	code	
120420010010-001AT	400976	7/17/2006	Field	Debris, Floating, Severity (1=none, 2=light, 3=moderate, 4=heavy, 5=total)		1	code	
120420010010-001AT	400976	7/17/2006	Field	Foaming, Severity (1=none, 2=light, 3=moderate, 4=heavy, 5=total)		1	code	

120420010010-001AT	A00751	5/23/2006	Biological	ENTEROCOCCI		31	CFU/100ML	9230C
120420010010-001AT	A00957	6/12/2006	Biological	COLIFORM, FECAL		410	NM/100ML	9222D
120420010010-001AT	400976	7/17/2006	Field	Scum, Severity (1=none, 2=light, 3=moderate, 4=heavy, 5=total)		1	code	
120420010010-001AT	400976	7/17/2006	Field	Turbidity, Type (1=inorganic, 2=organic, 3=mix)		3	code	
120420010010-001AT	400976	7/17/2006	Field	STREAM FLOW, SEVERITY (1=none, 2=light, 3=moderate, 4=heavy, 5=stormwater)		3	CODE	
120420010010-001AT	400976	7/17/2006	Field	Precipitation		0	inches	
120420010010-001AT	400976	7/17/2006	Field	Precipitation Type (1=fog, 2=rain, 3=sleet, 4=snow, 5=mix)		0	code	
120420010010-001AT	400976	7/17/2006	Field	TOTAL DISSOLVED SOLIDS (FIELD)		1200	MG/L	
120420010010-001AT	400976	7/17/2006	Field	SALINITY (FIELD)		1	G/L	
120420010010-001AT	400976	7/17/2006	Field	Periphyton, Severity (% of streambed; 1=0%, 2=25%, 3=50%, 4=75%, 5=100%)		1	code	
120420010010-001AT	400976	7/17/2006	Field	Periphyton Line, Visible (1=yes, 2=no)		2	code	
120420010010-001AT	400976	7/17/2006	Field	Flow, Instantaneous		2467.1	CFS	
120420010010-001AT	400976	7/17/2006	Field	Turbidity, Field		20	NTU	180.1
120420010010-001AT	400976	7/17/2006	Field	P-ALKALINITY (FIELD)		0	MG/L	
120420010010-001AT	400976	7/17/2006	Field	STREAM WIDTH		100	METERS	
120420010010-001AT	400976	7/17/2006	Field	STREAM TYPE		3	CODE	
120420010010-001AT	400976	7/17/2006	Field	Flow Measurement Tech (1=composite average, 2=rated, 3=DCP)		2	code	

120420010010-001AT	A00751	5/23/2006	Biological	ENTEROCOCCI		31	CFU/100ML	9230C
120420010010-001AT	A00957	6/12/2006	Biological	COLIFORM, FECAL		410	NM/100ML	9222D
120420010010-001AT	400976	7/17/2006	Field	DEPTH, MAXIMUM OF SAMPLE		0.4	METERS	
120420010010-001AT	400976	7/17/2006	Field	COLOR, BORGER COLOR SYSTEM		42	CODE	
120420010010-001AT	403480	8/22/2006	Field	Water Temperature		27.51	DEG CELS	2550B
120420010010-001AT	403480	8/22/2006	Field	AIR TEMPERATURE		32	DEG C	2550B
120420010010-001AT	403480	8/22/2006	Field	BARROMETRIC PRESSURE		764	MM HG	
120420010010-001AT	403480	8/22/2006	Field	CLOUD COVER		100	PERCENT	
120420010010-001AT	403480	8/22/2006	Field	WIND VELOCITY		2.5	MPH	
120420010010-001AT	403480	8/22/2006	Field	WIND DIRECTION		180	AZIMUTH	
120420010010-001AT	403480	8/22/2006	Field	STREAM STAGE		7.67	feet	
120420010010-001AT	403480	8/22/2006	Field	OXIDATION/REDUCTIO N POT. (FIELD)		419	MV	
120420010010-001AT	403480	8/22/2006	Field	Specific Conductance		1425	UMHOS/CM	120.1
120420010010-001AT	403480	8/22/2006	Field	DISSOLVED OXYGEN, analysis by probe		5.93	MG/L	
120420010010-001AT	403480	8/22/2006	Field	DISS OXY SATURATION		75.3	PERCENT	
120420010010-001AT	403480	8/22/2006	Field	PH (FIELD)		7.89	STD UNIT	150.1
120420010010-001AT	403480	8/22/2006	Field	TOT ALK FIELD CACO3		129	MG/L	
120420010010-001AT	403480	8/22/2006	Field	Hardness, Total (as CaCO3)		197	MG/L	
120420010010-001AT	403480	8/22/2006	Field	Oil and Grease, Severity (1=none, 2=light, 3=moderate, 4=heavy, 5=total)		2	code	
120420010010-001AT	403480	8/22/2006	Field	Odor, Atmospheric, Severity (1=none, 2=light, 3=moderate, 4=heavy, 5=severe)		2	code	

120420010010-001AT	A00751	5/23/2006	Biological	ENTEROCOCCI		31	CFU/100ML	9230C
120420010010-001AT	A00957	6/12/2006	Biological	COLIFORM, FECAL		410	NM/100ML	9222D
120420010010-001AT	403480	8/22/2006	Field	Debris, Floating, Severity (1=none, 2=light, 3=moderate, 4=heavy, 5=total)		1	code	
120420010010-001AT	403480	8/22/2006	Field	Foaming, Severity (1=none, 2=light, 3=moderate, 4=heavy, 5=total)		3	code	
120420010010-001AT	403480	8/22/2006	Field	Debris, Floating, Size (1=small, 2=medium, 3= large)		1	code	
120420010010-001AT	403480	8/22/2006	Field	Scum, Severity (1=none, 2=light, 3=moderate, 4=heavy, 5=total)		3	code	
120420010010-001AT	403480	8/22/2006	Field	Turbidity, Type (1=inorganic, 2=organic, 3=mix)		3	code	
120420010010-001AT	403480	8/22/2006	Field	STREAM FLOW, SEVERITY (1=none, 2=light, 3=moderate, 4=heavy, 5=stormwater)		3	CODE	
120420010010-001AT	403480	8/22/2006	Field	Precipitation		0	inches	
120420010010-001AT	403480	8/22/2006	Field	Precipitation Type (1=fog, 2=rain, 3=sleet, 4=snow, 5=mix)		0	code	
120420010010-001AT	403480	8/22/2006	Field	TOTAL DISSOLVED SOLIDS (FIELD)		912	MG/L	
120420010010-001AT	403480	8/22/2006	Field	SALINITY (FIELD)		0.8	G/L	
120420010010-001AT	403480	8/22/2006	Field	Periphyton, Severity (% of streambed; 1=0%, 2=25%, 3=50%, 4=75%, 5=100%)		1	code	

120420010010-001AT	A00751	5/23/2006	Biological	ENTEROCOCCI		31	CFU/100ML	9230C
120420010010-001AT	A00957	6/12/2006	Biological	COLIFORM, FECAL		410	NM/100ML	9222D
120420010010-001AT	403480	8/22/2006	Field	Periphyton Line, Visible (1=yes, 2=no)		2	code	
120420010010-001AT	403480	8/22/2006	Field	Flow, Instantaneous		2511.7	CFS	
120420010010-001AT	403480	8/22/2006	Field	Turbidity, Field		18	NTU	180.1
120420010010-001AT	403480	8/22/2006	Field	P-ALKALINITY (FIELD)		0	MG/L	
120420010010-001AT	403480	8/22/2006	Field	STREAM WIDTH		1650	METERS	
120420010010-001AT	403480	8/22/2006	Field	STREAM TYPE		2	CODE	
120420010010-001AT	403480	8/22/2006	Field	Flow Measurement Tech (1=composite average, 2=rated, 3=DCP)		2	code	
120420010010-001AT	403480	8/22/2006	Field	DEPTH, MAXIMUM OF SAMPLE		0.4	METERS	
120420010010-001AT	403480	8/22/2006	Field	COLOR, BORGER COLOR SYSTEM		30	CODE	

Inorganics

STATION_ID	SAMPLE_ID	SAMPLE_DATE	PARAMETER_TYPE	PARAMETER	REMARK	VALUE	UNITS	METHOD
120420010010-001AT	391007	1/23/2006	Inorganic	Nitrogen, Ammonia	<	0.05	mg/L	350.1
120420010010-001AT	391007	1/23/2006	Inorganic	Nitrogen, Kjeldahl		0.66	mg/L	351.3
120420010010-001AT	391007	1/23/2006	Inorganic	Nitrogen, Nitrate/Nitrite as N		1.02	mg/L	
120420010010-001AT	391007	1/23/2006	Inorganic	Phosphorous, Total		0.331	mg/L	365.3
120420010010-001AT	391007	1/23/2006	Inorganic	Chloride		795	mg/L	325.2
120420010010-001AT	391007	1/23/2006	Inorganic	Sulfate		151	mg/L	375.4
120420010010-001AT	391007	1/23/2006	Inorganic	Phosphorous, Ortho		0.273	mg/L	365.1
120420010010-001AT	393461	2/27/2006	Inorganic	Nitrogen, Ammonia	<	0.05	mg/L	350.1
120420010010-001AT	393461	2/27/2006	Inorganic	Nitrogen, Kjeldahl		0.79	mg/L	351.3
120420010010-001AT	393461	2/27/2006	Inorganic	Nitrogen, Nitrate/Nitrite as N		0.4	mg/L	
120420010010-001AT	393461	2/27/2006	Inorganic	Phosphorous, Total		0.203	mg/L	365.3
120420010010-001AT	393461	2/27/2006	Inorganic	Chloride		840	mg/L	325.2
120420010010-001AT	393461	2/27/2006	Inorganic	Sulfate		164	mg/L	375.4
120420010010-001AT	393461	2/27/2006	Inorganic	Phosphorous, Ortho		0.133	mg/L	365.1

120420010010-001AT	A00751	5/23/2006	Biological	ENTEROCOCCI		31	CFU/100ML	9230C
120420010010-001AT	A00957	6/12/2006	Biological	COLIFORM, FECAL		410	NM/100ML	9222D
120420010010-001AT	395293	4/3/2006	Inorganic	Nitrogen, Ammonia	<	0.05	mg/L	350.1
120420010010-001AT	395293	4/3/2006	Inorganic	Nitrogen, Kjeldahl		0.84	mg/L	351.3
120420010010-001AT	395293	4/3/2006	Inorganic	Nitrogen, Nitrate/Nitrite as N		0.54	mg/L	
120420010010-001AT	395293	4/3/2006	Inorganic	Phosphorous, Total		0.285	mg/L	365.3
120420010010-001AT	395293	4/3/2006	Inorganic	Chloride		648	mg/L	325.2
120420010010-001AT	395293	4/3/2006	Inorganic	Sulfate		146	mg/L	375.4
120420010010-001AT	395293	4/3/2006	Inorganic	Phosphorous, Ortho		0.16	mg/L	365.1
120420010010-001AT	397259	5/8/2006	Inorganic	Nitrogen, Ammonia		0.07	mg/L	350.1
120420010010-001AT	397259	5/8/2006	Inorganic	Nitrogen, Kjeldahl		1.02	mg/L	351.3
120420010010-001AT	397259	5/8/2006	Inorganic	Nitrogen, Nitrate/Nitrite as N		0.38	mg/L	
120420010010-001AT	397259	5/8/2006	Inorganic	Phosphorous, Total		0.223	mg/L	365.3
120420010010-001AT	397259	5/8/2006	Inorganic	Chloride		495	mg/L	325.2
120420010010-001AT	397259	5/8/2006	Inorganic	Sulfate		117	mg/L	375.4
120420010010-001AT	397259	5/8/2006	Inorganic	Phosphorous, Ortho		0.107	mg/L	365.1
120420010010-001AT	398905	6/12/2006	Inorganic	Nitrogen, Ammonia	<	0.05	mg/L	350.1
120420010010-001AT	398905	6/12/2006	Inorganic	Nitrogen, Kjeldahl		0.77	mg/L	351.3
120420010010-001AT	398905	6/12/2006	Inorganic	Nitrogen, Nitrate/Nitrite as N		0.19	mg/L	
120420010010-001AT	398905	6/12/2006	Inorganic	Phosphorous, Total		0.229	mg/L	365.3
120420010010-001AT	398905	6/12/2006	Inorganic	Chloride		303	mg/L	325.2
120420010010-001AT	398905	6/12/2006	Inorganic	Sulfate		97.9	mg/L	375.4
120420010010-001AT	398905	6/12/2006	Inorganic	Phosphorous, Ortho		0.136	mg/L	365.1
120420010010-001AT	400976	7/17/2006	Inorganic	Nitrogen, Ammonia		0.06	mg/L	350.1
120420010010-001AT	400976	7/17/2006	Inorganic	Nitrogen, Kjeldahl		0.86	mg/L	351.3
120420010010-001AT	400976	7/17/2006	Inorganic	Nitrogen, Nitrate/Nitrite as N	<	0.05	mg/L	
120420010010-001AT	400976	7/17/2006	Inorganic	Phosphorous, Total		0.232	mg/L	365.3
120420010010-001AT	400976	7/17/2006	Inorganic	Chloride		442	mg/L	325.2
120420010010-001AT	400976	7/17/2006	Inorganic	Sulfate		111	mg/L	375.4
120420010010-001AT	400976	7/17/2006	Inorganic	Phosphorous, Ortho		0.118	mg/L	365.1
120420010010-001AT	403480	8/22/2006	Inorganic	Nitrogen, Ammonia		0.1	mg/L	350.1
120420010010-001AT	403480	8/22/2006	Inorganic	Nitrogen, Kjeldahl		0.77	mg/L	351.3

120420010010-001AT	A00751	5/23/2006	Biological	ENTEROCOCCI		31	CFU/100ML	9230C
120420010010-001AT	A00957	6/12/2006	Biological	COLIFORM, FECAL		410	NM/100ML	9222D
120420010010-001AT	403480	8/22/2006	Inorganic	Nitrogen, Nitrate/Nitrite as N		0.21	mg/L	
120420010010-001AT	403480	8/22/2006	Inorganic	Phosphorous, Total		0.214	mg/L	365.3
120420010010-001AT	403480	8/22/2006	Inorganic	Chloride		322	mg/L	325.2
120420010010-001AT	403480	8/22/2006	Inorganic	Sulfate		90.4	mg/L	375.4
120420010010-001AT	403480	8/22/2006	Inorganic	Phosphorous, Ortho		0.14	mg/L	365.1
120420010010-001AT	406989	10/2/2006	Inorganic	Nitrogen, Ammonia	<	0.05	mg/L	350.1
120420010010-001AT	406989	10/2/2006	Inorganic	Nitrogen, Kjeldahl		1.17	mg/L	351.3
120420010010-001AT	406989	10/2/2006	Inorganic	Nitrogen, Nitrate/Nitrite as N		0.59	mg/L	
120420010010-001AT	406989	10/2/2006	Inorganic	Phosphorous, Total		0.256	mg/L	365.3
120420010010-001AT	406989	10/2/2006	Inorganic	Chloride		307	mg/L	325.2
120420010010-001AT	406989	10/2/2006	Inorganic	Sulfate		115	mg/L	375.4
120420010010-001AT	406989	10/2/2006	Inorganic	Phosphorous, Ortho		0.13	mg/L	365.1
120420010010-001AT	408926	11/8/2006	Inorganic	Nitrogen, Ammonia	<	0.05	mg/L	350.1
120420010010-001AT	408926	11/8/2006	Inorganic	Nitrogen, Kjeldahl		1.83	mg/L	351.3
120420010010-001AT	408926	11/8/2006	Inorganic	Nitrogen, Nitrate/Nitrite as N		1.72	mg/L	
120420010010-001AT	408926	11/8/2006	Inorganic	Phosphorous, Total		0.835	mg/L	365.3
120420010010-001AT	408926	11/8/2006	Inorganic	Chloride		268	mg/L	325.2
120420010010-001AT	408926	11/8/2006	Inorganic	Sulfate		125	mg/L	375.4
120420010010-001AT	408926	11/8/2006	Inorganic	Phosphorous, Ortho		0.646	mg/L	365.1
120420010010-001AT	410316	12/6/2006	Inorganic	Nitrogen, Ammonia		0.33	mg/L	350.1
120420010010-001AT	410316	12/6/2006	Inorganic	Nitrogen, Kjeldahl		1.19	mg/L	351.3
120420010010-001AT	410316	12/6/2006	Inorganic	Nitrogen, Nitrate/Nitrite as N		1.09	mg/L	
120420010010-001AT	410316	12/6/2006	Inorganic	Phosphorous, Total		0.365	mg/L	365.3
120420010010-001AT	410316	12/6/2006	Inorganic	Chloride		249	mg/L	325.2
120420010010-001AT	410316	12/6/2006	Inorganic	Sulfate		69.5	mg/L	375.4
120420010010-001AT	410316	12/6/2006	Inorganic	Phosphorous, Ortho		0.33	mg/L	365.1

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STATION_ID	SAMPLE_ID	SAMPLE_DATE	PARAMETER	REMARK	VALUE	UNITS	METHOD
120410010080-001AT	A00752	5/23/2006	COLIFORM, FECAL		40	NM/100ML	9222D
120410010080-001AT	A00752	5/23/2006	E. COLI QUANTI TRAY		10	MPN/100ML	9223
120410010080-001AT	A00752	5/23/2006	ENTEROCOCCI		10	CFU/100ML	9230C
120410010080-001AT	A00753	5/23/2006	COLIFORM, FECAL		20	NM/100ML	9222D
120410010080-001AT	A00753	5/23/2006	E. COLI QUANTI TRAY		10	MPN/100ML	9223
120410010080-001AT	A00753	5/23/2006	ENTEROCOCCI		30	CFU/100ML	9230C
120410010080-001AT	A00754	5/23/2006	COLIFORM, FECAL	<	10	NM/100ML	9222D
120410010080-001AT	A00754	5/23/2006	E. COLI QUANTI TRAY	<	10	MPN/100ML	9223
120410010080-001AT	A00754	5/23/2006	ENTEROCOCCI	<	10	CFU/100ML	9230C
120410010080-001AT	A00958	6/12/2006	COLIFORM, FECAL		20	NM/100ML	9222D
120410010080-001AT	A00958	6/12/2006	E. COLI QUANTI TRAY		10	MPN/100ML	9223
120410010080-001AT	A00958	6/12/2006	ENTEROCOCCI		63	CFU/100ML	9230C
120410010080-001AT	A00959	6/12/2006	COLIFORM, FECAL		120	NM/100ML	9222D
120410010080-001AT	A00959	6/12/2006	E. COLI QUANTI TRAY		52	MPN/100ML	9223
120410010080-001AT	A00959	6/12/2006	ENTEROCOCCI		62	CFU/100ML	9230C
120410010080-001AT	A00960	6/12/2006	COLIFORM, FECAL	<	10	NM/100ML	9222D
120410010080-001AT	A00960	6/12/2006	E. COLI QUANTI TRAY	<	10	MPN/100ML	9223
120410010080-001AT	A00960	6/12/2006	ENTEROCOCCI		10	CFU/100ML	9230C
120410010080-001AT	A01043	6/26/2006	COLIFORM, FECAL		10	NM/100ML	9222D
120410010080-001AT	A01043	6/26/2006	E. COLI QUANTI TRAY		10	MPN/100ML	9223
120410010080-001AT	A01043	6/26/2006	ENTEROCOCCI		10	CFU/100ML	9230C
120410010080-001AT	A01044	6/26/2006	COLIFORM, FECAL		50	NM/100ML	9222D
120410010080-001AT	A01044	6/26/2006	E. COLI QUANTI TRAY	<	10	MPN/100ML	9223
120410010080-001AT	A01044	6/26/2006	ENTEROCOCCI		10	CFU/100ML	9230C
120410010080-001AT	A01045	6/26/2006	COLIFORM, FECAL	<	10	NM/100ML	9222D
120410010080-001AT	A01045	6/26/2006	E. COLI QUANTI TRAY	<	10	MPN/100ML	9223
120410010080-001AT	A01045	6/26/2006	ENTEROCOCCI		10	CFU/100ML	9230C
120410010080-001AT	A01100	7/5/2006	COLIFORM, FECAL	<	10	NM/100ML	9222D
120410010080-001AT	A01100	7/5/2006	E. COLI QUANTI TRAY		10	MPN/100ML	9223
120410010080-001AT	A01100	7/5/2006	ENTEROCOCCI		10	CFU/100ML	9230C
120410010080-001AT	A01102	7/5/2006	COLIFORM, FECAL	<	10	NM/100ML	9222D
120410010080-001AT	A01102	7/5/2006	E. COLI QUANTI TRAY	<	10	MPN/100ML	9223
120410010080-001AT	A01102	7/5/2006	ENTEROCOCCI		10	CFU/100ML	9230C
120410010080-001AT	A01101	7/5/2006	COLIFORM, FECAL		30	NM/100ML	9222D
120410010080-001AT	A01101	7/5/2006	E. COLI QUANTI TRAY		10	MPN/100ML	9223

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STATION_ID	SAMPLE_ID	SAMPLE_DATE	PARAMETER	REMARK	VALUE	UNITS	METHOD
120410010080-001AT	A01101	7/5/2006	ENTEROCOCCI		20	CFU/100ML	9230C
120410010080-001AT	A01337	7/24/2006	COLIFORM, FECAL		120	NM/100ML	9222D
120410010080-001AT	A01337	7/24/2006	E. COLI QUANTI TRAY		20	MPN/100ML	9223
120410010080-001AT	A01337	7/24/2006	ENTEROCOCCI		74	CFU/100ML	9230C
120410010080-001AT	A01336	7/24/2006	COLIFORM, FECAL		130	NM/100ML	9222D
120410010080-001AT	A01336	7/24/2006	E. COLI QUANTI TRAY		10	MPN/100ML	9223
120410010080-001AT	A01336	7/24/2006	ENTEROCOCCI		10	CFU/100ML	9230C
120410010080-001AT	A01338	7/24/2006	COLIFORM, FECAL	<	10	NM/100ML	9222D
120410010080-001AT	A01338	7/24/2006	E. COLI QUANTI TRAY	<	10	MPN/100ML	9223
120410010080-001AT	A01338	7/24/2006	ENTEROCOCCI		10	CFU/100ML	9230C

STATION_ID	SAMPLE_ID	SAMPLE_DATE	PARAMETER	REMARK	VALUE	UNITS	METHOD
120410010080-001AT	391008	1/23/2006	Water Temperature		8.47	DEG CELS	2550B
120410010080-001AT	391008	1/23/2006	AIR TEMPERATURE		17.2	DEG C	2550B
120410010080-001AT	391008	1/23/2006	BARROMETRIC PRESSURE		769	MM HG	
120410010080-001AT	391008	1/23/2006	CLOUD COVER		2	PERCENT	
120410010080-001AT	391008	1/23/2006	WIND VELOCITY		5	MPH	
120410010080-001AT	391008	1/23/2006	WIND DIRECTION		0	AZIMUTH	
120410010080-001AT	391008	1/23/2006	STREAM STAGE		2.54	feet	
120410010080-001AT	391008	1/23/2006	OXIDATION/REDUCTION POT. (FIELD)		366	MV	
120410010080-001AT	391008	1/23/2006	Specific Conductance		2918	UMHOS/CM	120.1
120410010080-001AT	391008	1/23/2006	DISSOLVED OXYGEN, analysis by probe		6.79	MG/L	
120410010080-001AT	391008	1/23/2006	DISS OXY SATURATION		58	PERCENT	
120410010080-001AT	391008	1/23/2006	PH (FIELD)		8.03	STD UNIT	150.1
120410010080-001AT	391008	1/23/2006	TOT ALK FIELD CACO3		160	MG/L	
120410010080-001AT	391008	1/23/2006	Hardness, Total (as CaCO3)		304	MG/L	

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STATION_ID	SAMPLE_ID	SAMPLE_DATE	PARAMETER	REMARK	VALUE	UNITS	METHOD
120410010080-001AT	391008	1/23/2006	Oil and Grease, Severity (1=none, 2=light, 3=moderate, 4=heavy, 5=total)		1	code	
120410010080-001AT	391008	1/23/2006	Odor, Atmospheric, Severity (1=none, 2=light, 3=moderate, 4=heavy, 5=severe)		1	code	
120410010080-001AT	391008	1/23/2006	Debris, Floating, Severity (1=none, 2=light, 3=moderate, 4=heavy, 5=total)		1	code	
120410010080-001AT	391008	1/23/2006	Foaming, Severity (1=none, 2=light, 3=moderate, 4=heavy, 5=total)		1	code	
120410010080-001AT	391008	1/23/2006	Scum, Severity (1=none, 2=light, 3=moderate, 4=heavy, 5=total)		1	code	
120410010080-001AT	391008	1/23/2006	Turbidity, Type (1=inorganic, 2=organic, 3=mix)		1	code	
120410010080-001AT	391008	1/23/2006	STREAM FLOW, SEVERITY (1=none, 2=light, 3=moderate, 4=heavy, 5=stormwater)		2	CODE	
120410010080-001AT	391008	1/23/2006	TOTAL DISSOLVED SOLIDS (FIELD)		1867	MG/L	
120410010080-001AT	391008	1/23/2006	SALINITY (FIELD)		1.58	G/L	

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STATION_ID	SAMPLE_ID	SAMPLE_DATE	PARAMETER	REMARK	VALUE	UNITS	METHOD
120410010080-001AT	391008	1/23/2006	Periphyton, Severity (% of streambed; 1=0%, 2=25%, 3=50%, 4=75%, 5=100%)		1	code	
120410010080-001AT	391008	1/23/2006	Periphyton Line, Visible (1=yes, 2=no)		2	code	
120410010080-001AT	391008	1/23/2006	Flow, Instantaneous		553	CFS	
120410010080-001AT	391008	1/23/2006	Turbidity, Field		5	NTU	180.1
120410010080-001AT	391008	1/23/2006	P-ALKALINITY (FIELD)		0	MG/L	
120410010080-001AT	391008	1/23/2006	STREAM WIDTH		350	METERS	
120410010080-001AT	391008	1/23/2006	STREAM TYPE		2	CODE	
120410010080-001AT	391008	1/23/2006	Flow Measurement Tech (1=composite average, 2=rated, 3=DCP)		2	code	
120410010080-001AT	391008	1/23/2006	DEPTH, MAXIMUM OF SAMPLE		0.2	METERS	
120410010080-001AT	391008	1/23/2006	COLOR, BORGER COLOR SYSTEM		36	CODE	
120410010080-001AT	391009	1/23/2006	Water Temperature		8.47	DEG CELS	2550B
120410010080-001AT	391009	1/23/2006	AIR TEMPERATURE		17.2	DEG C	2550B
120410010080-001AT	391009	1/23/2006	BARROMETRIC PRESSURE		769	MM HG	
120410010080-001AT	391009	1/23/2006	CLOUD COVER		2	PERCENT	
120410010080-001AT	391009	1/23/2006	WIND VELOCITY		5	MPH	
120410010080-001AT	391009	1/23/2006	WIND DIRECTION		0	AZIMUTH	
120410010080-001AT	391009	1/23/2006	STREAM STAGE		2.54	feet	
120410010080-001AT	391009	1/23/2006	OXIDATION/REDUCTION POT. (FIELD)		366	MV	
120410010080-001AT	391009	1/23/2006	Specific Conductance		2918	UMHOS/CM	120.1
120410010080-001AT	391009	1/23/2006	DISSOLVED OXYGEN, analysis by probe		6.79	MG/L	

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STATION_ID	SAMPLE_ID	SAMPLE_DATE	PARAMETER	REMARK	VALUE	UNITS	METHOD
120410010080-001AT	391009	1/23/2006	DISS OXY SATURATION		58	PERCENT	
120410010080-001AT	391009	1/23/2006	PH (FIELD)		8.03	STD UNIT	150.1
120410010080-001AT	391009	1/23/2006	TOT ALK FIELD CACO3		160	MG/L	
120410010080-001AT	391009	1/23/2006	Hardness, Total (as CaCO3)		304	MG/L	
120410010080-001AT	391009	1/23/2006	Oil and Grease, Severity (1=none, 2=light, 3=moderate, 4=heavy, 5=total)		1	code	
120410010080-001AT	391009	1/23/2006	Odor, Atmospheric, Severity (1=none, 2=light, 3=moderate, 4=heavy, 5=severe)		1	code	
120410010080-001AT	391009	1/23/2006	Debris, Floating, Severity (1=none, 2=light, 3=moderate, 4=heavy, 5=total)		1	code	
120410010080-001AT	391009	1/23/2006	Foaming, Severity (1=none, 2=light, 3=moderate, 4=heavy, 5=total)		1	code	
120410010080-001AT	391009	1/23/2006	Scum, Severity (1=none, 2=light, 3=moderate, 4=heavy, 5=total)		1	code	
120410010080-001AT	391009	1/23/2006	Turbidity, Type (1=inorganic, 2=organic, 3=mix)		1	code	
120410010080-001AT	391009	1/23/2006	STREAM FLOW, SEVERITY (1=none, 2=light, 3=moderate, 4=heavy, 5=stormwater)		2	CODE	

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STATION_ID	SAMPLE_ID	SAMPLE_DATE	PARAMETER	REMARK	VALUE	UNITS	METHOD
120410010080-001AT	391009	1/23/2006	TOTAL DISSOLVED SOLIDS (FIELD)		1867	MG/L	
120410010080-001AT	391009	1/23/2006	SALINITY (FIELD)		1.58	G/L	
120410010080-001AT	391009	1/23/2006	Periphyton, Severity (% of streambed; 1=0%, 2=25%, 3=50%, 4=75%, 5=100%)		1	code	
120410010080-001AT	391009	1/23/2006	Periphyton Line, Visible (1=yes, 2=no)		2	code	
120410010080-001AT	391009	1/23/2006	Flow, Instantaneous		553	CFS	
120410010080-001AT	391009	1/23/2006	Turbidity, Field		5	NTU	180.1
120410010080-001AT	391009	1/23/2006	P-ALKALINITY (FIELD)		0	MG/L	
120410010080-001AT	391009	1/23/2006	STREAM WIDTH		350	METERS	
120410010080-001AT	391009	1/23/2006	STREAM TYPE		2	CODE	
120410010080-001AT	391009	1/23/2006	Flow Measurement Tech (1=composite average, 2=rated, 3=DCP)		2	code	
120410010080-001AT	391009	1/23/2006	DEPTH, MAXIMUM OF SAMPLE		0.2	METERS	
120410010080-001AT	391009	1/23/2006	COLOR, BORGER COLOR SYSTEM		36	CODE	
120410010080-001AT	393462	2/27/2006	Water Temperature		7.55	DEG CELS	2550B
120410010080-001AT	393462	2/27/2006	AIR TEMPERATURE		15	DEG C	2550B
120410010080-001AT	393462	2/27/2006	BAROMETRIC PRESSURE		765	MM HG	
120410010080-001AT	393462	2/27/2006	CLOUD COVER		1	PERCENT	
120410010080-001AT	393462	2/27/2006	WIND VELOCITY		23	MPH	
120410010080-001AT	393462	2/27/2006	WIND DIRECTION		180	AZIMUTH	
120410010080-001AT	393462	2/27/2006	STREAM STAGE		3.59	feet	
120410010080-001AT	393462	2/27/2006	OXIDATION/REDUCTION POT. (FIELD)		453	MV	
120410010080-001AT	393462	2/27/2006	Specific Conductance		2789	UMHOS/CM	120.1

Haskell Biological & Field Data

STATION_ID	SAMPLE_ID	SAMPLE_DATE	PARAMETER	REMARK	VALUE	UNITS	METHOD
120410010080-001AT	393462	2/27/2006	DISSOLVED OXYGEN, analysis by probe		11.07	MG/L	
120410010080-001AT	393462	2/27/2006	DISS OXY SATURATION		92.9	PERCENT	
120410010080-001AT	393462	2/27/2006	PH (FIELD)		7.83	STD UNIT	150.1
120410010080-001AT	393462	2/27/2006	TOT ALK FIELD CACO3		163	MG/L	
120410010080-001AT	393462	2/27/2006	Hardness, Total (as CaCO3)		261	MG/L	
120410010080-001AT	393462	2/27/2006	Oil and Grease, Severity (1=none, 2=light, 3=moderate, 4=heavy, 5=total)		2	code	
120410010080-001AT	393462	2/27/2006	Odor, Atmospheric, Severity (1=none, 2=light, 3=moderate, 4=heavy, 5=severe)		2	code	
120410010080-001AT	393462	2/27/2006	Debris, Floating, Severity (1=none, 2=light, 3=moderate, 4=heavy, 5=total)		2	code	
120410010080-001AT	393462	2/27/2006	Foaming, Severity (1=none, 2=light, 3=moderate, 4=heavy, 5=total)		3	code	
120410010080-001AT	393462	2/27/2006	Debris, Floating, Size (1=small, 2=medium, 3= large)		1	code	
120410010080-001AT	393462	2/27/2006	Scum, Severity (1=none, 2=light, 3=moderate, 4=heavy, 5=total)		3	code	

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STATION_ID	SAMPLE_ID	SAMPLE_DATE	PARAMETER	REMARK	VALUE	UNITS	METHOD
120410010080-001AT	393462	2/27/2006	Turbidity, Type (1=inorganic, 2=organic, 3=mix)		3	code	
120410010080-001AT	393462	2/27/2006	STREAM FLOW, SEVERITY (1=none, 2=light, 3=moderate, 4=heavy, 5=stormwater)		2	CODE	
120410010080-001AT	393462	2/27/2006	TOTAL DISSOLVED SOLIDS (FIELD)		1785	MG/L	
120410010080-001AT	393462	2/27/2006	SALINITY (FIELD)		1.5	G/L	
120410010080-001AT	393462	2/27/2006	Periphyton, Severity (% of streambed; 1=0%, 2=25%, 3=50%, 4=75%, 5=100%)		1	code	
120410010080-001AT	393462	2/27/2006	Periphyton Line, Visible (1=yes, 2=no)		2	code	
120410010080-001AT	393462	2/27/2006	Flow, Instantaneous		1710	CFS	
120410010080-001AT	393462	2/27/2006	Turbidity, Field		8	NTU	180.1
120410010080-001AT	393462	2/27/2006	P-ALKALINITY (FIELD)		0	MG/L	
120410010080-001AT	393462	2/27/2006	STREAM WIDTH		1100	METERS	
120410010080-001AT	393462	2/27/2006	STREAM TYPE		2	CODE	
120410010080-001AT	393462	2/27/2006	Flow Measurement Tech (1=composite average, 2=rated, 3=DCP)		2	code	
120410010080-001AT	393462	2/27/2006	DEPTH, MAXIMUM OF SAMPLE		0.6	METERS	
120410010080-001AT	393462	2/27/2006	COLOR, BORGER COLOR SYSTEM		32	CODE	
120410010080-001AT	393463	2/27/2006	Water Temperature		7.55	DEG CELS	2550B
120410010080-001AT	393463	2/27/2006	AIR TEMPERATURE		15	DEG C	2550B
120410010080-001AT	393463	2/27/2006	BAROMETRIC PRESSURE		765	MM HG	

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STATION_ID	SAMPLE_ID	SAMPLE_DATE	PARAMETER	REMARK	VALUE	UNITS	METHOD
120410010080-001AT	393463	2/27/2006	CLOUD COVER		1	PERCENT	
120410010080-001AT	393463	2/27/2006	WIND VELOCITY		23	MPH	
120410010080-001AT	393463	2/27/2006	WIND DIRECTION		180	AZIMUTH	
120410010080-001AT	393463	2/27/2006	STREAM STAGE		3.59	feet	
120410010080-001AT	393463	2/27/2006	OXIDATION/REDUCTION POT. (FIELD)		453	MV	
120410010080-001AT	393463	2/27/2006	Specific Conductance		2789	UMHOS/CM	120.1
120410010080-001AT	393463	2/27/2006	DISSOLVED OXYGEN, analysis by probe		11.07	MG/L	
120410010080-001AT	393463	2/27/2006	DISS OXY SATURATION		92.9	PERCENT	
120410010080-001AT	393463	2/27/2006	PH (FIELD)		7.83	STD UNIT	150.1
120410010080-001AT	393463	2/27/2006	TOT ALK FIELD CACO3		169	MG/L	
120410010080-001AT	393463	2/27/2006	Hardness, Total (as CaCO3)		251	MG/L	
120410010080-001AT	393463	2/27/2006	Oil and Grease, Severity (1=none, 2=light, 3=moderate, 4=heavy, 5=total)		2	code	
120410010080-001AT	393463	2/27/2006	Odor, Atmospheric, Severity (1=none, 2=light, 3=moderate, 4=heavy, 5=severe)		2	code	
120410010080-001AT	393463	2/27/2006	Debris, Floating, Severity (1=none, 2=light, 3=moderate, 4=heavy, 5=total)		2	code	
120410010080-001AT	393463	2/27/2006	Foaming, Severity (1=none, 2=light, 3=moderate, 4=heavy, 5=total)		3	code	

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STATION_ID	SAMPLE_ID	SAMPLE_DATE	PARAMETER	REMARK	VALUE	UNITS	METHOD
120410010080-001AT	393463	2/27/2006	Debris, Floating, Size (1=small, 2=medium, 3= large)		1	code	
120410010080-001AT	393463	2/27/2006	Scum, Severity (1=none, 2=light, 3=moderate, 4=heavy, 5=total)		3	code	
120410010080-001AT	393463	2/27/2006	Turbidity, Type (1=inorganic, 2=organic, 3=mix)		3	code	
120410010080-001AT	393463	2/27/2006	STREAM FLOW, SEVERITY (1=none, 2=light, 3=moderate, 4=heavy, 5=stormwater)		2	CODE	
120410010080-001AT	393463	2/27/2006	TOTAL DISSOLVED SOLIDS (FIELD)		1790	MG/L	
120410010080-001AT	393463	2/27/2006	SALINITY (FIELD)		1.5	G/L	
120410010080-001AT	393463	2/27/2006	Periphyton, Severity (% of streambed; 1=0%, 2=25%, 3=50%, 4=75%, 5=100%)		1	code	
120410010080-001AT	393463	2/27/2006	Periphyton Line, Visible (1=yes, 2=no)		2	code	
120410010080-001AT	393463	2/27/2006	Flow, Instantaneous		1710	CFS	
120410010080-001AT	393463	2/27/2006	Turbidity, Field		8	NTU	180.1
120410010080-001AT	393463	2/27/2006	P-ALKALINITY (FIELD)		0	MG/L	
120410010080-001AT	393463	2/27/2006	STREAM WIDTH		1100	METERS	
120410010080-001AT	393463	2/27/2006	STREAM TYPE		2	CODE	
120410010080-001AT	393463	2/27/2006	Flow Measurement Tech (1=composite average, 2=rated, 3=DCP)		2	code	

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STATION_ID	SAMPLE_ID	SAMPLE_DATE	PARAMETER	REMARK	VALUE	UNITS	METHOD
120410010080-001AT	393463	2/27/2006	DEPTH, MAXIMUM OF SAMPLE		0.6	METERS	
120410010080-001AT	393463	2/27/2006	COLOR, BORGER COLOR SYSTEM		32	CODE	
120410010080-001AT	395294	4/3/2006	Water Temperature		16.96	DEG CELS	2550B
120410010080-001AT	395294	4/3/2006	AIR TEMPERATURE		18.2	DEG C	2550B
120410010080-001AT	395294	4/3/2006	BAROMETRIC PRESSURE		766.8	MM HG	
120410010080-001AT	395294	4/3/2006	CLOUD COVER		2	PERCENT	
120410010080-001AT	395294	4/3/2006	WIND VELOCITY		8	MPH	
120410010080-001AT	395294	4/3/2006	WIND DIRECTION		315	AZIMUTH	
120410010080-001AT	395294	4/3/2006	STREAM STAGE		2.91	feet	
120410010080-001AT	395294	4/3/2006	OXIDATION/REDUCTION POT. (FIELD)		393	MV	
120410010080-001AT	395294	4/3/2006	Specific Conductance		2917	UMHOS/CM	120.1
120410010080-001AT	395294	4/3/2006	DISSOLVED OXYGEN, analysis by probe		11.66	MG/L	
120410010080-001AT	395294	4/3/2006	DISS OXY SATURATION		120.8	PERCENT	
120410010080-001AT	395294	4/3/2006	PH (FIELD)		8.64	STD UNIT	150.1
120410010080-001AT	395294	4/3/2006	TOT ALK FIELD CACO3		170	MG/L	
120410010080-001AT	395294	4/3/2006	Hardness, Total (as CaCO3)		292	MG/L	
120410010080-001AT	395294	4/3/2006	Oil and Grease, Severity (1=none, 2=light, 3=moderate, 4=heavy, 5=total)		1	code	
120410010080-001AT	395294	4/3/2006	Odor, Atmospheric, Severity (1=none, 2=light, 3=moderate, 4=heavy, 5=severe)		1	code	

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STATION_ID	SAMPLE_ID	SAMPLE_DATE	PARAMETER	REMARK	VALUE	UNITS	METHOD
120410010080-001AT	395294	4/3/2006	Debris, Floating, Severity (1=none, 2=light, 3=moderate, 4=heavy, 5=total)		1	code	
120410010080-001AT	395294	4/3/2006	Foaming, Severity (1=none, 2=light, 3=moderate, 4=heavy, 5=total)		1	code	
120410010080-001AT	395294	4/3/2006	Scum, Severity (1=none, 2=light, 3=moderate, 4=heavy, 5=total)		1	code	
120410010080-001AT	395294	4/3/2006	Turbidity, Type (1=inorganic, 2=organic, 3=mix)		1	code	
120410010080-001AT	395294	4/3/2006	STREAM FLOW, SEVERITY (1=none, 2=light, 3=moderate, 4=heavy, 5=stormwater)		2	CODE	
120410010080-001AT	395294	4/3/2006	TOTAL DISSOLVED SOLIDS (FIELD)		1867	MG/L	
120410010080-001AT	395294	4/3/2006	SALINITY (FIELD)		1.57	G/L	
120410010080-001AT	395294	4/3/2006	Periphyton, Severity (% of streambed; 1=0%, 2=25%, 3=50%, 4=75%, 5=100%)		1	code	
120410010080-001AT	395294	4/3/2006	Periphyton Line, Visible (1=yes, 2=no)		2	code	
120410010080-001AT	395294	4/3/2006	Flow, Instantaneous		835	CFS	
120410010080-001AT	395294	4/3/2006	Turbidity, Field		10	NTU	180.1
120410010080-001AT	395294	4/3/2006	P-ALKALINITY (FIELD)		0	MG/L	
120410010080-001AT	395294	4/3/2006	STREAM WIDTH		300	METERS	
120410010080-001AT	395294	4/3/2006	STREAM TYPE		2	CODE	

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STATION_ID	SAMPLE_ID	SAMPLE_DATE	PARAMETER	REMARK	VALUE	UNITS	METHOD
120410010080-001AT	395294	4/3/2006	Flow Measurement Tech (1=composite average, 2=rated, 3=DCP).		2	code	
120410010080-001AT	395294	4/3/2006	DEPTH, MAXIMUM OF SAMPLE		0.3	METERS	
120410010080-001AT	395294	4/3/2006	COLOR, BORGER COLOR SYSTEM		42	CODE	
120410010080-001AT	395295	4/3/2006	Water Temperature		16.96	DEG CELS	2550B
120410010080-001AT	395295	4/3/2006	AIR TEMPERATURE		18.2	DEG C	2550B
120410010080-001AT	395295	4/3/2006	BAROMETRIC PRESSURE		766.8	MM HG	
120410010080-001AT	395295	4/3/2006	CLOUD COVER		2	PERCENT	
120410010080-001AT	395295	4/3/2006	WIND VELOCITY		8	MPH	
120410010080-001AT	395295	4/3/2006	WIND DIRECTION		315	AZIMUTH	
120410010080-001AT	395295	4/3/2006	STREAM STAGE		2.91	feet	
120410010080-001AT	395295	4/3/2006	OXIDATION/REDUCTION POT. (FIELD)		393	MV	
120410010080-001AT	395295	4/3/2006	Specific Conductance		2917	UMHOS/CM	120.1
120410010080-001AT	395295	4/3/2006	DISSOLVED OXYGEN, analysis by probe		11.66	MG/L	
120410010080-001AT	395295	4/3/2006	DISS OXY SATURATION		120.8	PERCENT	
120410010080-001AT	395295	4/3/2006	PH (FIELD)		8.64	STD UNIT	150.1
120410010080-001AT	395295	4/3/2006	TOT ALK FIELD CACO3		170	MG/L	
120410010080-001AT	395295	4/3/2006	Hardness, Total (as CaCO3)		292	MG/L	
120410010080-001AT	395295	4/3/2006	Oil and Grease, Severity (1=none, 2=light, 3=moderate, 4=heavy, 5=total)		1	code	

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STATION_ID	SAMPLE_ID	SAMPLE_DATE	PARAMETER	REMARK	VALUE	UNITS	METHOD
120410010080-001AT	395295	4/3/2006	Odor, Atmospheric, Severity (1=none, 2=light, 3=moderate, 4=heavy, 5=severe)		1	code	
120410010080-001AT	395295	4/3/2006	Debris, Floating, Severity (1=none, 2=light, 3=moderate, 4=heavy, 5=total)		1	code	
120410010080-001AT	395295	4/3/2006	Foaming, Severity (1=none, 2=light, 3=moderate, 4=heavy, 5=total)		1	code	
120410010080-001AT	395295	4/3/2006	Scum, Severity (1=none, 2=light, 3=moderate, 4=heavy, 5=total)		1	code	
120410010080-001AT	395295	4/3/2006	Turbidity, Type (1=inorganic, 2=organic, 3=mix)		1	code	
120410010080-001AT	395295	4/3/2006	STREAM FLOW, SEVERITY (1=none, 2=light, 3=moderate, 4=heavy, 5=stormwater)		2	CODE	
120410010080-001AT	395295	4/3/2006	TOTAL DISSOLVED SOLIDS (FIELD)		1867	MG/L	
120410010080-001AT	395295	4/3/2006	SALINITY (FIELD)		1.57	G/L	
120410010080-001AT	395295	4/3/2006	Periphyton, Severity (% of streambed; 1=0%, 2=25%, 3=50%, 4=75%, 5=100%)		1	code	
120410010080-001AT	395295	4/3/2006	Periphyton Line, Visible (1=yes, 2=no)		2	code	
120410010080-001AT	395295	4/3/2006	Flow, Instantaneous		835	CFS	

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STATION_ID	SAMPLE_ID	SAMPLE_DATE	PARAMETER	REMARK	VALUE	UNITS	METHOD
120410010080-001AT	395295	4/3/2006	Turbidity, Field		10	NTU	180.1
120410010080-001AT	395295	4/3/2006	P-ALKALINITY (FIELD)		0	MG/L	
120410010080-001AT	395295	4/3/2006	STREAM WIDTH		300	METERS	
120410010080-001AT	395295	4/3/2006	STREAM TYPE		2	CODE	
120410010080-001AT	395295	4/3/2006	Flow Measurement Tech (1=composite average, 2=rated, 3=DCP)		2	code	
120410010080-001AT	395295	4/3/2006	DEPTH, MAXIMUM OF SAMPLE		0.3	METERS	
120410010080-001AT	395295	4/3/2006	COLOR, BORGER COLOR SYSTEM		42	CODE	
120410010080-001AT	397260	5/8/2006	Water Temperature		20.39	DEG CELS	2550B
120410010080-001AT	397260	5/8/2006	AIR TEMPERATURE		25	DEG C	2550B
120410010080-001AT	397260	5/8/2006	BAROMETRIC PRESSURE		760	MM HG	
120410010080-001AT	397260	5/8/2006	CLOUD COVER		100	PERCENT	
120410010080-001AT	397260	5/8/2006	WIND VELOCITY		7.5	MPH	
120410010080-001AT	397260	5/8/2006	WIND DIRECTION		180	AZIMUTH	
120410010080-001AT	397260	5/8/2006	STREAM STAGE		7.1	feet	
120410010080-001AT	397260	5/8/2006	OXIDATION/REDUCTIO N POT. (FIELD)		268	MV	
120410010080-001AT	397260	5/8/2006	Specific Conductance		2251	UMHOS/CM	120.1
120410010080-001AT	397260	5/8/2006	DISSOLVED OXYGEN, analysis by probe		7.56	MG/L	
120410010080-001AT	397260	5/8/2006	DISS OXY SATURATION		84.4	PERCENT	
120410010080-001AT	397260	5/8/2006	PH (FIELD)		8.32	STD UNIT	150.1
120410010080-001AT	397260	5/8/2006	TOT ALK FIELD CACO3		119	MG/L	
120410010080-001AT	397260	5/8/2006	Hardness, Total (as CaCO3)		239	MG/L	

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STATION_ID	SAMPLE_ID	SAMPLE_DATE	PARAMETER	REMARK	VALUE	UNITS	METHOD
120410010080-001AT	397260	5/8/2006	Oil and Grease, Severity (1=none, 2=light, 3=moderate, 4=heavy, 5=total)		2	code	
120410010080-001AT	397260	5/8/2006	Odor, Atmospheric, Severity (1=none, 2=light, 3=moderate, 4=heavy, 5=severe)		2	code	
120410010080-001AT	397260	5/8/2006	Debris, Floating, Severity (1=none, 2=light, 3=moderate, 4=heavy, 5=total)		2	code	
120410010080-001AT	397260	5/8/2006	Foaming, Severity (1=none, 2=light, 3=moderate, 4=heavy, 5=total)		2	code	
120410010080-001AT	397260	5/8/2006	Debris, Floating, Size (1=small, 2=medium, 3= large)		1	code	
120410010080-001AT	397260	5/8/2006	Scum, Severity (1=none, 2=light, 3=moderate, 4=heavy, 5=total)		2	code	
120410010080-001AT	397260	5/8/2006	Turbidity, Type (1=inorganic, 2=organic, 3=mix)		1	code	
120410010080-001AT	397260	5/8/2006	STREAM FLOW, SEVERITY (1=none, 2=light, 3=moderate, 4=heavy, 5=stormwater)		4	CODE	
120410010080-001AT	397260	5/8/2006	Precipitation		0	inches	
120410010080-001AT	397260	5/8/2006	Precipitation Type (1=fog, 2=rain, 3=sleet, 4=snow, 5=mix)		0	code	

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STATION_ID	SAMPLE_ID	SAMPLE_DATE	PARAMETER	REMARK	VALUE	UNITS	METHOD
120410010080-001AT	397260	5/8/2006	TOTAL DISSOLVED SOLIDS (FIELD)		1441	MG/L	
120410010080-001AT	397260	5/8/2006	SALINITY (FIELD)		1.2	G/L	
120410010080-001AT	397260	5/8/2006	Periphyton, Severity (% of streambed; 1=0%, 2=25%, 3=50%, 4=75%, 5=100%)		1	code	
120410010080-001AT	397260	5/8/2006	Periphyton Line, Visible (1=yes, 2=no)		2	code	
120410010080-001AT	397260	5/8/2006	Flow, Instantaneous		11400	CFS	
120410010080-001AT	397260	5/8/2006	Turbidity, Field		76	NTU	180.1
120410010080-001AT	397260	5/8/2006	P-ALKALINITY (FIELD)		0	MG/L	
120410010080-001AT	397260	5/8/2006	STREAM WIDTH		2400	METERS	
120410010080-001AT	397260	5/8/2006	STREAM TYPE		2	CODE	
120410010080-001AT	397260	5/8/2006	Flow Measurement Tech (1=composite average, 2=rated, 3=DCP)		2	code	
120410010080-001AT	397260	5/8/2006	DEPTH, MAXIMUM OF SAMPLE		0.1	METERS	
120410010080-001AT	397260	5/8/2006	COLOR, BORGER COLOR SYSTEM		32	CODE	
120410010080-001AT	397261	5/8/2006	Water Temperature		20.39	DEG CELS	2550B
120410010080-001AT	397261	5/8/2006	AIR TEMPERATURE		25	DEG C	2550B
120410010080-001AT	397261	5/8/2006	BAROMETRIC PRESSURE		760	MM HG	
120410010080-001AT	397261	5/8/2006	CLOUD COVER		100	PERCENT	
120410010080-001AT	397261	5/8/2006	WIND VELOCITY		7.5	MPH	
120410010080-001AT	397261	5/8/2006	WIND DIRECTION		180	AZIMUTH	
120410010080-001AT	397261	5/8/2006	STREAM STAGE		7.1	feet	
120410010080-001AT	397261	5/8/2006	OXIDATION/REDUCTION POT. (FIELD)		268	MV	
120410010080-001AT	397261	5/8/2006	Specific Conductance		2251	UMHOS/CM	120.1

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STATION_ID	SAMPLE_ID	SAMPLE_DATE	PARAMETER	REMARK	VALUE	UNITS	METHOD
120410010080-001AT	397261	5/8/2006	DISSOLVED OXYGEN, analysis by probe		7.56	MG/L	
120410010080-001AT	397261	5/8/2006	DISS OXY SATURATION		84.4	PERCENT	
120410010080-001AT	397261	5/8/2006	PH (FIELD)		8.32	STD UNIT	150.1
120410010080-001AT	397261	5/8/2006	TOT ALK FIELD CACO3		123	MG/L	
120410010080-001AT	397261	5/8/2006	Hardness, Total (as CaCO3)		247	MG/L	
120410010080-001AT	397261	5/8/2006	Oil and Grease, Severity (1=none, 2=light, 3=moderate, 4=heavy, 5=total)		2	code	
120410010080-001AT	397261	5/8/2006	Odor, Atmospheric, Severity (1=none, 2=light, 3=moderate, 4=heavy, 5=severe)		2	code	
120410010080-001AT	397261	5/8/2006	Debris, Floating, Severity (1=none, 2=light, 3=moderate, 4=heavy, 5=total)		2	code	
120410010080-001AT	397261	5/8/2006	Foaming, Severity (1=none, 2=light, 3=moderate, 4=heavy, 5=total)		2	code	
120410010080-001AT	397261	5/8/2006	Debris, Floating, Size (1=small, 2=medium, 3= large)		1	code	
120410010080-001AT	397261	5/8/2006	Scum, Severity (1=none, 2=light, 3=moderate, 4=heavy, 5=total)		2	code	

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STATION_ID	SAMPLE_ID	SAMPLE_DATE	PARAMETER	REMARK	VALUE	UNITS	METHOD
120410010080-001AT	397261	5/8/2006	Turbidity, Type (1=inorganic, 2=organic, 3=mix)		1	code	
120410010080-001AT	397261	5/8/2006	STREAM FLOW, SEVERITY (1=none, 2=light, 3=moderate, 4=heavy, 5=stormwater)		4	CODE	
120410010080-001AT	397261	5/8/2006	Precipitation		0	inches	
120410010080-001AT	397261	5/8/2006	Precipitation Type (1=fog, 2=rain, 3=sleet, 4=snow, 5=mix)		0	code	
120410010080-001AT	397261	5/8/2006	TOTAL DISSOLVED SOLIDS (FIELD)		1441	MG/L	
120410010080-001AT	397261	5/8/2006	SALINITY (FIELD)		1.2	G/L	
120410010080-001AT	397261	5/8/2006	Periphyton, Severity (% of streambed; 1=0%, 2=25%, 3=50%, 4=75%, 5=100%)		1	code	
120410010080-001AT	397261	5/8/2006	Periphyton Line, Visible (1=yes, 2=no)		2	code	
120410010080-001AT	397261	5/8/2006	Flow, Instantaneous		11400	CFS	
120410010080-001AT	397261	5/8/2006	Turbidity, Field		76	NTU	180.1
120410010080-001AT	397261	5/8/2006	P-ALKALINITY (FIELD)		0	MG/L	
120410010080-001AT	397261	5/8/2006	STREAM WIDTH		2400	METERS	
120410010080-001AT	397261	5/8/2006	STREAM TYPE		2	CODE	
120410010080-001AT	397261	5/8/2006	Flow Measurement Tech (1=composite average, 2=rated, 3=DCP)		2	code	
120410010080-001AT	397261	5/8/2006	DEPTH, MAXIMUM OF SAMPLE		0.1	METERS	
120410010080-001AT	397261	5/8/2006	COLOR, BORGER COLOR SYSTEM		32	CODE	

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STATION_ID	SAMPLE_ID	SAMPLE_DATE	PARAMETER	REMARK	VALUE	UNITS	METHOD
120410010080-001AT	398906	6/12/2006	Water Temperature		28.03	DEG CELS	2550B
120410010080-001AT	398906	6/12/2006	AIR TEMPERATURE		32	DEG C	2550B
120410010080-001AT	398906	6/12/2006	BARROMETRIC PRESSURE		746	MM HG	
120410010080-001AT	398906	6/12/2006	CLOUD COVER		100	PERCENT	
120410010080-001AT	398906	6/12/2006	WIND VELOCITY		0	MPH	
120410010080-001AT	398906	6/12/2006	WIND DIRECTION		0	AZIMUTH	
120410010080-001AT	398906	6/12/2006	STREAM STAGE		3.7	feet	
120410010080-001AT	398906	6/12/2006	OXIDATION/REDUCTION POT. (FIELD)		444	MV	
120410010080-001AT	398906	6/12/2006	Specific Conductance		856.2	UMHOS/CM	120.1
120410010080-001AT	398906	6/12/2006	DISSOLVED OXYGEN, analysis by probe		12.84	MG/L	
120410010080-001AT	398906	6/12/2006	DISS OXY SATURATION		167.8	PERCENT	
120410010080-001AT	398906	6/12/2006	PH (FIELD)		8.88	STD UNIT	150.1
120410010080-001AT	398906	6/12/2006	TOT ALK FIELD CACO3		142	MG/L	
120410010080-001AT	398906	6/12/2006	Hardness, Total (as CaCO3)		182	MG/L	
120410010080-001AT	398906	6/12/2006	Oil and Grease, Severity (1=none, 2=light, 3=moderate, 4=heavy, 5=total)		1	code	
120410010080-001AT	398906	6/12/2006	Odor, Atmospheric, Severity (1=none, 2=light, 3=moderate, 4=heavy, 5=severe)		1	code	
120410010080-001AT	398906	6/12/2006	Debris, Floating, Severity (1=none, 2=light, 3=moderate, 4=heavy, 5=total)		1	code	

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STATION_ID	SAMPLE_ID	SAMPLE_DATE	PARAMETER	REMARK	VALUE	UNITS	METHOD
120410010080-001AT	398906	6/12/2006	Foaming, Severity (1=none, 2=light, 3=moderate, 4=heavy, 5=total)		1	code	
120410010080-001AT	398906	6/12/2006	Scum, Severity (1=none, 2=light, 3=moderate, 4=heavy, 5=total)		1	code	
120410010080-001AT	398906	6/12/2006	Turbidity, Type (1=inorganic, 2=organic, 3=mix)		1	code	
120410010080-001AT	398906	6/12/2006	STREAM FLOW, SEVERITY (1=none, 2=light, 3=moderate, 4=heavy, 5=stormwater)		2	CODE	
120410010080-001AT	398906	6/12/2006	Precipitation		0	inches	
120410010080-001AT	398906	6/12/2006	Precipitation Type (1=fog, 2=rain, 3=sleet, 4=snow, 5=mix)		0	code	
120410010080-001AT	398906	6/12/2006	TOTAL DISSOLVED SOLIDS (FIELD)		548	MG/L	
120410010080-001AT	398906	6/12/2006	SALINITY (FIELD)		0.45	G/L	
120410010080-001AT	398906	6/12/2006	Periphyton, Severity (% of streambed; 1=0%, 2=25%, 3=50%, 4=75%, 5=100%)		1	code	
120410010080-001AT	398906	6/12/2006	Periphyton Line, Visible (1=yes, 2=no)		2	code	
120410010080-001AT	398906	6/12/2006	Flow, Instantaneous		1820	CFS	
120410010080-001AT	398906	6/12/2006	Turbidity, Field		13	NTU	180.1
120410010080-001AT	398906	6/12/2006	P-ALKALINITY (FIELD)		0	MG/L	
120410010080-001AT	398906	6/12/2006	STREAM WIDTH		300	METERS	
120410010080-001AT	398906	6/12/2006	STREAM TYPE		2	CODE	

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STATION_ID	SAMPLE_ID	SAMPLE_DATE	PARAMETER	REMARK	VALUE	UNITS	METHOD
120410010080-001AT	398906	6/12/2006	Flow Measurement Tech (1=composite average, 2=rated, 3=DCP)		2	code	
120410010080-001AT	398906	6/12/2006	DEPTH, MAXIMUM OF SAMPLE		0.5	METERS	
120410010080-001AT	398906	6/12/2006	COLOR, BORGER COLOR SYSTEM		36	CODE	
120410010080-001AT	398907	6/12/2006	Water Temperature		28.03	DEG CELS	2550B
120410010080-001AT	398907	6/12/2006	AIR TEMPERATURE		32	DEG C	2550B
120410010080-001AT	398907	6/12/2006	BAROMETRIC PRESSURE		746	MM HG	
120410010080-001AT	398907	6/12/2006	CLOUD COVER		100	PERCENT	
120410010080-001AT	398907	6/12/2006	WIND VELOCITY		0	MPH	
120410010080-001AT	398907	6/12/2006	WIND DIRECTION		0	AZIMUTH	
120410010080-001AT	398907	6/12/2006	STREAM STAGE		3.7	feet	
120410010080-001AT	398907	6/12/2006	OXIDATION/REDUCTION POT. (FIELD)		444	MV	
120410010080-001AT	398907	6/12/2006	Specific Conductance		856.2	UMHOS/CM	120.1
120410010080-001AT	398907	6/12/2006	DISSOLVED OXYGEN, analysis by probe		12.84	MG/L	
120410010080-001AT	398907	6/12/2006	DISS OXY SATURATION		167.8	PERCENT	
120410010080-001AT	398907	6/12/2006	PH (FIELD)		8.88	STD UNIT	150.1
120410010080-001AT	398907	6/12/2006	TOT ALK FIELD CACO3		142	MG/L	
120410010080-001AT	398907	6/12/2006	Hardness, Total (as CaCO3)		182	MG/L	
120410010080-001AT	398907	6/12/2006	Oil and Grease, Severity (1=none, 2=light, 3=moderate, 4=heavy, 5=total)		1	code	

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STATION_ID	SAMPLE_ID	SAMPLE_DATE	PARAMETER	REMARK	VALUE	UNITS	METHOD
120410010080-001AT	398907	6/12/2006	Odor, Atmospheric, Severity (1=none, 2=light, 3=moderate, 4=heavy, 5=severe)		1	code	
120410010080-001AT	398907	6/12/2006	Debris, Floating, Severity (1=none, 2=light, 3=moderate, 4=heavy, 5=total)		1	code	
120410010080-001AT	398907	6/12/2006	Foaming, Severity (1=none, 2=light, 3=moderate, 4=heavy, 5=total)		1	code	
120410010080-001AT	398907	6/12/2006	Scum, Severity (1=none, 2=light, 3=moderate, 4=heavy, 5=total)		1	code	
120410010080-001AT	398907	6/12/2006	Turbidity, Type (1=inorganic, 2=organic, 3=mix)		1	code	
120410010080-001AT	398907	6/12/2006	STREAM FLOW, SEVERITY (1=none, 2=light, 3=moderate, 4=heavy, 5=stormwater)		2	CODE	
120410010080-001AT	398907	6/12/2006	Precipitation		0	inches	
120410010080-001AT	398907	6/12/2006	Precipitation Type (1=fog, 2=rain, 3=sleet, 4=snow, 5=mix)		0	code	
120410010080-001AT	398907	6/12/2006	TOTAL DISSOLVED SOLIDS (FIELD)		548	MG/L	
120410010080-001AT	398907	6/12/2006	SALINITY (FIELD)		0.45	G/L	

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STATION_ID	SAMPLE_ID	SAMPLE_DATE	PARAMETER	REMARK	VALUE	UNITS	METHOD
120410010080-001AT	398907	6/12/2006	Periphyton, Severity (% of streambed; 1=0%, 2=25%, 3=50%, 4=75%, 5=100%)		1	code	
120410010080-001AT	398907	6/12/2006	Periphyton Line, Visible (1=yes, 2=no)		2	code	
120410010080-001AT	398907	6/12/2006	Flow, Instantaneous		18201	CFS	
120410010080-001AT	398907	6/12/2006	Turbidity, Field		13	NTU	180.1
120410010080-001AT	398907	6/12/2006	P-ALKALINITY (FIELD)		0	MG/L	
120410010080-001AT	398907	6/12/2006	STREAM WIDTH		300	METERS	
120410010080-001AT	398907	6/12/2006	STREAM TYPE		2	CODE	
120410010080-001AT	398907	6/12/2006	Flow Measurement Tech (1=composite average, 2=rated, 3=DCP)		2	code	
120410010080-001AT	398907	6/12/2006	DEPTH, MAXIMUM OF SAMPLE		0.5	METERS	
120410010080-001AT	398907	6/12/2006	COLOR, BORGER COLOR SYSTEM		36	CODE	
120410010080-001AT	400977	7/17/2006	Water Temperature		32.04	DEG CELS	2550B
120410010080-001AT	400977	7/17/2006	AIR TEMPERATURE		40	DEG C	2550B
120410010080-001AT	400977	7/17/2006	BAROMETRIC PRESSURE		744.5	MM HG	
120410010080-001AT	400977	7/17/2006	CLOUD COVER		0	PERCENT	
120410010080-001AT	400977	7/17/2006	WIND VELOCITY		5	MPH	
120410010080-001AT	400977	7/17/2006	WIND DIRECTION		180	AZIMUTH	
120410010080-001AT	400977	7/17/2006	STREAM STAGE		4.19	feet	
120410010080-001AT	400977	7/17/2006	OXIDATION/REDUCTION POT. (FIELD)		444	MV	
120410010080-001AT	400977	7/17/2006	Specific Conductance		1841	UMHOS/CM	120.1
120410010080-001AT	400977	7/17/2006	DISSOLVED OXYGEN, analysis by probe		9.46	MG/L	

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STATION_ID	SAMPLE_ID	SAMPLE_DATE	PARAMETER	REMARK	VALUE	UNITS	METHOD
120410010080-001AT	400977	7/17/2006	DISS OXY SATURATION		133.1	PERCENT	
120410010080-001AT	400977	7/17/2006	PH (FIELD)		8.59	STD UNIT	150.1
120410010080-001AT	400977	7/17/2006	TOT ALK FIELD CACO3		191	MG/L	
120410010080-001AT	400977	7/17/2006	Hardness, Total (as CaCO3)		164	MG/L	
120410010080-001AT	400977	7/17/2006	Oil and Grease, Severity (1=none, 2=light, 3=moderate, 4=heavy, 5=total)		1	code	
120410010080-001AT	400977	7/17/2006	Odor, Atmospheric, Severity (1=none, 2=light, 3=moderate, 4=heavy, 5=severe)		1	code	
120410010080-001AT	400977	7/17/2006	Debris, Floating, Severity (1=none, 2=light, 3=moderate, 4=heavy, 5=total)		1	code	
120410010080-001AT	400977	7/17/2006	Foaming, Severity (1=none, 2=light, 3=moderate, 4=heavy, 5=total)		2	code	
120410010080-001AT	400977	7/17/2006	Scum, Severity (1=none, 2=light, 3=moderate, 4=heavy, 5=total)		1	code	
120410010080-001AT	400977	7/17/2006	Turbidity, Type (1=inorganic, 2=organic, 3=mix)		3	code	
120410010080-001AT	400977	7/17/2006	STREAM FLOW, SEVERITY (1=none, 2=light, 3=moderate, 4=heavy, 5=stormwater)		3	CODE	

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STATION_ID	SAMPLE_ID	SAMPLE_DATE	PARAMETER	REMARK	VALUE	UNITS	METHOD
120410010080-001AT	400977	7/17/2006	Precipitation		0	inches	
120410010080-001AT	400977	7/17/2006	Precipitation Type (1=fog, 2=rain, 3=sleet, 4=snow, 5=mix)		0	code	
120410010080-001AT	400977	7/17/2006	TOTAL DISSOLVED SOLIDS (FIELD)		1170	MG/L	
120410010080-001AT	400977	7/17/2006	SALINITY (FIELD)		0.98	G/L	
120410010080-001AT	400977	7/17/2006	Periphyton, Severity (% of streambed; 1=0%, 2=25%, 3=50%, 4=75%, 5=100%)		1	code	
120410010080-001AT	400977	7/17/2006	Periphyton Line, Visible (1=yes, 2=no)		2	code	
120410010080-001AT	400977	7/17/2006	Flow, Instantaneous		2690	CFS	
120410010080-001AT	400977	7/17/2006	Turbidity, Field		20	NTU	180.1
120410010080-001AT	400977	7/17/2006	P-ALKALINITY (FIELD)		0	MG/L	
120410010080-001AT	400977	7/17/2006	STREAM WIDTH		300	METERS	
120410010080-001AT	400977	7/17/2006	STREAM TYPE		2	CODE	
120410010080-001AT	400977	7/17/2006	Flow Measurement Tech (1=composite average, 2=rated, 3=DCP)		2	code	
120410010080-001AT	400977	7/17/2006	DEPTH, MAXIMUM OF SAMPLE		0.5	METERS	
120410010080-001AT	400977	7/17/2006	COLOR, BORGER COLOR SYSTEM		39	CODE	
120410010080-001AT	400978	7/17/2006	Water Temperature		32.04	DEG CELS	2550B
120410010080-001AT	400978	7/17/2006	AIR TEMPERATURE		40	DEG C	2550B
120410010080-001AT	400978	7/17/2006	BARROMETRIC PRESSURE		744.5	MM HG	
120410010080-001AT	400978	7/17/2006	CLOUD COVER		0	PERCENT	
120410010080-001AT	400978	7/17/2006	WIND VELOCITY		5	MPH	
120410010080-001AT	400978	7/17/2006	WIND DIRECTION		180	AZIMUTH	
120410010080-001AT	400978	7/17/2006	STREAM STAGE		4.14	feet	

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STATION_ID	SAMPLE_ID	SAMPLE_DATE	PARAMETER	REMARK	VALUE	UNITS	METHOD
120410010080-001AT	400978	7/17/2006	OXIDATION/REDUCTION POT. (FIELD)		444	MV	
120410010080-001AT	400978	7/17/2006	Specific Conductance		1841	UMHOS/CM	120.1
120410010080-001AT	400978	7/17/2006	DISSOLVED OXYGEN, analysis by probe		9.46	MG/L	
120410010080-001AT	400978	7/17/2006	DISS OXY SATURATION		133.1	PERCENT	
120410010080-001AT	400978	7/17/2006	PH (FIELD)		8.59	STD UNIT	150.1
120410010080-001AT	400978	7/17/2006	TOT ALK FIELD CACO3		145	MG/L	
120410010080-001AT	400978	7/17/2006	Hardness, Total (as CaCO3)		160	MG/L	
120410010080-001AT	400978	7/17/2006	Oil and Grease, Severity (1=none, 2=light, 3=moderate, 4=heavy, 5=total)		1	code	
120410010080-001AT	400978	7/17/2006	Odor, Atmospheric, Severity (1=none, 2=light, 3=moderate, 4=heavy, 5=severe)		1	code	
120410010080-001AT	400978	7/17/2006	Debris, Floating, Severity (1=none, 2=light, 3=moderate, 4=heavy, 5=total)		1	code	
120410010080-001AT	400978	7/17/2006	Foaming, Severity (1=none, 2=light, 3=moderate, 4=heavy, 5=total)		2	code	
120410010080-001AT	400978	7/17/2006	Scum, Severity (1=none, 2=light, 3=moderate, 4=heavy, 5=total)		1	code	

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STATION_ID	SAMPLE_ID	SAMPLE_DATE	PARAMETER	REMARK	VALUE	UNITS	METHOD
120410010080-001AT	400978	7/17/2006	Turbidity, Type (1=inorganic, 2=organic, 3=mix)		3	code	
120410010080-001AT	400978	7/17/2006	STREAM FLOW, SEVERITY (1=none, 2=light, 3=moderate, 4=heavy, 5=stormwater)		3	CODE	
120410010080-001AT	400978	7/17/2006	Precipitation		0	inches	
120410010080-001AT	400978	7/17/2006	Precipitation Type (1=fog, 2=rain, 3=sleet, 4=snow, 5=mix)		0	code	
120410010080-001AT	400978	7/17/2006	TOTAL DISSOLVED SOLIDS (FIELD)		1170	MG/L	
120410010080-001AT	400978	7/17/2006	SALINITY (FIELD)		0.98	G/L	
120410010080-001AT	400978	7/17/2006	Periphyton, Severity (% of streambed; 1=0%, 2=25%, 3=50%, 4=75%, 5=100%)		1	code	
120410010080-001AT	400978	7/17/2006	Periphyton Line, Visible (1=yes, 2=no)		2	code	
120410010080-001AT	400978	7/17/2006	Flow, Instantaneous		2690	CFS	
120410010080-001AT	400978	7/17/2006	Turbidity, Field		20	NTU	180.1
120410010080-001AT	400978	7/17/2006	P-ALKALINITY (FIELD)		0	MG/L	
120410010080-001AT	400978	7/17/2006	STREAM WIDTH		300	METERS	
120410010080-001AT	400978	7/17/2006	STREAM TYPE		2	CODE	
120410010080-001AT	400978	7/17/2006	Flow Measurement Tech (1=composite average, 2=rated, 3=DCP)		2	code	
120410010080-001AT	400978	7/17/2006	DEPTH, MAXIMUM OF SAMPLE		0.5	METERS	
120410010080-001AT	400978	7/17/2006	COLOR, BORGER COLOR SYSTEM		39	CODE	

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STATION_ID	SAMPLE_ID	SAMPLE_DATE	PARAMETER	REMARK	VALUE	UNITS	METHOD
120410010080-001AT	403481	8/22/2006	Water Temperature		28.36	DEG CELS	2550B
120410010080-001AT	403481	8/22/2006	AIR TEMPERATURE		33	DEG C	2550B
120410010080-001AT	403481	8/22/2006	BARROMETRIC PRESSURE		764	MM HG	
120410010080-001AT	403481	8/22/2006	CLOUD COVER		100	PERCENT	
120410010080-001AT	403481	8/22/2006	WIND VELOCITY		2.5	MPH	
120410010080-001AT	403481	8/22/2006	WIND DIRECTION		180	AZIMUTH	
120410010080-001AT	403481	8/22/2006	STREAM STAGE		4.22	feet	
120410010080-001AT	403481	8/22/2006	OXIDATION/REDUCTION POT. (FIELD)		421	MV	
120410010080-001AT	403481	8/22/2006	Specific Conductance		1314	UMHOS/CM	120.1
120410010080-001AT	403481	8/22/2006	DISSOLVED OXYGEN, analysis by probe		6.42	MG/L	
120410010080-001AT	403481	8/22/2006	DISS OXY SATURATION		82.5	PERCENT	
120410010080-001AT	403481	8/22/2006	PH (FIELD)		8.12	STD UNIT	150.1
120410010080-001AT	403481	8/22/2006	TOT ALK FIELD CACO3		123	MG/L	
120410010080-001AT	403481	8/22/2006	Hardness, Total (as CaCO3)		184	MG/L	
120410010080-001AT	403481	8/22/2006	Oil and Grease, Severity (1=none, 2=light, 3=moderate, 4=heavy, 5=total)		2	code	
120410010080-001AT	403481	8/22/2006	Odor, Atmospheric, Severity (1=none, 2=light, 3=moderate, 4=heavy, 5=severe)		2	code	
120410010080-001AT	403481	8/22/2006	Debris, Floating, Severity (1=none, 2=light, 3=moderate, 4=heavy, 5=total)		2	code	

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STATION_ID	SAMPLE_ID	SAMPLE_DATE	PARAMETER	REMARK	VALUE	UNITS	METHOD
120410010080-001AT	403481	8/22/2006	Foaming, Severity (1=none, 2=light, 3=moderate, 4=heavy, 5=total)		3	code	
120410010080-001AT	403481	8/22/2006	Debris, Floating, Size (1=small, 2=medium, 3= large)		1	code	
120410010080-001AT	403481	8/22/2006	Scum, Severity (1=none, 2=light, 3=moderate, 4=heavy, 5=total)		3	code	
120410010080-001AT	403481	8/22/2006	Turbidity, Type (1=inorganic, 2=organic, 3=mix)		3	code	
120410010080-001AT	403481	8/22/2006	STREAM FLOW, SEVERITY (1=none, 2=light, 3=moderate, 4=heavy, 5=stormwater)		2	CODE	
120410010080-001AT	403481	8/22/2006	Precipitation		0	inches	
120410010080-001AT	403481	8/22/2006	Precipitation Type (1=fog, 2=rain, 3=sleet, 4=snow, 5=mix)		0	code	
120410010080-001AT	403481	8/22/2006	TOTAL DISSOLVED SOLIDS (FIELD)		841	MG/L	
120410010080-001AT	403481	8/22/2006	SALINITY (FIELD)		0.7	G/L	
120410010080-001AT	403481	8/22/2006	Periphyton, Severity (% of streambed; 1=0%, 2=25%, 3=50%, 4=75%, 5=100%)		1	code	
120410010080-001AT	403481	8/22/2006	Periphyton Line, Visible (1=yes, 2=no)		2	code	
120410010080-001AT	403481	8/22/2006	Flow, Instantaneous		2190	CFS	
120410010080-001AT	403481	8/22/2006	Turbidity, Field		59	NTU	180.1

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STATION_ID	SAMPLE_ID	SAMPLE_DATE	PARAMETER	REMARK	VALUE	UNITS	METHOD
120410010080-001AT	403481	8/22/2006	P-ALKALINITY (FIELD)		0	MG/L	
120410010080-001AT	403481	8/22/2006	STREAM WIDTH		1480	METERS	
120410010080-001AT	403481	8/22/2006	STREAM TYPE		2	CODE	
120410010080-001AT	403481	8/22/2006	Flow Measurement Tech (1=composite average, 2=rated, 3=DCP)		2	code	
120410010080-001AT	403481	8/22/2006	DEPTH, MAXIMUM OF SAMPLE		0.6	METERS	
120410010080-001AT	403481	8/22/2006	COLOR, BORGER COLOR SYSTEM		32	CODE	
120410010080-001AT	403482	8/22/2006	Water Temperature		28.36	DEG CELS	2550B
120410010080-001AT	403482	8/22/2006	AIR TEMPERATURE		33	DEG C	2550B
120410010080-001AT	403482	8/22/2006	BARROMETRIC PRESSURE		764	MM HG	
120410010080-001AT	403482	8/22/2006	CLOUD COVER		100	PERCENT	
120410010080-001AT	403482	8/22/2006	WIND VELOCITY		2.5	MPH	
120410010080-001AT	403482	8/22/2006	WIND DIRECTION		180	AZIMUTH	
120410010080-001AT	403482	8/22/2006	STREAM STAGE		4.22	feet	
120410010080-001AT	403482	8/22/2006	OXIDATION/REDUCTIO N POT. (FIELD)		421	MV	
120410010080-001AT	403482	8/22/2006	Specific Conductance		1314	UMHOS/CM	120.1
120410010080-001AT	403482	8/22/2006	DISSOLVED OXYGEN, analysis by probe		6.42	MG/L	
120410010080-001AT	403482	8/22/2006	DISS OXY SATURATION		82.5	PERCENT	
120410010080-001AT	403482	8/22/2006	PH (FIELD)		8.12	STD UNIT	150.1
120410010080-001AT	403482	8/22/2006	TOT ALK FIELD CACO3		127	MG/L	
120410010080-001AT	403482	8/22/2006	Hardness, Total (as CaCO3)		187	MG/L	

Haskell Biological & Field Data

STATION_ID	SAMPLE_ID	SAMPLE_DATE	PARAMETER	REMARK	VALUE	UNITS	METHOD
120410010080-001AT	403482	8/22/2006	Oil and Grease, Severity (1=none, 2=light, 3=moderate, 4=heavy, 5=total)		2	code	
120410010080-001AT	403482	8/22/2006	Odor, Atmospheric, Severity (1=none, 2=light, 3=moderate, 4=heavy, 5=severe)		2	code	
120410010080-001AT	403482	8/22/2006	Debris, Floating, Severity (1=none, 2=light, 3=moderate, 4=heavy, 5=total)		2	code	
120410010080-001AT	403482	8/22/2006	Foaming, Severity (1=none, 2=light, 3=moderate, 4=heavy, 5=total)		3	code	
120410010080-001AT	403482	8/22/2006	Debris, Floating, Size (1=small, 2=medium, 3= large)		1	code	
120410010080-001AT	403482	8/22/2006	Scum, Severity (1=none, 2=light, 3=moderate, 4=heavy, 5=total)		3	code	
120410010080-001AT	403482	8/22/2006	Turbidity, Type (1=inorganic, 2=organic, 3=mix)		3	code	
120410010080-001AT	403482	8/22/2006	STREAM FLOW, SEVERITY (1=none, 2=light, 3=moderate, 4=heavy, 5=stormwater)		2	CODE	
120410010080-001AT	403482	8/22/2006	Precipitation		0	inches	
120410010080-001AT	403482	8/22/2006	Precipitation Type (1=fog, 2=rain, 3=sleet, 4=snow, 5=mix)		0	code	

Haskell Biological & Field Data

STATION_ID	SAMPLE_ID	SAMPLE_DATE	PARAMETER	REMARK	VALUE	UNITS	METHOD
120410010080-001AT	403482	8/22/2006	TOTAL DISSOLVED SOLIDS (FIELD)		841	MG/L	
120410010080-001AT	403482	8/22/2006	SALINITY (FIELD)		0.7	G/L	
120410010080-001AT	403482	8/22/2006	Periphyton, Severity (% of streambed; 1=0%, 2=25%, 3=50%, 4=75%, 5=100%)		1	code	
120410010080-001AT	403482	8/22/2006	Periphyton Line, Visible (1=yes, 2=no)		2	code	
120410010080-001AT	403482	8/22/2006	Flow, Instantaneous		2190	CFS	
120410010080-001AT	403482	8/22/2006	Turbidity, Field		59	NTU	180.1
120410010080-001AT	403482	8/22/2006	P-ALKALINITY (FIELD)		0	MG/L	
120410010080-001AT	403482	8/22/2006	STREAM WIDTH		1480	METERS	
120410010080-001AT	403482	8/22/2006	STREAM TYPE		2	CODE	
120410010080-001AT	403482	8/22/2006	Flow Measurement Tech (1=composite average, 2=rated, 3=DCP)		2	code	
120410010080-001AT	403482	8/22/2006	DEPTH, MAXIMUM OF SAMPLE		0.6	METERS	
120410010080-001AT	403482	8/22/2006	COLOR, BORGER COLOR SYSTEM		32	CODE	

Inorganics

STATION_ID	SAMPLE_ID	SAMPLE_DATE	PARAMETER	REMARK	VALUE	UNITS	METHOD
120410010080-001AT	391008	1/23/2006	Nitrogen, Ammonia		0.06	mg/L	350.1
120410010080-001AT	391008	1/23/2006	Nitrogen, Kjeldahl		0.66	mg/L	351.3
120410010080-001AT	391008	1/23/2006	Nitrogen, Nitrate/Nitrite as N		0.63	mg/L	
120410010080-001AT	391008	1/23/2006	Phosphorous, Total		0.17	mg/L	365.3
120410010080-001AT	391008	1/23/2006	Chloride		815	mg/L	325.2
120410010080-001AT	391008	1/23/2006	Sulfate		152	mg/L	375.4
120410010080-001AT	391008	1/23/2006	Phosphorous, Ortho		0.12	mg/L	365.1

Haskell Biological & Field Data

STATION_ID	SAMPLE_ID	SAMPLE_DATE	PARAMETER	REMARK	VALUE	UNITS	METHOD
120410010080-001AT	391009	1/23/2006	Nitrogen, Ammonia		0.06	mg/L	350.1
120410010080-001AT	391009	1/23/2006	Nitrogen, Kjeldahl		0.68	mg/L	351.3
120410010080-001AT	391009	1/23/2006	Nitrogen, Nitrate/Nitrite as N		0.63	mg/L	
120410010080-001AT	391009	1/23/2006	Phosphorous, Total		0.165	mg/L	365.3
120410010080-001AT	391009	1/23/2006	Chloride		820	mg/L	325.2
120410010080-001AT	391009	1/23/2006	Sulfate		151	mg/L	375.4
120410010080-001AT	391009	1/23/2006	Phosphorous, Ortho		0.122	mg/L	365.1
120410010080-001AT	391010	1/24/2006	Nitrogen, Kjeldahl	<	0.05	mg/L	351.3
120410010080-001AT	391010	1/24/2006	Phosphorous, Total	<	0.005	mg/L	365.3
120410010080-001AT	393462	2/27/2006	Nitrogen, Ammonia		0.22	mg/L	350.1
120410010080-001AT	393462	2/27/2006	Nitrogen, Kjeldahl		0.96	mg/L	351.3
120410010080-001AT	393462	2/27/2006	Nitrogen, Nitrate/Nitrite as N		0.39	mg/L	
120410010080-001AT	393462	2/27/2006	Phosphorous, Total		0.313	mg/L	365.3
120410010080-001AT	393462	2/27/2006	Chloride		754	mg/L	325.2
120410010080-001AT	393462	2/27/2006	Sulfate		151	mg/L	375.4
120410010080-001AT	393462	2/27/2006	Phosphorous, Ortho		0.222	mg/L	365.1
120410010080-001AT	393463	2/27/2006	Nitrogen, Ammonia		0.22	mg/L	350.1
120410010080-001AT	393463	2/27/2006	Nitrogen, Kjeldahl		0.99	mg/L	351.3
120410010080-001AT	393463	2/27/2006	Nitrogen, Nitrate/Nitrite as N		0.39	mg/L	
120410010080-001AT	393463	2/27/2006	Phosphorous, Total		0.315	mg/L	365.3
120410010080-001AT	393463	2/27/2006	Chloride		738	mg/L	325.2
120410010080-001AT	393463	2/27/2006	Sulfate		150	mg/L	375.4
120410010080-001AT	393463	2/27/2006	Phosphorous, Ortho		0.225	mg/L	365.1
120410010080-001AT	393464	2/28/2006	Nitrogen, Kjeldahl		0.17	mg/L	351.3
120410010080-001AT	393464	2/28/2006	Phosphorous, Total		0.029	mg/L	365.3
120410010080-001AT	395294	4/3/2006	Nitrogen, Ammonia	<	0.05	mg/L	350.1
120410010080-001AT	395294	4/3/2006	Nitrogen, Kjeldahl		0.96	mg/L	351.3
120410010080-001AT	395294	4/3/2006	Nitrogen, Nitrate/Nitrite as N	<	0.05	mg/L	
120410010080-001AT	395294	4/3/2006	Phosphorous, Total		0.2	mg/L	365.3
120410010080-001AT	395294	4/3/2006	Chloride		767	mg/L	325.2
120410010080-001AT	395294	4/3/2006	Sulfate		158	mg/L	375.4

Haskell Biological & Field Data

STATION_ID	SAMPLE_ID	SAMPLE_DATE	PARAMETER	REMARK	VALUE	UNITS	METHOD
120410010080-001AT	395294	4/3/2006	Phosphorous, Ortho		0.036	mg/L	365.1
120410010080-001AT	395295	4/3/2006	Nitrogen, Ammonia	<	0.05	mg/L	350.1
120410010080-001AT	395295	4/3/2006	Nitrogen, Kjeldahl		1.02	mg/L	351.3
120410010080-001AT	395295	4/3/2006	Nitrogen, Nitrate/Nitrite as N	<	0.05	mg/L	
120410010080-001AT	395295	4/3/2006	Phosphorous, Total		0.203	mg/L	365.3
120410010080-001AT	395295	4/3/2006	Chloride		740	mg/L	325.2
120410010080-001AT	395295	4/3/2006	Sulfate		156	mg/L	375.4
120410010080-001AT	395295	4/3/2006	Phosphorous, Ortho		0.039	mg/L	365.1
120410010080-001AT	395296	4/4/2006	Nitrogen, Kjeldahl		0.11	mg/L	351.3
120410010080-001AT	395296	4/4/2006	Phosphorous, Total		0.129	mg/L	365.3
120410010080-001AT	397260	5/8/2006	Nitrogen, Ammonia	<	0.05	mg/L	350.1
120410010080-001AT	397260	5/8/2006	Nitrogen, Kjeldahl		1.03	mg/L	351.3
120410010080-001AT	397260	5/8/2006	Nitrogen, Nitrate/Nitrite as N		0.43	mg/L	
120410010080-001AT	397260	5/8/2006	Phosphorous, Total		0.267	mg/L	365.3
120410010080-001AT	397260	5/8/2006	Chloride		515	mg/L	325.2
120410010080-001AT	397260	5/8/2006	Sulfate		121	mg/L	375.4
120410010080-001AT	397260	5/8/2006	Phosphorous, Ortho		0.098	mg/L	365.1
120410010080-001AT	397261	5/8/2006	Nitrogen, Ammonia	<	0.05	mg/L	350.1
120410010080-001AT	397261	5/8/2006	Nitrogen, Kjeldahl		1.04	mg/L	351.3
120410010080-001AT	397261	5/8/2006	Nitrogen, Nitrate/Nitrite as N		0.4	mg/L	
120410010080-001AT	397261	5/8/2006	Phosphorous, Total		0.26	mg/L	365.3
120410010080-001AT	397261	5/8/2006	Chloride		519	mg/L	325.2
120410010080-001AT	397261	5/8/2006	Sulfate		122	mg/L	375.4
120410010080-001AT	397261	5/8/2006	Phosphorous, Ortho		0.094	mg/L	365.1
120410010080-001AT	397262	5/9/2006	Nitrogen, Kjeldahl	<	0.05	mg/L	351.3
120410010080-001AT	397262	5/9/2006	Phosphorous, Total		0.007	mg/L	365.3
120410010080-001AT	398906	6/12/2006	Nitrogen, Ammonia		0.058	mg/L	350.1
120410010080-001AT	398906	6/12/2006	Nitrogen, Kjeldahl		1.06	mg/L	351.3
120410010080-001AT	398906	6/12/2006	Nitrogen, Nitrate/Nitrite as N	<	0.05	mg/L	
120410010080-001AT	398906	6/12/2006	Phosphorous, Total		0.208	mg/L	365.3
120410010080-001AT	398906	6/12/2006	Chloride		297	mg/L	325.2

Haskell Biological & Field Data

STATION_ID	SAMPLE_ID	SAMPLE_DATE	PARAMETER	REMARK	VALUE	UNITS	METHOD
120410010080-001AT	398906	6/12/2006	Sulfate		97.5	mg/L	375.4
120410010080-001AT	398906	6/12/2006	Phosphorous, Ortho		0.061	mg/L	365.1
120410010080-001AT	398907	6/12/2006	Nitrogen, Ammonia	<	0.05	mg/L	350.1
120410010080-001AT	398907	6/12/2006	Nitrogen, Kjeldahl		1.06	mg/L	351.3
120410010080-001AT	398907	6/12/2006	Nitrogen, Nitrate/Nitrite as N	<	0.05	mg/L	
120410010080-001AT	398907	6/12/2006	Phosphorous, Total		0.208	mg/L	365.3
120410010080-001AT	398907	6/12/2006	Chloride		297	mg/L	325.2
120410010080-001AT	398907	6/12/2006	Sulfate		97.3	mg/L	375.4
120410010080-001AT	398907	6/12/2006	Phosphorous, Ortho		0.061	mg/L	365.1
120410010080-001AT	400977	7/17/2006	Nitrogen, Ammonia		0.06	mg/L	350.1
120410010080-001AT	400977	7/17/2006	Nitrogen, Kjeldahl		0.92	mg/L	351.3
120410010080-001AT	400977	7/17/2006	Nitrogen, Nitrate/Nitrite as N	<	0.05	mg/L	
120410010080-001AT	400977	7/17/2006	Phosphorous, Total		0.275	mg/L	365.3
120410010080-001AT	400977	7/17/2006	Chloride		430	mg/L	325.2
120410010080-001AT	400977	7/17/2006	Sulfate		110	mg/L	375.4
120410010080-001AT	400977	7/17/2006	Phosphorous, Ortho		0.137	mg/L	365.1
120410010080-001AT	400978	7/17/2006	Nitrogen, Ammonia		0.06	mg/L	350.1
120410010080-001AT	400978	7/17/2006	Nitrogen, Kjeldahl		0.89	mg/L	351.3
120410010080-001AT	400978	7/17/2006	Nitrogen, Nitrate/Nitrite as N	<	0.05	mg/L	
120410010080-001AT	400978	7/17/2006	Phosphorous, Total		0.276	mg/L	365.3
120410010080-001AT	400978	7/17/2006	Chloride		404	mg/L	325.2
120410010080-001AT	400978	7/17/2006	Sulfate		103	mg/L	375.4
120410010080-001AT	400978	7/17/2006	Phosphorous, Ortho		0.127	mg/L	365.1
120410010080-001AT	400979	7/18/2006	Nitrogen, Kjeldahl		0.07	mg/L	351.3
120410010080-001AT	400979	7/18/2006	Phosphorous, Total		0.009	mg/L	365.3
120410010080-001AT	403481	8/22/2006	Nitrogen, Ammonia	<	0.05	mg/L	350.1
120410010080-001AT	403481	8/22/2006	Nitrogen, Kjeldahl		1.1	mg/L	351.3
120410010080-001AT	403481	8/22/2006	Nitrogen, Nitrate/Nitrite as N		0.17	mg/L	
120410010080-001AT	403481	8/22/2006	Phosphorous, Total		0.275	mg/L	365.3
120410010080-001AT	403481	8/22/2006	Chloride		297	mg/L	325.2
120410010080-001AT	403481	8/22/2006	Sulfate		62.1	mg/L	375.4

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STATION_ID	SAMPLE_ID	SAMPLE_DATE	PARAMETER	REMARK	VALUE	UNITS	METHOD
120410010080-001AT	403481	8/22/2006	Phosphorous, Ortho		0.106	mg/L	365.1
120410010080-001AT	403482	8/22/2006	Nitrogen, Ammonia	<	0.05	mg/L	350.1
120410010080-001AT	403482	8/22/2006	Nitrogen, Kjeldahl		1.09	mg/L	351.3
120410010080-001AT	403482	8/22/2006	Nitrogen, Nitrate/Nitrite as N		0.17	mg/L	
120410010080-001AT	403482	8/22/2006	Phosphorous, Total		0.269	mg/L	365.3
120410010080-001AT	403482	8/22/2006	Chloride		297	mg/L	325.2
120410010080-001AT	403482	8/22/2006	Sulfate		97.6	mg/L	375.4
120410010080-001AT	403482	8/22/2006	Phosphorous, Ortho		0.104	mg/L	365.1
120410010080-001AT	403483	8/23/2006	Nitrogen, Kjeldahl	<	0.05	mg/L	351.3
120410010080-001AT	403483	8/23/2006	Phosphorous, Total	<	0.005	mg/L	365.3
120410010080-001AT	406990	10/2/2006	Nitrogen, Ammonia	<	0.05	mg/L	350.1
120410010080-001AT	406990	10/2/2006	Nitrogen, Kjeldahl		0.8	mg/L	351.3
120410010080-001AT	406990	10/2/2006	Nitrogen, Nitrate/Nitrite as N	<	0.05	mg/L	
120410010080-001AT	406990	10/2/2006	Phosphorous, Total		0.157	mg/L	365.3
120410010080-001AT	406990	10/2/2006	Chloride		319	mg/L	325.2
120410010080-001AT	406990	10/2/2006	Sulfate		102	mg/L	375.4
120410010080-001AT	406990	10/2/2006	Phosphorous, Ortho		0.059	mg/L	365.1
120410010080-001AT	406991	10/2/2006	Nitrogen, Ammonia	<	0.05	mg/L	350.1
120410010080-001AT	406991	10/2/2006	Nitrogen, Kjeldahl		0.89	mg/L	351.3
120410010080-001AT	406991	10/2/2006	Nitrogen, Nitrate/Nitrite as N	<	0.05	mg/L	
120410010080-001AT	406991	10/2/2006	Phosphorous, Total		0.153	mg/L	365.3
120410010080-001AT	406991	10/2/2006	Chloride		329	mg/L	325.2
120410010080-001AT	406991	10/2/2006	Sulfate		103	mg/L	375.4
120410010080-001AT	406991	10/2/2006	Phosphorous, Ortho		0.066	mg/L	365.1
120410010080-001AT	406992	10/2/2006	Nitrogen, Kjeldahl		0.14	mg/L	351.3
120410010080-001AT	406992	10/2/2006	Phosphorous, Total		0.01	mg/L	365.3
120410010080-001AT	408927	11/8/2006	Nitrogen, Ammonia	<	0.05	mg/L	350.1
120410010080-001AT	408927	11/8/2006	Nitrogen, Kjeldahl		2.17	mg/L	351.3
120410010080-001AT	408927	11/8/2006	Nitrogen, Nitrate/Nitrite as N		1.01	mg/L	
120410010080-001AT	408927	11/8/2006	Phosphorous, Total		0.62	mg/L	365.3
120410010080-001AT	408927	11/8/2006	Chloride		218	mg/L	325.2

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STATION_ID	SAMPLE_ID	SAMPLE_DATE	PARAMETER	REMARK	VALUE	UNITS	METHOD
120410010080-001AT	408927	11/8/2006	Sulfate		114	mg/L	375.4
120410010080-001AT	408927	11/8/2006	Phosphorous, Ortho		0.365	mg/L	365.1
120410010080-001AT	408928	11/8/2006	Nitrogen, Ammonia	<	0.05	mg/L	350.1
120410010080-001AT	408928	11/8/2006	Nitrogen, Kjeldahl		2.18	mg/L	351.3
120410010080-001AT	408928	11/8/2006	Nitrogen, Nitrate/Nitrite as N		1.01	mg/L	
120410010080-001AT	408928	11/8/2006	Phosphorous, Total		0.65	mg/L	365.3
120410010080-001AT	408928	11/8/2006	Chloride		218	mg/L	325.2
120410010080-001AT	408928	11/8/2006	Sulfate		114	mg/L	375.4
120410010080-001AT	408928	11/8/2006	Phosphorous, Ortho		0.367	mg/L	365.1
120410010080-001AT	408929	11/8/2006	Nitrogen, Ammonia	<	0.05	mg/L	350.1
120410010080-001AT	408929	11/8/2006	Nitrogen, Kjeldahl	<	0.05	mg/L	351.3
120410010080-001AT	408929	11/8/2006	Nitrogen, Nitrate/Nitrite as N	<	0.05	mg/L	
120410010080-001AT	408929	11/8/2006	Phosphorous, Total		0.009	mg/L	365.3
120410010080-001AT	408929	11/8/2006	Chloride	<	10	mg/L	325.2
120410010080-001AT	408929	11/8/2006	Sulfate	<	10	mg/L	375.4
120410010080-001AT	408929	11/8/2006	Phosphorous, Ortho	<	0.005	mg/L	365.1
120410010080-001AT	410317	12/6/2006	Nitrogen, Ammonia		0.32	mg/L	350.1
120410010080-001AT	410317	12/6/2006	Nitrogen, Kjeldahl		1.17	mg/L	351.3
120410010080-001AT	410317	12/6/2006	Nitrogen, Nitrate/Nitrite as N		1.09	mg/L	
120410010080-001AT	410317	12/6/2006	Phosphorous, Total		0.365	mg/L	365.3
120410010080-001AT	410317	12/6/2006	Chloride		249	mg/L	325.2
120410010080-001AT	410317	12/6/2006	Sulfate		69.1	mg/L	375.4
120410010080-001AT	410317	12/6/2006	Phosphorous, Ortho		0.328	mg/L	365.1
120410010080-001AT	410318	12/6/2006	Nitrogen, Ammonia		0.32	mg/L	350.1
120410010080-001AT	410318	12/6/2006	Nitrogen, Kjeldahl		1.09	mg/L	351.3
120410010080-001AT	410318	12/6/2006	Nitrogen, Nitrate/Nitrite as N		1.09	mg/L	
120410010080-001AT	410318	12/6/2006	Phosphorous, Total		0.37	mg/L	365.3
120410010080-001AT	410318	12/6/2006	Chloride		249	mg/L	325.2
120410010080-001AT	410318	12/6/2006	Sulfate		68.5	mg/L	375.4
120410010080-001AT	410318	12/6/2006	Phosphorous, Ortho		0.324	mg/L	365.1
120410010080-001AT	410319	12/6/2006	Nitrogen, Ammonia	<	0.05	mg/L	350.1

Haskell Biological & Field Data

STATION_ID	SAMPLE_ID	SAMPLE_DATE	PARAMETER	REMARK	VALUE	UNITS	METHOD
120410010080-001AT	410319	12/6/2006	Nitrogen, Kjeldahl		0.06	mg/L	351.3
120410010080-001AT	410319	12/6/2006	Nitrogen, Nitrate/Nitrite as N	<	0.05	mg/L	
120410010080-001AT	410319	12/6/2006	Phosphorous, Total		0.009	mg/L	365.3
120410010080-001AT	410319	12/6/2006	Chloride	<	10	mg/L	325.2
120410010080-001AT	410319	12/6/2006	Sulfate	<	10	mg/L	375.4
120410010080-001AT	410319	12/6/2006	Phosphorous, Ortho	<	0.005	mg/L	365.1

Appendix C

City of Tulsa
Monitoring Station Data

AR-1 (1992-2004)
Three (3) pages

AR-3 (1992-2004)
Four (4) pages

AR-4 (1992-2004)
Four (4) pages

AR-6 (1992-2004)
Four (4) pages

AR-8 (1992-2004)
Four (4) pages

AR-1B (2005-10)
One (1) page

AR-3 (2005-10)
One (1) page

AR-4 (2005-10)
One (1) page

AR-6 (2005-10)
One (1) page

AR-8 (2005-10)
One (1) page

City of Tulsa 2000-2004 Data AR-1

AREA	DATE	TEMP (°C)	pH (std.)	DO (mg/l)	BOD (mg/l)	NH_4 (mg/l)	NO_3 (mg/l)	NO_2 (mg/l)	NO_2+NO_3 (mg/l)	HRDNSS (mg/l)	COLIF F (N/100ml)	TSS (mg/l)	PO_4 (mg/l)	PHENOL (mg/l)	AS (ug/l)	CD (ug/l)	CR (ug/l)	CU (ug/l)	PB (ug/l)	HG (ug/l)	SE (ug/l)	AG (ug/l)	ZN (ug/l)	Kjeldahl (ug/l)
AR-1	01/03/00	8.90	7.80	11.00	10.0	0.18	0.99	0.03	1.02	252														
AR-1	01/11/00	8.90	7.90	11.00	2.0	0.14	1.02	0.02	1.04	276														
AR-1	01/19/00	8.40	8.30	11.00	2.0	0.11	1.06	0.02	1.08	275					<40	<4	<10	<20	<2	<0.2	<2	<0.5	20.0	
AR-1	01/24/00	4.40	8.20	12.00	11.0	0.23	0.99	0.02	1.01	304														
AR-1	02/01/00	4.60	8.10	12.00	2.2	0.13	1.03	<0.01	1.03	302														
AR-1	02/07/00	7.20	8.30	13.00	2.0	0.11	0.98	0.02	1.00	337														
AR-1	02/17/00	13.00	8.10	12.00	17.0	0.06	1.01	<0.01	1.02	330														
AR-1	02/22/00	12.00	8.30	12.00	2.0	0.05	0.79	0.02	0.80	346					60.0	<4	<10	<20	2.0	<0.2	<2	<0.5	20.0	
AR-1	03/01/00	11.00	8.50	12.00	2.0	0.12	0.91	<0.01	0.91	294														
AR-1	03/07/00	13.00	8.20	10.00	2.0	0.13	1.05	0.02	1.07	280														
AR-1	03/13/00	14.00	8.10	9.70	2.0	0.16	1.06	0.02	1.08	275					86.0	<4	<10	<20	<2	<0.2	<2	<0.5	54.0	
AR-1	03/22/00	11.00	7.90	11.00	2.0	0.13				223														
AR-1	04/06/00	15.00	7.80	10.00	2.0	0.18	0.81	0.02	0.83	199														
AR-1	04/11/00	15.00	8.00	9.90	2.0	0.08	0.76	0.02	0.79	225					<40	<4	<10	<20	<2	<0.2	<2	<0.5	20.0	
AR-1	04/19/00	18.00	8.00	8.10	2.0	0.07	1.70	0.03	1.73	349														
AR-1	04/27/00	18.00	8.10	7.90	2.0	0.10	0.55	<0.01	0.55	329														
AR-1	05/08/00	24.00	7.60	7.10	2.0	0.14	0.31	0.03	0.34	138	1,005													
AR-1	05/16/00	21.00	8.00	6.50	2.2	0.11	0.37	0.03	0.40	259	23													
AR-1	05/24/00	24.00	7.60	6.70	3.0	0.03	0.48	0.01	0.49	285	82													
AR-1	06/06/00	23.00	7.70	8.00	2.00	0.05	0.49	<0.01	0.50	239	80													
AR-1	06/15/00	24.00	8.00	7.90	2.00	<0.023	0.49	<0.01	0.49	227	109													
AR-1	06/19/00	24.00	7.90	6.40	2.00	0.29	0.52	<0.01	0.52	261	<10				<40	<4	<10	<20	<2	<0.2	<2	<0.5	<20	
AR-1	06/27/00	25.00	7.80	7.40	2.00	0.05	0.40	<0.01	0.40	246	2,000													
AR-1	07/06/00	26.00	7.90	7.30	2.00	0.07	0.50	<0.01	0.50	215	<10													✓
AR-1	07/11/00	27.00	7.70	6.20	2.00	<0.023	0.42	<0.01	0.43	203	90													
AR-1	07/19/00	28.00	7.80	5.30	2.00	0.09	0.27	<0.01	0.29	216	<10				50.00	<4	<10	<20	<2	<0.2	<2	<0.5	<20	
AR-1	07/27/00	27.00	7.90	7.30	7.30	0.07				250	13													
AR-1	08/03/00	27.00	7.50	6.40	2.00	0.09	0.40	0.03	0.43	228	<10													
AR-1	08/07/00	28.00	8.10	6.10	2.00	<0.023	0.30	<0.01	0.32	235	23													
AR-1	08/15/00	27.00	7.90	7.30	2.00	0.06	0.23	<0.01	0.24	239	52													
AR-1	08/23/00	29.10	8.2	9.30	2.7	0.0840	0.121	<0.01	0.121		80				52	<4	<10	<10	<1.0	<0.2	<2	<1	<10	
AR-1	09/07/00	26.00	7.9	8.60	<2	0.0600				251	58													
AR-1	09/11/00	27.20	8.40	9.90	3.7	0.09	0.04	<0.01	0.04	262	33													
AR-1	09/19/00	21.70		11.00	4.1	<0.023	0.029	<0.01	0.0290	258	40				<40	<4	<10	<10	<1.0	<0.2	<2	<1	190.00	
AR-1	09/26/00	19.40	8.10	9.20	<2	<0.023	0.116	<0.01	0.116	248	560													
AR-1	10/02/00	20.50	8.30	9.20	4.0	0.107	0.036	0.0130	0.0490	267														
AR-1	10/10/00	14.80	8.20	9.70	<2	0.210	0.125	<0.01	0.125	260														
AR-1	10/18/00	18.70	7.90	8.80	<2	0.0580	0.269	0.0140	0.283	256					49.00	<4	<10	<10	<1.0	<0.2	<2	<1	45	
AR-1	10/26/00	18.40	7.80	8.10	<4	0.152	0.986	0.0280	1.01	265														
AR-1	11/01/00	19.2	7.9	8.0	<2		0.187	0.0730	0.260	280														
AR-1	11/07/00	15.5	7.9	8.3	<2		0.419	0.0210	0.440	265														
AR-1	11/13/00	12.4	8.0	9.20	<2	0.060	0.66	0.021	0.68	256					<40	<4	<10	10.00	1.00	<0.2	<2	<1	38.00	
AR-1	11/28/00	8.20	8.0	11	<2	0.078	0.91	0.01	0.92	338														
AR-1	12/05/00	7.40	8.0	9.2	<2	0.059	0.92	<0.01	0.92	328														
AR-1	12/20/00	5.40	8.00	10.10	<2	0.11	0.87	<0.01	0.87	274														
AR-1	01/04/01	3.40	7.70		<2	0.05	1.00	0.01	1.00	311														
AR-1	01/11/01	4.10	7.90	8.10	<2	0.14				289														
AR-1	01/17/01	7.40	7.70	8.00	<2	0.12	1.10	0.02	1.10	270					48.00	<4	<10	<10	<1.0	<0.2	<2	<1	10.00	
AR-1	01/23/01	5.80	7.70	7.20	2.00	<0.05	0.89	0.02	0.91	350														

City of Tulsa 2000-2004 Data AR-1																								
AREA	DATE	TEMP	pH	DO	BOD	NH_4	NO_3	NO_2	NO_2+NO_3	HRDNSS	COLIF F	TSS	PO_4	PHENOL	AS	CD	CR	CU	PB	HG	SE	AG	ZN	Kjeldahl
		(°C)	(std.)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(N/100ml)	(mg/l)	(mg/l)	(mg/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)
AR-1	02/05/01	5.60	8.80	12.00	2.70	<0.05	0.65	0.02	0.67	288														
AR-1	02/15/01	4.80	8.50	13.00	2.30	<0.05	0.96	0.03	0.99	345														
AR-1	02/20/01	7.10	8.20	12.10	<2	0.17	1.10	0.04	1.20	323														
AR-1	02/28/01	8.10	7.90	9.40	4.70	0.13	1.40	<0.02	1.40															
AR-1	03/05/01	7.20	8.20	8.50	<2	0.20	1.15	0.04	1.18	258														
AR-1	03/15/01	10.40	7.90	7.80	<2	1.29	<0.02	0.45	0.03	243														
AR-1	03/20/01	9.60	8.20	11.00	<2	0.18	1.50	0.03	1.50	230					<40	<4	<10	<10	<2		<2	<3	21.10	
AR-1	03/28/01	10.00	7.80	7.60	<2	0.22	1.40	0.03	1.40	239														
AR-1	04/02/01	11.70	7.70	8.10	2.40	0.23	1.20	0.03	1.20	347														
AR-1	04/12/01	17.00	8.10	8.60	<2	0.14	1.26	0.04	1.30	272														
AR-1	04/18/01	14.50	8.10	8.30	<2	0.19	1.10	0.03	1.20	290														
AR-1	04/24/01	16.90	8.00	8.40	<2	0.14	1.20	0.03	1.20	173					70	<4	<10	<10	<2	<0.2	<2	<3	<10	
AR-1	05/10/01	21.40	8.10	9.10	<2	<0.05	0.73	0.11	0.83	320	18													
AR-1	05/16/01	22.20	7.70	8.00	<2	0.13	0.66	0.03	0.69	360	19				<40	<4	<10	<10	<2		<2	<3	<10	
AR-1	05/22/01	21.50	8.20	7.40	2.90	0.17	0.45	0.05	0.50	299														
AR-1	06/06/01	23.70	8.10	7.20	<2	<0.05	0.79	0.03	0.82	219	<1													
AR-1	06/11/01	27.40	7.80	7.10	<2	<0.05	0.79	0.02	0.81	189					<40	<4	<10	<10	<2	<0.2	4.40	<3	16.10	
AR-1	06/19/01	27.10	8.00	7.80	<2	0.09	0.84	0.02	0.84		32													
AR-1	06/25/01	26.60	7.30	6.90	<2	0.11	0.77	0.02	0.77	235														
AR-1	07/02/01	26.80	7.90	6.70	<2	0.57	0.72	0.02	0.75	264	<1				<40	<4	<10	14.50	<2	0.06	<2	<3	53.50	
AR-1	07/10/01	28.10	8.20	6.50	2.10	0.16	0.66	<0.02	0.66	244	13													
AR-1	07/18/01	28.30	8.00	6.30	<2	0.25	0.40	0.02	0.42	234	8													
AR-1	07/26/01	29.50	8.30	9.30	4.60	<0.05	0.14	<0.02	0.15	250	47													
AR-1	08/01/01	28.90	7.80	8.10	<2	0.09	0.24	0.03	0.27	233	69				<40	<4	<10	10.00	<2		<2	<3	<10	
AR-1	08/09/01	28.60	7.90	6.70	2.10	0.18	0.21	<0.02	0.21	237	100													
AR-1	08/14/01	24.50	7.60	7.10	2.40	0.07	0.09	<0.02	0.11	240	58													
AR-1	08/23/01	26.30	7.90	7.20	<2	0.25	0.21	0.03	0.23	240	144													
AR-1	09/05/01	27.20	8.10	6.60	2.00	0.09	0.10	0.02	0.12	243	2,000				<40	<4	<10	15.10	5.60	<0.2	<2	<3	14.30	
AR-1	09/19/01	23.00	8.00	6.60	<2	<0.05	0.41	<0.02	0.42	230	82													
AR-1	10/01/01	20.60	8.30	8.60	<2	0.05	0.42	<0.02	0.43	236	29					<4		10.00	<2				214.00	
AR-1	11/05/01	18.10	8.00	8.90	<2	0.27	0.79	<0.02	0.80	192	646					<4		10.00	<2				51.00	
AR-1	12/03/01	13.20	8.30	10.00	<2	0.18	0.94	<0.02	0.95		206					<4		10.00	<2	<0.2			21.00	
AR-1	01/07/02	5.00	8.50	NR	2.20	0.11	0.93	0.04	0.96	240	75					<4		10.00	<2				<10	0.72
AR-1	01/28/02	14.00	8.00	10.00																				
AR-1	02/04/02	6.50	8.40	12.00	<2	0.12	0.57	<0.02	0.59	253	60					<4		10.00	<2				36.00	0.63
AR-1	03/08/02	15.00	8.20	10.00	<2	0.14	0.52	<0.02	0.54	270	44					<4		5.00	<2				20.00	0.66
AR-1	04/15/02	21.50	8.40	7.60	2.50	0.09	0.27	0.02	0.3	280	208					4.10		5.00	<2				46.00	0.72
AR-1	05/13/02	20.20	7.69	7.52	2.10	0.14	2.38	0.05	2.44	290	26					4.50		5.00	<2				93.00	3.00
AR-1	06/04/02	22.70	7.70	6.70	<2	0.09	0.40	0.02	0.42	250	63					<4		5.00	<2				<10	0.63
AR-1	07/03/02	25.90	8.22	4.76	<2	0.25	0.74	<0.02	0.75	180	<1					<4		5.00	<2				20.00	0.64
AR-1	08/01/02	28.10	8.00	6.90	2.00	0.11	0.22	0.02	0.24	190	13					<4		5.00	<2				24.00	0.79
AR-1	09/05/02	27.60	8.00	6.60	<2	0.10	0.47	0.02	0.48	160	38					<4		5.00	<2				29.00	0.55
AR-1	10/03/02	22.70	7.45	6.74	<2	<0.03	1.05	<0.02	1.07	148	81					<4		5.00	2.26				47.00	0.64
AR-1	11/04/02	11.30	7.60	9.80	<2	<0.03	1.22	<0.02	1.23	180	651					<4		6.20	<2				49.00	0.57
AR-1	12/02/02	10.10	8.11	12.39	<2	0.17	1.23	0.07	1.30	290	290					<4		7.20	<2				27.00	0.41
AR-1	01/06/03	6.50	8.27	10.96	2.30	0.14	1.02	1.10	1.10	320	113					<1		5.00	<2				40.00	1.15
AR-1	02/05/03	5.10	8.40	11.10	<2	<0.04	0.84	0.09	0.93	380	189		0.11			<1		6.30	<2	<0.2			<10	0.74
AR-1	03/05/03	3.70	8.52	11.09	<2	<0.04	0.43	<0.01	0.43	380	19		<0.02			<1		5.40	<2				<10	0.76

City of Tulsa 2000-2004 Data AR-1																								
AREA	DATE	TEMP	pH	DO	BOD	NH_4	NO_3	NO_2	NO_2+NO_3	HRDNSS	COLIF F	TSS	PO_4	PHENOL	AS	CD	CR	CU	PB	HG	SE	AG	ZN	Kjeldahl
		(°C)	(std.)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(N/100ml)	(mg/l)	(mg/l)	(mg/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)
AR-1	04/02/03	15.00	8.00	7.80	<2	0.22	0.73	<0.01	0.74	280.00	22.00		0.21			<1		5.70	<2	<0.2			120.00	1.32
AR-1	05/05/03	20.00	8.20	6.80	<2	0.09	0.09	0.09	0.95	250	2		0.14			<1		6.60	<2				150.00	1.22
AR-1	06/02/03	23.00	7.70	5.90	<2	<0.04	0.92	<0.01	0.92	230	550		0.17			1.40		5.00	<2				120.00	1.96
AR-1	07/02/03	26.00	7.90	6.60	<2	0.05	0.53	<0.01	0.53	250	25		0.14			<1		5.00	<2				160.00	0.60
AR-1	08/04/03	26.00	7.90	5.80	2.00	0.12	0.23	0.02	0.26	220.00	78.00		0.12			1.00		5.20	2.18				160.00	0.44
AR-1	09/04/03	25.00	7.80	6.70	2.00	0.08	0.11	0.04	0.16	200.00	7000.00		0.12			1.00		5.00	2.00				0.13	0.70
AR-1	10/06/03	19.00	7.70	7.90	2.00	0.22	0.61	0.03	0.63	200	874		0.12			1.50		5.60	2.00				240.00	0.55
AR-1	11/04/03	19.00	7.50	8.60	2.40	0.12	1.01	0.02	1.03	180	118		0.13			1.00			2.00		<2	<2	120.00	
AR-1	12/03/03	9.30	7.20	11.00	2.00	0.11	0.95	0.02	0.98	190	36		0.13			1.50		5.00	2.00				18.00	<0.28
AR-1	01/05/04	4.20	8.00	10.00	2.00	0.24	0.76	0.01	0.78	230	513		0.23			1.00		5.60	5.30				150.00	0.91
AR-1	02/03/04	4.10	8.20	9.50	2.10	0.08	0.70	0.01	0.71	230	560		0.10			2.20		5.00	2.00				210.00	0.67
AR-1	03/03/04	8.30	8.20	8.10	2.90	0.09	0.94	0.01	0.96	230	213		0.12			2.20		5.00	3.07				45.00	1.01
AR-1	04/05/04	16.00	7.80	7.70	2.00	0.19	0.73	0.05	0.78	250	38		0.15			1.00		5.00	2.00				<10	0.75
AR-1	04/19/04	17.00	7.90	6.60																				
AR-1	05/03/04	17.00	7.80	6.30	2.00	<0.038			0.85	180	6		0.19			3.80		5.00	2.00				21.00	0.68
AR-1	06/07/04	25.00	8.30	7.70	2.00	<0.04			0.47	230	570		0.13			1.00		5.00	2.00				17.00	0.54
AR-1	07/01/04	23.00	7.70	5.80	2.00	<0.042			0.87	190	22		0.15			2.00		23.00	2.00				43.00	0.97
AR-1	08/02/04	25.00	7.80	6.60	2.00	<0.044			0.77	200	19		0.20			2.50		6.90	2.00				24.00	0.50
AR-1	09/01/04	22.00	7.80	6.20		0.11			0.75	160	75		0.18			1.30		5.00	2.00				25.00	0.58
AR-1	09/08/04	23.00	8.10	7.90	2.00																			
AR-1	10/06/04	20.00	8.20	8.30	2.00	<0.04			0.57	200	260		0.13			1.00		5.00	2.00				<10	0.57
AR-1	11/04/04	16.00	8.00	9.90	2.00	0.84			0.61	210	773		0.13			1.20		5.00	2.00				14.00	0.53
AR-1	12/06/04	11.00	7.80	11.00	2.00	0.23			0.90	250	1,650		0.22			1.00		5.00	2.00				99.00	0.78
	Avg. 2000	18.47	7.99	9.06	3.33	0.108	0.69	0.024	0.71	261.66	283.20				59.40	<4.0	<10.0	10.00	1.50	<0.20	<2.0	<1.0	55.90	
	Avg. 2001	17.68	8.00	8.29	2.74	0.21	0.77	0.05	0.77	263.42	231.40				59.00	<4	<10.0	14.80	5.60	0.06	4.40	<3.0	50.13	
	Avg. 2002	17.74	8.02	8.42	2.20	0.13	0.83	0.03	0.86	227.58	140.82					4.30		6.70	2.26				39.10	0.83
	Avg. 2003	16.47	7.92	8.35	2.08	0.126	0.04	0.18	0.72	256.67	752.17		0.14			1.23		5.60	2.04	<0.20			112.81	0.86
	Avg. 2004	16.54	7.97	7.97	2.08	0.25	0.78	0.02	0.75	213.33	391.58		0.16			1.68		6.70	2.36				64.80	0.71

City of Tulsa 2000-2004 Data AR-3																							
AREA	DATE	TEMP	pH	DO	BOD	NH_4	NO_3	$N0_2$	NO_2+NO_3	HRDNSS	COLIF F	TSS	PO_4	PHENOL	AS	CD	CR	CU	PB	HG	SE	AG	ZN
		(^{0}C)	(std.)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(N/100ml)	(mg/l)	(mg/l)	(mg/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)
AR-3	1/3/2000	10.00	7.50	10.00																			
AR-3	1/11/2000	10.00	8.00	11.00																			
AR-3	1/19/2000	9.00	8.00	12.00											<40	<4	<10	<20	<2	<0.2	<2	<0.5	<20
AR-3	1/24/2000	5.20	8.20	12.00																			
AR-3	2/1/2000	3.50	8.00	13.00																			
AR-3	2/7/2000	9.70	7.90	16.00																			
AR-3	2/17/2000	8.50	7.70	12.00															<2		<2	<0.5	<20
AR-3	2/22/2000	14.00	8.10	18.00																			
AR-3	3/1/2000	11.00	8.50	12.00										<10									
AR-3	3/7/2000	13.00	8.30	11.00																			
AR-3	4/11/2000	16.00	7.70	8.70																			
AR-3	4/19/2000	21.00	8.10	8.50																			
AR-3	4/27/2000	18.00	8.20	8.00																			
AR-3	5/8/2000	25.00	8.10	8.10							200												
AR-3	5/16/2000	20.00	8.00	7.60							891			<10		<4	<10	<20	<2	<0.2	<2	<0.5	<20
AR-3	5/24/2000	26.00	7.90	6.90							95												
AR-3	6/6/2000	23.00	7.90	8.60							214												
AR-3	6/15/2000	24.00	8.00	7.00							210												
AR-3	6/19/2000	24.00	8.00	6.70							3,000												
AR-3	6/27/2000	24.00	7.40	7.60							4,000												
AR-3	7/6/2000	27.00	8.00	7.10							34												
AR-3	7/11/2000	27.00	7.80	6.20							1,880												
AR-3	7/19/2000	29.00	7.80	5.20							560			<10						0.20	2.00	0.50	20.00
AR-3	7/27/2000	26.00	8.00	8.40							600												
AR-3	8/3/2000	27.00	7.90	8.40							31												
AR-3	8/7/2000	30.00	8.20	6.70							24												
AR-3	8/15/2000	28.00	7.90	7.60							51												
AR-3	8/23/2000	30.40	8.20	8.70							83			<5	<50	<4	<10	<10	<1	<0.2	<2	<1	15.00
AR-3	9/7/2000	26.00	7.40	10.4							390												
AR-3	9/11/2000	26.70	7.80	10.5							173												
AR-3	9/19/2000	21.70	7.40	11.4							28												
AR-3	9/26/2000	18.70	7.50	10.3							20,000												
AR-3	10/2/2000	19.70	8.00	9.80																			
AR-3	10/10/2000	12.90	8.20	11.2																			
AR-3	11/1/2000	20.0	8.0	8.60																			
AR-3	11/13/2000	10.3	8.2	10.6											<40	<4	<10	<11	1.1	<0.2	<2	<1	12
AR-3	11/28/2000	10.3	7.4	13.4																			
AR-3	11/7/2000	14.6	8.1	9.30																			
AR-3	12/5/2000	9.20	7.90	9.41																			
AR-3	12/20/2000	4.10	8.10	9.80											<40	<4	<10	<10	<1	<0.2	<2	<1	17
AR-3	1/4/2001	4.90	7.60																				
AR-3	1/11/2001	5.40	7.90	8.00																			
AR-3	1/17/2001	7.00	7.70	7.70																			
AR-3	1/23/2001	5.40	7.70	8.40																			
AR-3	2/5/2001	8.00	8.60	12.60																			
AR-3	2/15/2001	4.00	8.50	12.60																			
AR-3	2/20/2001	7.00	8.50	12.60																			
AR-3	2/28/2001	7.40	8.20	9.20																			
AR-3	3/5/2001	8.00	8.00	9.20																			
AR-3	3/15/2001	9.70	8.00	8.20																			

City of Tulsa 2000-2004 Data AR-3																							
AREA	DATE	TEMP	pH	DO	BOD	NH_4	NO_3	NO_2	NO_2+NO_3	HRDNSS	COLIF F	TSS	PO_4	PHENOL	AS	CD	CR	CU	PB	HG	SE	AG	ZN
		(°C)	(std.)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(N/100ml)	(mg/l)	(mg/l)	(mg/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)
AR-3	3/20/2001	10.10	8.30	11.40																			
AR-3	3/28/2001	9.70	7.70	8.00																			
AR-3	4/2/2001	12.90	8.00	7.20																			
AR-3	4/12/2001	17.40	8.20	10.60																			
AR-3	4/18/2001	16.30	7.80	8.55																			
AR-3	4/24/2001	16.90	7.40	9.53																			
AR-3	5/10/2001	23.30	7.50	8.01							45,000												
AR-3	5/16/2001	22.30	7.90	7.70							938				<40	<4	<10	<10	<2		<2	<3	<10
AR-3	5/22/2001	22.70	8.10	7.05							780												
AR-3	6/6/2001	23.00		7.05							3,000												
AR-3	6/11/2001	27.40	8.20	9.44							65				<40	<4	<10	<10	<2	<0.2	<3.5	<3	11.90
AR-3	6/19/2001	26.40	8.00	7.75							560												
AR-3	6/25/2001	26.40	7.80	9.21							227												
AR-3	7/2/2001	27.10	7.80	8.93							1,570												
AR-3	7/10/2001	28.80	8.10	9.22							210												
AR-3	7/18/2001	29.00	7.90	10.10							447												
AR-3	7/26/2001	32.00	7.50	8.52							53												
AR-3	8/1/2001	29.70	7.60	6.08						258	1,160				<40	<4	<10	<10	<2		<2	<3	<10
AR-3	8/9/2001	28.90	7.60	8.46							12,300												
AR-3	8/15/2001	26.80	8.10	10.80							125												
AR-3	9/5/2001	27.20	7.90	10.00																			
AR-3	9/19/2001	22.90	8.00	7.40							580												
AR-3	10/1/2001	20.50	8.20	6.60							440												
AR-3	10/22/2001	18.70	8.20	1.00							163												
AR-3	11/5/2001	18.40	8.70	19.10							520					<4		<10	<2				21.00
AR-3	11/26/2001	13.50	9.10	17.40							214												
AR-3	12/3/2001	14.60	7.40	14.40							192												
AR-3	12/18/2001	14.60	7.60	11.40							260												
AR-3	1/7/2002	8.20	7.70	NR							1,080												
AR-3	1/28/2002	15.3	9.5	12.8							15												
AR-3	2/4/2002	8.70	8.50	13.50						250	60			<5		<4		<1	<2	<0.2	<2	<2	30.00
AR-3	2/18/2002	13.10	9.00	10.30																			
AR-3	3/8/2002	16.00	8.80	16.00							22												
AR-3	3/28/2002	17.20	8.70	16.00						100													
AR-3	4/15/2002	23.50	9.00	12.50							16												
AR-3	4/29/2002	16.70	8.00	8.60							224												
AR-3	5/13/2002	23.50	7.91	10.57						290	490			<5	<2	<4		<5	<2		<2	<2	16.00
AR-3	5/28/2002	18.30	7.93	8.27							11,000												
AR-3	6/4/2002	26.90	7.90	8.10																			
AR-3	6/18/2002	23.20	8.00	7.80							420												
AR-3	7/3/2002	26.50	8.28	7.73							1,580												
AR-3	7/17/2002	25.90	7.50	6.30							960												
AR-3	8/1/2002	29.30	8.00	10.00							2,600			<5		<4		<5	<2		<2	<2	11.00
AR-3	8/15/2002	25.80	7.60	7.40							2,200												
AR-3	9/5/2002	30.00	8.20	11.40							164												
AR-3	9/19/2002	24.50	7.81	NR							270												
AR-3	10/3/2002	23.80	7.49	7.59							800												
AR-3	10/17/2002	14.90	7.56	8.79							31												
AR-3	11/4/2002	11.60	7.70	10.20						180	593			<5		<4		<20	<2		<2	<5	71.00
AR-3	11/18/2002	13.20	8.19	12.57							200												

City of Tulsa 2000-2004 Data AR-3																							
AREA	DATE	TEMP	pH	DO	BOD	NH_4	NO_3	NO_2	NO_2+NO_3	HRDNSS	COLIF F	TSS	PO_4	PHENOL	AS	CD	CR	CU	PB	HG	SE	AG	ZN
		(^{0}C)	(std.)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(N/100ml)	(mg/l)	(mg/l)	(mg/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)
AR-3	12/2/2002	10.30	8.58	14.75							26												
AR-3	12/16/2002	11.50	7.94	14.48							120												
AR-3	1/6/2003	7.60	7.61	12.13							78												
AR-3	1/22/2003	3.30	8.44	14.83							130												
AR-3	2/5/2003	6.20	8.50	10.00	1.00					370	10		0.09	<5		<1		6.70	<2	<0.2	<2	<2	<10
AR-3	2/19/2003	10.70	8.80	14.40							250		0.10										
AR-3	3/5/2003	4.20	8.57	12.93							260		0.02										
AR-3	3/19/2003	11.90	8.20	7.95							2,800		0.47										
AR-3	4/2/2003	16.00	8.00	7.60							120		0.24										
AR-3	4/16/2003	15.80	8.00	8.30							6,550		0.18										
AR-3	5/5/2003	20.00	8.00	6.70						240	100		0.14	<5					<2		<2	<2	140.00
AR-3	5/19/2003	25.30	8.10	8.06							7,450		0.11										
AR-3	6/2/2003	21.00	7.70	6.60							2,400		0.50										
AR-3	6/16/2003	27.00	8.00	6.20							667		0.23										
AR-3	7/2/2003	27.00	7.60	8.40							400		0.13										
AR-3	7/17/2003	27.00	8.00	6.50							440		0.14										
AR-3	8/4/2003	26.00	7.60	6.20						200	636		0.15			<1		<5	<2		<2	<2	180
AR-3	8/20/2003	29.00	8.00	8.20						455			0.11										
AR-3	9/4/2003	25.00	7.70	7.00						5000			0.14										
AR-3	9/22/2003	25.00	7.90	10.00						919			0.12										
AR-3	10/6/2003	19.00	8.40	14.00						1200			0.05										
AR-3	10/20/2003	21.00	7.30	8.00						330			0.16										
AR-3	11/4/2003	21.00	7.60	9.00						230	193		0.12						<2		<2	<2	<10
AR-3	11/18/2003	12.00	7.50	10.00							56000		0.1										
AR-3	12/3/2003										15500		0.12										
AR-3	1/5/2004	4.10	8.40	14.00																			
AR-3	1/20/2004	5.50	8.20	7.60																			
AR-3	2/3/2004	6.20	8.30	10.00																			
AR-3	2/17/2004	7.00	8.30	11.00																			
AR-3	3/3/2004	11.00	7.50	9.30																			
AR-3	3/17/2004	12.00	7.70	7.50																			
AR-3	4/5/2004	15.00	8.00	7.60																			
AR-3	4/19/2004	17.00	8.20	7.40																			
AR-3	5/3/2004	17.00	8.00	7.70							520												
AR-3	5/17/2004	22.00	7.80	6.10							11,400												
AR-3	6/7/2004	25.00	7.50	7.50							280												
AR-3	6/24/2004	24.00	7.80	5.10							600												
AR-3	7/1/2004	25.00	7.80	6.00							80												
AR-3	7/19/2004	26.00	7.40	7.20							325												
AR-3	8/2/2004	25.00	7.80	6.80							109												
AR-3	8/16/2004	25.00	7.90	7.70							1,540												
AR-3	9/1/2004	24.00	7.50	6.30							200												
AR-3	9/22/2004	25.00	7.80	9.60							91												
AR-3	10/6/2004	21.00	8.20	11.00							240												
AR-3	10/21/2004	23.00	8.00	8.60																			
AR-3	11/4/2004	17.00	8.00	14.00																			
AR-3	11/18/2004	16.00	8.00	11.00																			
AR-3	12/6/2004	12.00	7.90	12.00																			
AR-3	12/20/2004	6.90	8.10	15.00																			

City of Tulsa 2000-2004 Data AR-3																							
AREA	DATE	TEMP	pH	DO	BOD	NH_4	NO_3	$N0_2$	NO_2+NO_3	HRDNSS	COLIF F	TSS	PO_4	PHENOL	AS	CD	CR	CU	PB	HG	SE	AG	ZN
		(^{0}C)	(std.)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(N/100ml)	(mg/l)	(mg/l)	(mg/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)
	Avg. 2000	18.84	7.93	9.43							2119.33			<10	50.00	<4.0	10.00	11.00	1.10	<.2	<2	<1	16.00
	Avg. 2001	17.74	7.98	9.44						258.00	3276.38				<40	<4	<10	<10	<2	<.2	3.50	<3	16.45
	Avg. 2002	19.08	8.16	10.71						205.00	1089.10			<5	<2	<4		<20	<2		<2	<5	32.00
	Avg. 2003	18.23	7.98	9.23	1.00					993.78	5221.33		0.16	<5		<1		6.70	<2	<.2	<2	<2	160.00
	Avg. 2004	17.94	7.91	8.48							1398.64												

City of Tulsa 2000-2004 Data AR-4

AREA	DATE	TEMP	pH	DO	BOD	NH_4	NO_3	NO_2	NO_2+NO_3	HRDNSS	COLIF F	TSS	PO_4	PHENOL	AS	CD	CR	CU	Pb	HG	SE	AG	ZN
		(°C)	(std.)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(N/100ml)	(mg/l)	(mg/l)		(ug/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)
AR-4	1/3/2000	9.20	7.80	11.00																			
AR-4	1/11/2000	9.20	7.70	12.00																			
AR-4	1/19/2000	8.50	8.00	11.00																			
AR-4	1/24/2000	4.80	8.10	13.00																			
AR-4	2/1/2000	4.20	8.10	13.00																			
AR-4	2/7/2000	9.30	8.10	15.00																			
AR-4	2/17/2000	8.30	8.00	12.00																			
AR-4	2/22/2000	13.00	8.00	15.00																			
AR-4	3/1/2000	11.00	8.40	12.00																			
AR-4	3/7/2000	13.00	8.20	10.00																			
AR-4	4/11/2000	15.00	7.90	9.80																			
AR-4	4/19/2000	19.00	8.00	8.50																			
AR-4	4/27/2000	18.00	8.10	9.00																			
AR-4	5/8/2000	24.00	7.40	7.30							927												
AR-4	5/16/2000	20.00	8.00	7.80							709												
AR-4	5/24/2000	25.00	7.80	7.20							280												
AR-4	6/6/2000	23.00	7.60	7.60							89												
AR-4	6/15/2000	25.00	7.80	7.40							691												
AR-4	6/19/2000	24.00	7.90	6.60							27												
AR-4	6/27/2000	25.00	7.50	6.40							605												
AR-4	7/6/2000	27.00	7.90	7.10							10												
AR-4	7/11/2000	26.00	7.80	6.30							490												
AR-4	7/19/2000	28.00	7.90	5.20							300												
AR-4	7/27/2000	26.00	8.00	7.70							4,000												
AR-4	8/3/2000	27.00	7.80	8.30							1,120												
AR-4	8/7/2000	28.00	8.10	6.80							290												
AR-4	8/15/2000	29.00	8.00	7.90							627												
AR-4	8/23/2000	27.80	8.30	8.90							500												
AR-4	9/7/2000	25.70	8.00	9.18							430												
AR-4	9/11/2000	27.10	7.90	10.4							45												
AR-4	9/19/2000	21.00	8.00	10.9							36												
AR-4	9/26/2000	18.70	8.10	9.00							370												
AR-4	10/2/2000	20.00	8.30	9.40																			
AR-4	10/10/2000	13.60	8.30	10.8																			
AR-4	11/7/2000	14.4	8.1	9.30																			
AR-4	11/13/2000	11.1	8.3	10.4																			
AR-4	11/28/2000	8.90	8.1	11.7																			
AR-4	12/5/2000	7.70	8.00	8.22																			
AR-4	12/20/2000	5.90	8.10	7.90																			
AR-4	1/4/2001	3.60	7.60																				
AR-4	1/11/2001	4.60	7.90	7.70																			
AR-4	1/17/2001	7.70	7.60	8.40																			
AR-4	1/23/2001	6.10	7.70	8.90																			
AR-4	2/5/2001	5.50	8.90	12.20																			

City of Tulsa 2000-2004 Data AR-4																							
AREA	DATE	TEMP	pH	DO	BOD	NH_4	NO_3	NO_2	NO_2+NO_3	HRDNSS	COLIF F	TSS	PO_4	PHENOL	AS	CD	CR	CU	Pb	HG	SE	AG	ZN
		(°C)	(std.)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(N/100ml)	(mg/l)	(mg/l)		(ug/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)
AR-4	2/15/2001	4.10	8.60	13.20																			
AR-4	2/20/2001	7.10	8.50	12.40																			
AR-4	2/28/2001	7.20	8.20	8.70																			
AR-4	3/5/2001	7.30	8.10	9.00																			
AR-4	3/15/2001	9.60	7.90	8.70																			
AR-4	3/20/2001	10.00	8.30	10.20																			
AR-4	3/28/2001	10.10	7.90	8.20																			
AR-4	4/2/2001	12.00	7.70	8.00																			
AR-4	4/12/2001	15.50	7.70	10.70																			
AR-4	4/18/2001	15.30	7.90	9.41																			
AR-4	4/24/2001	17.40	7.80	9.81																			
AR-4	5/10/2001	22.90	8.00	8.05							171												
AR-4	5/16/2001	23.90	7.90	7.30							157												
AR-4	5/22/2001	22.00	8.20	7.22							407												
AR-4	6/6/2001	24.80	8.10	7.40							1,450												
AR-4	6/11/2001	26.50	7.90	7.64							32												
AR-4	6/19/2001	25.90	8.00	7.43							220												
AR-4	6/25/2001	26.20	7.80	8.01							20												
AR-4	7/2/2001	26.90	8.00	8.24							413												
AR-4	7/10/2001	28.80	8.20	8.71							119												
AR-4	7/18/2001	28.70	8.00	8.14							160												
AR-4	7/26/2001	30.50	7.70	8.68							107												
AR-4	8/1/2001	28.20	7.70	6.25						243	2,000												
AR-4	8/9/2001	28.40	7.70	6.72							5,100												
AR-4	8/15/2001	27.30	8.50	8.88							94												
AR-4	8/23/2001	25.70	8.30	8.10							400												
AR-4	9/5/2001	27.40	8.20	8.10							94												
AR-4	9/19/2001	23.90	8.00	6.60																			
AR-4	10/01/2001	21.60	8.30	6.60							200												
AR-4	10/22/2001	18.90	8.30	1.00							144												
AR-4	11/05/2001	19.80	7.90	8.35							1,610												
AR-4	11/26/2001	14.40	8.50	12.00							2,800												
AR-4	12/03/2001	14.00	8.30	9.70							4,000												
AR-4	12/18/2001	11.90	8.30	11.50							627												
AR-4	1/7/2002	3.10	7.90	NR							81												
AR-4	1/28/2002	12.70	8.70	13.90							29												
AR-4	2/4/2002	7.00	8.50	13.30							24												
AR-4	2/18/2002	8.80	8.50	7.60							2												
AR-4	3/8/2002	15.20	7.00	10.30																			
AR-4	3/28/2002	15.50	8.50	11.00							99												
AR-4	4/15/2002	22.20	8.40	8.50							580												

City of Tulsa 2000-2004 Data AR-4

AREA	DATE	TEMP	pH	DO	BOD	NH_4	NO_3	NO_2	NO_2+NO_3	HRDNSS	COLIF F	TSS	PO_4	PHENOL	AS	CD	CR	CU	Pb	HG	SE	AG	ZN
		(°C)	(std.)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(N/100ml)	(mg/l)	(mg/l)		(ug/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)
AR-4	4/29/2002	18.00	8.30	8.40							36												
AR-4	5/13/2002	21.10	7.29	9.26							470												
AR-4	5/28/2002	18.30	7.44	8.06							20,000												
AR-4	6/4/2002	24.70	7.90	7.30							148												
AR-4	6/18/2002	22.60	8.10	7.60							450												
AR-4	7/3/2002	26.30	8.29	7.01							400												
AR-4	7/17/2002	25.50	7.90	6.90							233												
AR-4	8/1/2002	28.60	8.30	8.80							63												
AR-4	8/15/2002	26.30	8.30	7.40							367												
AR-4	9/5/2002	28.60	8.00	7.30							40												
AR-4	9/19/2002	25.30	8.20	NA							720												
AR-4	10/3/2002	24.10	7.95	6.98							93												
AR-4	10/17/2002	15.60	7.68	9.23							75												
AR-4	11/4/2002	11.80	7.70	10.40							530												
AR-4	11/18/2002	13.00	8.05	10.84							373												
AR-4	12/2/2002	11.50	7.55	13.51							94												
AR-4	12/16/2002	12.20	7.51	13.62							88												
AR-4	1/6/2003	7.30	7.72	12.55							50												
AR-4	1/22/2003	3.10	8.74	11.95							255												
AR-4	2/5/2003	6.30	8.30	11.30							420												
AR-4	2/19/2003	8.70	8.80	12.30							NR		0.12										
AR-4	3/5/2003	4.30	8.58	11.32							240		0.02										
AR-4	3/19/2003	11.90	8.20	8.17							5,500		0.36										
AR-4	4/2/2003	15.00	8.00	7.70							160		0.24										
AR-4	4/16/2004	15.70	8.20	8.20							3,700		0.16										
AR-4	5/5/2003	20.00	8.00	6.60							84		0.14										
AR-4	5/19/2003	24.80	8.00	8.10							2,700		0.35										
AR-4	6/2/2003	22.00	7.80	6.60							3,700		0.14										
AR-4	6/16/2003	26.00	7.80	5.50							621		0.14										
AR-4	7/2/2003	26.00	8.00	7.70							50		0.16										
AR-4	7/17/2003	27.00	8.10	6.80							14		0.14										
AR-4	8/4/2003	26.00	8.00	6.8							127		0.13										
AR-4	8/20/2003	28.00	8.00	6.8							96		0.13										
AR-4	9/4/2003	24.00	7.80	7.2							2,600		0.10										
AR-4	9/22/2003	24.00	8.00	8.6							818		0.13										
AR-4	10/6/2003	20.00	8.00	8.50							2,700		0.48										
AR-4	10/20/2003	20.00	7.50	7.70							75		0.15										
AR-4	11/4/2003	21.00	7.80	9.10							124		0.13										
AR-4	11/18/2003	15.00	8.00	9.20							581		0.00										
AR-4	12/3/2003										11,400		0.11										
AR-4	1/5/2004	3.90	8.20	12.00																			
AR-4	1/20/2004	4.10	8.30	10.00																			
AR-4	2/3/2004	5.20	8.30	10.00																			

City of Tulsa 2000-2004 Data AR-4																							
AREA	DATE	TEMP	pH	DO	BOD	NH_4	NO_3	NO_2	NO_2+NO_3	HRDNSS	COLIF F	TSS	PO_4	PHENOL	AS	CD	CR	CU	Pb	HG	SE	AG	ZN
		(°C)	(std.)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(N/100ml)	(mg/l)	(mg/l)		(ug/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)
AR-4	2/17/2004	7.50	8.30	10.00																			
AR-4	3/3/2004	9.90	8.00	8.40																			
AR-4	3/17/2004	11.00	7.80	8.40																			
AR-4	4/5/2004	16.00	8.00	7.20																			
AR-4	4/19/2004	18.00	8.10	7.40																			
AR-4	5/3/2004	17.00	7.90	7.00							410												
AR-4	5/17/2004	22.00	7.60	6.50							440												
AR-4	6/7/2004	23.00	7.70	7.30							162												
AR-4	6/24/2004	24.00	8.00	5.30							119												
AR-4	7/1/2004	22.00	7.50	6.00							58												
AR-4	7/19/2004	26.00	7.20	7.40							152												
AR-4	8/2/2004	25.00	7.80	6.60							127												
AR-4	8/16/2004	25.00	7.90	7.50							1,320												
AR-4	9/1/2004	24.00	7.70	6.40							200												
AR-4	9/22/2004	23.00	8.00	7.50							127												
AR-4	10/6/2004	20.00	8.40	10.00							260												
AR-4	10/21/2004	21.00	8.10	7.90																			
AR-4	11/4/2004	15.00	8.20	11.00																			
AR-4	11/18/2004	17.00	8.10	10.00																			
AR-4	12/6/2004	12.00	7.60	14.00																			
AR-4	12/20/2004	5.60	8.10	15.00																			
	Avg.2000	18.53	7.97	9.21							726.07												
	Avg.2001	17.74	8.05	8.58						243.00	923.86												
	Avg.2002	18.25	8.00	9.42							1086.74												
	Avg.2003	18.00	8.06	8.85							1637.05		0.17										
	Avg.2004	16.55	7.95	8.70							306.82												

City of Tulsa 2000-2004 Data AR-6																								
AREA	DATE	TEMP	pH	DO	BOD	NH_4	NO_3	NO_2	NO_2+NO_3	HRDNSS	COLIF F	TSS	PO_4	PHENOL	AS	CD	CR	CU	PB	HG	SE	AG	ZN	Kjeldahl
		(^0C)	(std.)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(N/100ml)	(mg/l)	(mg/l)	(mg/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)	(mg/l)
AR-6	1/3/2000	9.30	7.90	11.00																				
AR-6	1/11/2000	8.70	8.00	11.00																				
AR-6	1/19/2000	8.10	8.00	11.00																				
AR-6	1/24/2000	4.60	8.30	12.00																				
AR-6	2/1/2000	5.40	8.00	13.00																				
AR-6	2/7/2000	8.50	7.90	13.00																				
AR-6	2/17/2000	8.10	8.20	11.00																				
AR-6	2/22/2000	13.00	8.00	11.00																				
AR-6	3/1/2000	10.00	8.30	12.00																				
AR-6	3/7/2000	13.00	8.10	10.00																				
AR-6	4/11/2000	16.00	8.00	9.10																				
AR-6	4/19/2000	22.00	8.00	8.00																				
AR-6	4/27/2000	19.00	8.20	9.10																				
AR-6	5/8/2000	23.00	7.50	6.80							809													
AR-6	5/16/2000	20.00	7.80	7.50							736													
AR-6	5/24/2000	26.00	8.00	7.20							100													
AR-6	6/6/2000	23.00	7.80	8.00							680													
AR-6	6/15/2000	24.00	7.70	7.60							727													
AR-6	6/19/2000	25.00	8.00	6.70							480													
AR-6	6/27/2000	24.00	8.00	6.90							1,300													
AR-6	7/6/2000	27.00	8.10	6.80							206													
AR-6	7/11/2000	28.00	7.80	6.30							90													
AR-6	7/19/2000	29.00	8.00	5.80							35													
AR-6	7/27/2000	24.00	8.10	8.40							4,000													
AR-6	8/3/2000	28.00	8.10	8.90							650													
AR-6	8/7/2000	28.00	8.10	6.70							470													
AR-6	8/15/2000	28.00	8.20	8.10							493													
AR-6	8/23/2000	27.40	8.00	7.50	3.6						88				46									
AR-6	9/7/2000	13.70	8.20	9.40							400													
AR-6	9/11/2000	28.00	8.40	10.0							164													
AR-6	9/19/2000	23.00	8.30	10.7																				
AR-6	9/26/2000	19.00	8.10	9.40							220													
AR-6	10/2/2000	22.70	8.50	9.50																				
AR-6	10/10/2000	13.20	8.40	11.00																				
AR-6	11/7/2000	13.5	8.2	9.40																				
AR-6	11/13/2000	9.70	8.3	10.8																				
AR-6	11/28/2000	8.70	8.2	11.4																				
AR-6	12/5/2000	8.30	8.10	7.95																				
AR-6	12/20/2000	5.20	8.00	9.40																				
AR-6	1/4/2001	3.40	7.80																					
AR-6	1/11/2001	5.00	7.80	8.40																				
AR-6	1/17/2001	6.80	7.80	7.50																				
AR-6	1/23/2001	5.90	7.90	8.60																				

City of Tulsa 2000-2004 Data AR-6																								
AREA	DATE	TEMP	pH	DO	BOD	NH_4	NO_3	NO_2	NO_2+NO_3	HRDNSS	COLIF F	TSS	PO_4	PHENOL	AS	CD	CR	CU	PB	HG	SE	AG	ZN	Kjeldahl
		(^{0}C)	(std.)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(N/100ml)	(mg/l)	(mg/l)	(mg/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)	(mg/l)
AR-6	2/5/2001	7.30	8.00	9.58																				
AR-6	2/15/2001	6.60	8.30	11.70																				
AR-6	2/20/2001	8.30	8.40	12.70																				
AR-6	2/28/2001	8.40	8.10	8.10																				
AR-6	3/20/2001	10.40	8.30	10.10																				
AR-6	3/28/2001	9.60	7.90	8.40																				
AR-6	4/2/2001	11.60	7.70	8.20																				
AR-6	4/12/2001	18.10	8.00	8.91																				
AR-6	4/18/2001	13.90	8.10	9.63																				
AR-6	4/24/2001	16.20	8.10	9.18																				
AR-6	5/10/2001	22.40	8.10	7.98							45													
AR-6	5/16/2001	24.20	7.70	7.10							220													
AR-6	5/22/2001	22.10	8.10	7.49							400													
AR-6	6/6/2001	24.70	8.10	7.28							986													
AR-6	6/11/2001	26.40	8.10	8.60							88													
AR-6	6/19/2001	26.20	7.90	7.89							393													
AR-6	6/25/2001	27.50	7.80	8.29							63													
AR-6	7/2/2001	27.80	8.20	8.52							510													
AR-6	7/10/2001	29.00	8.40	7.38							88													
AR-6	7/18/2001	29.10	8.90	8.95							310													
AR-6	7/26/2001	32.40	8.60	6.19							103													
AR-6	8/1/2001	28.40	8.10	6.36						251.00	317													
AR-6	8/9/2001	28.20	8.10	7.32							14,400													
AR-6	8/15/2001	27.30	8.30	7.69							177													
AR-6	8/23/2001	25.30	8.30	7.50							250													
AR-6	9/5/2001	27.90	8.10	8.40	2.90	0.13	0.11	0.02	0.12		240				<40	<4	<10	<10	4.50	<0.2	22.00	<3	<10	
AR-6	9/19/2001	23.40	8.10	6.80	2.00	0.05	0.39	0.02	0.41		3,300													
AR-6	10/1/2001	20.90	8.20	6.20	47.00	0.05	0.74	0.02	0.75		300					<4		13.50	<2				10.50	
AR-6	10/22/2001	20.10	8.00	1.00							4,400													
AR-6	11/5/2001	20.30	7.50	6.71	3.30	0.17	0.89	0.02	0.90		4,500					<4		<10	4.90				40.00	
AR-6	11/26/2001	13.40	8.30	10.70							320													
AR-6	12/03/2001	14.00	8.40	10.20	2.00	0.12	0.72	0.02	0.73		119					<4		<10	<2	<0.2			26.00	
AR-6	12/18/2001	11.00	8.00	10.70							1,210													
AR-6	1/7/2002	5.00	8.50	NR	2.00	0.21	0.82	0.03	0.86		113					<4		<10	<2				<10	0.74
AR-6	1/28/2002	12.40	8.70	11.40							28													
AR-6	2/4/2002	7.30	8.40	12.40	2.00	0.12	0.56	0.020	0.58		32					<4		<10	<2	4.00			<10	0.74
AR-6	2/18/2002	12.40	8.50	8.80	4.30	0.77	0.44	0.022	0.46		15													1.68
AR-6	3/8/2002	14.80	7.60	9.10	2.10	0.29	0.59	0.025	0.62	280	54					<4		5.8	<2				16	1.18
AR-6	3/28/2002	13.80	7.80	9.30							100													
AR-6	4/15/2002	22.10	8.20	7.40	3.40	0.35	0.29	0.033	0.32	210	61					4.1		<5	2.5				43	1.5
AR-6	4/29/2002	19.10	7.90	8.00							64													
AR-6	5/13/2002	18.30	7.00	7.65	4.30	0.25	0.14	0.027	0.16	250	1,420					<4		11	8.28				54	1.77

City of Tulsa 2000-2004 Data AR-6																								
AREA	DATE	TEMP	pH	DO	BOD	NH_4	NO_3	NO_2	NO_2+NO_3	HRDNSS	COLIF F	TSS	PO_4	PHENOL	AS	CD	CR	CU	PB	HG	SE	AG	ZN	Kjeldahl
		(°C)	(std.)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(N/100ml)	(mg/l)	(mg/l)	(mg/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)	(mg/l)
AR-6	5/28/2002	20.80	7.70	7.08							1,020													
AR-6	6/4/2002	25.80	8.00	7.60	3.00	0.09	0.19	0.020	0.21	260	440					<4		<5	2.34				31	0.92
AR-6	6/18/2002	23.80	8.20	7.80							2,100													
AR-6	7/3/2002	26.10	8.24	6.98	2.00	0.19	0.69	0.015	0.69	190	2,770					<4		<10	6.1				60	0.91
AR-6	7/17/2002	25.60	8.00	6.80							83													
AR-6	8/1/2002	29.40	8.60	9.40	2.00	0.03	0.11	0.015	0.12	190	520					<4		<5	2.01				21	0.87
AR-6	8/15/2002	26.70	8.30	7.20							2,500													
AR-6	9/5/2002	29.50	8.40	8.80	4.30	0.06	0.22	0.018	0.24		1,180					<4		6.4	2.4				33	0.92
AR-6	9/19/2002	24.40	8.10	NR						165	4,700													
AR-6	10/3/2002	24.30	7.91	6.89	2.00	0.13	0.97	0.020	0.99	150	920					<4		<5	3.56				31	0.82
AR-6	10/17/2002	15.20	7.74	9.40							131													
AR-6	11/4/2002	12.30	7.70	10.20	2.00	0.05	1.17	0.015	1.18	180	490					<4		**20**	2.6				83	1.06
AR-6	11/18/2002	12.40	8.10	10.94							197													
AR-6	12/2/2002	10.00	7.99	11.92	2.00	0.16	1.12	0.057	1.18	250	71					<4		5.8	<2				<10	0.46
AR-6	12/16/2002	12.10	7.72	10.58							98													
AR-6	1/6/2003	7.80	7.65	9.65	2.00	0.28	0.87	0.026	0.9	370	28					**<1**		<5	<2				75	1.08
AR-6	1/22/2003	3.00	8.71	11.27							180													
AR-6	2/5/2003	6.30	8.30	10.20	2.00	0.07	0.65	0.047	0.7	380	88		0.13			<1		6.1	<2	**<0.2**			13	1.08
AR-6	2/19/2003	9.10	8.60	11.00							300		0.052											
AR-6	3/5/2003	5.00	8.65	11.29	2.00	0.04	0.29	0.018	0.31	380	50		0.02			<1		8.4	<2				120	1.05
AR-6	3/19/2003	14.50	7.59	6.40							2,100		0.41											
AR-6	4/2/2003	16.00	8.10	7.70	2.00	0.25	0.72	0.010	0.72	270	96		0.26			<1		7.4	2.21				95	1.27
AR-6	4/16/2003	16.20	8.20	8.20							270		0.13											
AR-6	5/5/2003	21.00	8.10	6.80	2.00	0.10	0.82	0.094	0.91	250	535		0.14			<1		<5	2.00				200	0.83
AR-6	5/19/2003	25.00	7.70	6.88							2,000		0.14											
AR-6	6/2/2003	22.00	7.80	6.40	3.20	0.10	0.89	0.035	0.92	190	21,000		0.22						3.83					
AR-6	6/16/2003	25.00	7.90	5.60							250		0.15											
AR-6	7/2/2003	28.00	8.20	7.90	2.00	0.04	0.45	0.011	0.457	240	18		0.16			<1		<5	2.33				150	0.74
AR-6	7/17/2003	28.00	8.40	6.80							280		0.17											
AR-6	8/4/2003	27.00	7.90	6.20	2.00	0.04	0.26	0.021	0.22	220	900		0.17			<1		<5	<2				170	0.82
AR-6	8/20/2003	29.00	8.30	6.80							160		0.15											
AR-6	9/4/2003	26.00	7.80	7.40	2.00	0.04	..16	0.026	0.18	190	15,000		0.13			0.005		<5	<2				0.012	0.7
AR-6	9/22/2003	24.00	8.00	8.10							2,100		0.15											
AR-6	10/6/2003	20.00	7.80	7.80	2.00	0.20	0.62	0.025	0.65	200			0.12			1.5		<5	<2				230	0.46
AR-6	10/20/2003	20.00	7.60	8.00							400		0.18											
AR-6	11/4/2003	21.00	8.20	9.10	2.00	0.04	0.95	0.022	0.98	190	260		0.2			<1		<5	<2				10	0.68
AR-6	11/18/2003	16.00	7.80	9.10							766		0.17											
AR-6	12/3/2003	8.70	7.60	12.00	2.00	0.04	1.03	0.024	1.06	200	4,300		0.38			1.4		<5	<2				10	0.28
AR-6	1/5/2004	3.10	7.90	10.00	2.00	0.40	0.65	0.033	0.68	240	350		0.15			<1		5.6	<2				180	0.69
AR-6	1/20/2004	3.50	8.30	10.00																				
AR-6	2/3/2004	4.90	8.20	9.50	2.00	0.09	0.67	0.033	0.68	230	230		0.11			2.4		<5	<2				140	0.7
AR-6	2/17/2004	6.10	8.20	8.70																				
AR-6	3/3/2004	10.00	8.30	8.20	2.80	0.19	0.74	0.033	0.77	250	700		0.16			1.7		<5	<2				16	1.08
AR-6	3/17/2004	11.00	7.80	7.40																				
AR-6	4/5/2004	15.00	7.90	7.20	2.00	0.13	0.87	0.053	0.92	220	156		0.17			1		<5	2.21				20	0.77
AR-6	4/19/2004	18.00	8.00	7.50																				
AR-6	5/3/2004	18.00	8.00	7.40	2.30	0.04			0.81	200	274		0.35			1.8		<5	2.89				19	0.91
AR-6	5/17/2004	22.00	8.00	6.30							950													
AR-6	6/7/2004	23.00	8.00	6.30	2.00	0.04			0.49	220	490		0.21			1		7.2	<2				10	0.27
AR-6	6/24/2004	24.00	7.80	5.50							220													

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AREA	DATE	TEMP	pH	DO	BOD	NH_4	NO_3	NO_2	NO_2+NO_3	HRDNSS	COLIF F	TSS	PO_4	PHENOL	AS	CD	CR	CU	PB	HG	SE	AG	ZN	Kjeldahl
		(^oC)	(std.)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(N/100ml)	(mg/l)	(mg/l)	(mg/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)	(mg/l)
AR-6	7/1/2004	25.00	7.80	5.40	2.00	0.04			0.64	210	182					1.5		11					20	0.78
AR-6	7/19/2004	26.00	7.50	6.80							77													
AR-6	8/2/2004	26.00	7.90	6.80															<2					
AR-6	8/16/2004	25.00	7.90	7.40							425													
AR-6	9/1/2004	24.00	7.90	6.50		0.04			0.59	170	250		0.027			1.4		<5					14	0.054
AR-6	9/8/2004	23.00	8.50	8.90	7.10																			
AR-6	9/22/2004	23.00	8.10	7.30							109													
AR-6	10/6/2004	19.00	8.40	9.10	2.10	0.04	0.54		0.54	250	420		0.3			1		<5	<2				10	0.67
AR-6	10/21/2004	21.00	8.10	7.80																				
AR-6	11/4/2004	13.00	7.90	11.00	2.00	0.12			0.52	140			0.2			1.1		5.2	3.25				22	0.68
AR-6	12/6/2004	11.00	7.90	11.00	2.00	0.04			0.15	150	1,800		0.21			1		<5	<2				140	0.79
AR-6	12/20/2004	6.20	8.10	14.00																				
	Avg. 2000	18.42	8.06	9.06							724													
	Avg. 2001	17.97	8.09	8.25	11.44	0.10	0.57	0.02	0.58	251.00	1,423				<40	<10	<10	13.50	4.70	<.2	22.00	<3	25.50	
	Avg. 2002	18.48	8.05	8.89	2.72	0.21	0.56	0.02	0.59	212.50	796.13					4.10		7.33	3.72	4.00			41.33	1.04
	Avg. 2003	18.20	8.04	8.29	2.10	0.10	0.69	0.03	0.67	256.67	2321.86		0.17			0.97		7.30	2.79	<.2			97.55	0.82
	Avg. 2004	17.29	8.02	8.09	2.63	0.08	0.71	0.04	0.61	204.00	448.79		0.19			1.39		7.25	2.78				41.10	0.67

City of Tulsa 2000-2004 AR-8																								
AREA	DATE	TEMP (°C)	pH (std.)	DO (mg/l)	BOD (mg/l)	NH_4 (mg/l	NO_3 (mg/l)	NO_2 (mg/l)	NO_2+NO_3 (mg/l)	HRDNSS (mg/l)	COLIF F (N/100ml)	TSS (mg/l)	P04 (mg/l)	PHENOL (mg/l)	AS (ug/l)	CD (ug/l)	CR (ug/l)	CU (ug/l)	PB (ug/l)	HG (ug/l)	SE (ug/l)	AG (ug/l)	Zn (ug/l)	Kjeldahl (ug/l)
AR-8	1/3/2000	9.80	7.90	10.00	20.00	0.17	0.94	0.02	0.96	238														
AR-8	1/11/2000	9.40	8.10	10.00	2.00	0.19	1.08	0.02	1.10	275														
AR-8	1/19/2000	8.50	8.00	11.00	2.00	0.08	1.04	0.02	1.06	280					<40	<4	<10	<20	<2	<0.2	<2	<0.5	<20	
AR-8	1/24/2000	5.20	8.30	12.00	12.00	0.13	0.03	0.00	0.03	280														
AR-8	2/1/2000	4.90	7.70	13.00	2.40	0.07	0.91	0.01	0.91	286														
AR-8	2/7/2000	9.80	8.00	12.00	2.00	0.10	0.91	0.02	0.93	288														
AR-8	2/17/2000	8.00	8.30	12.00	17.00	0.07	1.00	0.01	1.01	322					74.0	<4	<10	<20	<2	<0.2	<2	<0.5	<20	
AR-8	2/22/2000	14.00	8.50	12.00	2.20	0.03	0.73	0.01	0.75	314														
AR-8	3/1/2000	10.00	8.30	11.00	20.00	0.05	0.92	0.01	0.92	206														
AR-8	3/7/2000	13.00	8.10	10.00	2.10	0.15	1.00	0.02	1.02	278														
AR-8	3/13/2000	13.00	8.10	10.00	2.00	0.14	1.08	0.02	1.10	264														
AR-8	3/22/2000	13.00	8.10	10.00	2.00	0.14				245					61	<4	<10	<20	<2	<0.2	<2	<0.5	44	
AR-8	4/6/2000	15.00	7.80	9.60	2.00	0.12	0.84	0.02	0.87	201														
AR-8	4/11/2000	15.00	7.90	9.20	2.00	0.08	0.70	0.02	0.72	257														
AR-8	4/19/2000	21.00	8.00	8.20	2.00	0.05	0.71	0.02	0.73	332					78	<4	<10	<20	<2	<0.2	<2	<0.5	<20	
AR-8	4/27/2000	19.00	8.10	8.80	2.10	0.03	0.57	0.01	0.57	328														
AR-8	5/8/2000	23.00	7.20	6.50	2.00	0.18	0.35	0.03	0.39	108	164													
AR-8	5/16/2000	20.00	8.00	7.40	2.50	0.13	0.48	0.03	0.51	260	430				<40	<4	<10	<20	<2	<0.2	<2	<0.5	<20	
AR-8	5/24/2000	27.00	8.10	7.20	2.70	0.02	0.33	0.02	0.35	273	64													
AR-8	6/6/2000	23.00	7.90	7.80	2.70	0.06	0.48	0.13	0.48	231.00	100													
AR-8	6/15/2000	24.00	7.70	7.20	2.00	0.02	0.50	0.13	0.50	230.00	5,600													
AR-8	6/19/2000	25.00	8.00	6.80	2.00	0.07	0.55	0.13	0.55	254.00	515				<40	<4	<10	<20	<2	<0.2	<2	<0.5	<20	
AR-8	6/27/2000	26.00	7.70	7.00	3.40	0.05	0.35	0.03	0.38	116.00	500													
AR-8	7/6/2000	30.00	8.30	7.10	2.00	0.04	0.10	0.01	0.10	224.00	88													
AR-8	7/11/2000	29.00	8.10	6.40	3.20	0.02	0.23	0.01	0.23	194.00	450													
AR-8	7/19/2000	29.00	8.10	6.00	2.00	0.05	0.31		0.32	219.00	165				47.00	<4	<10	<20	<2	<0.2	<2	<0.5	<20	
AR-8	7/27/2000	25.00	8.00	8.30	5.20	0.18				205.00	4,000													
AR-8	8/3/2000	29.00	7.90	10.00	2.30	0.08	0.18	0.01	0.19	192.00	355													
AR-8	8/7/2000	29.00	8.20	7.20	3.10	0.02	0.06	0.01	0.07	254.00	217													
AR-8	8/15/2000	30.00	8.50	8.10	5.20	0.02	1.56	0.06	1.62	235.00	455													
AR-8	8/23/2000	27.30	8.30	7.90		0.0450	0.134	0.01	0.134		55					<4	<10		<1	<0.2	<2	<1	33	
AR-8	9/7/2000	25.40	8.30	9.6	2.0	0.06				250	530													
AR-8	9/11/2000	28.50	8.20	10.00	3.2	0.0640	0.274	0.01	0.274	269	250													
AR-8	9/19/2000		8.00	10.8	3.6	0.0660	0.219	0.01	0.219	245	148				<40	<4	<10	<10	<1	<0.2	<2	<1	<10	
AR-8	9/26/2000	20.80	7.60	8.40	2.00	0.157	0.509	0.02	0.529	176	2,000													
AR-8	10/2/2000	22.30	8.30	9.50	4.20	0.06	0.22	0.01	0.22	228														
AR-8	10/10/2000	14.00	8.40	11.00	3.10	0.05	0.32	0.02	0.33	262														
AR-8	10/18/2000	19.30	7.80	7.80	2.50	0.13	0.40	0.02	0.42	178					60	< 4.0	< 10	11	1.5	<0.2	<2	<1	44.00	
AR-8	10/26/2000	18.90	7.80	7.70	8.70	0.13	0.61	0.04	0.65	66.0														
AR-8	11/1/2000	21.3	8.2	8.5	2.8		0.170	0.0410	0.211	255														
AR-8	11/7/2000	13.2	8.2	9.4	2.00		0.440	0.0190	0.459	242														
AR-8	11/13/2000	11.0	7.9	10.5	2.00	0.095	0.65	0.018	0.67	248					<40	<4	<10	<10	1.0	<0.2	<2	<1	48	
AR-8	11/28/2000	9.70	8.2	11	2.00	0.16	0.84	0.027	0.87	307														
AR-8	12/5/2000	8.10	8.00	8.10	2.00	0.05	0.96	0.01	0.97	311.00														
AR-8	12/20/2000	5.40	8.20	10.10	2.00	0.15	0.87	0.01	0.87	244.00														
AR-8	1/4/2001	3.40	7.80		2.00	0.05	1.00	0.01	1.00	256.00														
AR-8	1/11/2001	4.90	7.70	9.10	2.00	0.13				271.00														
AR-8	1/17/2001	8.10	7.90	8.30	2.00	0.12	1.00	0.01	1.00	258.00					51.00	<4	<10	<10	<1	<0.2	<2	<1	10.00	
AR-8	1/23/2001	5.40	8.00	7.80	2.40	0.05	0.85	0.02	0.87	356.00														
AR-8	2/5/2001	6.10	8.80	11.00	2.90	0.05	0.56	0.01	0.57	271.00														

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AREA	DATE	TEMP (°C)	pH (std.)	DO (mg/l)	BOD (mg/l)	NH_4 (mg/l	NO_3 (mg/l)	NO_2 (mg/l)	NO_2+NO_3 (mg/l)	HRDNSS (mg/l)	COLIF F (N/100ml)	TSS (mg/l)	P04 (mg/l)	PHENOL (mg/l)	AS (ug/l)	CD (ug/l)	CR (ug/l)	CU (ug/l)	PB (ug/l)	HG (ug/l)	SE (ug/l)	AG (ug/l)	Zn (ug/l)	Kjeldahl (ug/l)
AR-8	2/15/2001	6.70	8.60	12.00	4.00	0.17	0.97	0.02	0.99	316.00														
AR-8	2/20/2001	8.60	8.50	12.30	2.00	0.18	1.00	0.02	1.00	294.00														
AR-8	2/28/2001	7.00	8.00	9.00	2.00	0.16	1.30	0.02	1.30															
AR-8	3/5/2001	7.60	8.30	8.90	2.00	2.85	1.19	0.04	1.23	256.00														
AR-8	3/15/2001	10.90	7.90	9.30	3.50	0.18	0.02	0.03	0.03	296.00														
AR-8	3/20/2001	10.10	8.10	11.00	2.30	0.34	1.40	0.03	1.40	254.00					<40	<4	<10	11.80	<2		<2	<3	21.20	
AR-8	3/28/2001	9.40	8.00	7.70	2.00	0.26	1.20	0.04	1.30	251.00														
AR-8	4/2/2001	12.20	7.90	7.90	2.00	0.18	1.20	0.04	1.20	328.00														
AR-8	4/12/2001	19.60	8.00	9.10	3.20	0.18	0.97	0.04	1.01	275.00														
AR-8	4/18/2001	14.60	8.20	9.60	2.90	0.15	1.20	0.03	1.20	270.00														
AR-8	4/24/2001	18.10	7.80	9.30	4.80	0.23	1.00	0.07	1.10	112.00					42	<4	<10	12	4.3	<0.2	<2	<3	29	
AR-8	5/10/2001	22.10	8.00	8.40	2.10	0.05	0.63	0.06	0.69		54													
AR-8	5/16/2001	23.00	7.90	7.80	2.40	0.08	0.54	0.03	0.57	372.00	200				<40	<4	<10	<10	<2		<2	<3	<10	
AR-8	5/22/2001	20.60	8.20	7.40	3.80	0.10	0.48	0.04	0.51	286.00	613													
AR-8	6/6/2001	24.40	8.00	7.40	2.00	0.05	0.75	0.03	0.78	217.00	829													
AR-8	6/11/2001	26.70	8.00	8.40	3.80	0.05	0.79	0.02	0.79	197.00	113				<40	<4	<10	<10	5.20	<0.2	<2	<3	10.80	
AR-8	6/19/2001	27.10	7.50	8.60	2.40	0.08	0.74	0.02	0.74	194.00	320													
AR-8	6/25/2001	27.50	7.70	8.40	2.00	0.34	0.66	0.02	0.66	231.00	91													
AR-8	7/2/2001	28.60	7.70	7.40	2.90	0.14	0.49	0.04	0.54	160.00	1,360				<40	4.10	<10	18.00	<2	0.03	<2	<3	48.50	
AR-8	7/10/2001	29.20	8.00	7.40	2.30	0.16	0.54	0.02	0.54	244.00	550													
AR-8	7/18/2001	30.20	8.90	11.00	35.00	0.10	0.02	0.02	0.02	224.00	4,000													
AR-8	7/26/2001	29.90	8.60	9.70	6.40	0.05	0.07	0.02	0.08	294.00	330													
AR-8	8/1/2001	28.60	8.30	7.80	4.90	0.05	0.15	0.02	0.17	252.00	220				<40	<4	<10	<10	<2		<2	<3	42.4	
AR-8	8/9/2001	27.10	8.20	8.10	4.20	0.12	0.28	0.02	0.26	242.00	125													
AR-8	8/14/2001	26.60	8.50	8.40	4.30	0.06	0.12	0.02	0.13	249.00	96													
AR-8	8/23/2001	25.10	8.50	8.90	5.20	0.06	0.09	0.02	0.11	249.00	50													
AR-8	9/5/2001	28.20	8.70	10.00						244.00	131													
AR-8	10/01/2001	22.20	8.30	9.30							72													
AR-8	10/22/2001	20.10	8.20							223.00	500													
AR-8	11/05/2001	20.10	7.80	7.90							1,820													
AR-8	11/26/2001	14.00	8.00	10.00							310													
AR-8	12/18/2001	11.30	7.50	10.00							2,000													
AR-8	1/7/2002	1.70	8.00	NR							106													
AR-8	1/28/2002	14.00	8.00	10.00							69													
AR-8	2/4/2002	6.80	8.00	12.00							1,610													
AR-8	2/18/2002	12.60	7.70	7.00							69													
AR-8	3/8/2002	15.80	7.40	10.50							76													
AR-8	3/28/2002	15.40	7.80	9.40							124													
AR-8	4/15/2002	21.90	7.90	8.10							183													
AR-8	4/29/2002	19.50	7.30	7.00							280													
AR-8	5/13/2002	17.40	7.25	7.27							2,000													
AR-8	5/28/2002	19.40	7.22	7.57							20,000													
AR-8	6/4/2002	28.00	8.40	9.00							1,360													
AR-8	6/18/2002	24.20	8.30	8.00							1													
AR-8	7/3/2002	27.20	8.27	6.84							1,000													
AR-8	7/17/2002	25.80	8.20	7.40							333													
AR-8	8/1/2002	31.10	8.80	11.40							560													
AR-8	8/15/2002	27.00	8.30	7.30							2,800													
AR-8	9/5/2002	30.80	8.60	10.90							180													
AR-8	9/19/2002	24.00	7.40	NR							2,170													

City of Tulsa 2000-2004 AR-8																								
AREA	DATE	TEMP (°C)	pH (std.)	DO (mg/l)	BOD (mg/l)	NH_4 (mg/l	NO_3 (mg/l)	NO_2 (mg/l)	NO_2+NO_3 (mg/l)	HRDNSS (mg/l)	COLIF F (N/100ml)	TSS (mg/l)	P04 (mg/l)	PHENOL (mg/l)	AS (ug/l)	CD (ug/l)	CR (ug/l)	CU (ug/l)	PB (ug/l)	HG (ug/l)	SE (ug/l)	AG (ug/l)	Zn (ug/l)	Kjeldahl (ug/l)
AR-8	10/3/2002	25.10	7.98	7.13							200													
AR-8	10/17/2002	15.70	7.83	9.40							290													
AR-8	11/4/2002	12.50	7.40	9.60							1,370													
AR-8	11/18/2002	13.70	8.01	9.85							547													
AR-8	12/2/2002	12.30	7.34	10.39							110													
AR-8	12/16/2002	12.20	7.24	9.34							176													
AR-8	1/6/2003	8.00	7.80	10.12							58													
AR-8	1/22/2003	3.00	8.59	11.71							400													
AR-8	2/5/2003	6.00	8.40	11.20							124		0.13											
AR-8	2/19/2003	9.10	7.80	9.20							NR		0.13											
AR-8	3/5/2003	5.00	8.68	11.43							167													
AR-8	3/19/2003	13.50	7.81	7.04							10,000													
AR-8	4/2/2003	17.00	8.10	7.60							246		0.48											
AR-8	4/16/2004	16.40	8.30	8.20							470		0.19											
AR-8	5/5/2003	22.00	8.10	6.70							350		0.18											
AR-8	5/19/2003	25.00	7.70	6.27							7,270		0.08											
AR-8	6/2/2003	23.00	7.70	5.90							28,000		0.62											
AR-8	6/16/2003	27.00	8.00	5.80							127		0.20											
AR-8	7/2/2003	29.00	8.20	9.00							220		0.18											
AR-8	7/17/2003	29.00	8.60	7.60							400		0.16											
AR-8	8/4/2003	27.00	8.0	6.4							2,000		0.20											
AR-8	8/20/2003	31.00	8.5	8.3							1,330		0.15											
AR-8	9/4/2003	26.00	7.7	7.3							1,360		0.18											
AR-8	9/22/2003	25.00	7.8	8.5							3,000		0.15											
AR-8	10/6/2003	19.00	7.6	7.5							1,140		0.16											
AR-8	10/20/2003	21.00	7.6	7.9							143		0.19											
AR-8	11/4/2003	22.00	8.1	7.9							780		0.49											
AR-8	11/18/2003	15.00	7.5	8.2							3,400		0.16											
AR-8	12/3/2003										1,420		0.14											
AR-8	1/5/2004	5.70	7.7	9.6																				
AR-8	1/20/2004	3.70	8.30	10.00																				
AR-8	2/3/2004	4.90	8.10	9.60																				
AR-8	2/17/2004	6.70	8.20	8.30																				
AR-8	3/3/2004	11.00	7.80	8.20																				
AR-8	3/17/2004	11.00	7.80	7.90																				
AR-8	4/5/2004	16.00	7.90	7.30																				
AR-8	4/19/2004	19.00	7.90	6.40																				
AR-8	5/3/2004	18.00	8.00	7.40							440													
AR-8	5/17/2004	22.00	8.10	6.40																				
AR-8	6/7/2004	24.00	7.60	5.40							360													
AR-8	6/24/2004	25.00	7.90	5.60							200													
AR-8	7/1/2004	25.00	7.50	5.90							136													
AR-8	7/19/2004	27.00	7.60	6.90																				
AR-8	8/2/2004	27.00	7.90	6.60							183													
AR-8	8/16/2004	25.00	7.90	7.50							270													
AR-8	9/1/2004	25.00	8.10	7.30							117													
AR-8	9/22/2004	23.00	8.20	8.10							109													
AR-8	10/6/2004	10.00	8.20	20.00							230													
AR-8	10/21/2004	22.00	8.10	8.00																				
AR-8	11/4/2004	15.00	7.80	10.00																				

City of Tulsa 2000-2004 AR-8

AREA	DATE	TEMP (°C)	pH (std.)	DO (mg/l)	BOD (mg/l)	NH_4 (mg/l	$N0_3$ (mg/l)	NO_2 (mg/l)	NO_2+NO_3 (mg/l)	HRDNSS (mg/l)	COLIF F (N/100ml)	TSS (mg/l)	P04 (mg/l)	PHENOL (mg/l)	AS (ug/l)	CD (ug/l)	CR (ug/l)	CU (ug/l)	PB (ug/l)	HG (ug/l)	SE (ug/l)	AG (ug/l)	Zn (ug/l)	Kjeldahl (ug/l)
AR-8	11/18/2004	17.00	8.00	9.80																				
AR-8	12/6/2004	11.00	7.70	4.70																				
AR-8	12/20/2004	9.10	7.70	12.00																				
	Avg. 2000	18.69	8.04	9.06	4.12	0.09	0.63	0.03	0.64	248.25	1,007				65.00	4.00	<10	11.00	1.25	<.2	<2	<1	42.25	
	Avg. 2001	17.98	8.11	8.99	4.05	0.22	0.71	0.03	0.73	256.19	656				46.50	4.10	<10	13.90	4.75	0.03	2.00	<3	30.38	
	Avg. 2002	18.92	7.86	8.88							1483.92													
	Avg. 2003	19.05	8.13	8.41							2836.59		0.22											
	Avg. 2004	16.80	7.93	8.23							227.22													

City of Tulsa 2005-2006 Data AR-1																											
AREA	DATE	TEMP	pH	DO		BOD		NH_4		NO_2+NO_3	HRDNSS		COLIF F		PO_4		CD		CU		PB		HG		ZN		Kjeldahl
		(°C)	(std.)	(mg/l)		(mg/l)		(mg/l)		(mg/l)	(mg/l)		(N/100ml)		(mg/l)		(ug/l)		(ug/l)		(ug/l)		(ug/l)		(ug/l)		(ug/l)
AR-1b	01/05/05	7	8.1	13		2		0.092		0.88	290		740		0.15		1		5		2				17		0.78
AR-1b	02/03/05	5	8	7.8		2		0.16		1.03	300		8		0.15		1		5		4.19				14		0.2
AR-1b	03/07/05	11	8.2	15	<	3		0.053		0.87	320		156		0.16		1.0	<	5	<	2				19		0.76
AR-1b	04/04/05	15	8.2	9.6	<	3		0.040		0.71	310		50		0.093		1.3	<	5	<	2				14		0.55
AR-1b	05/02/05	14	8.3	9.2	<	3		0.21		0.38	340		3000		0.091		1.8	<	5	<	2				20		0.92
AR-1b	06/01/05	22	8.1	7.1	<	3		0.057		0.27	290		600		0.13		1.8		6.4	<	2				21		0.72
AR-1b	07/06/05	26	7.6	4.7	<	3		0.097		0.44	220	<	1		0.19		1		7.4	<	2				12		0.38
AR-1b	08/04/05	no record	no record	no record	<	3		0.077		0.32	230				0.2		1.6		5.7	<	2			<	10		0.68
AR-1b	09/01/05	26	7.6	6.8									561														
AR-1b	10/03/05	24	7.9	6.7									156														
AR-1b	11/03/05	15	8	9.1	<	3	<	0.05		0.7	230		112		0.15		1.2	<	5	<	2				15		0.76
AR-1b	12/07/05	4	8.1	nr	<	3	<	0.05		0.63	300		183		0.13		1.6	<	5		0.44				30		110
AR-1b	12/16/05	4	8.3	13																							
mean	2005	14.42	8.03	9.27		2.00		0.10		0.04	157.00		160.09		0.10		0.74		5.90		2.21				16.71		11.28
AR-1b	01/04/06	10	8.2	11		8.8		0.064		0.76	360		64		0.12		1.5	<	5	<	2				14		73
AR-1b	02/06/06	6	8.2	13	<	3		0.076		0.66	340		44		0.067		1.6	<	5	<	1				19		1.42
AR-1b	03/27/06	13	8.2	9.6	<	3		0.099		0.71	330		5		0.19		5.1		5.5		6.77				19		0.64
AR-1b	04/10/06	15	8.4	10	<	3	<	0.05		0.11	340		150		0.065		1.2		1.2	<	1				12		0.71
AR-1b	05/08/06	19	8	7.1	<	3		0.089		0.27	280		780		0.11		2.5		6		1.76				20		1.02
AR-1b	06/07/06	24	7.9	7.1	<	3	<	0.05		0.47	240		860		0.13		2.6		13		19.6				59		1.15
AR-1b	07/06/06	24	7.9	7.1	<	3		0.08		0.15	220		1950		0.2		1.3		6.6	<	1			<	10		1.18
AR-1b	08/07/06	27	7.8	4.8	<	3		0.066		0.2	240		36000		0.16		1.4		7.4	<	1				12		1.18
AR-1b	09/07/06	23	7.7	6.6									180														
mean	2006	17.89	8.03	8.48		8.80		0.08		0.42	293.75		4448.11		1.04		0.13		6.62		9.38				22.14		10.04

City of Tulsa 2005-2006 Data AR-3																
AREA	DATE	TEMP	pH	DO	BOD	NH_4	NO_2+NO_3	HRDNSS	COLIF F	PO_4	CD	CU	PB	HG	ZN	Kjeldahl
		(°C)	(std.)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(N/100ml)	(mg/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)
AR-3	01/05/05	5.0	8	14												
AR-3	01/19/05	5.0	8	13												
AR-3	02/03/05	5.7	8	7.4												
AR-3	02/17/05	7.9	7.8	8.1												
AR-3	03/07/05	11.0	8.1	15												
AR-3	03/22/05	13.0	8.2	18												
AR-3	04/04/05	15.0	8	9.7												
AR-3	04/18/05	24.0	8.3	13												
AR-3	05/02/05	13.0	8.3	16					60							
AR-3	05/16/05	21.0	8.3	15					57							
AR-3	06/01/05	23.0	8	9												
AR-3	06/15/05	24.0	7.8	5.8					3980							
AR-3	06/20/05	26.0	7.7	6.3					840							
AR-3	07/06/05	25.0	7.7	6.1					3900							
AR-3	07/20/05	26.0	7.7	6.3					840							
AR-3	08/03/05	27.0	7.3	6.7					450							
AR-3	08/17/05	26.1	7.5	6.1					4100							
AR-3	09/01/05	28.6	7.7	6.2					697							
AR-3	09/19/05	25.0	7.5	6.3					1720							
AR-3	10/17/05	19.0	7.9	7.7												
AR-3	11/03/05	15.0	7.9	12												
AR-3	11/17/05	9.0	7.5	11												
AR-3	12/07/05	3.8	7.6	nr												
AR-3	12/16/05	11.0	8.3	15												
AR-3	12/21/05	4.9	8.1	13					570							
mean	2005	16.56	7.89	10.28					1192.45							
AR-3	01/04/06	11.0	8.3	17					22							
AR-3	01/19/06	9.1	7.1	9.4					130							
AR-3	02/06/06	2.8	8.3	15					23							
AR-3	02/24/06	7.9	8	7.9					165							
AR-3	03/13/06	9.0	7	15					387							
AR-3	03/27/06	13.0	8.1	12					144							
AR-3	04/10/06	14.0	8.1	13					818							
AR-3	04/24/06	22.0	8	7.2					7500							
AR-3	05/08/06	18.0	7.9	7.7					2700							
AR-3	05/22/06	23.0	7.8	8.5					467							
AR-3	06/07/06	31.0	8.2	9					300							
AR-3	06/21/06	24.0	7.9	7.5					1700							
AR-3	07/06/06	25.0	7.8	8.3					1150							
AR-3	07/21/06	28.0	7.9	6.4					800							
AR-3	08/07/06	27.0	8	7					901							
AR-3	08/21/06	26.0	7.7	4.9					2100							
AR-3	09/07/06	22.0	7.9	7.6					400							
mean	2006	18.40	7.88	9.61					1159.24							

City of Tulsa 2005-2006 Data AR-4																
AREA	DATE	TEMP	pH	DO	BOD	NH_4	NO_2+NO_3	HRDNSS	COLIF F	PO_4	CD	CU	PB	HG	ZN	Kjeldahl
		(°C)	(std.)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(N/100ml)	(mg/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)
AR-4	01/05/05	5.2	8.2	14												
AR-4	01/19/05	5.7	8	12												
AR-4	02/03/05	5.1	8.1	9.4												
AR-4	02/17/05	8.1	7.8	8.2												
AR-4	03/07/05	11.0	8.2	16												
AR-4	03/22/05	15.0	8.2	15												
AR-4	04/04/05	15.0	8.3	11												
AR-4	04/18/05	21.0	8.1	10												
AR-4	05/02/05	15.0	7.4	12					9							
AR-4	05/16/05	21.0	7.6	10					< 20000							
AR-4	06/01/05	23.0	8.1	8.1					675							
AR-4	06/15/05	24.0	7.8	6					2400							
AR-4	06/20/05	27.0	7.7	6.5					186							
AR-4	07/06/05	26.0	7.7	6					2000							
AR-4	07/20/05	27.0	7.7	6.5					186							
AR-4	08/03/05	27.0	7.7	6.4					240							
AR-4	08/17/05	26.5	7.8	6.1					3500							
AR-4	09/01/05	29.1	7.8	6.5					872							
AR-4	09/19/05	25.0	7.9	6.4					1000							
AR-4	10/17/05	19.0	7.9	8.1												
AR-4	11/03/05	15.0	8.2	10												
AR-4	11/17/05	10.0	8.1	11												
AR-4	12/07/05	1.6	8.4	no record												
AR-4	12/16/05	7.0	8.5	15												
AR-4	12/21/05	4.4	8.1	13					124							
mean	2005	16.55	7.97	9.72					2342.33							
AR-4	01/04/06	10.0	8.2	14					25							
AR-4	01/19/06	8.8	8.4	11					240							
AR-4	02/06/06	7.3	7.6	14					720							
AR-4	02/24/06	7.8	8.3	12					28							
AR-4	03/13/06	10.0	7	11					280							
AR-4	03/27/06	12.0	7.9	12					6500							
AR-4	04/10/06	15.0	8.5	11					410							
AR-4	04/24/06	19.0	8	8.1					267							
AR-4	05/08/06	18.0	8	7.7					620							
AR-4	05/23/06	23.0	7.9	6.9					360							
AR-4	06/07/06	27.0	8.1	84					1700							
AR-4	06/21/06	24.0	8	7.6					2220							
AR-4	07/06/06	25.0	8	7.8					960							
AR-4	07/21/06	28.0	8	6.2					420							
AR-4	08/07/06	27.0	8	7.3					545							
AR-4	08/21/06	27.0	8	5.6					1910							
AR-4	09/07/06	23.0	8	7.7					200							
mean	2006	311.90	18.35	13.76					1023.82							

City of Tulsa 2005-2006 Data AR-6

AREA	DATE	TEMP	pH	DO	BOD	NH_4	NO_2+NO_3	HRDNSS	COLIF F	PHOS	CD	CU	PB	HG	ZN	Kjeldahl
		(°C)	(std.)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(N/100ml)	(mg/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)
AR-6	01/05/05	5.4	8.1	15	2	0.15	0.77	230	2330	0.33	1	5.6	2.04		13	1.02
AR-6	01/19/05	5.7	8	13												
AR-6	02/03/05	5.2	8.1	9.1	2	0.3	1.02	270	96	0.33	1.1	5.9			27	2.62
AR-6	02/17/05	7.8	7.9	8.2												
AR-6	03/22/05	14.0	8.4	13												
AR-6	04/04/05	16.0	8.3	11	< 3	0.052	0.61	300	56	0.10	1.1	BDL(5.0)	< 2		19	0.81
AR-6	04/18/05	21.0	8.7	11												
AR-6	05/02/05	15.0	7.7	7.9	3.2	0.13	0.57	390	42	0.16	1.6	BDL(5.0)	< 2		12	0.84
AR-6	05/16/05	21.0	7.7	7					982							
AR-6	06/01/05	23.0	8.2	7.8	3.8	< 0.03	0.16	300	1200	0.26	1.7	7.5	2.84		22	1.40
AR-6	06/15/05	24.0	7.8	6.1					980							
AR-6	06/20/05	27.0	7.9	6.4					2900							
AR-6	07/06/05	26.0	7.8	6.3	< 3	< 0.03	0.44	220	900	0.25	1	8.6	< 2		12	0.46
AR-6	07/20/05	27.0	7.9	6.4					2900							
AR-6	08/03/05	29.0	8	6.3	< 3	< 0.03	0.21	230		0.21	1.6	< 5	< 2		< 10	0.84
AR-6	08/17/05	26.6	7.8	6.3					3000							
AR-6	09/01/05	28.5	7.8	6.7					628							
AR-6	09/19/05	28.0	8.1	7.2					1300							
AR-6	10/03/05	25.0	7.3	7					< 1							
AR-6	10/17/05	20.0	7.8	8												
AR-6	11/03/05	16.0	8.2	10	< 3	< 0.05	0.63	220	210	0.15	1.2	33	< 2		10	< 0.2
AR-6	11/17/05	9.0	8	12												
AR-6	12/07/05	1.6	8.4	nr	< 3	0.19	0.65	270	226	0.23	1.1	< 5	1.24		< 10	1.42
AR-6	12/16/05	6.1	8.5	16												
AR-6	12/21/05	3.8	8.2	13					3300							
mean	2005	17.27	8.02	8.83	2.75	0.16	0.41	160.00	1046.53	0.17	0.78	12.12	2.04		16.42	1.18
AR-6	01/04/06	11.0	8.2	12	8	0.38	0.69	380	189	0.22	1.5	< 5	< 2		11	1.36
AR-6	01/19/06	8.1	8.4	11					112							
AR-6	02/06/06	5.9	8.2	12	< 3	0.58	0.74	350	224	0.36	1.9	5	1.93		14	1.75
AR-6	02/24/06	8.2	8.3	11					112							
AR-6	03/13/06	12.0	7.2	9.6					176							
AR-6	03/27/06	13.0	8	9	0.38	1.2	0.50	310	112	0.61	2.8	9.5	3.98		24	< 0.1
AR-6	04/10/06	15.0	8.4	10	< 3	0.51	0.21	360	64	0.93	< 1	15	7.69		43	2.8
AR-6	04/24/06	21.0	7.9	7.1					764							
AR-6	05/08/06	20.0	8	8.1	< 3	0.16	0.30	290	1600	0.46	2.6	6.7	4.71		18	1.51
AR-6	05/23/06	23.0	7.9	6.5					580							
AR-6	06/07/06	25.0	8	7.8	3	< 0.05	0.39	250	180	0.21	1.2	7.2	1.16		10	0.87
AR-6	06/21/06	25.0	8.1	6.9					4100							
AR-6	07/06/06	26.0	8.1	7.9	< 3	< 0.05	0.10	220	348	0.16	1.4	12	3.82		16	1.37
AR-6	07/21/06	30.0	8.1	6.3					455							
AR-6	08/07/06	29.0	8	7	3.3	0.066	0.12	240	455	0.2	1.5	13	< 1		13	1.26
AR-6	08/21/06	28.0	7.9	5.8					11000							
AR-6	09/07/06	23.0	8.1	7.8					< 1							
mean	2006	19.01	8.05	8.58	3.89	0.48	0.38	300.00	1204.24	1.84	1.74	9.77	3.88		18.60	1.56

City of Tulsa 2005-2006 Data																
AREA	DATE	TEMP	pH	DO	BOD	NH_4	NO_2+NO_3	HRDNSS	COLIF F	PO_4	CD	CU	PB	HG	ZN	Kjeldahl
		(°C)	(std.)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(N/100ml)	(mg/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)
AR-8	01/05/05	5.5	7.8	15												
AR-8	01/19/05	5.8	8	13												
AR-8	02/03/05	5.4	8	8.9												
AR-8	02/17/05	7.7	7.9	8.1												
AR-8	03/07/05	12	8	15												
AR-8	03/22/05	13	8.3	13												
AR-8	04/04/05	16	8.2	10												
AR-8	04/18/05	21	8.6	9.7												
AR-8	05/02/05	15	8.4	11					26							
AR-8	05/16/05	21	7.5	6.8					1430							
AR-8	06/01/05	23	8.2	7.3					1620							
AR-8	06/15/05	25	7.9	6.2					1710							
AR-8	06/20/05	28	8.1	7.4					2950							
AR-8	07/06/05	26	7.8	6.3					553							
AR-8	07/20/05	28	8.1	7.4					2950							
AR-8	08/03/05	29	8.2	7.8					440							
AR-8	08/17/05	26.8	7.9	6.6					580							
AR-8	09/01/05	28.7	7.7	6.4					864							
AR-8	09/19/05	29	8	7.9					983							
AR-8	10/17/05	20	7.6	7.6												
AR-8	11/03/05	16	8.2	9.9												
AR-8	11/17/05	9.7	8.3	12												
AR-8	12/07/05	0.3	8.3	no record												
AR-8	12/16/05	8.5	7.6	14												
AR-8	12/21/05	3.3	7.6	12					263							
mean	2005	16.95	8.00	9.55					798.83							
AR-8	01/04/06	13	8.2	11					3300							
AR-8	01/19/06	8.4	8.5	11					400							
AR-8	02/06/06	6.3	7.8	11					86							
AR-8	03/13/06	13	6.9	9.6					290							
AR-8	03/27/06	14	7.7	9.2					240							
AR-8	04/10/06	17	7.6	9.4					380							
AR-8	04/24/06	7.1	7.9	7.1					519							
AR-8	05/08/06	20	8	8.1					740							
AR-8	05/23/06	25	8	7.2					960							
AR-8	06/07/06	24	7.4	5.7					10000							
AR-8	06/21/06	26	7.6	7.1					5700							
AR-8	07/06/06	26	8	8.3					870							
AR-8	07/21/06	31	8.3	8.4					460							
AR-8	08/07/06	30	8	6.4					818							
AR-8	08/21/06	27	7.6	5.4					22000							
AR-8	09/07/06	23	7.6	8.4					131							
mean	2006	19.42	7.82	8.33					2930.88							

Appendix D

Table 1: Tulsa City-County Health Department;
Water Quality Data (1976-1980)
Four (4) pages

Table 2: Tulsa City-County Health Department;
Bacteriological Data (1976-1980)
Three (3) pages

Table 3: Tulsa City-County Health Department;
Bacteriological Data (1989-2000)
One (1) page

Tulsa County Department of Health,
Arkansas River Water Quality Reports

(1989)	Six (6) pages
(1990)	Six (6) pages
(1991)	Twenty-six (26) pages
(1992)	Twenty-six (26) pages
(1993)	Twenty-three (23) pages
(1994)	Thirty (30) pages
(1995)	Twenty-seven (27) pages
(1996)	Seven (7) pages
(1997)	Eight (8) pages
(1998)	Eight (8) pages
(1999)	Nine (9) pages
(2000)	Nine (9) pages

Table 1: Tulsa City—County Health Department (Water Quality Data)

***Zink Lake Water Quality Assessment-1983; Keystone Dam to I-44 Bridge, 1976-1980 Data**

Annual Water Quality Reports-1991 to 1995;
Zink Lake Transects Along 11th St. Bridge, 21st St. Bridge, Pedestrian Bridge, Indian Ave. Sanitary Drain & 26th St. Sanitary Drain

Constituent/Measurement	1976-1980* range (mean)	1991 range (mean)	1992 range (mean)	1993 range (mean)	1994 range (mean)	1995 range (mean)
Temperature C°	3.0 to 27.5 (13.5 to 16.5)	----	----	----	----	----
pH	6.0 to 7.5 (6.75 to 7.5)	----	----	----	----	----
Dissolved Oxygen, mg/l	4.38 to 14.5 (8.75 to 10)	----	----	----	----	----
Total Hardness, mg/l	120 to 365 (240 to 315)	----	----	----	----	----
TDS, mg/l	350 to 2,750 (1,100 to 1,300)	----	----	----	----	----
Chloride, mg/l	88 to 1,375 (425 to 662.5)	----	----	----	----	----
Conductivity, umhos/cm	900 to 4,500 (1,900 to 2,350)	----	----	----	----	----

Table 1: Tulsa City—County Health Department (Water Quality Data)

***Zink Lake Water Quality Assessment-1983; Keystone Dam to I-44 Bridge, 1976-1980 Data**

Annual Water Quality Reports-1991 to 1995;
Zink Lake Transects Along 11th St. Bridge, 21st St. Bridge, Pedestrian Bridge, Indian Ave. Sanitary Drain & 26th St. Sanitary Drain

Constituent/Measurement	1976-1980* range (mean)	1991 range (mean)	1992 range (mean)	1993 range (mean)	1994 range (mean)	1995 range (mean)
Total Suspended Solids, mg/l	4.5 to 120 (5.25 to 26.25)	----	----	----	----	----
Total Volatile Solids, mg/l	3.0 to 240 (8.25 to 15.75)	----	----	----	----	----
Orthophosphate, mg/l	0.20 to 1.85 (0.38 to 0.70)	----	----	----	----	----
Total Phosphorous, mg/l	0.45 to 4.2 (1.1 to 1.52)	0.041 to 1.33 (0.152)	0.012 to 6.025 (0.338)	<0.04 to 2.58 (0.310)	<0.02 to 1.4 (0.276)	<0.02 to 3.71 (0.261)
Biochemical Oxygen Demand, mg/l	1.25 to 23.5 (3.0 to 6.0)	<1.0 to >6.4 (2.3)	<1.0 to 7.7 (2.1)	<1.0 to 6.7 (2.2)	<1.0 to 17.0 (3.4)	<1.0 to 3.9 (1.9)
Chemical Oxygen Demand, mg/l	10 to 110 (20 to 27.5)	<1.0 to 286.4 (25.7)	<5.0 to 76.8 (18.0)	<5.0 to 109.6 (18.6)	<5.0 to 85.0 (14.8)	<5.0 to 58.0 (16.0)

Table 1: Tulsa City—County Health Department (Water Quality Data)

***Zink Lake Water Quality Assessment-1983; Keystone Dam to I-44 Bridge, 1976-1980 Data**

Annual Water Quality Reports-1991 to 1995;
Zink Lake Transects Along 11th St. Bridge, 21st St. Bridge, Pedestrian Bridge, Indian Ave. Sanitary Drain & 26th St. Sanitary Drain

Constituent/Measurement	1976-1980* range (mean)	1991 range (mean)	1992 range (mean)	1993 range (mean)	1994 range (mean)	1995 range (mean)
Ammonia, mg/l	0.10 to 1.75 (0.25 to 0.40)	<0.01 to 0.62 (0.086)	<0.01 to 0.42 (0.080)	<0.01 to 0.32 (0.060)	<0.02 to 8.2 (0.770)	<0.02 to 0.40 (0.050)
Nitrogen, Nitrate, mg/l	0.2 to 4.5 (0.3 to 0.5)	----	----	----	----	----
Nitrogen, Nitrite, mg/l	0.015 to 0.098 (0.019 to 0.035)	----	----	----	----	----
Nitrate/Nitrite, mg/l	0.215 to 4.60 (0.319 to 0.535)	<0.02 to >40 (1.50)	0.02 to 4.69 (0.84)	<0.02 to 3.9 (0.71)	<0.02 to 6.7 (0.79)	0.1 to 1.98 (0.53)
Total Kjeldahl Nitrogen, mg/l	1.0 to 29 (3.75 to 5.25)	----	----	----	----	----
Iron, mg/l	0.3 to 9.09 (0.5 to 1.15)	----	----	----	----	----

Table 1: Tulsa City—County Health Department (Water Quality Data)

***Zink Lake Water Quality Assessment-1983; Keystone Dam to I-44 Bridge, 1976-1980 Data**

Annual Water Quality Reports-1991 to 1995;
Zink Lake Transects Along 11th St. Bridge, 21st St. Bridge, Pedestrian Bridge, Indian Ave. Sanitary Drain & 26th St. Sanitary Drain

Constituent/Measurement	1976-1980* range (mean)	1991 range (mean)	1992 range (mean)	1993 range (mean)	1994 range (mean)	1995 range (mean)
Manganese, mg/l	0.05 to 0.95 (0.1 to 0.22)	----	----	----	----	----
Zinc, mg/l	<0.05 to 2.05 (0.05 to 0.575)	----	----	----	----	----
Cadmium, mg/l	<0.05 to 9.4 (0.06 to 0.36)	<0.005 to 0.015 (0.0080)	<0.003 to 0.034 (0.0129)	<0.003 to 0.0596 (0.0157)	<0.003 to 0.302 (0.0110)	<0.003 to 0.022 (0.0083)
Chromium, mg/l	<0.018 to 1.56 (0.048 to 0.09)	<0.03 to 0.07 (0.044)	<0.030 to 0.139 (0.089)	<0.030 to 0.194 (0.0561)	<0.030 to 0.147 (0.0557)	<0.030 to 0.062 (0.0402)
Mercury, mg/l	----	<0.0005 to 0.0009 (0.00055)	<0.0005 to 0.002 (0.002)	<0.0005 to 0.0036 (0.001)	<0.0005 (<0.0005)	<0.0005 to 0.0042 (0.00116)
Lead, mg/l	----	----	<0.005 to 0.258 (0.0152)	<0.005 to 0.1002 (0.0134)	<0.005 to 0.080 (0.0099)	<0.005 to 0.024 (0.0089)

Table 2: Tulsa City—County Health Department (Bacteriological Data)

***Zink Lake Water Quality Assessment-1983; Keystone Dam to I-44 Bridge, 1976-1980 Data**

Annual Water Quality Reports-1989 to 2000;
Zink Lake Transects Along 11th St. Bridge, 21st St. Bridge, Pedestrian Bridge, Indian Ave. Sanitary Drain & 26th St. Sanitary Drain

	Primary Body Contact Exceedences (Fecal Coliform, >200/100 ml & >400/100 ml)					
	11th St. Bridge		21st St. Bridge		Pedestrian Bridge	
Year	Geometric Mean Value Exceedence >200 & Month	Number of Sample Exceedences >400	Geometric Mean Value Exceedence >200 & Month	Number of Sample Exceedences >400	Geometric Mean Value Exceedence >200 & Month	Number of Sample Exceedences >400
*1983	209 (Aug)	2 (410-3300)	----	3 (510-6000)	303 (Aug)	2 (490-5600)
1989	335.0 (Aug)	7 (560-71000)	308.9 (May) 336.3 (Aug)	4 (410-27000)	----	6 (500-31000)
1990	365.7 (Aug)	7 (550-19000)	385.3 (Aug) 526.6 (Sept)	11 (410-58000)	----	11 (450-19000)
1991	237.8 (May) 391.8 (Aug) 410.4 (Sept) 586.2 (Sept) 749.4 (Sept)	9 (430-67000)	503.7 (May) 524.5 (Aug) 954.7 (Sept) 627.0 (Sept) 1,455.3 (Sept)	10 (420-25000)	481.2 (Sept) 882.4 (Sept) 1,068.8 (Sept)	9 (440-22000)
1992	726.6 (May) 233.8 (June) 301.1 (June)	10 (450-12000)	681.6 (May) 243.1 (June) 229.2 (June)	12 (450-43000)	256.3 (May)	11 (420-13000)
1993	212.1 (Sept) 341.8 (Sept) 3,825.3 (Sept)	4 (450-9000)	301.0 (Sept) 560.1 (Sept) 4,560.9 (Sept)	7 (410-14000)	533.1 (July) 214.7 (Aug) 295.7 (Sept) 491.4 (Sept) 1,268.5 (Sept)	6 (480-28000)

Table 2: Tulsa City—County Health Department (Bacteriological Data)

*Zink Lake Water Quality Assessment-1983; Keystone Dam to I-44 Bridge, 1976-1980 Data

Annual Water Quality Reports-1989 to 2000;
Zink Lake Transects Along 11th St. Bridge, 21st St. Bridge, Pedestrian Bridge, Indian Ave. Sanitary Drain & 26th St. Sanitary Drain

	Primary Body Contact Exceedences (Fecal Coliform, >200/100 ml & >400/100 ml)					
	11th St. Bridge		21st St. Bridge		Pedestrian Bridge	
Year	Geometric Mean Value Exceedence >200 & Month	Number of Sample Exceedences >400	Geometric Mean Value Exceedence >200 & Month	Number of Sample Exceedences >400	Geometric Mean Value Exceedence >200 & Month	Number of Sample Exceedences >400
1994	200.5 (June) 295.3 (July) 6,583.1 (July) 1,263.7 (Aug)	6 (450-53000)	310.2 (July) 503.5 (July) 1,080.1 (July) 418.3 (Aug)	5 (900-35000)	438.0 (July) 1,267.4 (July)	6 (430-14000)
1995	----	----	----	----	----	----
1996	869.48 (May) 291.83 (May) 340.04 (May) 560.45 (June) 340.70 (June) 2,611.58 (June) 643.03 (July)	11 (410-72000)	321.31 (May) 1,984.51 (May) 335.86 (June) 3,965.08 (June) 381.32 (July)	11 (420-61000)	488.65 (June) 790.57 (June) 896.62 (June)	5 (480-27000)
1997	----	3 (1600-3000)	----	3 (1800-9500)	218.49 (June)	3 (2400-3500)

Table 2: Tulsa City—County Health Department (Bacteriological Data)

***Zink Lake Water Quality Assessment-1983; Keystone Dam to I-44 Bridge, 1976-1980 Data**

Annual Water Quality Reports-1989 to 2000;
Zink Lake Transects Along 11th St. Bridge, 21st St. Bridge, Pedestrian Bridge, Indian Ave. Sanitary Drain & 26th St. Sanitary Drain

	Primary Body Contact Exceedences (Fecal Coliform, >200/100 ml & >400/100 ml)					
	11th St. Bridge		21st St. Bridge		Pedestrian Bridge	
Year	Geometric Mean Value Exceedence >200 & Month	Number of Sample Exceedences >400	Geometric Mean Value Exceedence >200 & Month	Number of Sample Exceedences >400	Geometric Mean Value Exceedence >200 & Month	Number of Sample Exceedences >400
1998	1,718.06 (Aug) 1,820.54 (Aug) 2,108.89 (Aug) 1,426.01 (Sept) 1,193.14 (Sept) 1,627.66 (Sept)	10 (420-12000)	349.53 (Aug) 331.73 (Aug) 339.54 (Aug) 2,216.00 (Sept) 1,927.39 (Sept) 2,052.77 (Sept)	10 (500-100000)	378.57 (June)	---- (800-12000)
1999	213.95 (June) 295.89 (Sept) 286.91 (Sept) 629.44 (Sept)	6 (420-12000)	230.38 (Sept) 286.05 (Sept) 499.28 (Sept)	7 (420-3200)	285.29 (June)	3 (480-4200)
2000	567.45 (May) 720.19 (May) 598.83 (May) 423.23 (June) 1,019.94 (Sept) 807.28 (Sept) 843.54 (Sept)	14 (410-39000)	323.15 (May) 373.34 (May) 329.51 (May) 312.19 (June) 1,254.82 (June) 225.31 (Aug) 237.05 (Aug) 1,550.24 (Sept) 1,514.97 (Sept) 1,462.57 (Sept)	14 (420-43000)	259.09 (May) 539.76 (June) 307.07 (Sept)	9 (460-15000)

Table 3: Tulsa City—County Health Department (Bacteriological Data)

Annual Water Quality Reports-1989 to 2000;
Zink Lake Transects Along 11th St. Bridge, 21st St. Bridge, Pedestrian Bridge, Indian Ave. Sanitary Drain & 26th St. Sanitary Drain

	Fecal Coliform; Highest Concentrations, counts/100 ml			
Year	11th St. Storm Drain	Indian Avenue Storm Drain	21st Storm Drain	26th St. Storm Drain
1989	100,000	100,000	100,000	----
1990	140,000	120,000	130,000	42,000
1991	110,000	98,000	60,000	48,000
1992	60,001	250,000	200,000	760,000
1993	280,000	60,001	300,000	120,000
1994	300,000	56,000	440,000	90,000
1995	310,000	22,000	160,000	110,000
1996	110,000	110,000	99,000	96,000
1997	52,000	130,000	47,000	1,100,000
1998	56,000	30,000	47,000	150,000
1999	35,000	70,000	29,000	10,000
2000	320,000	----	260,000	52,000

Arkansas River Water Quality Report for 1989

Data from the 1989 sampling of the Arkansas River indicates that there are still severe problems with the water quality in regards to bacterial parameters. Tulsa River Parks Authority would like to promote primary body contact recreation like swimming and wading as well as secondary recreational activities such as canoeing and boating. In order to allow these types of activities, water quality of the river would have to meet the requirements of the Oklahoma Water Quality Standards. For primary body contact activities, the standard states that the geometric mean of all samples collected for that location should not reach a count of 100 Fecal Coliforms. For secondary contact activities the standard is 200 counts. In addition, the standards say that 10% or more of the samples may not exceed a count of 400. To calculate the geometric mean, it is necessary to collect a minimum of 5 samples in a 30 day period. Since this is the case, we simply took all the samples collected in a month and calculated the geometric mean for each month at each sampling site. These standards only apply to in-stream water quality and so cannot be applied directly to the storm drain data.

Samples are collected at 3 river sites. At each of the sites 3 samples are taken to get a cross sectional picture of the river. Since we sample for a 5 month period this gives us a total of 15 data points for each of the 3 sites.

Data for the 11th Street Bridge site indicates that it would have failed the primary standard only once in 15 data points. However, it would have failed the 400 count limitation on 7 of the 15 data points. The range of values for the entire sampling period went from a low of 9 to a high of 71,000

At the 21st Street Bridge the data indicates that the primary standard would have been violated in 3 of the 15 data points. The 400 count limitation would have failed on 6 of the 15 data points. The range of values at this site was a low of 9 to a high of 27,000.

The data for the Pedestrian Bridge Station indicates that the primary standard would have been violated only once in 15 data points. However, the 400 count limit would have been violated 9 times in 15 data sets. The range of values at this site was 9 to 31,000.

While Fecal Streptococcus numbers are not actually part of the Water Quality Criteria, scientists feel that this organism is a useful indicator of the source of contamination. Researchers have developed a Fecal Coliform/Fecal Streptococcus ratio to indicate whether most of the contamination is related to animal waste or human waste. A low ratio (one or less) strongly indicates contamination by animal wastes while a high ratio (4 or higher) is a strong indication of contamination by human wastes. Values in-between may be indicative of trends but technically are not very clear. Ratios were determined for all of the Arkansas River stations. Overall, it can be seen that most of the contamination comes from animal waste. However, there were several occasions where the contamination can be attributed to human wastes.

A perusal of the data from the three storm drains that were studied gives us a good indication of why the Arkansas River can't meet in-stream water quality standards in regards to bacterial problems. Elevated bacterial counts can be found at any of these drains at any time. In fact, there were some instances where all 3 drains were contributing large amounts of bacterial contaminants (e.g., July 17, August 14). This readily illustrates the problems facing Tulsa in controlling these contaminants. There are several other storm drains on both the east and west banks of the Arkansas River. Undoubtedly, some or all of these drains are contributing bacterial contamination to the river. It is evident that something will have to be done to treat storm-water if we wish to achieve the desired water quality criteria for the Arkansas River. At this time, however, it is clear that the river does not qualify for primary body contact activities.

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BACTERIOLOGICAL QUALITY OF THE ARKANSAS RIVER AT ZINK LAKE, 1989

11TH STREET BRIDGE (OA020)

	West Bank (A)			Mid Channel (B)			East Bank (C)		
	F. Colif.	F. Strep.	FC/FS	F. Colif.	F. Strep.	FC/FS	F. Colif.	F. Strep.	FC/FS
01-May-89	9	27	0.30	9	45	0.20	9	120	0.075
03-May-89	45	150	0.30	54	220	0.24	770	26000	0.029
08-May-89	45	63	0.70	63	160	0.39	130	220	0.59
10-May-89	10	18	0.50	9	45	0.20	45	360	0.12
15-May-89	870	240	3.60	9	27	0.33	72	18	4
17-May-89	27	190	0.14	72	72	1.00	36	170	0.21
22-May-89	2400	2700	0.80	500	730	0.68			
24-May-89	10	130	0.07	18	63	0.28	90	230	0.39
31-May-89	63	280	0.22	54	450	0.12	140	680	0.2
G.MEAN	57.1			35.3			77.6		
05-Jun-89	18	940	0.02	9	350	0.02	560	800	0.7
07-Jun-89	10	27	0.37	10	72	0.13	130	280	0.46
19-Jun-89	10	27	0.37	36	27	1.30	18	81	0.22
21-Jun-89	10	10	1.00	10	9	1.10	27	45	0.6
26-Jun-89	10	27	0.37	36	18	2.00	27	72	0.37
28-Jun-89	9	160	0.05	9	99	0.09	180	140	1.20
G.MEAN	10.8			14.7			74.5		
05-Jul-89	10	10	1.00	10	27	0.37	9	36	0.25
10-Jul-89	9	9	1.00	9	9	1.00	9	220	0.04
12-Jul-89	9	63	0.14	10	81	0.12	9	270	0.03
19-Jul-89	10	680	0.01	10	5100	0.002	130	650	0.2
24-Jul-89	18	27	0.66	18	10	1.80	81	81	1
26-Jul-89	9	54	0.16	10	10	1.00	27	90	0.3
31-Jul-89	27	130	0.20	9	36	0.25	120	120	1
G.MEAN	11.9			10.5			30.5		
02-Aug-89	54	63	0.85	150	45	3.30	140	220	0.63
07-Aug-89	99	45	2.20	27	27	1.00	270	81	3.30
07-Aug-89	18	360	0.05	9	430	0.02	1000	2500	0.40
14-Aug-89	150	90	1.60	290	220	1.30	71000	67000	1.050
16-Aug-89	90	860	0.10	54	910	0.05	160	3300	0.048
21-Aug-89	2100	240	8.70	200	27	7.40	1000	430	2.30
23-Aug-89	36	54	0.66	9	45	0.20	36	120	0.30
28-Aug-89	10	63	0.16	18	10	1.80	130	320	0.40
30-Aug-89	18	200	0.09	10	90	0.10	27	280	0.09
G.MEAN	63.8			38.4			335		
06-Sep-89	10	540	0.01	10	170	0.05	27	520	0.05
11-Sep-89	9	130	0.06	10	27	0.37	27	90	0.3
18-Sep-89	210	190	1.1	200	120	1.6	270	140	1.92
20-Sep-89	170	330	0.51	130	200	0.65	640	540	1.25
25-Sep-89	27	130	0.2	18	72	0.25	45	330	0.13
G.MEAN	38.6			34.2			89.2		

21ST STREET BRIDGE (OA006)

	West Bank (A)			Mid Channel (B)			East Bank (C)		
	F. Colif.	F. Strep.	FC/FS	F. Colif.	F. Strep.	FC/FS	F. Colif.	F. Strep.	FC/FS
01-May-89	18	210	0.08	45	63	0.70	310	230	1.30
03-May-89	160	320	0.50	310	590	0.52	330	620	0.53
10-May-89	110	18	6.00	18	18	1.00	99	81	1.20
15-May-89	81	45	1.80	18	18	1.00	720	230	3.10
17-May-89	27	150	0.18	45	90	0.50	18	90	0.20
22-May-89	2000	260	7.60	550	370	1.40	27000	24000	1.10
24-May-89	54	120	0.45	10	45	0.20	130	140	0.90
31-May-89	18	99	0.18	9	90	0.10	180	4200	0.04
G.MEAN	77.8			42.2			308.9		
05-Jun-89	18	240	0.07	45	140	0.30	2000	5400	0.37
07-Jun-89	18	36	0.50	99	140	0.70	250	280	0.89
19-Jun-89	10	18	0.50	10	36	0.27	9	36	0.25
21-Jun-89	10	10	1.00	9	9	1.00	10	45	0.22
26-Jun-89	10	9	1.10	45	81	0.50	45	63	0.71
28-Jun-89	54	160	0.30	90	280	0.32	140	260	0.53
G.MEAN	16.1			34.2			81		
Gm									
05-Jul-89	10	18	0.5	10	54	0.18	99	130	0.76
10-Jul-89	10	18	0.5	9	99	0.11	9	190	0.04
12-Jul-89	9	360	0.03	10	530	0.01	9	410	0.02
19-Jul-89	18	860	0.02	9	4300	0.002	130	630	0.20
24-Jul-89	36	18	2.00	10	27	0.30	130	120	1.00
26-Jul-89	18	9	2.00	9	27	0.30	18	81	0.22
31-Jul-89	9	170	0.05	18	72	0.25	200	160	1.25
G.MEAN	13.7			10.3			46.7		
02-Aug-89	63	72	0.87	54	54	1	150	270	0.55
07-Aug-89	18	200	0.09	99	300	0.33	410	250	1.6
09-Aug-89	18	140	0.12	10	290	0.03	450	440	1
14-Aug-89	360	250	1.4	1500	340	4.4	26000	6500	4
16-Aug-89	72	360	0.2	36	220	0.16	490	350	1.4
21-Aug-89	27	110	0.24	54	27	2	1300	400	3.25
23-Aug-89	63	54	1.1	10	45	0.22	45	72	0.62
28-Aug-89	10	170	0.05	10	72	0.13	99	270	0.36
30-Aug-89	18	140	0.12	10	200	0.05	27	470	0.05
G.MEAN	37.9			37.7			336.3		
09-Sep-89	18	2000	0.009	10	660	0.01	150	610	0.24
11-Sep-89	18	54	0.30	9	45	0.20	27	160	0.16
18-Sep-89	210	200	1.05	230	120	1.90	280	230	1.20
20-Sep-89	45	220	0.20	81	270	0.30	110	370	0.29
25-Sep-89	36	630	0.05	45	380	0.11	90	370	0.24
G.MEAN	40.5			37.6			102.3		

PEDESTRIAN BRIDGE (0A005)

	West Bank (A)			Mid Channel (B)			East Bank (C)		
	F. Colif.	F. Strep.	FC/FS	F. Colif.	F. Strep.	FC/FS	F. Colif.	F. Strep.	FC/FS
01-May-89	9	63	0.14	9	54	0.16	18	36	0.50
03-May-89	36	260	0.13	130	160	0.81	2400	2100	1.10
08-May-89	27	110	0.24	18	90	0.59	99	170	0.59
10-May-89	36	54	0.66	36	45	0.80	63	72	0.87
15-May-89	54	54	1.00	81	81	1.00	81	200	0.40
17-May-89	160	350	0.45	170	320	0.53	150	260	0.57
22-May-89	8000	2000	4.00	6000	7500	0.80	7500	5800	1.29
24-May-89	9	10	0.90	10	9	1.10	9	36	0.25
31-May-89	210	2900	0.07	320	3800	0.08	250	3900	0.06
G.MEAN	70.1			83.6			156.1		
05-Jun-89	54	90	0.60	36	72	0.50	330	1800	0.18
07-Jun-89	500	520	0.96	580	420	1.30	500	410	1.20
19-Jun-89	9	18	0.50	10	9	1.10	10	9	1.10
21-Jun-89	10	10	1.00	10	10	1.00	10	27	0.30
26-Jun-89	99	140	0.70	180	200	0.90	240	220	1.00
28-Jun-89	27	140	0.19	27	130	0.20	45	180	0.25
G.MEAN	43.1			46.5			75		
05-Jul-89	9	27	0.33	10	45	0.20	18	45	0.40
10-Jul-89	9	220	0.04	10	9	1.10	9	9	1.00
12-Jul-89	27	270	0.10	9	140	0.06	27	230	0.11
9-Jul-89	18	680	0.02	10	250	0.04	36	660	0.05
24-Jul-89	10	18	0.55	10	27	0.37	9	45	0.20
26-Jul-89	10	10	1.00	9	10	0.90	10	36	0.27
31-Jul-89	9	200	0.04	10	110	0.09	45	72	0.62
G.MEAN	11.9			9.7			24.7		
02-Aug-89	81	120	0.67	63	81	0.77	120	200	0.60
07-Aug-89	45	110	0.40	10	250	0.04	10	90	0.11
07-Aug-89	45	270	0.16	63	170	0.37	270	210	1.20
14-Aug-89	31000	5000	6.20	1200	670	1.70	6000	4500	1.30
16-Aug-89	45	110	0.40	36	110	0.32	18	63	0.28
21-Aug-89	130	45	2.80	54	36	1.50	180	240	0.75
23-Aug-89	54	27	2.00	18	18	1.00	45	120	0.37
28-Aug-89	18	220	0.08	18	190	0.09	9	140	0.06
30-Aug-89	18	45	0.40	9	18	0.50	220	730	0.30
G.MEAN	93			40.1			93.7		
06-Sep-89	9	170	0.05	10	180	0.05	10	240	0.04
11-Sep-89	10	36	0.27	9	9	1.00	27	90	0.30
18-Sep-89	160	130	1.20	220	130	1.60	330	200	1.65
20-Sep-89	110	99	1.10	200	99	2.00	200	170	1.10
25-Sep-89	27	290	0.09	36	320	0.11	72	310	0.23
G.MEAN	33.5			42.7			66.3		

BACTERIOLOGICAL QUALITY OF ZINK LAKE TRIBUTARY STORM DRAIN
FAIR WEATHER FLOWS, 1989

	11TH ST. STORM DRAIN			INDIAN AVENUE STORM DRAIN			21ST ST. STORM DRAIN		
DATE	F.COLIF	F.STREP.	FC/FS	F.COLIF	F.STREP.	FC/FS	F.COLIF	F.STREP.	FC/FS
07-Jun-89	24000	39000	0.34	440	750	0.58	8000	6000	1.33
19-Jun-89	590	430	1.30	200	830	0.24	120	200	0.60
21-Jun-89	300	680	0.44				1500	300	5.00
26-Jun-89	18	54	0.33	3000	350	8.60	1600	790	2.00
05-Jul-89	6000	4600	1.30				570	480	1.01
10-Jul-89	250	550	0.45				560	610	0.90
12-Jul-89	770	8100	0.095				4000	2700	1.4
17-Jul-89	60000	100000	0.6	69000	100000	0.69	60000	100000	0.6
19-Jul-89	250	6500	0.03	140	800	0.17	2400	5700	0.42
24-Jul-89	140	1700	0.08	36	200	0.18	170	440	0.38
26-Jul-89	700	3400	0.2	99	400	0.24	180	480	0.37
31-Jul-89	3300	550	6	3600	740	4.8	99	450	0.22
02-Aug-89	2300	76000	0.03	2800	900	3.1	3600	920	3.9
07-Aug-89	260	4500	0.05	2200	2900	0.75	600	590	1
09-Aug-89	30000	100000	0.3	2300	690	3.3	210	380	0.55
14-Aug-89	74000	6500	11.4	23000	67000	0.34	60000	75000	0.8
16-Aug-89	60000	100000	0.6	640	600	1	2100	650	3.2
21-Aug-89	27000	4900	5.5	1200	800	1.5	60000	5800	10
23-Aug-89	6000	54000	0.11	27	560	0.04	28000	7400	3.7
28-Aug-89	5400	2500	2.1	160	500	0.32	1600	720	2.2
30-Aug-89	39000	100000	0.39	180	4500	0.04	5100	1900	2.6
06-Sep-89	43000	100000	0.43	530	5400	0.1	4200	1700	2.4
11-Sep-89	2700	8500	0.31	72	440	0.16	150	250	0.6
20-Sep-89	60000	3000	20	48000	510	94	250	310	0.8
25-Sep-89	3100	310	10	140	250	0.56	220	610	0.36

1990 ZINK LAKE WATER QUALITY REPORT

The Bacteriological Water Sampling Project was continued in 1990 as has been done in the years past. The project is undertaken to study whether or not the Zink Lake area of the Arkansas River can meet the criteria of the Oklahoma Water Quality Standards (Revised 1988). The primary standard calls for a Geometric Mean Value of 200 counts per 100 ml of water for a minimum of five samples collected over a 30 day period. In addition, no more than 10 percent of the samples may exceed a count of 400 colonies in the same 30 day period.

In 1990, a total of 324 samples were collected at the three bridge stations in the Zink Lake area. In addition, another 144 samples were collected from four major storm drains that yield a constant flow of water to the Zink Lake area at all times. The data derived from those samples is presented in the accompanying tables. The Geometric Mean for each month is included in the tables as well as a Fecal Coliform/Fecal Streptococcus Ratio. There are no Geometric Means for the storm drain data since the Water Quality Standards only apply to in-stream samples.

In looking at the data for the 11th Street Bridge we can see that it failed the Geometric Mean only once in 15 data sets. However, it failed the 400 colony count 13.8% of the time for <u>all</u> samples collected. In addition, at least one station failed at least once during every sampling period (each month). Therefore, the 11th Street Bridge site failed to meet the criteria in any of the five months of the study. In looking at the data, it can be seen that most of the violations occurred on the east bank. This can likely be attributed to the proximity of the 11th Street storm drain. Values ranged from a low of 9 to a high of 19,000 colonies.

In perusing the data from the 21st Street Bridge we can see that it failed the Geometric Mean Standard in three of 15 data sets. Again, at least one sample from each site failed the 400 colony count in every sampling period. A total of 17.5% of <u>all</u> samples collected failed this criteria. The east bank seemed to have the most problems at this site as well. This may also be attributable to the 11th Street storm drain since this site is up-river of the 21st Street storm drain. Values at this station ranged from a low of 9 to a high of 58,000 colonies per sample.

The data from the Pedestrian Bridge reveals that this station did not fail the Geometric Mean Standard in any of the 15 data sets. However, 11.1% of <u>all</u> samples collected failed the 400 colony standard and, as in the other two cases, at least one station failed at each site during every sampling period. Therefore, this station would never satisfy the Water Quality Standards either. The values at this site ranged from a low of 9 to a high of 19,000 colonies per sample.

The Fecal Coliform to Fecal Streptococcus (FC/FS) Ratio is used to indicate the source of the bacterial contaminants. Values of four or greater generally indicate that the main contributing factor is human waste. Values of one or less generally indicate that the main contributing source is animal wastes. Values in between may reveal a trend but are less reliable in indicating the source of contamination. In looking at the FC/FS values for the river stations, it is obvious that most of the contamination comes from animal waste. However, on several occasions, it is apparent that human sewage contributes a significant amount of contamination to the rivers' problem. This may indicate a continuance of the past problem of sanitary sewer lines being hooked into the stormwater drainage system.

In 1990, four stormwater drains were studied to help quantify their contributions to the rivers' bacteriological problem. These storm drains included: 11th Street, Indian Avenue, 21st Street and 26th Street. In looking over the storm drain data, it is apparent that these four storm drains alone contribute a significant amount of the bacterial pollution in the river. For example, high counts for each storm drain are as follows: 11th Street 140,000; Indian Avenue 120,000; 21st Street 130,000; 26th Street 42,000. In addition, while only 10% of the river samples had an FC/FS ratio indicating contamination by human wastes, fully 27% of the storm drain samples indicate that human sewage is the main contributing factor. This data does not take into account the contributions of several other storm drains that are not currently under study. Thus, it can be seen that the storm drains are probably the major contributing factor as to why the Arkansas River can not meet Oklahomas' Water Quality Standards.

BACTERIOLOGICAL WATER QUALITY
OF STORM DRAINS
1990

DATE	11TH ST. STORM DRAIN F.COLIF	11TH ST. STORM DRAIN F.STREP	11TH ST. STORM DRAIN FC/FS	INDIAN AVENUE STORM DRAIN F.COLIF	INDIAN AVENUE STORM DRAIN F.STREP	INDIAN AVENUE STORM DRAIN FC/FS	21TH ST. STORM DRAIN F.COLIF	21TH ST. STORM DRAIN F.STREP	21TH ST. STORM DRAIN FC/FS	26TH STREET DRAIN F.COLIF	26TH STREET DRAIN F.STREP	26TH STREET DRAIN FC/F
07-May-90	490	460	1.07	1100	360	3.06	5100	8800	0.58	40000	42000	0.5
10-May-90	540	370	1.46	360	330	1.09	550	260	2.12	1200	370	3.2
14-May-90	2900	800	3.63	2500	430	5.81	560	330	1.70	42000	900	46.6
17-May-90	17000	4200	4.05	6000	3000	2.00	2200	2700	0.81	2600	1900	1.3
21-May-90	24000	20000	1.20	300	780	0.38	22000	550	40.00	170	460	0.3
24-May-90	2200	3300	0.67	2400	510	4.71	2100	620	3.39	5100	4900	1.0
31-May-90	16000	6300	2.54	2900	250	11.60	14000	650	21.54	3000	200	15.0
04-Jun-90	540	800	0.68	250	810	0.31	450	540	0.83	21000	540	38.89
07-Jun-90	7000	590	11.86	9000	3300	2.73	360	2200	0.16	640	560	1.14
11-Jun-90	2400	720	3.33	21000	600	35.00	460	410	1.12	320	470	0.68
14-Jun-90	730	630	1.16	150	180	0.83	240	400	0.60	5500	2100	2.62
18-Jun-90	12000	34000	0.35	21000	7500	2.80	20000	46000	0.43	21000	6300	3.33
21-Jun-90	1700	4900	0.35	730	310	2.35	32000	37000	0.89	21000	3100	6.77
25-Jun-90	1100	720	1.53	1500	270	5.56	1300	720	1.81	18000	590	30.51
28-Jun-90	1800	3400	0.53	120	330	0.36	240	230	1.04	1500	250	6.00
02-Jul-90	1700	3700	0.46	460	800	0.58	4800	3300	1.45	730	760	0.96
09-Jul-90	1300	2000	0.65	39000	2400	16.25	2600	670	3.38	15000	2500	6.00
12-Jul-90	4200	1600	2.63	5000	2700	1.85	310	1700	0.13	3200	1600	2.00
16-Jul-90	18000	3000	6.00	1100	640	1.72	1100	430	2.56	2800	810	3.46
19-Jul-90	200	230	0.87	6000	1300	4.62	65000	105000	0.62	4500	900	5.00
26-Jul-90	4300	3400	1.26	1500	2600	0.58	4000	2800	1.43	15000	3000	5.00
30-Jul-90	3000	560	5.36	2700	1500	1.80	260	820	0.32	370	2200	0.17
02-Aug-90	1700	1500	1.13	4600	590	7.80	2100	1800	1.17	2500	2100	1.19
06-Aug-90	12000	2700	4.44	1900	2500	0.76	1200	820	1.46	2700	590	4.58
09-Aug-90	4000	4400	0.91	4000	2200	1.82	1500	2200	0.68	820	1300	0.63
13-Aug-90	19000	31000	0.61	37000	49000	0.76	4900	1800	2.72	3200	430	7.44
16-Aug-90	1600	3500	0.46	3000	1100	2.73	2700	1400	1.93	2600	1500	1.73
20-Aug-90	2000	1600	1.25	1600	290	5.52	3600	1500	2.40	580	160	3.63
23-Aug-90	30000	550	54.55	820	1700	0.48	2000	2700	0.74	2600	2900	0.90
27-Aug-90	3500	1200	2.92	5500	3000	1.83	1500	4500	0.33	1600	530	3.02
06-Sep-90	3100	2900	1.07	360	1300	0.28	1500	730	2.05	1500	1400	1.07
10-Sep-90	5200	6000	0.87	3500	1200	2.92	1100	500	2.20	200	2100	0.10
13-Sep-90	3600	560	6.43	11000	47000	0.23	2000	1100	1.82	1500	1700	0.88
20-Sep-90	140000	81000	1.73	120000	69000	1.74	130000	100000	1.30	28000	43000	0.65
24-Sep-90	2000	240	8.33	2400	270	8.89	280	350	0.80	2400	540	4.44
27-Sep-90	3900	3400	1.15	2400	2300	1.04	560	590	0.95	550	1100	0.50

BACTERIOLOGICAL QUALITY OF THE ARKANSAS RIVER AT ZINK LAKE, 1990

11TH STREET BRIDGE (OA020)

	West Bank (A)			Mid Channel (B)			East Bank (C)		
	F. Colif.	F. Strep.	FC/FS	F. Colif.	F. Strep.	FC/FS	F. Colif.	F. Strep.	FC/FS
07-May-90	36	120	0.30	14	93	0.15	120	110	1.09
10-May-90	45	45	1.00	18	81	0.22	9	110	0.08
14-May-90	9	18	0.50	19	81	0.23	10	45	0.22
17-May-90	36	63	0.57	9	9	1.00	9	45	0.20
21-May-90	13000	2600	5.00	300	710	0.42	210	550	0.38
24-May-90	18	36	0.50	10	54	0.19	45	81	0.56
31-May-90	110	27	4.07	45	9	5.00	220	18	12.22
G.MEAN	75.1			24.8			41.2		
04-Jun-90	9	18	0.50	27	9	3.00	140	63	2.22
07-Jun-90	18	72	0.25	10	140	0.07	10	180	0.06
11-Jun-90	10	27	0.37	10	27	0.37	910	63	14.44
14-Jun-90	9	54	0.17	10	27	0.37	150	72	2.08
18-Jun-90	18	63	0.29	180	140	1.29	19000	9100	2.09
21-Jun-90	9	63	0.14	72	110	0.65	36	27	1.33
25-Jun-90	9	340	0.03	10	440	0.02	9	1500	0.01
28-Jun-90	18	160	0.11	9	170	0.05	10	150	0.07
G.MEAN	11.8			20.5			102.1		
02-Jul-90	9	550	0.02	36	4100	0.01	54	3100	0.02
09-Jul-90	27	1200	0.02	27	480	0.06	9	2800	0.003
12-Jul-90	9	550	0.02	15	120	0.13	1900	750	2.53
16-Jul-90	45	10	4.50	9	9	1.00	18	200	0.09
19-Jul-90	18	9	2.00	27	18	1.50	27	90	0.30
26-Jul-90	36	81	0.44	9	81	0.11	1400	1500	0.93
30-Jul-90	81	480	0.17	81	1200	0.07	290	4200	0.07
G.MEAN	24.4			22.1			108.9		
02-Aug-90	110	640	0.17	36	1300	0.03	140	3000	0.05
06-Aug-90	190	1400	0.14	72	500	0.14	1400	550	2.55
09-Aug-90	120	310	0.39	370	270	1.37	550	600	0.92
13-Aug-90	280	640	0.44	280	570	0.49	10000	3600	2.78
16-Aug-90	140	490	0.29	130	400	0.33	130	450	0.29
20-Aug-90	18	63	0.29	45	63	0.71	36	120	0.30
23-Aug-90	400	120	3.33	140	99	1.41	640	340	1.88
27-Aug-90	99	260	0.38	54	90	0.60	99	210	0.47
G.MEAN	127.6			102.2			365.7		
06-Sep-90	36	150	0.24	18	90	0.20	—	—	—
10-Sep-90	180	340	0.53	260	120	2.17	340	240	1.42
13-Sep-90	45	140	0.32	9	150	0.06	130	240	0.54
20-Sep-90	150	170	0.88	250	140	1.79	3700	2700	1.37
24-Sep-90	2000	250	8.00	1500	18	83.33	1000	240	4.17
27-Sep-90	63	54	1.17	36	45	0.80	90	130	0.69
G.MEAN	132.9			91.0			156.5		

21ST STREET BRIDGE (0A006)

	West Bank (A)			Mid Channel (B)			East Bank (C)		
	F. Colif.	F. Strep.	FC/FS	F. Colif.	F. Strep.	FC/FS	F. Colif.	F. Strep.	FC/FS
07-May-90	86	120	0.72	43	71	0.61	110	170	0.65
10-May-90	27	54	0.50	10	27	0.37	9	63	0.14
14-May-90	10	27	0.37	10	81	0.12	18	45	0.40
17-May-90	9	45	0.20	10	36	0.28	54	140	0.39
21-May-90	3800	660	5.76	160	560	0.29	45	180	0.25
24-May-90	45	54	0.83	18	27	0.67	81	27	3.00
31-May-90	110	9	12.22	36	45	0.80	220	18	12.22
G.MEAN	63.0			23.7			49.9		
04-Jun-90	18	110	0.16	27	72	0.38	150	110	1.36
07-Jun-90	10	890	0.01	10	110	0.09	36	160	0.23
11-Jun-90	10	36	0.28	18	18	1.00	640	170	3.76
14-Jun-90	10	120	0.08	10	120	0.08	240	54	4.44
18-Jun-90	300	740	0.41	1100	490	2.24	820	4500	0.18
21-Jun-90	90	81	1.11	18	99	0.18	27	54	0.50
25-Jun-90	10	320	0.03	9	250	0.04	120	210	0.57
28-Jun-90	9	110	0.08	9	45	0.20	10	90	0.11
G.MEAN	21.4			23.0			110.4		
02-Jul-90	27	240	0.11	54	810	0.07	18	690	0.03
09-Jul-90	18	370	0.05	27	240	0.11	54	1100	0.05
12-Jul-90	9	640	0.01	760	260	2.92	1600	3500	0.46
16-Jul-90	18	9	2.00	18	9	2.00	250	430	0.58
19-Jul-90	10	36	0.28	18	9	2.00	54	340	0.16
26-Jul-90	72	220	0.33	10	90	0.11	450	470	0.96
30-Jul-90	130	2500	0.05	130	580	0.22	160	1200	0.13
G.MEAN	25.7			46.5			147.4		
02-Aug-90	230	1000	0.23	90	1700	0.05	250	1600	0.16
06-Aug-90	640	72	8.89	910	72	12.64	460	90	5.11
09-Aug-90	63	120	0.53	160	240	0.67	250	910	0.27
13-Aug-90	1900	220	8.64	2700	390	6.92	58000	14000	4.14
16-Aug-90	140	220	0.64	81	150	0.54	54	160	0.34
20-Aug-90	9	10	0.90	36	9	4.00	81	10	8.10
23-Aug-90	72	160	0.45	90	150	0.60	370	450	0.82
27-Aug-90	9	81	0.11	18	9	2.00	180	170	1.06
G.MEAN	104.7			142.2			385.3		
06-Sep-90	54	150	0.36	27	170	0.16	99	200	0.50
10-Sep-90	560	220	2.55	410	45	9.11	27	220	0.12
13-Sep-90	110	110	1.00	9	210	0.04	1500	500	3.00
20-Sep-90	2200	4000	0.55	220	250	0.88	4900	5700	0.86
24-Sep-90	180	9	20.00	90	63	1.43	3100	390	7.95
27-Sep-90	54	120	0.45	9	45	0.20	350	420	0.83
G.MEAN	203.6			51.1			526.6		

PEDESTRIAN BRIDGE (0A005)

	West Bank (A)			Mid Channel (B)			East Bank (C)		
	F. Colif.	F. Strep.	FC/FS	F. Colif.	F. Strep.	FC/FS	F. Colif.	F. Strep.	FC/FS
07-May-90	510	320	1.59	71	120	0.59	93	160	0.58
10-May-90	9	27	0.33	18	27	0.67	18	27	0.67
14-May-90	18	18	1.00	10	18	0.56	18	18	1.00
17-May-90	18	36	0.50	10	9	1.11	18	36	0.50
21-May-90	81	320	0.25	—	—	—	63	220	0.29
24-May-90	9	18	0.50	18	36	0.50	72	140	0.51
31-May-90	27	10	2.70	36	18	2.00	27	9	3.00
G.MEAN	31.3			20.9			33.1		
04-Jun-90	9	9	1.00	9	63	0.14	81	90	0.90
07-Jun-90	10	110	0.09	10	81	0.12	18	110	0.16
11-Jun-90	10	10	1.00	10	10	1.00	54	10	5.40
14-Jun-90	9	18	0.50	9	27	0.33	36	18	2.00
18-Jun-90	12000	7500	1.60	8000	7500	1.07	3300	4500	0.73
21-Jun-90	36	10	3.60	18	63	0.29	9	81	0.11
25-Jun-90	10	160	0.06	54	72	0.75	18	45	0.40
28-Jun-90	10	280	0.04	9	81	0.11	9	18	0.50
G.MEAN	27.7			29.5			43.8		
02-Jul-90	45	280	0.16	90	230	0.39	63	340	0.19
09-Jul-90	10	160	0.06	18	470	0.04	9	190	0.05
12-Jul-90	45	440	0.10	9	490	0.02	36	250	0.14
16-Jul-90	10	9	1.11	9	27	0.33	10	10	1.00
19-Jul-90	130	54	2.41	36	36	1.00	27	54	0.50
26-Jul-90	110	45	2.44	45	140	0.32	640	250	2.56
30-Jul-90	63	410	0.15	18	280	0.06	110	380	0.29
G.MEAN	40.6			23.4			45.2		
02-Aug-90	18	340	0.05	27	470	0.06	150	1600	0.09
06-Aug-90	200	10	20.00	330	10	33.00	270	9	30.00
09-Aug-90	9	54	0.17	27	72	0.38	54	72	0.75
13-Aug-90	6000	330	18.18	910	450	2.02	2000	330	6.06
16-Aug-90	370	380	0.97	—	—	—	360	470	0.77
20-Aug-90	45	45	1.00	81	10	8.10	10	10	1.00
23-Aug-90	63	54	1.17	81	45	1.80	170	180	0.94
27-Aug-90	90	9	10.00	81	9	9.00	63	120	0.53
G.MEAN	107.9			102.2			142.4		
06-Sep-90	27	110	0.25	45	90	0.50	54	140	0.39
10-Sep-90	63	9	7.00	160	9	17.78	36	9	4.00
13-Sep-90	54	130	0.42	36	110	0.33	18	110	0.16
20-Sep-90	1600	730	2.19	360	410	0.88	19000	22000	0.86
24-Sep-90	450	99	4.55	470	90	5.22	560	90	6.22
27-Sep-90	36	36	1.00	36	36	1.00	9	99	0.09
G.MEAN	115.6			107.9			122.3		

WATER QUALITY REPORT FOR THE ZINK LAKE -

RIVER PARKS AREA OF THE ARKANSAS RIVER

FOR 1991

PREPARED BY THE TULSA CITY-COUNTY
HEALTH DEPARTMENT

JUNE 10, 1992

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ZINK LAKE BACTERIOLOGICAL REPORT - 1991

As in the past, bacteriological sampling of the Zink Lake area of the Arkansas River was conducted in 1991. Samples were collected at three river stations and from four major storm drains in this area of the river from May 1st to September 30th. This stretch of the river has been designated for "Primary Body Contact Recreation" usage in the Oklahoma Water Quality Standards (OWQS). In addition, the River Parks Authority would like to promote boating, canoeing and wading activities in the park area. To undertake these activities would require that the river meet the bacteriological standards of the OWQS. The sampling program is required to be conducted by the City of Tulsa as part of their United States Army Corps of Engineers permit to build the low water dam.

Samples are collected twice weekly. At each river station three samples are collected. One sample is collected near each bank and one is collected from the middle of the river in order to get a cross-sectional idea of what the bacteriological water quality looks like. An open plastic container is lowered to the surface of the water and is allowed to submerge. It is then retrieved when the container is full. This method is called taking a grab sample. Samples are also collected at four different storm drains in order to determine the bacteriological contamination contributed by these sources. Samples are analyzed for fecal coliform and fecal streptococcus organisms.

The OWQS include certain criteria associated with the "Primary Body Contact" beneficial use designation. These criteria require that a minimum of five samples be collected and analyzed in a 30 day period. Next the "Geometric Mean" of the values is calculated (this is done by taking the "n" root of the product of the n values)*. The obtained value can then be compared to the value established in the OWQS. In addition, the standards contain a total count limitation and this is simply checked against the actual counts that are obtained. We also calculate a "Fecal Coliform to Fecal Streptococcus Ratio" (FC/FS). While this ratio is not part of the OWQS, it is generally accepted as an indicator of whether the bacterial contamination is contributed by animal wastes or is of human origin.

The OWQS state that the "Geometric Mean" of the collected samples may not exceed 200 colonies. In addition, the standards state that the total fecal coliform count may not exceed 400 colonies in more than 10% of the samples. If the "FC/FS Ratio" is greater than five, then the contamination is considered to be mainly of human origin. If the ratio is less than two, the contamination is considered to be of an animal origin. Intermediate values are generally considered to be inconclusive.

*NOTE: Geometric Mean Calculation= $\sqrt[n]{X_1 \times X_2 \times X_3 \ldots Xn}$

Samples collected at the 11th Street Bridge did not meet the "Geometric Mean" criterion in 5 out of 15 data sets*. In addition, the 400 total count criterion was violated 23% of the time over the whole 5 month sampling period. The range in count values was 9 (nondetectable) to 67,000. While the "FC/FS Ratio" tends to indicate that overall contamination is mainly due to animal wastes, there were six occasions where the contamination could be attributed to human waste. For this station, June and July were the better months, while September was by far the worst month.

At the 21st Street Bridge, the "Geometric Mean" fell below the criterion in 5 of 15 data sets, and the 400 total count criterion failed 27% of the time over the entire period. The range in values was 9 to 25,000. The "FC/FS Ratio" also indicated six instances of probable human contamination. Again, June and July were the better months for this station while September was the worst.

At the Pedestrian Bridge the "Geometric Mean" did not meet the criterion in 3 of 15 data sets, but only in the month of September. The 400 colony count failed every month and in 21% of all the samples collected. The "FC/FS Ratio" indicates that on 14 different occasions the bacterial contamination could mainly be attributed to human sources. As it was at the other two sites, June and July were the better months while September was the worst.

A review of the bacteriological data from the storm drains reveals why this stretch of the river can't meet the OWQS criterion. In general, it can be seen that bacteriological counts in the routine water flow from these drains are relatively high. We can summarize the storm drain data as follows:

(A) At the 11th Street Storm Drain, the range of fecal coliform counts was 190 to 110,000 and the range of fecal streptococcus counts was 180 to 150,000. The "FC/FS Ratio" ranged from .14 to 50.0. The ratio indicated that on 9 of 32 sampling dates, the major part of the contamination could be attributed to human origins.

(B) At the Indian Avenue Storm Drain, the range of fecal coliform counts was 9 to 98,000 and the range of fecal streptococcus counts was 54 to 82,000. The "FC/FS Ratio" ranged from .08 to 49.0. The ratio indicated that on 6 of 32 sampling dates, the greater part of the contamination could be contributed by human wastes.

*NOTE: Data Set = Geometric Mean Calculation for all samples collected in the period of a month. (5 months x 3 substations = 15 data sets).

(C) At the 21st Street Storm Drain, fecal coliform counts ranged from 9 to 60,000 and fecal streptococcus counts ranged from 54 to 84,000. The "FC/FS Ratio" ranged from .11 to 83.33. The ratio indicated that on 6 of the 32 sampling dates the major portion of the bacterial contamination could be attributed to human sources.

(D) At the 26th Street Storm Drain, the fecal coliform counts ranged from 9 to 48,000 and the fecal streptococcus counts ranged from 9 to 100,000. The "FC/FS Ratio" ranged from .17 to 44.44. The results of 8 of 32 samples collected for which the FC/FS was calculated, showed an increased number of fecal coliforms presumably of human origin.

As in every year past, the Arkansas River in the downtown Tulsa area was not able to meet the OWQS criteria for the "Primary Body Contact Recreational Usage" in 1991. It is evident that much of the bacterial contamination can be attributed to human sewage entering the City's storm drainage system. This sewage may be discharged purposefully, through illegal connections, or accidentally, through line breakages and infiltration. In any case, the City faces a major challenge in trying to locate and correct these types of problems. Until this task can be completed, we can expect it to be very difficult to achieve the level of water quality we would like for the Arkansas River.

WATER CHEMISTRY OF THE ZINK LAKE AREA - 1991

In 1991, samples were collected at four sites in the Zink Lake area for the purpose of performing several routine water chemistry analyses. The four sites used were the 11th Street Bridge, the 21st Street Bridge, the Pedestrian Bridge and the 26th Street storm drain. This storm drain was chosen because it has not been extensively sampled in the past.

Routine analyses performed can be placed in three general categories. These are:

1. Heavy Metals - Chromium, Cadmium, Mercury.

2. Oxygen Depleting Materials - Biochemical Oxygen Demand (BOD) and Chemical Oxygen Demand (COD).

3. Nutrients - Nitrates/Nitrites, Total Phosphates, Ammonia.

Chromium and cadmium were chosen because these metals are often constituents of routine low water flows from the storm drains. Mercury was chosen because it is found in small amounts in many of the fish collected for toxicology studies. BOD and COD are both widely used and accepted techniques of measuring oxygen depleting materials in the water. The oxygen levels have a strong correlation with the quality of the aquatic community that can survive in the water. The nutrient components were chosen because these materials are often contributed by routine agricultural practices (even in urban areas) and because they are constituents often found in human sewage.

The OWQS do not have actual numerical limitations for all of these parameters. There are certain restrictive limits that apply to heavy metals when the beneficial use designation is for "Public Water Supply" but the region of the river being studied does not fall into that use category. There are no numerical criteria for the nutrient parameters. Instead, these problems are supposed to be covered by the "Anti-degradation Statement" of the OWQS. There are also no criteria for the oxygen depleting parameters. These problems are addressed by loading restrictions written into National Pollution Discharge Elimination System permits and by the preservation of the dissolved oxygen criteria of the OWQS. Therefore, it is somewhat difficult to make comparisons or judgements as to what the data really signifies.

The term "non-detectable (ND)" is used frequently throughout this section of the report. Use of this term does not necessarily imply that a certain contaminant is not present in the water. It simply means that the level of the analyte fell below the detection capabilities of the analytical equipment. The following lists the detection limits for certain of the analytes (in parts per million): Chromium .03, Cadmium .005, Mercury.0005, Nitrates .02, Phosphates .01 and Ammonia .01.

DISCUSSION OF PARAMETERS:

A. Chromium

Chromium was detectable in 16% of all the river samples collected. The range of values was non-detectable (ND) to .07 mg/l. In only three of 135 samples was chromium found to be greater than .05 mg/l. To put this into perspective it would mean that the Arkansas River could probably be designated as a "Public Drinking Water Source" in relation to this parameter. Chromium was only detected twice in 15 sample sets from the 26th Street storm drain and these levels were barely detectable. All this signifies is that the levels of chromium in any one sample do not seem to be very high. It does not tell us anything about its' cumulative effects in the aquatic ecosystem.

B. Cadmium

Cadmium was found in 51% of all the samples collected. The range of values was ND to .02 mg/l. While cadmium was detected in a majority of samples, its' maximum values would allow for the river to be used as a public water source. Cadmium was detectable in eight of 15 storm drain samples. While the values are not very high, this does indicate that a significant amount of cadmium is entering the river continuously from this source.

C. Mercury

Mercury is the one heavy metal encountered routinely in fish tissue studies. While the levels in the fish tissue do not approach Food and Drug Administration limitations, it is interesting to note that it is a chronic contaminant. Mercury was detected in only 8% of all the water samples. The range of values was ND to .0009 mg/l. These values are minute and would allow for the river to be used as a public water supply. Mercury was non-detectable in any of the storm drain samples.

D. Nitrates/Nitrites

Nitrates/nitrites can be expected to be encountered in almost all of the samples. They were non-detectable in only nine of 135 samples. The range of values encountered was non-detectable to greater than 40 mg/l (in one sample). There were no clear trends distinguishable in the data. On three of the 15 sampling dates (5-8, 5-15, 7-10) the values were elevated but the reason for this is unknown. In general, it does not appear that nitrate/nitrite levels in the river present a problem. Samples from the storm drain were usually higher than in-stream values because activities such as fertilizing yards and lawn watering carry nutrients from fertilized yards into the storm drainage.

E. Total Phosphates

Total phosphate values were detected in every sample collected. The range of values was .041 mg/l to .384 mg/l and phosphate levels were generally lower than nitrate levels. Unlike the nitrate values, the phosphate values were not elevated on any one day. Phosphate levels do not appear to be a major problem in the river itself. Total phosphate levels in the storm drain were often higher than many of the in-stream values.

F. Biochemical Oxygen Demand (BOD)

BOD represents the measure of various types of organic materials on the oxygen supply dissolved in the water. These materials include living biological organisms, decaying organic matter and the oxidation of organic chemicals. The BOD values ranged from 1.0 to 4.4 mg/l in the river samples. These levels are not very high. In addition, variables in the in-stream flow change continuously and thus the oxygen demand is continuously modified. BOD is an important parameter when aquatic plants and algae exhibit over-stimulated growth through the addition of nutrient loadings or when storm water discharges carry increased amounts of terrestrial organic matter to a receiving stream. Our values do not indicate an increased BOD from these organic materials. In most instances the BOD values of the storm drain were as high or higher than in-stream BOD values. This is just another indication of how routine urban storm water flows contribute to the degradation of in-stream water quality.

G. Chemical Oxygen Demand (COD)

The COD determination is a measure of the oxygen equivalent of that portion of the organic matter in a sample that is susceptible to oxidation by a strong oxidant. It does not measure all organic compounds that are readily available to stream organisms and measures some that are not so readily available to biological organisms. It is a useful tool for measuring the oxygen demand of the organic chemicals present in water. COD values ranged from 1.0 to 74.1 mg/l. It is readily apparent that COD levels are much higher than BOD levels and represent a much greater oxygen depletion threat to the stream. Fortunately, natural processes (mainly physical) continuously replenish the dissolved oxygen supply in the water and this COD loading can be carried without adversely impacting the indigenous aquatic community. This is not to imply that the receiving stream can take continued increasing COD loading without suffering adverse effects. Our COD values are highly variable throughout this segment of the river and serve to indicate just how different the in-stream water quality can be from day to day. For the most part, COD levels found in the storm drain were comparable to levels found in the river. However, some anomalies were apparent. On two dates (5-15, 5-22) the COD values for the storm drain were very high. Then, on four other dates (5-29, 7-31, 8-14 and 8-21), COD values were extremely low. These values serve to emphasize the variability found in routine storm water flows from urban areas.

H. Ammonia

Ammonia, when present in sufficient quantity, can be toxic to an aquatic community. Ammonia compounds can be contributed to a watershed by various types of fertilizers and from human and animal wastes. Ammonia in water may also result from the breakdown of nitrogenous compounds under low oxygen concentrations. Ammonia values in the river ranged from non-detectable to .62 mg/l. Some level of ammonia showed up in nearly 70% of the samples. There is no criterion for ammonia in the OWQS. Other Environmental Protection Agency literature has suggested a numerical criterion of .02 mg/l for the protection of aquatic life. If we compare this criterion with our values for the river we can see that a significant portion of the samples exceed this value. While our overall levels may not result in the death of aquatic organisms, they may contribute to the stress on the organisms and therefore make them more susceptible to other environmental abnormalities.

In the previous pages we have discussed the findings of our water chemistry analyses and reported some values that exceed desired standards. Not all of the problem can be attributed to human activities because each constituent results from natural environmental processes. It would be extremely difficult and costly to separate the natural component from the human component because of the pervasiveness of human activity over the entire watershed. However, human activities are easily documented and careless human activities can contribute a variety of pollutants to our watersheds that will degrade water quality. Thus a public education program, along with some control techniques, may reduce the contaminants unnecessarily entering the environment and improve surface water quality.

CONTAMINANTS IN FISH OF THE ZINK LAKE AREA (1991)

In May 1991, specimens of several fish species were collected at the Zink Lake Dam in conjunction with the Oklahoma Department of Wildlife Conservation. The specimens were then transported to the OSDH. The OSDH ran a series of 24 analyses on the fish tissue including heavy metals, Polychlorinated Biphenyls (PCB's) and pesticides and their derivatives. All of the analytical results are presented with this report.

The five species of fish that were studied include: Largemouth Buffalo, Striped Bass, Channel Catfish, Gizzard Shad and River Carpsucker. Five specimens of each species were collected and these were weighed, measured and the age estimated. OSDH only performs analyses on fish filets because this is the tissue that would be consumed by the public. The United States Fish and Wildlife Service performs the same type of studies across the state but utilizes the whole fish since some of these contaminants can be concentrated in specific organs.

In general, none of the compounds measured in these fish species exceeded the Federal Drug Administration (FDA) "Action Level" (level of contamination acceptable for human or animal consumption). <u>This is not to imply that no contaminants were found in the fish</u>. Each species will be discussed separately.

The <u>Largemouth Buffalo</u> is a member of the Carp family that obtains its food by rooting around in the bottom sediments. Studies have shown that the levels of contaminants in sediments may be many times higher than amounts found in the water column due to settling and concentration of materials. Bottom feeders thus have a greater risk of exposure to higher concentrations of contaminants through ingestion of the sediments, and may absorb more into their tissues. The Buffalo that were captured ranged from three to six years old and had a mean weight of 3.83 pounds. The only contaminant found in these fish was a small amount of mercury (.16 mg/Kg). All other analytes were below detectable limits.

The Striped Bass is an important game and food fish to many anglers. This fish is migratory and spends most of its time in open water. Larger members of this species are at the top of the predatory aquatic food chain and so have the capacity to bioaccumulate contaminants by ingesting large numbers of smaller organisms with lesser amounts of contamination. In addition, since they are fairly long lived, they have a greater chance of absorbing materials into their tissues. The "Stripers" collected ranged in age from 11 to 16 years with a mean weight of 11.22 pounds. Several contaminants were found in them including Chlordane, Nonachlor, Dichlorodiphenyltrichloroethane (DDT) derivatives, PCB's and mercury. The amounts measured would allow human consumption of this species. The low levels of contaminants in these older fish is an indication that the Arkansas River is not overly contaminated by pesticides.

The Channel Catfish is sought by anglers more than any other local fish species. These fish are generally considered scavengers (opportunistic feeders), feeding mainly in bottom sediments but also capturing forage fish when available. Four of the five specimens captured were between one and three years old. The fifth fish, a much larger specimen, was approximately 21 years old. The mean weight of these fish was 3.9 pounds. The only contaminant found in these fish was a low level of mercury. All of the other analytes were below detectable limits. Thus, there appears to be little danger to the public from eating catfish from the Zink Lake area.

Gizzard Shad were studied because they are the most common forage fish that are consumed by the game fish species. These fish feed by filtering phytoplankton and other bits of organic matter from the water. These materials may be carrying contaminants or have these contaminants incorporated in their tissue. These fish do not attain great size and are not long lived but they occur in much larger numbers than do the game fish. The specimens ranged in age from one to five years old and the mean weight was .30 pounds. No contaminants were detected in these fish.

The River Carpsucker is one of the smaller members of the Carp family. It is common in the Arkansas River and it feeds on materials growing on the bottom and on other substrates. The specimens collected ranged from three to six years in age and the mean weight was 1.78 pounds. Several contaminants were detected in these fish. These included Chlordane, DDT derivatives, PCB's and mercury.

Several inferences may be drawn from this data regarding levels of contaminants in the Arkansas River and its endemic fish population. Because only low levels of contaminants were found, we can infer that the Arkansas River is not seriously polluted with these materials. On the other hand, substances like DDT, whose use has been banned for more than twenty years, and Chlordane, whose use has been banned for a few years, persist in the environment. Because fish bioaccumulate these materials in their muscle tissues over a period of time and these contaminants become detectable in larger and older fish, we conclude:

(1) that although none of the contaminants discovered in the fish reached the FDA "Action Level", the fish are not entirely free of all hazardous contaminants.

(2) that larger and older fish have had a longer life to accumulate contaminants and the public should consume only smaller members of the game species to minimize the risk of ingesting these contaminants.

(3) that many of the contaminants enter the river via the major storm drains and the public should not consume carp or catfish caught in the immediate area of a storm drain.

APPENDIX A - BACTERIOLOGICAL DATA

BACTERIOLOGICAL QUALITY OF THE ARKANSAS RIVER AT ZINK LAKE
MAY - SEPTEMBER 1991

11TH STREET BRIDGE (0A020)

	West Bank (A)			Mid Channel (B)			East Bank (C)		
	FC*	FS*	FC/FS*	FC*	FS*	FC/FS*	FC*	FS*	FC/FS*
06-May-91	63	140	0.45	9	63	0.14	27	240	0.11
08-May-91	72	18	4.00	10	27	0.37	140	810	0.17
13-May-91	45	27	1.67	10	9	1.11	18	10	1.80
15-May-91	45	54	0.83	9	18	0.50	63	200	0.32
20-May-91	730	900	0.81	81	290	0.28	3100	8400	0.37
22-May-91	1100	960	1.15	140	5900	0.02	40000	7200	5.56
29-May-91	45	99	0.45	18	250	0.07	81	400	0.20
G.MEAN*	118.7			20.7			237.8		
03-Jun-91	54	54	1.00	9	18	0.50	140	240	0.58
10-Jun-91	36	81	0.44	1	45	0.02	72	150	0.48
12-Jun-91	10	200	0.05	9	9	1.00	36	9	4.00
17-Jun-91	72	63	1.14	110	140	0.79	610	580	1.05
19-Jun-91	45	81	0.56	120	190	0.63	220	480	0.46
G.MEAN*	36.3			16.1			137.2		
08-Jul-91	9	290	0.03	99	120	0.83	63	45	1.40
10-Jul-91	99	590	0.17	63	650	0.10	140	1200	0.117
15-Jul-91	10	190	0.05	9	140	0.06	220	170	1.29
17-Jul-91	36	340	0.11	54	370	0.15	99	480	0.2
22-Jul-91	110	470	0.23	110	480	0.23	200	490	0.41
29-Jul-91	90	27	3.33	90	190	0.47	200	140	1.43
31-Jul-91	27	150	0.18	27	170	0.16	140	290	0.48
G.MEAN*	36.5			50.3			140.4		
05-Aug-91	9	36	0.25	27	63	0.43	230	400	0.58
07-Aug-91	430	110	3.91	54	240	0.23	120	380	0.32
12-Aug-91	9	90	0.10	10	27	0.37	63	45	1.40
14-Aug-91	730	320	2.28	4300	250	17.20	67000	8000	8.38
19-Aug-91	72	81	0.89	45	110	0.41	290	240	1.21
21-Aug-91	430	320	1.34	72	99	0.73	420	490	0.86
26-Aug-91	18	45	0.40	9	9	1.00	230	72	3.19
28-Aug-91	90	200	0.45	18	170	0.11	170	290	0.59
G.MEAN*	77.3			48.9			391.8		
04-Sep-91	910	510	1.78	570	1400	0.41	13000	20000	0.65
09-Sep-91	170	150	1.13	2300	130	17.69	3700	410	9.02
11-Sep-91	210	120	1.75	160	72	2.22	910	250	3.64
16-Sep-91	560	470	1.19	1100	850	1.29	9	9	1.00
30-Sep-91	640	210	3.05	300	27	11.11	600	160	3.75
G.MEAN*	410.4			586.2			749.4		

*FC = Fecal Coliform
*FS = Fecal Streptococcus
*FC/FS = Fecal Coliform/Fecal Streptococcus Ratio
*G Mean = Geometric Mean

BACTERIOLOGICAL QUALITY OF THE ARKANSAS RIVER AT ZINK LAKE
MAY - SEPTEMBER 1991

21ST STREET BRIDGE (0A006)

	West Bank (A)			Mid Channel (B)			East Bank (C)		
	FC*	FS*	FC/FS*	FC*	FS*	FC/FS*	FC*	FS*	FC/FS*
06-May-91	150	90	1.67	18	9	2.00	81	280	0.29
08-May-91	63	72	0.88	18	27	0.67	1200	2700	0.44
13-May-91	460	63	7.30	72	27	2.67	120	63	1.90
15-May-91	45	18	2.50	45	18	2.50	3300	5300	0.62
20-May-91	470	3200	0.15	18	210	0.09	81	180	0.45
22-May-91	540	890	0.61	120	390	0.31	1200	2400	0.50
29-May-91	54	270	0.20	36	260	0.14	2200	250	8.80
G.MEAN*	160.0			36.2			503.7		
03-Jun-91	81	230	0.35	36	27	1.33	440	570	0.77
10-Jun-91	10	140	0.07	36	90	0.40	45	99	0.45
12-Jun-91	27	190	0.15	18	18	1.00	18	63	0.29
17-Jun-91	130	200	0.65	99	99	1.00	130	380	0.34
19-Jun-91	54	45	1.20	54	27	2.00	230	770	0.30
G.MEAN*	43.4			41.6			101.3		
08-Jul-91	10	160	0.06	10	120	0.08	27	54	0.50
10-Jul-91	90	240	0.38	54	380	0.14	550	620	0.89
15-Jul-91	9	27	0.33	18	36	0.50	27	45	0.60
17-Jul-91	27	420	0.06	27	190	0.14	72	200	0.36
22-Jul-91	9	45	0.20	9	9	1.00	27	9	3.00
29-Jul-91	10	10	1.00	27	27	1.00	180	99	1.82
31-Jul-91	27	120	0.23	10	110	0.09	160	200	0.80
G.MEAN*	17.6			18.1			80.3		
05-Aug-91	160	110	1.45	81	27	3.00	120	110	1.09
07-Aug-91	72	140	0.51	260	300	0.87	5800	3300	1.76
12-Aug-91	450	140	3.21	27	54	0.50	3000	90	33.33
14-Aug-91	4000	230	17.39	450	1000	0.45	25000	1400	17.86
19-Aug-91	99	63	1.57	18	45	0.40	110	99	1.11
21-Aug-91	140	510	0.27	9	10	0.90	72	72	1.00
26-Aug-91	18	18	1.00	27	10	2.70	99	170	0.58
28-Aug-91	110	280	0.39	45	110	0.41	140	260	0.54
G.MEAN*	165.7			51.6			524.5		
04-Sep-91	2300	8000	0.29	2800	7700	0.36	3100	4200	0.74
09-Sep-91	340	110	3.09	640	290	2.21	1500	410	3.66
11-Sep-91	210	72	2.92	99	63	1.57	440	290	1.52
16-Sep-91	2300	4700	0.49	420	350	1.20	2900	9000	0.32
30-Sep-91	2100	160	13.13	1300	18	72.22	1100	330	3.33
G.MEAN*	954.7			627.0			1455.3		

*FC = Fecal Coliform
*FS = Fecal Streptococcus
*FC/FS = Fecal Coliform/Fecal Streptococcus Ratio
*G Mean = Geometric Mean

BACTERIOLOGICAL QUALITY OF THE ARKANSAS RIVER AT ZINK LAKE
MAY - SEPTEMBER 1991

PEDESTRIAN BRIDGE (0A005)

	West Bank (A)			Mid Channel (B)			East Bank (C)		
	FC*	FS*	FC/FS*	FC*	FS*	FC/FS*	FC*	FS*	FC/FS*
06-May-91	110	45	2.44	72	72	1.00	18	63	0.29
08-May-91	9	10	0.90	45	18	2.50	910	3700	0.25
13-May-91	36	36	1.00	9	10	0.90	18	27	0.67
15-May-91	9	45	0.20	10	10	1.00	63	230	0.27
20-May-91	2500	3700	0.68	140	360	0.39	430	850	0.51
22-May-91	200	520	0.38	140	550	0.25	600	790	0.76
29-May-91	36	81	0.44	18	180	0.10	360	220	1.64
G.MEAN*	66.5			18.5			138.0		
03-Jun-91	63	72	0.88	27	36	0.75	220	480	0.46
10-Jun-91	18	760	0.02	10	220	0.05	10	63	0.16
12-Jun-91	10	9	1.11	27	150	0.18	9	72	0.13
17-Jun-91	99	110	0.90	63	54	1.17	530	620	0.85
19-Jun-91	36	72	0.50	110	140	0.79	90	210	0.43
G.MEAN*	33.2			34.7			62.4		
08-Jul-91	9	18	0.50	9	63	0.14	18	63	0.29
10-Jul-91	54	2400	0.02	120	240	0.50	63	200	0.32
15-Jul-91	27	10	2.70	18	10	1.80	72	90	0.80
17-Jul-91	9	140	0.06	45	180	0.25	18	200	0.09
22-Jul-91	27	140	0.19	45	9	5.00	9	18	0.50
29-Jul-91	350	54	6.48	170	140	1.21	63	18	3.50
31-Jul-91	63	45	1.40	54	36	1.50	54	72	0.75
G.MEAN*	35.4			44.8			33.3		
05-Aug-91	9	18	0.50	36	9	4.00	250	72	3.47
07-Aug-91	350	72	4.86	260	45	5.78	81	110	0.74
12-Aug-91	120	36	3.33	9	18	0.50	54	36	1.50
14-Aug-91	22000	1200	18.33	12000	680	17.65	8000	480	16.67
19-Aug-91	18	18	1.00	45	81	0.56	450	63	7.14
21-Aug-91	18	18	1.00	10	36	0.28	18	10	1.80
26-Aug-91	9	9	1.00	9	9	1.00	10	72	0.14
28-Aug-91	54	72	0.75	27	54	0.50	18	81	0.22
G.MEAN*	77.6			58.9			103.1		
04-Sep-91	2900	8100	0.36	5000	8000	0.63	7000	9400	0.74
09-Sep-91	320	45	7.11	440	36	12.22	410	120	3.42
11-Sep-91	81	54	1.50	130	10	13.00	90	18	5.00
16-Sep-91	730	680	1.07	1700	3700	0.46	3600	13000	0.28
30-Sep-91	470	90	5.22	1100	36	30.56	1500	36	41.67
G.MEAN*	481.2			882.4			1068.8		

*FC = Fecal Coliform
*FS = Fecal Streptococcus
*FC/FS = Fecal Coliform/Fecal Streptococcus Ratio
*G Mean = Geometric Mean

BACTERIOLOGICAL WATER QUALITY
OF STORM DRAINS
MAY - SEPTEMBER 1991

	11TH ST STORM DRAIN OK 002			INDIAN AVE STORM DRAIN OK 003			21ST ST STORM DRAIN OK 008			26TH ST STC	
DATE	FC*	FS*	FC/FS*	FC*	FS*	FC/FS*	FC*	FS*	FC/FS*	FC*	FS*
06-May-91	14000	460	30.43	170	590	0.29	2200	590	3.73	1400	810
08-May-91	4800	7000	0.69	2500	4900	0.51	5500	8800	0.63	2700	4400
13-May-91	1100	550	2.00	3000	610	4.92	500	310	1.61	1200	440
15-May-91	4600	3800	1.21	910	590	1.54	450	750	0.60	1500	720
20-May-91	76000	88000	0.86	39000	82000	0.48	51000	78000	0.65	15000	71000
22-May-91	100000	53000	1.89	35000	41000	0.85	25000	84000	0.30	22000	47000
29-May-91	27000	3500	7.71	45	590	0.08	1600	670	2.39	3000	430
03-Jun-91	8000	680	11.76	3200	2000	1.60	10000	840	11.90	4800	950
10-Jun-91	1100	400	2.75	210	410	0.51	3300	530	6.23	1600	460
12-Jun-91	5100	620	8.23	530	570	0.93	1600	610	2.62	2000	45
17-Jun-91	60000	74000	0.81	2000	440	4.55	910	280	3.25	410	550
19-Jun-91	570	360	1.58	5600	3500	1.60	720	400	1.80	690	670
08-Jul-91	1400	400	3.50	140	240	0.58	2700	700	3.86	640	340
10-Jul-91	810	460	1.76	210	2100	0.10	3000	3100	0.97	13000	1600
15-Jul-91	6000	4500	1.33	4900	830	5.90	9	54	0.17	820	540
17-Jul-91	2800	450	6.22	500	580	0.86	99	900	0.11	190	510
22-Jul-91	190	610	0.31	4300	2000	2.15	3600	1500	2.40	220	650
29-Jul-91	2000	180	11.11	10000	860	11.63	3500	720	4.86	2100	3700
31-Jul-91	2900	600	4.83	16000	1400	11.43	450	790	0.57	460	590
05-Aug-91	27000	73000	0.37	98000	2000	49.00	60000	720	83.33	1500	630
07-Aug-91	4400	2700	1.63	10	54	0.19	360	270	1.33	1800	1400
12-Aug-91	2000	880	2.27	110	530	0.21	470	690	0.68	1300	290
14-Aug-91	110000	4400	25.00	27000	1600	16.88	28000	2000	14.00	11000	1600
19-Aug-91	21000	150000	0.14	910	540	1.69	9000	710	12.68	820	890
21-Aug-91	4800	5700	0.84	510	490	1.04	1000	730	1.37	3700	1400
26-Aug-91	300	620	0.48	550	640	0.86	240	240	1.00	9	10
28-Aug-91	410	250	1.64	910	690	1.32	2700	540	5.00	9000	4600
04-Sep-91	34000	24000	1.42	24000	17000	1.41	19000	39000	0.49	48000	11000
09-Sep-91	22000	3000	7.33	4000	6300	0.63	1500	510	2.94	2000	260
11-Sep-91	2600	570	4.56	34000	930	36.56	340	550	0.62	3000	570
16-Sep-91	9000	30000	0.30	40000	6000	6.67	60000	28000	2.14	17000	100000
30-Sep-91	100000	2000	50.00	5300	380	13.95	1400	260	5.38	4100	310

*FC = Fecal Coliform
*FS = Fecal Streptococcus
*FC/FS = Fecal Coliform/Fecal Streptococcus Ratio

APPENDIX B - WATER CHEMISTRY DATA

ARKANSAS RIVER PROJECT

WATER CHEMISTRY DATA

1991

DATE	SITE	*Cr	*Cd	*Hg	$^*NO_3/NO_2$	$^*TPO_4$	*BOD	*COD	$^*NH_3$
5/8	11th St. Br. A	< .03	.015	< .0005	9.3	.072	1.45	18	.066
	11th St. Br. B	< .03	.005	< .0005	33.2	.058	1.38	15.4	.05
	11th St. Br. C	< .03	.005	< .0005	9.3	.098	2.52	20.5	.054
	21st St. Br. A	.07	.007	< .0005	.69	.098	1.48	41	.064
	21st St. Br. B	.07	.007	< .0005	< .02	.075	1.75	15.4	.062
	21st St. Br. C	.07	.005	< .0005	.11	.118	2.25	18	.04
	11th St. S.D.	< .03	.007	< .0005	> 40	.198	2.0	30.8	.026
	Ped. Bridge B	< .03	.008	< .0005	12.3	.070	1.27	10.2	.04
	Ped. Bridge C	< .03	.013	< .0005	10.8	.108	2.27	18	.057
	26th St. S.D.	< .03	.006	< .0005	.11	.185	2.5	15.4	.058
5/15	11th St. Br. A	< .03	.005	< .0005	25.9	.078	1.5	42.3	<.01
	11th St. Br. B	< .03	.006	< .0005	7.35	.080	1.8	19.2	<.01
	11th St. Br. C	< .03	.005	< .0005	0.22	.095	1.7	30.8	.11
	21st St. Br. A	< .03	.005	< .0005	0.44	.092	2.7	23.1	.1
	21st St. Br. B	< .03	.005	< .0005	4.86	.080	3.5	15.4	.13
	21st St. Br. C	< .03	.007	< .0005	< .02	.105	1.9	< 1	.12
	Ped. Bridge A	< .03	.005	< .0005	6.72	.088	2.2	< 1	<.01
	Ped. Bridge B	< .03	.005	< .0005	9.75	.080	1.1	< 1	.098
	Ped. Bridge C	< .03	.005	< .0005	29.9	.105	1.2	< 1	<.01
	26th St. S.D.	< .03	.010	< .0005	>40	.114	3.0	150	<.01
5/22	11th St. Br. A	<.03	.007	< .0005	.24	.123	4.2	32.4	.04
	11th St. Br. B	<.03	.006	< .0005	< .02	.095	2.7	13.5	.03
	11th St. Br. C	<.03	.020	< .0005	.47	.260	4.4	52.7	.03
	21st St. Br. A	<.03	.006	< .0005	.18	.112	2.2	18.9	<.02
	21st St. Br. B	<.03	.009	< .0005	.13	.103	2.5	16.2	.1
	21st St. Br. C	<.03	< .005	< .0005	.08	.133	2.9	21.6	.06
	Ped. Bridge A	<.03	.014	< .0005	.13	.112	4.3	5.4	.04
	Ped. Bridge B	<.03	.007	< .0005	.13	.088	2.5	21.6	.04
	Ped. Bridge C	<.03	.007	< .0005	.29	.136	2.9	< 5	.05
	26th St. S.D.	<.03	.014	< .0005	2.15	1.33	> 6.4	286.4	.08

NOTES: *Cr = Chromium
Cd = Cadmium
Hg = Mercury
NO_3/NO_2 = Nitrate/Nitrite

TPO_4 = Total Phosphate
BOD = Biochemical Oxygen Demand
COD = Chemical Oxygen Demand
NH_3 = Ammonia

ARKANSAS RIVER PROJECT
WATER CHEMISTRY DATA
1991

DATE	SITE	*Cr	*Cd	*Hg	*NO_3/NO_2	*TPO_4	*BOD	*COD	*NH_3
29/91	11th St. Br. A	< .03	.005	< .0005	.18	.096	1.83	15.4	.09
	11th St. Br. B	< .03	.005	< .0005	.10	.055	2.05	12.8	.037
	11th St. Br. C	< .03	.005	< .0005	.13	.110	1.80	12.8	.04
	21st St. Br A	< .03	< .005	< .0005	.35	.094	2.85	20.5	.056
	21st St. Br. B	< .03	.005	< .0005	.35	.053	2.31	12.8	.034
	21st St. Br. C	< .03	< .005	< .0005	.50	.076	1.48	< 5	.064
	Ped. Bridge A	< .03	< .005	< .0005	.18	.062	1.7	11.5	.054
	Ped. Bridge B	< .03	< .005	< .0005	.13	.055	2.06	12.8	.035
	Ped. Bridge C	< .03	< .005	< .0005	.44	.085	2.2	18.9	.05
	26th St. S.D.	< .03	< .005	< .0005	1.79	.101	2.7	< 5	.05
12/91	11th St. Br. A	.03	< .005	< .0005	.10	.158	2.1	12.8	.04
	11th St. Br. B	.03	.006	< .0005	.16	.092	2.2	17.9	.04
	11th St. Br. C	.03	.007	< .0005	.16	.101	2.0	17.9	.02
	21st St. Br. A	.03	< .005	< .0005	.13	.110	2.0	28.2	.06
	21st St. Br. B	.03	< .005	< .0005	.03	.102	2.0	15.4	.06
	21st St. Br. C	.03	.006	< .0005	.13	.105	2.7	15.4	.02
	Ped. Bridge A	.03	.005	< .0005	.53	.119	1.9	23.1	.04
	Ped. Bridge B	.03	.006	< .0005	.10	.119	2.2	12.8	.06
	Ped. Bridge C	.03	< .005	< .0005	.18	.126	2.0	23.1	.04
	26th St. S.D.	.03	< .005	< .0005	.21	.153	2.3	12.8	.05
19/91	11th St. Br. A	.05	< .005	< .0005	.05	.135	2.8	37.0	.03
	11th St. Br. B	.05	.006	< .0005	.11	.153	3.0	74.1	.04
	11th St. Br. C	.05	< .005	< .0005	.13	.142	3.3	17.3	.03
	21st St. Br. A	.05	< .005	< .0005	.11	.120	2.5	56.8	.02
	21st St. Br. B	.05	.006	< .0005	.05	.120	2.8	34.6	< .01
	21st St. Br. C	.05	< .005	< .0005	.19	.142	3.2	44.0	< .01
	Ped. Bridge A	.05	.005	< .0005	.13	.131	1.9	39.5	.01
	Ped. Bridge B	.05	.005	< .0005	.19	.078	3.3	39.5	.01
	Ped. Bridge C	.05	.009	< .0005	.02	.100	2.3	39.5	.02
	26th St. S.D.	.05	< .005	< .0005	.31	.115	2.4	32.1	.03

NOTES: *Cr = Chromium
Cd = Cadmium
Hg = Mercury
NO_3/NO_2 = Nitrate/Nitrite
TPO_4 = Total Phosphate
BOD = Biochemical Oxygen Demand
COD = Chemical Oxygen Demand
NH_3 = Ammonia

ARKANSAS RIVER PROJECT
WATER CHEMISTRY DATA
1991

ATE	SITE	*Cr	*Cd	*Hg	*NO_3/NO_2	*TPO_4	*BOD	*COD	*NH_3
-10-91	11th St. Br. A	<.03	<.005	<.0005	2.75	.165	1.9	21	.11
	11th St. Br. B	<.03	<.005	<.0005	1.09	.137	<1.0	23.7	.11
	11th St. Br. C	<.03	<.005	<.0005	2.07	.158	1.5	17.1	.11
	21st St. Br. A	<.03	<.005	<.0005	1.83	.167	1.5	21	.11
	21st St. Br. B	<.03	<.005	<.0005	3.60	.142	1.5	21	.11
	21st St. Br. C	<.03	<.005	<.0005	2.42	.137	2.0	21	.06
	Ped. Bridge A	<.03	<.005	<.0005	1.83	.112	1.9	15.8	.13
	Ped. Bridge B	<.03	<.005	<.0005	.48	.128	1.6	21	.12
	Ped. Bridge C	<.03	<.005	<.0005	3.25	.153	2.0	21	.20
	26th St. S.D.	<.03	<.005	<.0005	.61	.158	1.9	21	.13
-17-91	11th St. Br. A	<.03	.008	<.0005	.02	.178	—	19.5	<.01
	11th St. Br. B	<.03	.009	<.0005	<.02	.178	—	14.6	<.01
	11th St. Br. C	<.03	.006	<.0005	.02	.174	—	17.1	<.01
	21st St. Br. A	<.03	.008	<.0005	<.02	.162	—	14.6	<.01
	21st St. Br. B	<.03	.011	<.0005	.05	.155	—	14.6	<.01
	21st St. Br. C	<.03	.010	<.0005	.02	.197	—	22.0	<.01
	Ped. Bridge A	<.03	.010	<.0005	.10	.162	—	24.4	<.01
	Ped. Bridge B	<.03	.012	<.0005	.05	.178	—	24.4	<.01
	Ped. Bridge C	<.03	.009	<.0005	.08	.149	—	24.4	<.01
	26th St. S.D.	<.03	.011	<.0005	.13	.162	—	19.5	<.01
'-31-91	11th St. Br. A	<.03	.010	<.0005	.07	.162	1.5	21.1	.08
	11th St. Br. B	<.03	.010	<.0005	.06	.168	1.4	15.8	.09
	11th St. Br. C	<.03	.010	<.0005	.04	.175	2.1	21.1	.03
	21st St. Br. A	<.03	.008	.0005	.04	.158	2.1	19.8	.04
	21st St. Br. B	<.03	.008	<.0005	.04	.078	1.6	<5	.04
	21st St. Br. C	<.03	.010	<.0005	.02	.173	2.4	15.8	<.01
	Ped. Bridge A	<.03	.005	<.0005	<.02	.068	2.2	7.9	<.01
	Ped. Bridge B	<.03	.007	<.0005	<.02	.068	1.9	13.2	<.01
	Ped. Bridge C	<.03	.006	<.0005	<.02	.073	2.1	18.4	<.01
	26th St. S.D.	<.03	.007	<.0005	.06	.318	2.0	<5	<.01

NOTES: *Cr = Chromium
Cd = Cadmium
Hg = Mercury
NO_3/NO_2 = Nitrate/Nitrite

TPO_4 = Total Phosphate
BOD = Biochemical Oxygen Demand
COD = Chemical Oxygen Demand
NH_3 = Ammonia

BOD data for 7/17 was unavailable.

ARKANSAS RIVER PROJECT

WATER CHEMISTRY DATA

1991

DATE	SITE	*Cr	*Cd	*Hg	* NO_3/NO_2	* TPO_4	*BOD	*COD	* NH_3
3-7-91	11th St. Br. A	<.03	.008	.0005	.08	.270	1.8	19.2	.2
	11th St. Br. B	<.03	.009	<.0005	.13	.208	1.2	19.2	.23
	11th St. Br. C	<.03	.006	.0006	.08	.260	1.5	2.7	.19
	21st St. Br A	<.03	.008	.0005	.11	.226	2.6	13.7	.15
	21st St. Br. B	<.03	.011	.0005	.05	.221	<1	19.2	.24
	21st St. Br. C	<.03	.010	<.0005	.19	-	1.3	13.7	.19
	Ped. Bridge A	<.03	.010	<.0005	.25	.242	3.2	27.4	.62
	Ped. Bridge B	<.03	.012	.0005	.16	.266	1.5	16.4	.59
	Ped. Bridge C	<.03	.009	<.0005	.16	.237	1.3	13.7	.60
	26th St. S.D.	<.03	.011	<.0005	.63	.231	3.5	15.1	.2
3-14	11th St. Br. A	<.03	<.005	.0009	.50	.221	3.0	19.8	.01
	11th St. Br. B	<.03	<.005	<.0005	.02	.185	2.2	17.3	<.01
	11th St. Br. C	<.03	<.005	<.0005	.13	.162	1.6	17.3	.01
	21st St. Br. A	<.03	<.005	.0006	.10	.240	2.4	14.8	<.[illegible]
	21st St. Br. B	<.03	.005	<.0005	.10	.155	2.0	14.8	.01
	21st St. Br. C	<.03	<.005	<.0005	.21	.208	3.1	14.8	.01
	Ped. Bridge A	<.03	<.005	<.0005	.38	.203	3.4	27.2	.01
	Ped. Bridge B	<.03	<.005	<.0005	.21	.233	2.9	19.8	.01
	Ped. Bridge C	<.03	<.005	<.0005	.15	.201	2.8	12.4	.01
	26th St. S.D.	<.03	<.005	<.0005	.91	.192	1.9	<1	.01
-21	11th St. Br. A	<.03	<.005	.0007	<.02	.194	3.5	<1	.02
	11th St. Br. B	<.03	<.005	<.0005	.56	.205	2.8	4.9	.01
	11th St. Br. C	<.03	<.005	<.0005	2.72	.203	3.0	14.8	.01
	21st St. Br. A	<.03	<.005	<.0005	.21	.226	2.2	4.9	.02
	21st St. Br. B	<.03	<.005	.0006	.07	.167	2.0	12.4	<.01
	21st St. Br. C	<.03	<.005	.0006	.18	.169	2.4	7.4	<.01
	Ped. Bridge A	<.03	<.005	<.0005	.18	.167	1.3	4.9	.01
	Ped. Bridge B	<.03	<.005	<.0005	.18	.203	1.3	4.9	.01
	Ped. Bridge C	<.03	<.005	<.0005	.10	.164	1.7	4.9	.01
	26th St. S.D.	<.03	.007	<.0005	.26	.185	3.8	<1	.01

NOTE: *Cr = Chromium
Cd = Cadmium
Hg = Mercury
NO_3/NO_2 = Nitrate/Nitrite

TPO_4 = Total Phosphate
BOD = Biochemical Oxygen Demand
COD = Chemical Oxygen Demand
NH_3 = Ammonia

ARKANSAS RIVER PROJECT
WATER CHEMISTRY DATA
1991

DATE	SITE	*Cr	*Cd	*Hg	*NO_3/NO_2	*TPO_4	*BOD	*COD	*NH
8-28	11th St. Br. A	<.03	<.005	<.0005	.23	.155	2.2	2.5	.01
	11th St. Br. B	<.03	<.005	<.0005	.29	.198	1.8	<1	.01
	11th St. Br. C	<.03	<.005	<.0005	.29	.191	1.9	5.4	.01
	21st St. Br. A	<.03	<.005	<.0005	.18	.201	2.0	7.4	<.0
	21st St. Br. B	<.03	<.005	<.0005	.21	.137	1.7	2.5	.02
	21st St. Br. C	<.03	<.005	<.0005	2.41	.157	2.3	9.9	.01
	Ped. Bridge A	<.03	<.005	<.0005	.21	.139	1.9	14.8	.02
	Ped. Bridge B	<.03	<.005	<.0005	.21	.144	1.7	14.8	.02
	Ped. Bridge C	<.03	<.005	<.0005	.21	.184	1.8	4.9	.02
	26th St. S.D.	<.03	.009	<.0005	.52	.169	3.0	4.9	<.01
9-4	11th St. Br. A	.045	<.005	<.0005	.13	.162	3.3	3.3	<.01
	11th St. Br. B	<.03	<.005	<.0005	.10	.119	2.7	2.7	<.01
	11th St. Br. C	<.03	<.005	<.0005	.10	.164	3.4	3.4	<.01
	21st St. Br. A	<.03	<.005	<.0005	.13	.144	3.1	3.1	<.01
	21st St. Br. B	<.03	<.005	<.0005	.10	.167	3.0	3.0	<.01
	21st St. Br. C	<.03	<.005	<.0005	.13	.108	3.0	3.0	<.01
	Ped. Bridge A	<.03	<.005	<.0005	.05	.384	3.3	3.3	<.01
	Ped. Bridge B	<.03	<.005	<.0005	.07	.135	-	-	<.01
	Ped. Bridge C	<.03	<.005	<.0005	.21	.094	2.9	2.9	<.01
	26th St. S.D.	<.03	<.005	<.0005	.10	.232	3.0	3.0	<.01
9-11	11th St. Br. A	<.03	<.005	<.0005	.08	.104	3.3	10.2	<.01
	11th St. Br. B	<.03	<.005	<.0005	.08	.102	2.7	5.1	<.01
	11th St. Br. C	<.03	<.005	<.0005	.08	.111	3.4	10.2	<.01
	21st St. Br. A	<.03	<.005	<.0005	.08	.063	3.1	10.2	<.01
	21st St. Br. B	<.03	<.005	<.0005	.08	.084	3.0	10.2	<.01
	21st St. Br. C	<.03	<.005	<.0005	.03	.041	3.0	10.2	<.01
	Ped. Bridge A	<.03	<.005	<.0005	.03	.091	3.3	10.2	<.01
	Ped. Bridge B	<.03	<.005	<.0005	.05	.079	-	5.1	<.01
	Ped. Bridge C	<.03	<.005	<.0005	.03	.073	2.9	7.7	<.01
	26th St. S.D.	<.03	<.005	<.0005	.58	.088	3.0	5.1	<.01

NOTE: *Cr = Chromium
Cd = Cadmium
Hg = Mercury
NO_3/NO_2 = Nitrite/Nitrite

TPO_4 = Total Phosphate
BOD = Biochemical Oxygen Demand
COD = Cemical Oxygen Demand
NH_3 = Ammonia

APPENDIX C - ALERT AND CONCERN LEVELS OF TOXICANTS IN FISH TISSUE FROM THE OKLAHOMA WATER QUALITY STANDARDS

TABLE 4. Alert and Concern Levels in Fish Tissue [1]

SUBSTANCE	ALERT LEVEL (mg/kg)	CONCERN LEVEL (mg/kg)
Aldrin	0.3	0.15
Chlordane	0.3	0.15
DDT*	5.0	2.5
Dieldrin	0.3	0.15
Endrin	0.3	0.15
Heptachlor	0.3	0.15
Mercury	1.0	0.5
PCB's*	2.0	1.0
Toxaphene	5.0	2.5

NOTES: [1] Copied directly from OWQS

*DDT = Dichlorodiphenyltrichloroethane

*PCB's = Polychlorinated Biphenyls

APPENDIX D - FISH TOXICOLOGY DATA

CONTAMINANTS IN FISH IN THE ZINK LAKE AREA - MAY, 1991

CONTAMINANT (Units)	LMB*	SB*	CC*	GS*	RC*
Aldrin (ug/Kg)	<6.00	<6.00	<6.00	<6.00	<6.00
Alpha BHC (mg/Kg)	<.004	<.004	<.004	<.004	<.004
Gamma BHC (ug/Gm)	<.004	<.004	<.004	<.004	<.004
Chlordane Cis Iso. (mg/Kg)	<.020	.028	<.020	<.020	<.020
Chlordane Trn Iso. (ug/Gm)	<.020	.131	<.020	<.020	.024
Nonachlor Cis Iso. (ug/Gm)	<.020	.051	<.020	<.020	<.020
Nonachlor Trn Iso. (mg/Kg)	<.020	<.020	<.020	<.020	<.020
Chlordane [Total] (mg/Kg)	<.020	.210	<.020	<.020	<.024
o,p'DDD (mg/Kg)	<.040	<.040	<.040	<.040	<.040
o,p'DDE (mg/Kg)	<.040	<.040	<.040	<.040	<.040
o,p'DDT(mg/Kg)	<.040	<.040	<.040	<.040	<.040
p,p'DDD (mg/Kg)	<.040	.078	<.040	<.040	<.040
p,p'DDE (mg/Kg)	<.040	.283	<.040	<.040	.100
p,p'DDT (mg/Kg)	<.040	<.040	<.040	<.040	<.040
DDT [Total] (mg/Kg)	<.040	.361	<.040	<.040	.100
Dieldrin (mg/Kg)	<.012	<.012	<.012	<.012	<.012
Endrin (ug/Kg)	<6.00	<6.00	<6.00	<6.00	<6.00
Heptachlor (ug/Kg)	<6.00	<6.00	<6.00	<6.00	<6.00
Heptachlor epoxide (ug/Kg)	<6.00	<6.00	<6.00	<6.00	<6.00
Hexachlorobenzene (ug/Kg)	<4.00	<4.00	<4.00	<4.00	<4.00
Methoxychlor (ug/Kg)	<20.0	<20.0	<20.0	<20.0	<20.0
PCB [Total] (ug/Kg)	<60.0	365	<60.0	<60.0	100
Toxaphene (ug/Kg)	<60.0	<60.0	<60.0	<60.0	<60.0
Mercury (mg/Kg)	.160	.120	.140	<.100	.140

NOTES:* LMB= Large Mouth Buffalo
SB= Striped Bass
CC= Channel Catfish
GS= Gizzard Shad
RC= River Carpsucker

UNITS
(ug/Kg)= micrograms/kilogram
(mg/Kg)= milligrams/kilogram
(ug/Gm)= micrograms/gram

PCB identified as Arochlor 1260

Any value with this notation < (less than) indicates that the stated

PHYSICAL DATA OF FISH SPECIES STUDIED

SPECIES	MEAN LENGTH (INCHES)	MEAN WEIGHT (POUNDS)	RANGE OF AGES (YEARS)
Largemouth Buffalo	19.02	3.83	03-06
Striped Bass	27.40	11.22	11-16
Channel Catfish	14.29	3.90	01-21
Gizzard Shad	8.58	.30	01-05
River Carpsucker	15.98	1.78	03-06

NOTE:

The data is based on a sample containing five specimens of each specie collected.

WATER QUALITY REPORT FOR THE ZINK LAKE - RIVER PARKS AREA OF THE ARKANSAS RIVER FOR 1992

PREPARED BY THE TULSA CITY-COUNTY
HEALTH DEPARTMENT

JANUARY 20, 1994

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BACTERIOLOGICAL WATER QUALITY

In 1992 bacteriological samples were collected in the same manner that has been used since the inception of the sampling program. The same three bridge locations and the same four storm drains were utilized as sampling points. The sampling regime was again designed to meet the criteria set forth in the Oklahoma Water Quality Standards (OWQS). The data was analyzed in accordance with the "Primary Body Contact" standards set forth in the OWQS. In addition, we again calculated a "Fecal Coliform/Fecal Streptococcus Ratio (FC/FS)" to use as an indicator of the source of the pollution. "FC/FS Ratios" of 5 or higher are indicative that much of the bacteria is of human origin while ratios of 2 or less are more indicative of animal contamination.

As was the case in all the previous years this study was undertaken, the Arkansas River results indicated that the water quality does not meet the criteria for "Primary Body Contact" standards. Both the Geometric Mean values and the total count values exceeded the required criteria of the OWQS. Each of the river stations will be discussed separately and then a discussion of the storm drains will follow.

11th Street Bridge

The Geometric Mean criteria (200 colonies) was exceeded in 3 of the 15 sets of data. These all occurred in the first 2 months of the sampling program. The total count criteria (400 colonies in 10% of samples) was exceeded in 22% of the samples collected. The range of values was 9 - 12,000 for fecal coliform. The FC/FS Ratio indicated that in 5 of the 108 samples, the contamination might be attributable to human origin. Three of these occurred in July and were all located at the west bank sampling point. This would seem to indicate that an unsampled storm drain or some other unknown source was contributing sewage flow to the river. Most of the criteria violations occurred on both the east and west banks which would tend to suggest that the incoming storm drain water tends to stay near the banks and is poorly mixed with the routine river flow. At this station the month of September had the least violations of the total count while the months of May and June had the most.

21st Street Bridge

At the 21st Street bridge, the Geometric Mean criteria was exceeded in 3 of the 15 data sets. These all occurred in the first two months of the sampling period. In fact, the exceedances exactly mirrored those encountered at the 11th Street station. The total count criteria was exceeded in 22% of all of the samples collected. The range of values for Fecal Coliform was 9 - 43,000 colonies while the range of Fecal Streptococcus values was 9 - 88,000. The FC/FS Ratio indicated that 3 samples out of 108 might be the result of human contamination.

Most of the total count exceedances also occurred on the east and west banks of this station. July and September had the least problems at this station while June was the worst month.

Pedestrain Bridge

The Pedestrian Bridge station exhibited fewer problems than the others, probably because it is furthest removed from the major downtown storm drains. The Geometric Mean Criteria of the OWQS was exceeded in only one of 15 data sets and this occurred in May on the west bank. The total colony count was exceeded in 20% of all samples collected. The range of Fecal Coliform values was 9 - 13,000 colonies and the range of Fecal Streptococcus was 9 - 34,000 colonies. The FC/FS Ratio indicated that only one sample in 108 samples had contamination that might have been caused by human wastes. The exceedances of the total count criteria were pretty evenly spread across all 3 stations at this site although the most still occurred on the east bank. This may indicate that the storm drain flows along both banks have mixed better with the regular flow before reaching this point. The least problems with total counts occurred in July and September while the worst month was May.

Compared to the 1991 data, there were some major differences. In 1991, the total number of exceedances of the Geometric Mean was 13 while in 1992 there was a total of 7. In addition, the percentage of samples exceeding the total colony count was slightly higher in 1991 than in 1992. Also, the number of times the FC/FS Ratio seemed to indicate the possibility of human waste contamination was much less. 1992 was an unusual year for Oklahoma. We had more rain across the state than was usual from early spring to mid-summer. This in turn kept our lakes very high and caused the Army Corp of Engineers to release greater than usual flows through its' dams. Keystone had much higher volume releases than are usually encountered and these occurred through much of the summer. The greater volume of water released, the greater the effect of dilution on water entering the river from the storm drains. This serves to explain the apparent improvement in bacterial data in 1992. There was a greater dilution factor, not an improvement in stormwater quality that is entering the river.

Storm Drains

An examination of the storm drain data for 1992 is quite revealing. Some of Fecal Coliform and Fecal Streptococcus counts are very high. The highest Fecal Coliform count was 760,000 colonies (26th Street storm drain, August 5, 1992) while the highest Fecal Streptococcus count was 250,000 colonies (Indian Avenue storm drain, September 2, 1992). Many of the counts in the drains were in the tens of thousands while several counts were 100,000 or greater. The values for the FC/FS Ratio are much worse for the storm drains. A total of 17 samples indicated that the main source of contamination was probably due to human wastes. The 11th Street storm drain and the 21st Street storm drain were worst in this respect.

Obviously, we are still encountering the same type of problems we have in the past. The storm drains are still contributing large amounts of bacterial contaminants to the Arkansas River in the Zink Lake area. It should be remembered that these drains are studied because they have a continuous flow even when there is no rainfall. Therefore, they are a routine source of bacteria that are undoubtedly making it more difficult to achieve the desired level of water quality in the Arkansas River. In addition, we are only studying 4 of the storm drains contributing discharges to the river. The problem is undoubtedly more widespread and presents a major concern to the City of Tulsa. It will be difficult for the City to reduce the bacterial contributions of the storm drain system.

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ZINK LAKE WATER CHEMISTRY

Water chemistry samples were collected at the 3 bridge sites and 4 drains in 1992. The same nine parameters were analyzed in 1992 as were used in 1991. These include Lead (Pb), Chromium (Cr), Cadmium (Cd), Mercury (Hg), Nitrate/Nitrite (NO_3/NO_2), Total Phosphates (TPO_4), Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD) and Ammonia (NH_3). The findings regarding each of these parameters will be discussed separately.

LEAD (Pb)

Lead was detectable (>5.0 ppb) in 62% of the samples that were collected. The highest value was 258.3 ppb at the 11th Street storm drain. The highest value encountered in the river was 64 ppb and this was encountered at the East bank station of the Pedestrian Bridge. On several occasions, lead was virtually non-detectable in any of the samples collected on a specific date. In addition, while the 2 highest values found have already been mentioned, 90% of the samples were in the 10 to 20 ppb range. Therefore, while we have discovered small amounts of lead in some of the samples it generally seems to be a low level and somewhat sporadic problem. Lead was not analyzed in water samples during the 1991 study.

CHROMIUM (Cr)

Chromium was detectable (> 30 ppb) in 25% of all the samples collected. The highest value found was 177.2 ppb and this was encountered at the 26th Street storm drain. The highest value at a river station was 176.2 ppb and this occurred at the west bank of the Pedestrian Bridge. On certain dates, Chromium was undetectable in any of the samples. While the chromium values were routinely higher than for those of lead, they were encountered less frequently and should not be a major cause for concern. Compared to the 1991 data, the highest level found was more than twice as much as the previous year. In addition, it was found in a larger percentage of the samples.

CADMIUM (Cd)

Cadmium was detected in only 12.5% of all samples collected. The highest river value encountered was 34 ppb and this occurred on the west bank of the 11th Street Bridge. The highest storm drain value was 18.5 ppb and this occurred at the Indian Avenue storm drain. Cadmium was undetectable in any of the samples on several days. While amounts were not appreciably higher in 1992 when compared to 1991, the frequency of occurrence of detectable amounts of cadmium was much decreased from the previous year.

MERCURY (Hg)

Mercury was only detected in one sample out of the 160 that were collected. This value was 2.0 ppb and was found at the 21st Street storm drain. Obviously, mercury did not appear to be much of a problem in 1992. This reflects on the fish toxicology data which showed that mercury was detectable in only one species of fish.

NITRATE/NITRITE (NO_3/NO_2)

Nitrate/Nitrite radicals were undetectable in only one of the 160 samples. The highest value for a storm drain was 4.69 ppm and this occurred in the Indian Avenue storm drain. The highest value in the river was .94 ppm and this was found at the east bank of the 11th Street Bridge. Overall, the storm drains had much higher levels of NO_3/NO_2 than the river samples did. NO_3/NO_2 is mainly contributed by use of fertilizers from residential areas. However, some in contributed by fertilizers used on agricultural land and some in contributed through animal droppings in residential areas. This pollutant is probably the most important one in the consideration to maintain our surface water quality. The city will probably have to institute educational programs in order to teach the public to minimize and control the indiscriminate use of fertilizers. The 1991 data is very much similar to the 1992 data.

TOTAL PHOSPHATES (TPO_4)

Total phosphates were detectable in all samples but one. The range of values encountered was <.01 ppm to 6.076 ppm. The highest value occurred at the west bank of the Pedestrian bridge. The highest value found at a storm drain was 4.278 ppm and this occurred at the 26th Street storm drain. These levels were much higher than any encountered in 1991. While 94% of the samples had less than .50 ppm levels, a spate of the higher values were encountered on the June 10th sampling excursion. The reason for the high values encountered on this date could not be ascertained. Levels of phosphates in the river were comparable to levels found in the storm drains. Overall, phosphates do not appear to pose a major problem in the river.

BIOCHEMICAL OXYGEN DEMAND (BOD)

BOD represents the measure of various types of organic materials on the oxygen supply dissolved in the water. These materials include living biological organisms, decaying organic matter and the oxidation of organic materials. Only 50% of the samples collected had measurable, detectable readings. Values ranged from non-detectable (<1.0 ppm) to 7.7 ppm. The highest values occurred at the 21st Street and Indian Avenue storm drains. The highest in-stream value was 2.9 ppm and these readings were found at both the 21st and Pedestrian bridges along the east bank. Overall, storm drain values were much higher than in-stream values. This indicates that the storm drains are a major source of materials that lead to the degradation of in-stream water quality by causing the depletion of available dissolved oxygen concentrations.

CHEMICAL OXYGEN DEMAND (COD)

The COD determination is a measure of the oxygen equivalent of that portion of the organic matter in a sample that is susceptible to oxidation by a strong oxidant. It does not measure all organic compounds that are readily available to stream organisms and measures some that are not so readily available to biological organisms. It is a useful tool for measuring the oxygen demand of the organic chemicals present in water. As opposed to BOD values, COD values were undetectable in only 5% of the samples. COD values were often much higher than BOD levels. Results for COD ranged from <5.0 ppm to 76.8 ppm. The highest value was encountered at the 26th Street storm drain. The highest in-stream value detected was 57.8 ppm and this was found along the east bank at the Pedestrian Bridge. The highest values in 1992 were comparable to those found in 1991. In general, values for the storm drains were much higher than for in-stream samples. It is obvious that the storm drains contribute a significant portion of oxygen depleting materials to the Arkansas River.

AMMONIA

Ammonia values ranged from non-detectable (<.01 ppm) to .42 ppm (Indian Avenue Storm Drain). The highest in-stream value was .37 ppm and this occurred on the east bank at the Pedestrian Bridge. Ammonia was detectable in approximately 66% of all samples collected. While no ammonia criterion has been developed in the Oklahoma Water Quality Standards, EPA literature suggests a value of .02 ppm to protect aquatic life. Using this as a comparison, 50% of all samples collected exceeded this value. While we have no direct evidence that ammonia levels are severely impacting the aquatic community, it would be prudent to take steps to assure that ammonia levels in the river are not augmented by unnecessary materials entering via the storm drains.

CONCLUSION

We have discussed some of the results of our water chemistry data on the previous pages. For the most part, it is not much different from what we have encountered in past years. Our study is very basic and ignores such things as volatile hydrocarbons and the myriad of pesticides available to farmers and the general public. Undoubtedly, many of these compounds can and do have a serious impact on the quality of our surface waters. Still, our study does emphasize one obvious point. It is that the major storm drainages flowing out of our urban area are a major source of many of the contaminants effecting the water quality of the Arkansas River. Our study concentrates on four of the largest and worst drainages, but several more add their flows to the river and what they may contribute is unknown. It is clear that if we want to correct water quality problems and try to achieve standards set forth in the OWQS, we will have to make a concerted effort to control the various pollutants being generated in the metropolitan area. This will undoubtedly prove to be a difficult task.

CONTAMINANTS IN FISH OF THE ZINK LAKE AREA (1992)

In May of 1992, five species of fish were collected at the Zink Lake Dam on the Arkansas River. Tissue samples were collected, prepared and preserved and then transported to the Oklahoma State Department of Health (OSDH) for analysis of contaminants. The OSDH laboratory tested for 24 contaminants including heavy metals, pesticides and polychlorinated biphenyls (PCB's). We would like to thank Mr. Mark Ambler and his personnel from the Oklahoma Department of Wildlife Conservation for obtaining the specimens while collecting striped bass for their brood program.

In 1992, two different species of fish were checked than were examined in 1991. One was the Carp, which had been checked in several previous studies. The other specie was the Freshwater Drum which had never been studied before. The other species that are usually studied include the (1) Striped Bass (2) Channel Catfish (3) River Carpsucker. 1992 proved to be a more difficult sampling year than 1991 resulting in more man-hours spent in collecting and preparing tissue samples for the study. Fish just were not as readily available in this area this past year. In addition, of the fish that were captured, many were smaller specimens than those obtained the previous year. This generally means that they are younger and have had less time to accumulate contaminants in their tissues.

Of the 24 parameters analyzed, only 13 of them were detectable in the fish tissue samples. Of the 13 detectable contaminants, 4 were found that were not detectable last year. Three of these four were found to be barely over the detection limits. Only p-p' DDT was encountered in much larger levels than previously and it was detected in only one specie of fish. None of the levels of the contaminants exceeded the Food and Drug Administration's (FDA) "Action Levels" or " Concern Levels" designed for determining the edibility of fish tissue.

Striped Bass

The Striped Bass that were collected were the largest fish collected in 1992. Therefore, it is not surprising that they showed the greatest degree of contamination. Contaminants in the Stripers include Mercury, Chlordane, DDT, PCB's, Dieldrin and Heptachlor. None of the levels of these contaminants exceeded the FDA standards. The Stripers did not yield detectable levels of Nonachlor which was detectable in 1991.

Carp

The Carp also showed levels of certain contaminants such as Chlordane, DDT and its derivatives and PCB's. None of the levels encountered would be considered excessive. Carp was not one of the species analyzed in the 1991 study.

River Carpsucker

The River Carpsucker exhibited contamination by Chlordane, PCB's and Heptachlor Epoxide. None of the levels were very high. Mercury and DDT compounds were not detectable in these fish as opposed to 1991.

Channel Catfish

The Channel Catfish exhibited contamination by Chlordane, Nonachlor, DDT and its' derivatives, PCB's and Dieldrin. None of these contaminants were encountered in last year's study. Mercury, which was detectable last year, was not encountered this year.

Freshwater Drum

This species has never been examined before. It is mainly a bottom feeder, feeding on molluscs, but it will also capture small fish as food. It was expected that this fairly large species would exhibit quite a number of contaminants in its tissues. This was not the case, however. We did find low levels of DDT and its' derivatives and PCB's. But, overall, this was the least contaminated fish in our study.

All in all, the 1992 data is not very different from the 1991 data. While some contaminants changed or were no longer detectable, none of the detectable contaminants occurred at very high levels. One positive trend of note is the apparent decline of Mercury levels in the fish samples. Mercury has been a persistent contaminant over the years and was detectable in 4 of the 5 species in 1991. In 1992 it was detectable only in one of the five species.

While the data does not indicate any need for issuing a fish consumption advisory, it should be made clear that the choice to consume any fish is left up to the individual. While none of the contamination levels are considered unsafe by FDA standards, all of the contaminants are considered to be potentially injurious to public health.

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APPENDIX A - BACTERIOLOGICAL DATA

BACTERIOLOGICAL QUALITY OF THE ARKANSAS RIVER AT ZINK LAKE
MAY - SEPTEMBER 1992

11TH STREET BRIDGE (0A020)

	West Bank (A)			Mid Channel (B)			East Bank (C)		
	FC*	FS*	FC/FS*	FC*	FS*	FC/FS*	FC*	FS*	FC/FS*
04-May-92	18	18	1.00	9	63	0.14	45	108	0.42
06-May-92	9	63	0.14	9	36	0.25	160	72	2.22
11-May-92	7000	2900	2.41	1300	3700	0.35	12000	50000	0.24
13-May-92	180	240	0.75	250	690	0.36	5500	670	8.21
18-May-92	910	3500	0.26	390	850	0.46	1000	3800	0.26
20-May-92	320	600	0.53	90	170	0.53	450	510	0.88
27-May-92	45	36	1.25	9	90	0.10	500	560	0.89
G.MEAN*	159.9			70.1			726.6		
03-Jun-92	2400	3900	0.62	730	2700	0.27	640	2200	0.29
08-Jun-92	27	120	0.23	9	54	0.17	110	190	0.58
10-Jun-92	54	90	0.60	36	54	0.67	2400	960	2.50
15-Jun-92	910	1800	0.51	27	110	0.25	140	930	0.15
17-Jun-92	27	9	3.00	9	18	0.50	27	150	0.18
22-Jun-92	550	760	0.72	9	410	0.02	350	1300	0.27
24-Jun-92	27	90	0.30	9	18	0.50	63	170	0.37
29-Jun-92	7000	19000	0.37	72	1400	0.05	4800	8000	0.60
G.MEAN*	233.8			27.6			301.1		
06-Jul-92	560	81	6.91	9	18	0.50	18	63	0.29
08-Jul-92	130	45	2.89	9	36	0.25	9	63	0.14
13-Jul-92	580	45	12.89	9	36	0.25	9	9	1.00
15-Jul-92	640	100	6.40	140	140	1.00	370	120	3.08
20-Jul-92	130	280	0.46	27	110	0.25	72	170	0.42
22-Jul-92	81	370	0.22	9	45	0.20	72	410	0.18
29-Jul-92	18	54	0.33	9	27	0.33	9	36	0.25
G.MEAN*	175.5			15.6			30.6		
05-Aug-92	4800	15000	0.32	63	160	0.39	640	490	1.31
10-Aug-92	54	110	0.49	220	63	3.49	450	460	0.98
17-Aug-92	18	290	0.06	18	27	0.67	820	27	30.37
19-Aug-92	18	220	0.08	9	18	0.50	18	180	0.10
24-Aug-92	81	160	0.51	18	63	0.29	120	90	1.33
26-Aug-92	180	230	0.78	18	36	0.50	54	45	1.20
31-Aug-92	9	72	0.13	9	18	0.50	90	99	0.91
G.MEAN*	73.0			25.3			158.2		
02-Sep-92	18	170	0.11	9	36	0.25	310	320	0.96875
09-Sep-92	9	36	0.25	9	18	0.50	72	27	2.67
14-Sep-92	18	130	0.14	36	27	1.33	180	110	1.64
16-Sep-92	490	110	4.45	9	18	0.50	27	45	0.60
21-Sep-92	9	130	0.07	72	36	2.00	81	72	1.13
23-Sep-92	27	140	0.19	9	200	0.05	9	9	1.00
28-Sep-92	18	18	1.00	9	36	0.25	130	63	2.06
G.MEAN*	25.1			14.8			72.3		

*FC = Fecal Coliform
*FS = Fecal Streptococcus
*FC/FS = Fecal Coliform/Fecal Streptococcus Ratio
*G Mean = Geometric Mean

BACTERIOLOGICAL QUALITY OF THE ARKANSAS RIVER AT ZINK LAKE
MAY - SEPTEMBER 1992

21ST STREET BRIDGE (OA006)

	West Bank (A)			Mid Channel (B)			East Bank (C)		
	FC*	FS*	FC/FS*	FC*	FS*	FC/FS*	FC*	FS*	FC/FS*
04-May-92	9	27	0.33	9	180	0.05	54	480	0.11
06-May-92	9	72	0.13	27	300	0.09	90	190	0.47
11-May-92	5800	6800	0.85	4000	8400	0.48	43000	88000	0.49
13-May-92	210	90	2.33	450	370	1.22	400	280	1.43
18-May-92	730	2900	0.25	550	2200	0.25	400	690	0.58
20-May-92	270	630	0.43	27	99	0.27	730	820	0.89
27-May-92	36	90	0.40	63	510	0.12	2800	230	12.17
G.MEAN*	132.0			122.3			681.6		
03-Jun-92	24000	2600	9.23	730	1800	0.41	480	2900	0.17
08-Jun-92	36	170	0.21	9	63	0.14	90	380	0.24
10-Jun-92	480	380	1.26	45	1900	0.02	460	1700	0.27
15-Jun-92	400	2600	0.15	27	2000	0.01	470	3800	0.12
17-Jun-92	18	2800	0.01	9	1300	0.01	72	7800	0.01
22-Jun-92	27	710	0.04	27	520	0.05	140	860	0.16
24-Jun-92	27	560	0.05	9	820	0.01	9	470	0.02
29-Jun-92	5600	19000	0.29	460	2100	0.22	9000	12000	0.75
G.MEAN*	243.1			41.0			229.2		
06-Jul-92	270	180	1.50	9	18	0.50	45	170	0.26
08-Jul-92	140	72	1.94	9	63	0.14	45	120	0.38
13-Jul-92	730	45	16.22	9	9	1.00	27	36	0.75
15-Jul-92	99	36	2.75	230	54	4.26	640	190	3.37
20-Jul-92	27	90	0.30	9	110	0.08	200	220	0.91
22-Jul-92	54	270	0.20	18	9	2.00	190	290	0.66
29-Jul-92	9	9	1.00	27	63	0.43	45	110	0.41
G.MEAN*	86.4			18.5			92.9		
05-Aug-92	8000	8600	0.93	210	350	0.60	560	360	1.56
10-Aug-92	150	220	0.68	160	72	2.22	240	150	1.60
17-Aug-92	27	230	0.12	9	9	1.00	36	120	0.30
19-Aug-92	27	120	0.23	27	54	0.50	640	81	7.90
24-Aug-92	45	54	0.83	27	72	0.38	63	72	0.88
26-Aug-92	110	190	0.58	9	45	0.20	120	380	0.32
31-Aug-92	27	63	0.43	18	81	0.22	270	590	0.46
G.MEAN*	102.3			32.2			180.8		
02-Sep-92	450	200	2.25	81	110	0.74	5000	4600	1.09
09-Sep-92	90	81	1.11	9	27	0.33	200	540	0.37
14-Sep-92	27	90	0.30	18	27	0.67	27	9	3.00
16-Sep-92	9	54	0.17	27	27	1.00	18	36	0.50
21-Sep-92	36	45	0.80	72	120	0.60	300	180	1.67
23-Sep-92	9	9	1.00	9	45	0.20	300	300	1.00
28-Sep-92	9	27	0.33	36	36	1.00	99	120	0.83
G.MEAN*	31.2			26.1			171.3		

*FC = Fecal Coliform
*FS = Fecal Streptococcus
*FC/FS = Fecal Coliform/Fecal Streptococcus Ratio
*G Mean = Geometric Mean

BACTERIOLOGICAL QUALITY OF THE ARKANSAS RIVER AT ZINK LAKE
MAY - SEPTEMBER 1992

PEDESTRIAN BRIDGE (0A005)

	West Bank (A)			Mid Channel (B)			East Bank (C)		
	FC*	FS*	FC/FS*	FC*	FS*	FC/FS*	FC*	FS*	FC/FS*
04-May-92	27	600	0.05	9	63	0.14	18	36	0.50
06-May-92	18	18	1.00	36	9	4.00	18	45	0.40
11-May-92	13000	26000	0.50	12000	34000	0.35	7000	18000	0.39
13-May-92	320	260	1.23	470	220	2.14	580	420	1.38
18-May-92	1500	2100	0.71	520	2000	0.26	570	1800	0.32
20-May-92	380	1300	0.29	220	480	0.46	420	510	0.82
27-May-92	63	5100	0.01	45	4600	0.01	9	9	1.00
G.MEAN*	256.3			78.3			166.9		
03-Jun-92	3200	2800	1.14	530	4800	0.11	480	2300	0.21
08-Jun-92	18	400	0.05	9	430	0.02	9	270	0.03
10-Jun-92	81	3800	0.02	1500	2800	0.54	5800	2500	2.32
15-Jun-92	270	4200	0.06	18	2800	0.01	36	4200	0.01
17-Jun-92	45	6300	0.01	36	4400	0.01	110	9400	0.01
22-Jun-92	63	2900	0.02	27	4400	0.01	110	1300	0.08
24-Jun-92	18	2000	0.01	9	2500	0.00	9	2300	0.00
29-Jun-92	1700	7200	0.24	910	2800	0.33	5800	18000	0.32
G.MEAN*	134.8			75.2			104.3		
06-Jul-92	140	190	0.74	9	150	0.06	110	190	0.58
08-Jul-92	90	160	0.56	9	72	0.13	27	18	1.50
13-Jul-92	460	81	5.68	18	73	0.25	9	18	0.50
15-Jul-92	210	310	0.68	81	120	0.68	350	180	1.94
20-Jul-92	9	90	0.10	18	110	0.16	140	380	0.37
22-Jul-92	45	27	1.67	18	54	0.33	150	480	0.31
29-Jul-92	9	9	1.00	9	9	1.00	18	9	2.00
G.MEAN*	64.1			16.6			62.0		
05-Aug-92	2100	2300	0.91	450	210	2.14	1500	2200	0.68
10-Aug-92	18	130	0.14	99	81	1.22	36	54	0.67
17-Aug-92	9	54	0.17	9	36	0.25	9	18	0.50
19-Aug-92	45	54	0.83	9	36	0.25	9	45	0.20
24-Aug-92	27	63	0.43	27	27	1.00	81	72	1.13
26-Aug-92	36	36	1.00	27	72	0.38	140	45	3.11
31-Aug-92	9	36	0.25	9	9	1.00	270	510	0.53
G.MEAN*	38.9			30.3			75.0		
02-Sep-92	9	36	0.25	54	54	1.00	2000	2100	0.95
09-Sep-92	9	27	0.33	9	36	0.25	180	150	1.20
14-Sep-92	54	150	0.36	9	36	0.25	27	9	3.00
16-Sep-92	45	26	1.73	9	9	1.00	36	54	0.67
21-Sep-92	36	45	0.80	18	36	0.50	120	72	1.67
23-Sep-92	18	9	2.00	18	27	0.67	110	36	3.06
28-Sep-92	9	36	0.25	9	18	0.50	36	63	0.57
G.MEAN*	19.7			14.2			107.5		

*FC = Fecal Coliform
*FS = Fecal Streptococcus
*FC/FS = Fecal Coliform/Fecal Streptococcus Ratio
*G Mean = Geometric Mean

BACTERIOLOGICAL WATER QUALITY
OF STORM DRAINS
MAY - SEPTEMBER 1992

DATE	11TH ST STORM DRAIN OK 002 FC*	FS*	FC/FS*	INDIAN AVE STORM DRAIN OK 003 FC*	FS*	FC/FS*	21ST ST STORM DRAIN OK 008 FC*	FS*	FC/FS*	26TH ST STORM DRAI FC*	FS*	FC/FS
04-May-92	7700	1600	4.81	6100	162	37.65	620	9	68.89	440	117	3.7
06-May-92	3500	520	6.73	550	410	1.34	1500	2000	0.75	360	400	0.9
11-May-92	23000	57000	0.40	17000	47000	0.36	40000	180000	0.22	37000	75000	0.4
13-May-92	3400	600	5.67	820	2600	0.32	21000	3000	7.00	910	470	1.9
18-May-92	29000	630000	0.05	530	930	0.57	6400	1500	4.27	2000	4200	0.4
20-May-92	33000	4900	6.73	1400	2100	0.67	29000	5500	5.27	2100	2400	0.8
27-May-92	220	1700	0.13	1100	3700	0.30	820	540	1.52	820	3900	0.2
03-Jun-92	10000	4700	2.13	4100	2800	1.46	4800	3800	1.26	1500	5600	0.27
08-Jun-92	18000	21000	0.86	3900	4400	0.89	6000	2600	2.31	5600	2500	2.2
10-Jun-92	60001	97001	0.62	28000	79000	0.35	60001	100001	0.60	12000	38000	0.32
15-Jun-92	1400	6900	0.20	9	27	0.33	2200	1400	1.57	450	6100	0.0
17-Jun-92	1500	16000	0.09	10000	15000	0.67	60001	100001	0.60	1300	25000	0.05
22-Jun-92	2100	5600	0.38	3600	2600	1.38	4300	5200	0.83	1500	3100	0.4
24-Jun-92	910	2900	0.31	460	750	0.61	12000	100001	0.12	3800	47000	0.08
29-Jun-92	60001	100001	0.60	60001	100001	0.60	60001	100001	0.60	60001	100001	0.6
06-Jul-92	570	620	0.92	610	490	1.24	1200	870	1.38	380	550	0.69
08-Jul-92	290	210	1.38	170	380	0.45	530	560	0.95	170	490	0.35
13-Jul-92	270	160	1.69	270	170	1.59	60001	21000	2.86	350	390	0.90
15-Jul-92	22000	4900	4.49	1800	430	4.19	2300	140	16.43	21000	1600	13.13
20-Jul-92	730	440	1.66	1200	490	2.45	640	860	0.74	910	460	1.98
22-Jul-92	730	970	0.75	730	780	0.94	60001	1600	37.50	730	950	0.77
29-Jul-92	5100	5300	0.96	410	880	0.47	2100	480	4.38	9000	2600	3.46
05-Aug-92	60001	100001	0.60	60001	100001	0.60	80000	140000	0.57	760000	93000	8.17
10-Aug-92	580	320	1.81	560	300	1.87	460	300	1.53	480	300	1.60
17-Aug-92	290	480	0.60	380	190	2.00	72	140	0.51	250	90	2.78
19-Aug-92	560	490	1.14	380	250	1.52	280	310	0.90	450	370	1.22
24-Aug-92	470	2100	0.22	2300	1600	1.44	1900	1300	1.46	490	1500	0.33
26-Aug-92	430	530	0.81	100	140	0.71	8000	3100	2.58	360	350	1.03
31-Aug-92	23000	3800	6.05	72000	100000	0.72	110000	72000	1.53	5900	3200	1.84
02-Sep-92	46000	9000	5.11	250000	250000	1.00	200000	77000	2.60	46000	37000	1.24
09-Sep-92	370	500	0.74	2900	3500	0.83	3600	1200	3.00	200	2000	0.10
14-Sep-92	31000	42000	0.74	2200	570	3.86	1500	340	4.41	240	210	1.14
16-Sep-92	4000	20000	0.20	3800	2400	1.58	440	150	2.93	230	200	1.15
21-Sep-92	1400	520	2.69	22000	8000	2.75	1600	390	4.10	2500	470	5.32
23-Sep-92	2900	6100	0.48	25000	7600	3.29	2700	5200	0.52	220	420	0.52
28-Sep-92	2500	580	4.31	4800	720	6.67	4700	630	7.46	1400	370	3.78

C = Fecal Coliform
*FS = Fecal Streptococcus
*FC/FS = Fecal Coliform/Fecal Streptococcus Ratio

APPENDIX B - WATER CHEMISTRY DATA

RIVER PROJECT

WATER CHEMICAL MEASUREMENTS

1992

DATE	SITE	Pb	Cr	Cd	Hg	NO_3/NO_2	TPO_4	BOD	COD	NH_3
5/13/92										
	11th ST.SD	258.3	<30	<3	<.5	1.22	.145	1.4	19.5	.11
	11th ST A	19.2	<30	<3	<.5	.23	.151	1.7	14.6	.11
	11th ST C	15.1	<30	4	<.5	.94	.117	1.7	12.1	.37
	21st ST SD	10.8	51.3	4	<.5	2.18	.193	1.5	7.3	.10
	21st ST A	20.2	102.6	<3	<.5	.19	.128	1.4	22	.10
	21st St C	44.7	138.6	<3	<.5	.21	.180	1.7	12.2	.10
	26th St SD	15.9	<30	<3	<.5	1.02	.141	1.3	22	.13
	Ped Br A	23.9	<30	<3	<.5	.34	.136	1.4	19.5	.18
	Ped Br C	64.0	<30	<3	<.5	.28	.141	1.5	12.2	.10
	I Ave SD	9.9	101.9	<3	<.5	4.16	.180	<1	7.3	.19
5/20/92		x482/10	394.4/4	9/2	—	10.77/10	1.512/10			
	11th St SD	22.3	<30	<3	<.5	1.18	<.01	2.5	5.1	<.01
	11th St A	22.0	<30	<3	<.5	.15	.095	<1	10.3	.09
	11th ST C	6.0	120.9	9	<.5	.18	.012	<1	10.3	.11
	21st ST SD	9.3	<30	<3	<.5	1.26	.018	1.5	25.6	<.01
	21st ST A	13.9	124.1	<3	<.5	.20	.010	<1	12.8	.15
	21st ST C	5.6	<30	<3	<.5	.22	.015	1.1	17.9	.13
	26th ST SD	14.7	177.2	4	<.5	1.12	.030	<1	15.4	.16
	Ped Br A	17.2	176.2	4	<.5	.22	.038	<1	5.1	.12
	Ped Br C	14.6	91.8	3	<.5	.20	.020	<1	12.8	.16
	I Ave SD	14.4	<30	<3	<.5	.78	.028	<1	15.4	.15
5/27/92		x140/10	690.2/5	20/4	—	5.51/10	.266/9			
	11th St SD	<5	<30	<3	<.5	1.22	.119	1.6	5.1	.07
	11th St A	<5	<30	<3	<.5	.17	.143	2.3	12.7	.09
	11th St C	<5	<30	<3	<.5	.61	.207	2.6	10.1	<.01
	21st St SD	<5	66.7	<3	<.5	2.35	.276	<1	<5	.01
	21st St A	<5	<30	<3	<.5	.16	.155	2.0	17.7	.13
	21st ST C	<5	<30	<3	<.5	.15	.122	1.9	20.3	.01
	26th St SD	<5	<30	<3	<.5	1.04	.143	1.4	5.1	.06
	Ped Br A	<5	<30	<3	<.5	.16	.137	1.9	17.7	.03
	Ped Br C	<5	<30	<3	<.5	.16	.119	2.8	12.7	.01
	I Ave SD	<5	<30	<3	<.5	4.69	.250	1.3	25.3	.04
		—	66.7/1	—	—	10.71/10	1.671/10			

1151.3/10 28/6 —

Pb - Lead
Cr - Chromium
Cd - Cadmium
Hg - Mercury
NO_3/NO_2 - Nitrate/Nitrite

TPO_4 - Total Phosphorous
BOD - Biochemical Oxygen Demand
COD - Chemical Oxygen Demand
NH_3 - Ammonia

623/20

WATER CHEMICAL MEASUREMENTS

1992

DATE	SITE	Pb	Cr	Cd	Hg	NO_3/NO_2	TPO_4	BOD	COD	NH_3
6-3-92										
	11th ST.SD	11.7	<30	<3	<.5	1.04	.134	<1	17.7	.13
	11th ST A	13.2	82.8	<3	<.5	.17	.154	2.5	45.6	.15
	11th ST C	17.3	<30	<3	<.5	.15	.152	1.7	<5	.13
	21st ST SD	<5	<30	<3	<.5	2.59	.126	<1	10.1	.03
	21st ST A	16.4	<30	<3	<.5	.21	.144	1.2	20.3	.16
	21st St C	11.8	<30	<3	<.5	.14	.122	1.6	<5	.16
	26th St SD	14.9	<30	<3	<.5	1.26	.081	1.2	15.2	.12
	Ped Br A	14.9	<30	<3	<.5	.17	.134	<1	20.3	.16
	Ped Br C	14.3	65.2	<3	<.5	.17	.109	<1	7.6	.16
	I Ave SD	13.6	<30	<3	<.5	1.54	.117	<1	12.5	.13
6-10-92		128.1/9	148/2	—	—	7.44/10				
	11th St SD	10.8	65.4	<3	<.5	.87	2.506		42.1	.07
	11th St A	13.3	<30	<3	<.5	.22	6.076		21.1	<.01
	11th ST C	19.2	<30	<3	<.5	.21	.056		7.6	<.01
	21st ST SD	19.6	34.0	<3	<.5	.81	.289		65.8	.04
	21st ST A	15.0	<30	<3	<.5	.23	.063	No samples submitted	17.7	<.01
	21st ST C	17.7	<30	<3	<.5	.25	5.494		28.9	.02
	26th ST SD	6.3	<30	<3	<.5	1.14	4.278		65.8	.08
	Ped Br A	12.1	<30	<3	<.5	.28	6.025		23.7	<.01
	Ped Br C	12.9	<30	<3	<.5	.31	.063		34.2	<.01
	I Ave SD	12.6	<30	<3	<.5	1.01	.114		---	.07
6-24-92		139.5/10	99.4/2	—	—	5.33/10				
	11th St SD	11.5	<30	<3	<.5	.84	.134	1.9	23.7	.09
	11th St A	5.6	<30	<3	<.5	.40	.072	1.7	23.7	.05
	11th St C	<5	<30	<3	<.5	.39	.056	1.9	18.4	.06
	21st St SD	6.1	<30	<3	<.5	2.68	.224	1.7	10.5	.14
	21st St A	6.8	<30	<3	<.5	.44	.156	1.7	26.3	.06
	21st ST C	<5	<30	<3	<.5	.42	.579	1.7	18.4	.08
	26th St SD	9.6	<30	<3	<.5	.52	.226	1.8	21.0	.12
	Ped Br A	<5	<30	<3	<.5	.44	.162	1.9	26.3	.07
	Ped Br C	<5	<30	<3	<.5	.40	.063	2.2	26.3	.07
	I Ave SD	6.3	<30	<3	<.5	.02	.176	2.2	28.9	.07
		45.9/6	—	—	—	6.55/10				

247.4/4 —

Pb - Lead
Cr - Chromium
Cd - Cadmium
Hg - Mercury
NO_3/NO_2 - Nitrate/Nitrite

TPO_4 - Total Phosphorous
BOD - Biochemical Oxygen Demand
COD - Chemical Oxygen Demand
NH_3 - Ammonia

313.5/25
935.5/46

WATER CHEMICAL MEASUREMENTS

DATE	SITE	Pb (ppb)	Cr (ppb)	Cd (ppb)	Hg (ppb)	NO_3/NO_2	TPO_4	BOD	COD	NH-
7-8-92										
	11th ST. SD	11.2	<30	4.6	<.5	.69	.229	1.2	23.7	.09
	11th ST A	5.2	35.4	22.0	<.5	.65	.181	<1	23.7	.01
	11th ST C	<5	101.6	34.0	<.5	.67	.206	<1	28.9	.01
	21st ST SD	8.9	87.9	<3	<.5	1.10	.211	<1	13.2	.03
	21st ST A	<5	<30	<3	<.5	.69	.191	<1	39.5	.01
	21st ST C	<5	<30	3.4	<.5	.69	.072	<1	18.4	.02
	26th St.S.D.	13.9	<30	<3	<.5	.76	.184	<1	23.7	.02
	Ped Br A	8.5	<30	26.9	<.5	.69	.201	<1	28.9	.03
	Ped Br C	19.0	<30	<3	<.5	.72	.211	<1	34.2	.04
	I Ave SD	5.2	<30	<3	<.5	.75	.199	<1	<5	.06
7-15-92		71.9/7	224.9/3	90.9/5	—	7.41/10				
	11th ST SD	<5	<30	<3	<.5	.97	.227	1.1	13.3	.01
	11th ST A	<5	<30	<3	<.5	.65	.200	<1	13.3	.02
	11th ST C	<5	<30	<3	<.5	.70	.210	<1	13.3	.02
	21st ST SD	<5	<30	<3	<.5	2.52	.190	1.4	11.1	<.01
	21st ST A	<5	<30	<3	<.5	.67	.205	<1	13.3	<.r
	21st ST C	<5	<30	<3	<.5	.66	.175	<1	13.3	<.01
	26th St.S.D.	<5	<30	<3	<.5	.97	.198	1.0	20	<.01
	Ped Br A	<5	<30	<3	<.5	.67	.207	<1	11.1	<.01
	Ped Br C	<5	<30	<3	<.5	.66	.203	<1	26.7	<.01
	I Ave SD	<5	<30	<3	<.5	.81	.187	1.2	20	<.01
7-22-92		—	—	—	—	9.28/10				
	11th ST SD	<5	<30	<3	<.5	.81	.198	1.4	<5	.04
	11th ST A	<5	<30	<3	<.5	.63	.217	1.2	57.8	.05
	11th ST C	<5	<30	<3	<.5	.66	.234	1.3	13.3	.03
	21st ST SD	6.7	<30	<3	2.0	3.08	.242	4.0	11.1	.03
	21st ST A	<5	<30	<3	<.5	.68	.175	<1	20	.04
	21st ST C	<5	<30	<3	<.5	.66	.223	1.4	15.6	.02
	26th St.S.D.	<5	<30	<3	<.5	.77	.195	<1	---	.03
	Ped Br A	<5	<30	<3	<.5	.65	.212	1.3	13.3	.02
	Ped Br C	6.2	<30	<3	<.5	68	.231	<1	15.6	.03
	I AVe SD	<5	<30	<3	<.5	.73	.210	<1	16.5	.02
		12.9/2	—	—		9.35/10				

224.9/3 90.9/5 2/1

Pb - Lead
Cr - Chromium
Cd - Cadmium
Hg - Mercury
NO_3/NO_2 - Nitrate/Nitrite

TPO_4 - Total Phosphorous
BOD - Biochemical Oxygen Demand
COD - Chemical Oxygen Demand
NH_3 - Ammonia

64.8/9

WATER CHEMICAL MEASUREMENTS

DATE	SITE	Pb (ppb)	Cr (ppb)	Cd (ppb)	Hg (ppb)	NO_3/NO_2	TPO_4	BOD	COD	NH_3
7-29-92										
	11th ST.SD	<5	91.2	<3	<.5	2.66	1.133	3.6	12.7	.05
	11th St A	6.5	<30	<3	<.5	.55	1.118	<1	7.6	.02
	11th ST C	<5	50.5	<3	<.5	.55	.197	<1	<5	.02
	21st ST SD	6.6	54.0	<3	<.5	2.85	.285	1.6	5.1	.08
	21st ST A	<5	89.2	<3	<.5	.69	.197	1.1	15.2	.01
	21st ST C	<5	87.8	<3	<.5	.68	.185	<1	5.1	<.01
	26th St.S.D.	<5	<30	<3	<.5	1.11	.136	<1	7.6	.04
	Ped Br A	<5	37.3	<3	<.5	.75	.172	<1	7.6	.06
	Ped Br C	<5	50.3	<3	<.5	.78	.185	<1	10.1	.03
	I-Ave SD	<5	62.6	<3	<.5	.84	.223	<1	10.1	.06
8-5-92		13.1/2	522.9/8	—	—	11.46/10				
	11st ST SD	28.3	<30	16.9	<.5	.60	.097	4.6	17.7	.24
	11th St A	5.1	<30	11.7	<.5	.61	.364	<1	5.12	.05
	11th ST C	<5	<30	<3	<.5	.63	.310	<1	5.12	.07
	21st ST SD	11.6	<30	15.1	<.5	.38	.376	4.0	15.4	.05
	21st ST A	5.9	<30	16.2	<.5	.63	.261	<1	10.2	.07
	21st ST C	5.0	<30	11.6	<.5	.62	.225	<1	<5	.03
	26th St.S.D.	23.9	<30	<3	<.5	.29	.185	3.4	76.8	.04
	Ped Br A	<5	<30	<3	<.5	.62	.305	<1	10.2	.12
	Ped Br C	6.1	<30	23.1	<.5	.64	.164	<1	5.1	.07
	I Ave SD	21.2	<30	18.5	<.5	.19	.520	2.0	20.5	.10
8-19-92		107.1/8	—	113.1/7	—	5.21/10				
	11th ST SD	6.2	39.9	<3	<.5	1.10	.365	1.2	15.2	.02
	11th ST A	5.3	<30	<3	<.5	.81	.125	<1	12.7	<.01
	11th ST C	12.2	<30	<3	<.5	.85	.075	<1	12.7	<.01
	21st ST SD	5.9	<30	<3	<.5	1.32	.048	1.0	17.7	<.01
	21st ST A	12.9	<30	<3	<.5	.73	.052	<1	20.2	<.01
	21st ST C	8.0	77.2	<3	<.5	.73	.048	1.3	25.3	.02
	26th St.S.D.	9.6	53.1	<3	<.5	.83	.038	<1	19.0	.12
	Ped Br A	10.2	<30	<3	<.5	.70	.058	<1	15.2	<.01
	Ped Br C	<5.0	<30	<3	<.5	.70	.080	<1	17.7	<.01
	I Ave SD	5.1	<30	<3	<.5	.78	.082	<1	29.1	<.01
		75.4/9	170.2/3	—	—	8.55/10				

693.1/11 113.1/7 —

Pb - Lead
Cr - Chromium
Cd - Cadmium
Hg - Mercury
NO_3/NO_2 - Nitrate/Nitrite

TPO_4 - Total Phosphorous
BOD - Biochemical Oxygen Demand
COD - Chemical Oxygen Demand
NH_3 - Ammonia

195.6/19
1213.9/73

WATER CHEMICAL MEASUREMENTS

1992

DATE	SITE	Pb	Cr	Cd	Hg	NO_3/NO_2	TPO_4	BOD	COD	NH_3
8-26-92										
	11th ST.SD	9.1	<30	<3	<.5	.91	.168	2.2	24.3	.01
	11th ST A	<5	<30	<3	<.5	.71	.085	<1	24.3	<.0
	11th ST C	14.1	<30	<3	<.5	.75	.058	<1	24.3	.07
	21st ST SD	7.3	<30	<3	<.5	2.80	.040	<1	9.7	.02
	21st ST A	10.8	<30	<3	<.5	.76	.060	1.1	24.3	<.01
	21st St C	13.3	<30	<3	<.5	.76	.085	<1	19.4	<.01
	26th St SD	7.1	<30	<3	<.5	.83	.072	1.4	24.3	<.01
	Ped Br A	11.8	<30	<3	<.5	.77	.060	<1	9.7	<.01
	Ped Br C	<5	<30	<3	<.5	.77	.195	<1	19.4	<.01
	I Ave SD	<5	<30	<3	<.5	.93	.198	1.6	14.6	<.01
9-2-92		73.5/7	—	–	—	9.99/10				
	11th St SD	14.8	55.4	<3	<.5	.83	.204	4.6	41.0	<.01
	11th St A	9.8	<30	<3	<.5	.63	.187	<1	5.1	<.01
	11th ST C	7.2	<30	<3	<.5	.64	.171	<1	10.2	<.01
	21st ST SD	9.0	<30	<3	<.5	.88	.366	7.7	35.8	.16
	21st ST A	22.0	<30	<3	<.5	.66	.276	<1	15.4	<.01
	21st ST C	13.5	<30	<3	<.5	.66	.199	1.1	10.2	<.01
	26th ST SD	10.1	66.3	<3	<.5	.82	.343	3.7	25.6	.14
	Ped Br A	8.9	88.9	<3	<.5	.64	.192	<1	10.2	<.01
	Ped Br C	11.8	105.4	<3	<.5	.67	.32	<1	10.2	<.01
	I Ave SD	<5	<30	<3	<.5	.96	.245	7.6	30.7	.42
		107.1/9	316/4	—	—	7.39/10				
9-9-92	11th St SD	<5	80.1	<3	<.5	.78	.215	2.8	10.2	<.01
	11th St A	12.3	44.4	<3	<.5	.72	.245	2.6	20.5	<.01
	11th St C	<5	<30	<3	<.5	.73	.189	2.9	10.2	<.01
	21st St SD	6.4	<30	<3	<.5	2.04	.248	2.6	10.2	<.01
	21st St A	<5	6.4	<3	<.5	.77	.230	2.8	5.1	<.01
	21st ST C	6.8	<30	<3	<.5	.73	.197	2.8	5.1	<.01
	26th St SD	6.4	<30	<3	<.5	.74	.215	2.6	10.2	<.01
	Ped Br A	<5	<30	<3	<.5	.73	.189	2.8	20.5	<.01
	Ped Br C	<5	<30	<3	<.5	.72	.199	2.9	10.2	<.01
	I Ave SD	<5	<30	<3	<.5	.96	.199	2.7	5.1	<.01
		31.9/4	130.9/3	—	—	8.92/10				

446.9/7

Pb - Lead
Cr - Chromium
Cd - Cadmium
Hg - Mercury
NO_3/NO_2 - Nitrate/Nitrite

TPO_4 - Total Phosphorous
BOD - Biochemical Oxygen Demand
COD - Chemical Oxygen Demand
NH_3 - Ammonia

212.5/20

WATER CHEMICAL MEASUREMENTS

1992

DATE	SITE	Pb	Cr	Cd	Hg	NO_3/NO_2	TPO_4	BOD	COD	NH_3
9/16/92										
	11th ST.SD	7.6	<30	<3	<.5	2.15	.450	<1	<5	<.01
	11th ST A	<5	<30	<3	<.5	.82	.210	<1	12.5	<.01
	11th ST C	<5	<30	<3	<.5	.78	.220	<1	12.5	<.01
	21st ST SD	<5	100.1	<3	<.5	2.26	.205	<1	7.5	<.01
	21st ST A	<5	<30	<3	<.5	.77	.208	<1	17.5	<.01
	21st St C	5.4	<30	<3	<.5	.78	.200	<1	10	<.01
	26th St SD	<5	<30	<3	<.5	.79	.222	<1	10	<.01
	Ped Br A	<5	70.6	<3	<.5	.78	.205	<1	22.5	<.01
	Ped Br C	<5	83.8	<3	<.5	.77	.228	<1	12.5	<.01
	I Ave SD	<5	97.8	<3	<.5	1.16	.242	<1	12.5	<.01
		13/2	353/4	—	—	11.06/10				
	11th St SD									
	11th St A									
	11th ST C									
	21st ST SD									
	21st ST A									
	21st ST C									
	26th ST SD									
	Ped Br A									
	Ped Br C									
	I Ave SD									
	11th St SD									
	11th St A									
	11th St C									
	21st St SD									
	21st St A									
	21st ST C									
	26th St SD									
	Ped Br A									
	Ped Br C									
	I Ave SD									
		1441.4/95	3115.9/35	232.6/18	2/1					

12.5

Pb - Lead
Cr - Chromium
Cd - Cadmium
Hg - Mercury
NO_3/NO_2 - Nitrate/Nitrite

TPO_4 - Total Phosphorous
BOD - Biochemical Oxygen Demand
COD - Chemical Oxygen Demand
NH_3 - Ammonia

APPENDIX C - ALERT AND CONCERN LEVELS OF TOXICANTS IN FISH TISSUE FROM THE OKLAHOMA WATER QUALITY STANDARDS

TABLE 4. Alert and Concern Levels in Fish Tissue[1]

SUBSTANCE	ALERT LEVEL (mg/kg)	CONCERN LEVEL (mg/kg)
Aldrin	0.3	0.15
Chlordane	0.3	0.15
DDT*	5.0	2.5
Dieldrin	0.3	0.15
Endrin	0.3	0.15
Heptachlor	0.3	0.15
Mercury	1.0	0.5
PCB's*	2.0	1.0
Toxaphene	5.0	2.5

NOTES: [1]Copied directly from OWQS

*DDT = Dichlorodiphenyltrichloroethane

*PCB's = Polychlorinated Biphenyls

APPENDIX D - FISH TOXICOLOGY DATA

CONTAMINANTS IN FISH IN THE ZINK LAKE AREA - JUNE 1992

CONTAMINANT (UNITS)	CA*	SB*	CC*	FD*	RC*
Aldrin (ug/Kg)	<6.00	<6.00	<6.00	<6.00	<6.00
Alpha BHC (mg/Kg)	<.004	<.004	<.004	<.004	<.004
Gamma BHC (ug/Gm)	<.004	<.004	<.004	<.004	<.004
Chlordane Cis Iso. (mg/Kg)	<.020	.051	.065	<.020	.065
Chlordane Trn Iso. (mg/Kg)	.022	<.020	.038	<.020	.040
Nonachlor Cis Iso. (mg/Kg)	<.020	<.020	.021	<.020	<.020
Nonachlor Trn Iso. (mg/Kg)	<.020	<.020	<.020	<.020	<.020
Chlordane [Total] (mg/Kg)	.022	.051	.124	<.020	.105
o,p'DDD (mg/Kg)	<.040	<.040	<.040	<.040	<.040
o,p'DDE (mg/Kg)	<.040	<.040	<.040	<.040	<.040
o,p'DDT (mg/Kg)	<.040	<.040	<.040	<.040	<.040
p,p'DDD (mg/Kg)	<.040	.04	<.040	<.040	<.040
p,p'DDE (mg/Kg)	.13	.17	.09	.15	<.040
p,p'DDT (ug/Kg)	<40.00	<40.00	50.0	<40.00	<40.00
DDT [Total] (mg/Kg)	.13	.218	.137	.151	<.040
Dieldrin (mg/Kg)	<.01	.01	.01	<.01	<.01
Endrin(ug/Kg)	<6.00	<6.00	<6.00	<6.00	<6.00
Heptachlor (ug/Kg)	<6.00	7.0	<6.00	<6.00	<6.00
Heptachlor epoxide (ug/Kg)	<6.00	<6.00	<6.00	<6.00	9.00
Hexachlorobenzene (ug/Kg)	<4.00	<4.00	<4.00	<4.00	<4.00
Methoxychlor (ug/Kg)	<20.0	<20.0	<20.0	<20.0	<20.0
PCB [Total] (ug/Kg)	277.0	232.0	173.0	63.0	104.0
Toxaphene (ug/Kg)	<60.0	<60.0	<60.0	<60.0	<60.0
Mercury (mg/Kg)	<.10	.25	<.10	<.10	<.10

NOTES:* CA= Carp
SB= Striped Bass
CC= Channel Catfish
FD= Freshwater Drum
RC= River Carpsucker

UNITS
(ug/Kg)= micrograms/kilogram
(mg/Kg)= milligrams/kilogram
(ug/Gm)= micrograms/gram

PCB identified as Archlor 1260

PHYSICAL DATA OF FISH SPECIES STUDIED

SPECIES	MEAN LENGTH (INCHES)	MEAN WEIGHT (POUNDS)
Carp	22.48	5.10
Striped Bass	25.35	7.75
Channel Catfish	18.84	3.09
Freshwater Drum	22.03	5.76
River Carpsucker	14.00	1.35

NOTE: The data is based on a sample containing five specimans of each specie collected.

WATER QUALITY REPORT FOR THE ZINK LAKE - RIVER PARKS AREA OF THE ARKANSAS RIVER FOR 1993

PREPARED BY THE TULSA CITY-COUNTY
HEALTH DEPARTMENT

TABLE OF CONTENTS

INTRODUCTION

In 1993, the Zink Lake Water Quality Project was again undertaken as has been done for the last ten years. This project is an annual study required of the City of Tulsa by the U.S. Army Corps of Engineers permit for the low water dam. 1993 was a somewhat atypical year for the study. The study period starts in May and from the middle of May to the end of June the Arkansas River watershed was inundated by unusually heavy rainfalls. This caused some minor flooding while the river ran bank full for this six week period. Due to the high water conditions, the storm drains were flooded by the river and could not be safely sampled during this period. This study usually also includes a study of contaminants in the local fish population of the river. This study is done in conjunction with the Oklahoma Department of Wildlife Conservation and the Oklahoma Department of Environmental Quality Bio-monitoring Project. Because of the flooding conditions, it was deemed to be too dangerous to even attempt the fish sampling project this year. The flooding also probably had another effect on the project. It may have resulted in some skewed data being gathered. While some increased flow is normally expected during the spring and early summer, 1993 flows probably provided a much greater dilution factor than normal. This may have resulted in the data appearing somewhat better than would normally be expected. In spite of all the problems, the study was performed in much the same manner as before. The same three bridge sites and the same four storm drains were used as sampling locations, yielding 13 sampling sites. For the bacterial study, a minimum of at least five samples were collected in each 30 day period. In 1993, 241 bacterial samples were collected in the river and 88 samples were collected at the storm drains. In addition, 143 water chemistry samples were collected yielding a total of 472 samples collected for the project. The results of the project and the actual data are presented in the following pages.

BACTERIOLOGICAL WATER QUALITY

In 1993 bacteriological samples were collected in the same manner that has been used since the inception of the sampling program. The same three bridge locations and the same four storm drains were utilized as sampling points. The sampling regime was again designed to meet the criteria set forth in the Oklahoma Water Quality Standards (OWQS). The data was analyzed in accordance with the "Primary Body Contact" standards set forth in the OWQS. In addition, we again calculated a "Fecal Coliform/Fecal Streptococcus Ratio (FC/FS)" to use as an indicator of the source of the pollution. "FC/FS Ratios" of 5 or higher are indicative that much of the bacteria is of human origin while ratios of 2 or less are more indicative of animal contamination.

As was the case in all the previous years this study was undertaken, the Arkansas River results indicated that the water quality does not meet the criteria for "Primary Body Contact" standards. Both the Geometric Mean values and the total count values exceeded the required criteria of the OWQS. Each of the river stations will be discussed separately and then a discussion of the storm drains will follow.

11TH STREET BRIDGE

The Geometric Mean criteria (>200 colonies) was exceeded in 3 of the 15 data sets. All three occurred at a different substation and all of them occurred in the month of September. The total count criteria (400 colonies in 10% of all samples) was found to have been exceeded in 14.7% of the samples. The range of values was 9-8,000 for fecal coliform. The range of values for fecal streptococcus was 9-5,500. The "FC/FS Ratio" indicated that in 3 of the 81 samples collected the contamination could be attributed to human origin. This amounts to only 3.7% of the samples. On the other hand, the FC/FS ratio also indicates that animal wastes were the major bacterial source in 77.7% of the cases. September was the only really bad month at this station. This was the only month when the geometric mean was violated and 10 of the 12 samples that exceeded the 400 colony count were recorded. At this station the east bank sampling point was the worst during the year, reflecting the influence of the storm water entering the river from the 11th street storm drain.

21ST STREET BRIDGE

The Geometric Mean Criterion was exceeded in 3 of the 15 data sets. All three exceedances occurred in September. The total count criteria was found to have been exceeded in 22.5% of the samples (18/80). The fecal coliform counts ranged in value from 9-14,000. The fecal streptococcus counts ranged in value from 9-7,300. The"FC/FS ratio" indicated that in 9 of the 80 samples, the contamination source could be considered to be human related. This amounts to 11.25% of the samples collected. From another standpoint, 82.5% of the samples indicated an animal source as contamination according to the FC/FS ratio. September was the worst month for this station, with all three exceedances of the geometric mean occurring then. Also, most of the 400 colony count exceedances occurred in this month. At this station the east bank sampling point was again the worst point. This continues to reflect the influence of the 11th street and Indian Avenue storm drains.

PEDESTRIAN BRIDGE

The Geometric Mean Criterion was exceeded in 5 of the 15 data sets obtained at this station. While September was also the worst month for this station, it also failed the Geometric Mean Criterion in July and August. The total count criterion was found to have been exceeded in 20% of the samples (16/80). The fecal coliform values ranged from 9-28,000 while the fecal streptococcus counts ranged in value from 9-22,000. The "FC/FS ratio" indicated that in 11.25% of the samples (9/80) the contamination source could be considered human in origin. It also indicated that in 82.5% of the samples (66/80) the contamination source could be considered to be of animal origin. In September, all three of the substations had values exceeding the Geometric Mean criterion with the highest being at the east bank station. In addition, the east bank station was the point where the Geometric Mean exceeded the criterion in July and August. A large portion of the total count exceedances also occurred in September at this station. This tends to agree well with the data from the other two bridge sites.

STORM DRAINS

As usual, bacterial counts found in the storm drain samples indicate how much bacterial contamination they contribute to the Arkansas River. Storm drain counts are routinely much higher than those encountered in the in-stream samples. The highest value encountered for fecal coliform was 300,000 and this occurred in August at the 21st street storm drain. The highest fecal streptococcus count was 440,000 and occurred in August at the 26th street storm drain. The range of values for each storm drain is as follows:

11th Street	Fecal Coliform	180 - 280,000
	Fecal Strep	260 - 88,000
Indian Avenue	Fecal Coliform	90 - 60,000
	Fecal Strep	100 - 37,000

21st Street	Fecal Coliform	260 - 300,000
	Fecal Strep	360 - 370,000
26th Street	Fecal Coliform	140 - 120,000
	Fecal Strep	230 - 440,000

This data makes it easy to see that the continuous influx of water from these drains is a major source of bacterial contamination in the river. The "FC/FS ratio" of the various storm drains is much more definitive than the ratios for the river samples. The "FC/FS ratio" indicated that in 18.2% of the storm drain samples, the bacterial contamination could be attributed to human wastes. In 61.4% of the samples the contamination source was determined to be mainly of animal origin. In addition, the "FC/FS ratio" of the storm drain samples resulted in values that were often much higher than the 5 determination level, indicating that human sewage is still a rather prevalent factor in many stormwater discharges. While all four storm drains seem to have problems stemming from human wastes, the least correlation was noted at the 26th street storm drain while the greatest correlation was noted at the 21st street storm drain.

DISCUSSION

Overall, the bacterial data for 1993 did not appear to be too bad. Exceedances of the Geometric Mean were about the same as in previous years and most of the exceedances occurred in the month of September at all three stations. Unfortunately, it is believed that the data was somewhat misleading. The Arkansas River basin experienced an above normal rainfall period in May and June. This led to a greatly increased volume of flow in the river, with the river being virtually bank full for several weeks. This is why the storm drains were not sampled from May 10th to June 23rd. The drains were engulfed by the river flow and were too hazardous to try to sample. Obviously this very large flow increase provided a big dilution factor for contaminants entering the river. Once the flow in the river finally receded, the constant contribution of bacterial contamination from the storm drain discharges became readily apparent. By the end of summer bacterial counts had risen greatly at all three river sites, resulting in the exceedances of the geometric mean criterion. Without the increased high volume of flow in the river it is likely there would have been more exceedances.

For the most part the east bank sampling points were the worst area of the river. This is logical since most of the storm drains are on the east bank and that side of the river is much more heavily urbanized. Therefore, they present a much greater chance of providing contaminants to the river. While much of the river contamination can be attributed to animal wastes a decent percentage can be attributed to contamination by human wastes. This is indicative of the continued problem of human sewage getting into the storm drainage system, either by accident or design. The

City of Tulsa still has a long way to go in excluding human sewage from the storm water system. However, this is one of the best techniques available to reduce bacterial contamination of our surface waters. The City of Tulsa is still a long way away from attaining the bacterial standards of the OWQS for the Arkansas River and this condition is expected to persist into the forseeable future.

ZINK LAKE WATER CHEMISTRY

In 1993, water chemistry samples were collected at three bridge sites and four major storm drains. Because of excessive flooding early in the year, some of the storm drains were not sampled as extensively as the bridge sites. In 1993, 143 sets of water chemistry samples were collected from these sites. The samples were again tested for nine parameters as in the previous year. These included Lead (Pb), Chromium (Cr), Cadmium (Cd), Mercury (Hg), Nitrate/Nitrite (NO_3/NO_2), Total Phosphates (TPO_4), Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD) and Ammonia (NH_3). The results obtained for each parameter will be discussed separately.

LEAD (Pb)

Lead was detected (>5.0 ppb) in 73% of all samples collected. This is up from the 62% of the samples it was found in in 1992. The highest level encountered was 100.2 ppb at the 21st street storm drain. The highest in-stream value found was 46.3 ppb at the west bank station of the Pedestrian Bridge. Both of these values were lower than the highest values encountered in 1992. Ninety percent of the detectable values were between 10 and 20 ppb in 1992. In 1993 that figure was down to 45% of the detectable values, the rest being under 10 ppb. In general, the 21st street storm drain had the highest lead values found in the study, but even here it was undetectable at certain times. Overall, while lead was detected in a larger number of the samples, the levels encountered seem to indicate a decrease in the amount of lead entering the river from the storm drains.

CHROMIUM (Cr)

Chromium was detectable (>30 ppb) in 22% of all samples collected. This is virtually the same as the 25% occurrence encountered in 1992. The highest value found was 194 ppb and this was at the west bank of the Arkansas River at the 21st street bridge. The highest storm drain value was 85.9 ppb found at the 21st street storm drain. These values are generally in line with what was encountered in 1992. In this study, the highest values were found in-stream when same day storm drain samples showed no detectable chromium levels. This may be an indication of either short, episodic discharges of chromium from storm drains or another possible source that is not currently included in the study.

CADMIUM (Cd)

Cadmium was detected (>3.0 ppb) in 47% of the samples collected. This reflects a large increase over the previous years data. The highest level encountered was 59.6 ppb and this was found at the 11th street storm drain. The highest in-stream value encountered was 47.4 ppb and this occurred at the east bank station of the 11th street bridge. These values are two to three times higher than the 1992 values. Obviously, the cadmium problem seemed to worsen in 1993.

MERCURY (Hg)

Mercury was detected (>.5 ppb) in only 15% of the samples collected. However, this represents a twenty-fold increase in detectable mercury levels when compared to 1992 data. The highest storm drain level encountered was .8 ppb and this occurred at the 21st street storm drain. The highest river value found was 3.6 ppb and this occurred on the west bank of the 11th street bridge. Mercury contamination appeared to be a much more widespread problem in 1993 as compared to 1992.

NITRATE/NITRITE (NO_3/NO_2)

Nitrate/Nitrite radicals were at detectable levels (>.02 ppm) in 79% of all the samples that were collected. The highest value for a storm drain was 3.9 ppm and occurred at the Indian Avenue storm drain. The highest river value was 1.31 ppm and this occurred at the west bank of the Pedestrian Bridge. These values were in line with the highest values found in 1992.

Overall, the storm drains had much higher levels of No_3/NO_2 than the river samples did. NO_3/NO_2 is mainly contributed by use of fertilizers from residential areas. However, some is contributed by fertilizers used on agricultural land and some is contributed through animal droppings in residential areas. This pollutant is probably the most important one in the consideration to maintain our surface water quality. The city will probably have to institute educational programs in order to teach the public to minimize and control the indiscriminate use of fertilizers.

TOTAL PHOSPHATES (TPO_4)

Detectable phosphate levels were found in all but three of the samples collected. The range of values was <.04 ppm to 2.58 ppm. The highest value was encountered in a sample from the 11th street storm drain. The highest river value was .976 ppm and was found at the east bank station of the 21st street bridge. These values are somewhat lower when compared to the 1992 data. In a few instances, storm drain values were somewhat higher than river values but not to any great degree.

BIOCHEMICAL OXYGEN DEMAND (BOD)

BOD represents the measure of various types of organic materials on the oxygen supply dissolved in the water. These materials include living biological organisms, decaying organic matter and the oxidation of organic materials. Forty-six percent of the samples collected had measurable BOD loading as compared to 50% in 1992. Values ranged from <1.0 ppm to 6.7 ppm, the highest value occurring at the 11th street storm drain. The highest river value was 3.5 ppm and was found at the west bank of the 21st street bridge. In general, storm drain values tend to be higher than in-stream values. This is a good indication of the scope of pollutant loading contributed by urban storm drains.

CHEMICAL OXYGEN DEMAND (COD)

The COD determination is a measure of the oxygen equivalent of that portion of the organic matter in a sample that is susceptible to oxidation by a strong oxidant. It does not measure all organic compounds that are readily available to stream organisms and measures some that are not so readily available to biological organisms. It is a useful tool for measuring the oxygen demand of the organic chemicals present in water. COD values were detectable (>5.0 ppm) in 92% of the samples. The highest storm drain value was 109.6 ppm and occurred at the 26th street storm drain. The highest river value was 41 ppm and was found along the east bank of the river at the 11th street bridge. The storm drain value was much higher than any found in 1992. For the most part, levels of COD in the storm drains were much higher than those encountered in the river. Obviously, our urban storm drainage system contributes a large portion of the contaminants that effect dissolved oxygen levels in the Arkansas River.

AMMONIA (NH_3)

Ammonia levels ranged from non-detectable (<.01 ppm) to a high of .32 ppm which occurred at the 21st street storm drain. The highest river value was .29 ppm and occurred on the east bank of the 11th street bridge. Ammonia was detectable in 79% of all samples collected. This is a somewhat higher rate of occurrence than was encountered in 1992 (66%). In the past, EPA has suggested a criterion of .02 ppm for the protection of aquatic life. Based on this recommendation, 70% of our samples exceeded this ammonia level compared with a 50% exceed in 1992. While the values are not extremely high, ammonia appears to be a routine cause of water quality degradation in the Arkansas River. While part of the ammonia is generated by the natural decomposition of organic materials in the water, the ubiquitous nature of ammonia is indicative of the high level of organic matter loading the river receives from the watershed.

DISCUSSION

During May and June of 1993, the Tulsa area and Arkansas River basin were subjected to higher than normal rainfall. This resulted in very high river levels and effected the sampling period from May 12th to June 23rd. Samples collected during this period were more diluted than would normally be expected due to the high flows in the river. However, even with the increased dilution factor we found the highest levels of Nitrate/Nitrite, Lead and Cadmium during this period. This might be indicative of increased contamination from some source or sources. Over the entire study, Cadmium appeared to be a bigger problem in 1993 than in 1992. While Lead generally was found at lower levels it was encountered much more frequently in 1993. Mercury was also encountered more often in 1993. Ammonia contamination also seemed to worsen in 1993. The other parameters were not much changed from the previous year.

As in our past studies it is evident that our storm drains are a major source of water quality degradation in the Arkansas River. With the emphasis placed on commercial and industrial expansion as well as the growth of both human and animal populations, it is clear that our urban storm sewer system is likely to be an increasingly important source of contaminants to the Arkansas River into the forseeable future. Any attempt at improving or maintaining water quality in the river will take a concerted effort by the City of Tulsa to reduce and control the entrance of contaminants into the system.

APPENDIX A - BACTERIOLOGICAL DATA

BACTERIOLOGICAL QUALITY OF THE ARKANSAS RIVER AT ZINK LAKE
MAY - SEPTEMBER 1993

11TH STREET BRIDGE (0A020)

	West Bank (A)			Mid Channel (B)			East Bank (C)		
	FC*	FS*	FC/FS*	FC*	FS*	FC/FS*	FC*	FS*	FC/FS*
03-May-93	72	120	0.60	72	99	0.73	81	63	1.29
05-May-93	260	260	1.00	160	170	0.94	140	180	0.78
10-May-93	45	300	0.15	45	180	0.25	9	280	0.03
17-May-93	54	240	0.23	36	240	0.15	18	230	0.08
24-May-93	45	110	0.41	9	72	0.13	54	140	0.39
G.MEAN*	72.8			44.2			39.7		
09-Jun-93	27	27	1.00	9	9	1.00	54	63	0.86
16-Jun-93	9	27	0.33	9	9	1.00	72	27	2.67
23-Jun-93	9	54	0.17	9	63	0.14	200	27	7.41
29-Jun-93	45	54	0.83	9	63	0.14	110	36	3.06
30-Jun-93	18	45	0.40	18	18	1.00	54	36	1.50
G.MEAN*	17.8			10.3			85.7		
12-Jul-93	9	9	1.00	9	18	0.50	260	9	28.89
14-Jul-93	18	27	0.67	9	9	1.00	110	54	2.04
19-Jul-93	18	420	0.04	9	240	0.04	100	80	1.25
21-Jul-93	27	150	0.18	27	45	0.60	120	100	1.20
26-Jul-93	54	220	0.25	9	72	0.13	9	210	0.04
G.MEAN*	21.2			11.2			79.1		
02-Aug-93	9	200	0.05	9	81	0.11	18	230	0.08
04-Aug-93	18	480	0.04	9	200	0.05	18	410	0.04
16-Aug-93	36	240	0.15	9	100	0.09	9	210	0.04
18-Aug-93	9	160	0.06						
23-Aug-93	27	240	0.11	54	290	0.19	810	220	3.68
25-Aug-93	27	130	0.21	180	54	3.33	2900	27	107.41
G.MEAN*	18.4			23.4			92.7		
01-Sep-93	9	610	0.01	9000	2300	3.91	910	1400	0.65
08-Sep-93	450	650	0.69	36	130	0.28	8000	3100	2.58
20-Sep-93	1300	540	2.41	530	270	1.96	5800	5500	1.05
22-Sep-93	200	140	1.43	140	280	0.50	2000	670	2.99
28-Sep-93	360	280	1.29	390	90	4.33	7000	3600	1.94
29-Sep-93	240	72	3.33	170	54	3.15	5300	1200	4.42
G.MEAN*	212.1			341.8			3825.3		

*FC = Fecal Coliform
*FS = Fecal Streptococcus
*FC/FS = Fecal Coliform/Fecal Streptococcus Ratio
*G Mean = Geometric Mean

BACTERIOLOGICAL QUALITY OF THE ARKANSAS RIVER AT ZINK LAKE
MAY - SEPTEMBER 1992

21ST STREET BRIDGE (0A006)

	West Bank (A)			Mid Channel (B)			East Bank (C)		
	FC*	FS*	FC/FS*	FC*	FS*	FC/FS*	FC*	FS*	FC/FS*
03-May-93	140	170	0.82	45	63	0.71	63	210	0.30
05-May-93	230	170	1.35	160	320	0.50	170	430	0.40
10-May-93	36	350	0.10	27	180	0.15	180	420	0.43
17-May-93	45	250	0.18	36	140	0.26	36	240	0.15
24-May-93	45	81	0.56	90	110	0.82	54	90	0.60
G.MEAN*	74.9			57.5			82.2		
09-Jun-93	36	27	1.33	18	45	0.40	63	81	0.78
16-Jun-93	18	18	1.00	9	9	1.00	63	63	1.00
23-Jun-93	27	27	1.00	9	54	0.17	290	45	6.44
29-Jun-93	54	99	0.55	9	18	0.50	120	170	0.71
30-Jun-93	54	63	0.86	9	9	1.00	45	36	1.25
G.MEAN*	34.8			10.3			90.9		
12-Jul-93	18	36	0.50	140	18	7.78	460	90	5.11
14-Jul-93	54	36	1.50	18	18	1.00			
19-Jul-93	81	140	0.58	9	230	0.04	420	170	2.47
21-Jul-93	9	81	0.11	18	9	2.00	54	140	0.39
26-Jul-93	89	410	0.22	9	130	0.07	150	370	0.41
G.MEAN*	36.3			20.6			198.9		
02-Aug-93	9	120	0.08	45	63	0.71	27	290	0.09
04-Aug-93	10	270	0.04	9	200	0.05	150	360	0.42
16-Aug-93	27	270	0.10	9	63	0.14	100	190	0.53
18-Aug-93	18	910	0.02	9	120	0.08	81	660	0.12
23-Aug-93	2000	1500	1.33	460	210	2.19	9	150	0.06
25-Aug-93	45	36	1.25	630	27	23.33	2100	110	19.09
G.MEAN*	39.7			46.0			92.3		
01-Sep-93	27	690	0.04	36	90	0.40	1900	690	2.75
08-Sep-93	720	700	1.03	630	370	1.70	10000	3800	2.63
20-Sep-93	810	660	1.23	2800	1600	1.75	14000	7300	1.92
22-Sep-93	410	81	5.06	250	180	1.39	9000	5000	1.80
28-Sep-93	360	250	1.44	2700	300	9.00	8000	4200	1.90
29-Sep-93	320	63	5.08	720	90	8.00	470	160	2.94
G.MEAN*	301.0			560.1			4560.9		

*FC = Fecal Coliform
*FS = Fecal Streptococcus
*FC/FS = Fecal Coliform/Fecal Streptococcus Ratio
*G Mean = Geometric Mean

BACTERIOLOGICAL QUALITY OF THE ARKANSAS RIVER AT ZINK LAKE
MAY - SEPTEMBER 1992

PEDESTRIAN BRIDGE (0A005)

	West Bank (A)			Mid Channel (B)			East Bank (C)		
	FC*	FS*	FC/FS*	FC*	FS*	FC/FS*	FC*	FS*	FC/FS*
03-May-93	54	110	0.49	20	45	0.44	81	230	0.35
05-May-93	170	170	1.00	160	190	0.34	100	330	0.30
10-May-93	36	170	0.21	36	130	0.28	9	340	0.03
17-May-93	9	280	0.03	27	360	0.08	54	400	0.14
24-May-93	9	220	0.04	9	18	0.50	110	140	0.79
G.MEAN*	30.6			30.9			53.4		
09-Jun-93	9	9	1.00	9	9	1.00	18	9	2.00
16-Jun-93	9	9	1.00	9	18	0.50	18	18	1.00
23-Jun-93	18	9	2.00	9	9	1.00	180	81	2.22
29-Jun-93	9	9	1.00	9	18	0.50	54	63	0.86
30-Jun-93	9	9	1.00	9	18	0.50	18	9	2.00
G.MEAN*	10.3			9.0			35.5		
12-Jul-93	9	9	1.00	9	9	1.00	370	18	20.56
14-Jul-93				18	18	1.00	120	110	1.09
19-Jul-93	9	27	0.33	18	45	0.40	1400	170	8.24
21-Jul-93	9	27	0.33	9	27	0.33	110	81	1.36
26-Jul-93	9	130	0.07	9	130	0.07	6300	280	22.50
G.MEAN*	9.0			11.9			533.1		
02-Aug-93	9	81	0.11	9	120	0.08	45	270	0.17
04-Aug-93	9	550	0.02	9	140	0.06	100	340	0.29
16-Aug-93	9	100	0.09	9	36	0.25	36	260	0.14
18-Aug-93	9	45	0.20	9	72	0.13	45	410	0.11
23-Aug-93	540	190	2.84	45	45	1.00	28000	22000	1.27
25-Aug-93	36	18	2.00	320	9	35.56	480	18	26.67
G.MEAN*	22.4			21.3			214.7		
01-Sep-93	27	210	0.13	36	63	0.57	1300	680	1.91
08-Sep-93	45	63	0.71	230	200	1.15	5800	3500	1.66
20-Sep-93	490	550	0.39	1000	2200	0.45	5600	6000	0.93
22-Sep-93	1300	600	2.17	810	650	1.25	810	380	2.13
28-Sep-93	1200	240	5.00	1400	90	15.56	580	63	9.21
29-Sep-93	720	130	4.00	1500	90	16.67	210	120	1.75
G.MEAN*	295.7			491.4			1268.5		

*FC = Fecal Coliform
*FS = Fecal Streptococcus
*FC/FS = Fecal Coliform/Fecal Streptococcus Ratio
*G Mean = Geometric Mean

BACTERIOLOGICAL WATER QUALITY
OF STORM DRAINS
MAY - SEPTEMBER 1993

	11TH ST STORM DRAIN OK 002			INDIAN AVE STORM DRAIN OK 003			21ST ST STORM DRAIN OK 008			26TH ST STORM DRAIN		
DATE	FC*	FS*	FC/FS*	FC*	FS*	FC/FS*	FC*	FS*	FC/FS*	FC*	FS*	FC/FS*
03-May-93	180	260	0.69	180	250	0.72	9000	23000	0.39	220	590	0.37
05-May-93	400	660	0.61	400	710	0.56	16000	16000	1.00	140	400	0.35
10-May-93	NA	NA	NA	NA	NA	NA	NA	4100	1.00	NA	NA	NA
17-May-93	NA	NA	NA	NA	NA	NA	21000	73000	0.29	NA	NA	NA
24-May-93	NA	NA	NA	NA	NA	NA	1100	1800	0.61	NA	NA	NA
09-Jun-93	NA	NA	NA	NA	NA	NA	630	650	0.97	NA	NA	NA
16-Jun-93	NA	NA	NA	NA	NA	NA	370	420	0.88	NA	NA	NA
23-Jun-93	NA	NA	NA	NA	NA	NA	4200	1700	2.47	NA	NA	NA
29-Jun-93	2200	940	2.34	220	360	0.61	3400	650	5.23	250	480	0.52
30-Jun-93	3100	390	7.95	90	220	0.41	260	390	0.67	200	290	0.69
12-Jul-93	14000	14000	1.00	570	100	5.70	1700	1700	1.00	640	230	2.78
14-Jul-93	60001	22000	2.73	60001	37000	1.62	60001	63000	0.95	NA	NA	NA
19-Jul-93	2400	2600	0.92	4600	3100	1.48	4200	2400	1.75	6001	4800	1.25
21-Jul-93	21000	21000	1.00	220	500	0.44	3000	360	8.33	190	470	0.40
26-Jul-93	3800	2000	1.90	2600	620	4.19	2800	1500	1.87	1500	270	5.56
02-Aug-93	810	440	1.84	900	570	1.58	1500	380	3.95	1200	580	2.07
04-Aug-93	5700	2400	2.38	2100	540	3.89	10000	1800	5.56	1200	390	3.08
16-Aug-93	6300	2000	3.15	16000	630	25.40	10000	2300	4.35	2700	1500	1.80
18-Aug-93	7300	630	11.59	530	1200	0.44	17000	770	22.08	2800	1600	1.75
23-Aug-93	420	1400	0.30	25000	27000	0.93	300000	370000	0.81	120000	440000	0.27
25-Aug-93	80000	39000	2.05	8100	1000	8.10	27000	7800	3.46	7200	5100	1.41
01-Sep-93	15000	2400	6.25	10000	1500	6.67	6300	1800	3.50	4300	2400	1.79
08-Sep-93	80000	66000	1.21	16000	16000	1.00	100000	63000	1.59	38000	39000	0.97
20-Sep-93	280000	88000	3.18	13000	22000	0.59	190000	16000	11.88	23000	24000	0.96
22-Sep-93	16000	5700	2.81	17000	4400	3.86	8100	7300	1.11	7200	6400	1.13
28-Sep-93	33000	53000	0.62	1400	8900	0.16	90000	1900	47.37	4400	2800	1.57
29-Sep-93	2100	420	5.00	16000	15000	1.07	1300	510	2.55	7200	1300	5.54

NA = No Sample
*FC = Fecal Coliform
*FS = Fecal Streptococcus
*FC/FS = Fecal Coliform/Fecal Streptococcus Ratio

APPENDIX B - WATER CHEMISTRY DATA

ARKANSAS RIVER PROJECT
WATER CHEMICAL MEASUREMENTS
1993

DATE	SITE	Pb	Cr	Cd	Hg	NO_3/NO_2	TPO_4	BOD	COD	NH_3
5/5/93	11A	7.8	<30	35.9	.61	.62	.413	1.6	23.1	.20
	11C	10.2	<	15.3	2.73	.59	.393	1.6	35.9	.29
	11SD	7.6	<30	13.8	.58	.78	.405	1.6	28.2	.20
	21A	9.8	<30	<3	.58	.74	.435	1.4	20.5	.19
	21C	9.7	<30	<3	<.5	.56	.527	2.2	23.1	.20
	21SD	100.2	68.0	<3	<.5	1.39	.583	2.2	20.5	.32
	26SD	12.0	<30	<3	<.5	.68	.288	1.7	23.1	.17
	P-A	6.2	<30	<3	<.5	1.03	.315	2.1	23.1	.14
	P-C	14.1	55	18.4	<.5	.81	.338	1.9	23.1	.16
	I-A	9.4	<30	6.9	<.5	1.26	.377	2.1	18	.15
5/12/93										
	11A	31.7	<30	9.5	<.5	.65	.516	2.2	28.2	.08
	11C	27.7	<30	<3	<.5	.64	.400	3.0	41.0	.10
	11SD	------	------	Not	sampled	------	------	------	------	------
	21A	26.9	<30	<3	<.5	.65	.625	1.8	30.8	.06
	21C	25.1	<30	25.2	<.5	1.03	.266	1.5	23.1	.04
	21SD	15.8	<30	<3	<.5	.62	.226	5.6	12.8	<.01
	26SD	------	------	Not	sampled	------	------	------	------	------
	P-A	17.4	<30	8.4	<.5	1.31	.372	1.5	25.6	.07
	P-C	27.4	<30	10.0	<.5	.47	.358	1.1	25.6	.08
	IA	------	------	Not	sampled	------	------	------	------	------

Pb - Lead - ppb

Cr - Chromium - ppb

Cd - Cadmium - ppb

Hg - Mercury - ppb

NO_3/NO_2 - Nitrate/Nitrite - ppm

TPO_4 - Total Phosphorous - ppm

BOD - Biochemical Oxygen Demand - ppm

COD - Chemical Oxygen Demand - ppm

NH_3- Ammonia - ppm

ARKANSAS RIVER PROJECT
WATER CHEMICAL MEASUREMENTS
1993

DATE	SITE	Pb	Cr	Cd	Hg	NO_3/NO_2	TPO_4	BOD	COD	NH_3
5/19/93	11A	15.4	<30	<3	<.5	.41	.351	<1	21.4	.05
	11C	<5	<30	<3	<.5	.38	.229	<1	34.7	.04
	11SD	———	———	Not	Sampled	———	———	———	———	———
	21A	9.1	<30	3.6	<.5	.39	.233	<1	21.3	.04
	21C	13.3	<30	<3	<.5	.38	.369	<1	26.7	.04
	21SD	11.1	<30	<3	<.5	.45	.238	<1	32	.05
	26SD	———	———	Not	Sampled	———	———	———	———	———
	P-A	14.0	<30	<3	<.5	.39	.236	1.1	24	.03
	P-C	4.2 ?	<30	<3	<.5	.39	.215	<1	24	.03
	I-A	———	———	Not	Sampled	———	———	———	———	———
6/2/93										
	11A	7.6	<30	<3	<.5	.47	.145	<1	14.7	.06
	11C	19.5	<30	<3	<.5	.47	.170	<1	20.6	.06
	11SD	14.4	<30	59.6	<.5	.46	.160	<1	17.7	.04
	21A	7.4	<30	45.8	<.5	.47	.143	<1	23.5	.05
	21C	22	<30	42.5	<.5	.47	.158	<1	14.7	.07
	21SD	14.9	<30	<3	<.5	.68	.131	<1	23.5	.07
	26SD	———	———	Not	sampled	———	———	———	———	———
	P-A	46.3	<30	<3	<.5	.46	.138	<1	17.7	.07
	P-C	25.2	<30	<3	<.5	.46	.115	<1	17.7	.04
	IA	———	———	Not	sampled	———	———	———	———	———

Pb - Lead - ppb

Cr - Chromium - ppb

Cd - Cadmium - ppb

Hg - Mercury - ppb

NO_3/NO_2 - Nitrate/Nitrite - ppm

TPO_4 - Total Phosphorous - ppm

BOD - Biochemical Oxygen Demand - ppm

COD - Chemical Oxygen Demand - ppm

NH_3 - Ammonia - ppm

ARKANSAS RIVER PROJECT
WATER CHEMICAL MEASUREMENTS
1993

DATE	SITE	Pb	Cr	Cd	Hg	NO_3/NO_2	TPO_4	BOD	COD	NH_3
6/9/93	11A	8.3	<30	<3	<.5	.58	.196	1.2	17.7	.07
	11C	5.0	32.6	<3	<.5	.58	.161	1.2	17.7	.07
	11SD	——	——	Not	Sampled	——	——	——	——	——
	21A	42.4	<30	8.1	<.5	.57	.175	1.1	23.5	.04
	21C	6.7	34.7	12.4	.6	.56	.176	1.1	20.6	.02
	21SD	8.2	<30	8.3	<.5	.70	.185	1.6	11.8	.07
	26SD	——	——	Not	sampled	——	——	——	——	——
	P-A	<5	<30	<3	.6	.56	.175	1.1	15.4	.07
	P-C	<5		<3	.8	.55	.177	1.0		.07
	I-A	——	——	Not	sampled	——	——	——	——	——
6/16/93										
	11A	<5	<30	7.3	<.5	.54	.218	<1	17.9	.03
	11C	<5	44.5	47.4	<.5	.54	.222	<1	23.1	.07
	11SD	——	——	Not	Sampled	——	——	——	——	——
	21A	9.0	<30	38.2	<.5	.55	.226	<1	15.4	<01
	21C	8.9	<30	9.4	.8	.60	.208	<1	15.4	.01
	21SD	14.2	<30	<3	<.5	.93	.242	<1	12.8	.08
	26SD	——	——	Not	Sampled	——	——	——	——	——
	P-A	11.0	<30	<3	<.5	.53	.053	<1	15.4	<.01
	P-C	16.2	<30	7.7	<.5	.55	.203	<1	12.8	<.01
	I-A	——	——	Not	Sampled	——	——	——	——	——

Pb - Lead - ppb

Cr - Chromium - ppb

Cd - Cadmium - ppb

Hg - Mercury - ppb

NO_3/NO_2 - Nitrate/Nitrite - ppm

TPO_4 - Total Phosphorous - ppm

BOD - Biochemical Oxygen Demand - ppm

COD - Chemical Oxygen Demand - ppm

NH_3 - Ammonia - ppm

DATE	SITE	Pb	Cr	Cd	Hg	NO_3/NO_2	TPO_4	BOD	COD	NH_3
623/93	11A	9.2	45.1	<3	.7	.57	.223	<1	12.8	<.01
	11C	12.9	<30	<3	<.5	.58	.173	<1	10.3	<.01
	11SD	——	——	Not	Sampled	——	——	——	——	——
	21A	12.1	<30	<3	<.5	.56	.157	<1	5.1	<.01
	21C	9.5	51.3	<3	<.5	.62	.056	<1	17.9	<.01
	21SD	6.6	53.6	<3	<.5	2.27	.199	<1	5.1	.19
	26SD	——	——	Not	Sampled	——	——	——	——	——
	P-A	<5	41.1	14.1	.7	.57	.233	<1	12.8	<.01
	P-C	23.2	31.4	26.7	<.5	.57	.308	<1	12.8	<.01
	IA	——	——	Not	Sampled	——	——	——	——	——
6/30/93	11A	5.6	<30	45.3	<.5	.70	.325	<1	10.3	01
	11C	6.8	<30	27.2	<.5	.54	.256	<1	10.2	<.01
	11SD	<5	<30	3.3	<.5	.64	.364	<1	15.4	.05
	21A	<5	<30	22.2	<.5	.58	.059	<1	12.8	<.01
	21C	5.3	<30	21.2	<.5	.70	.059	<1	12.8	<.01
	21SD	36	46.3	12.3	<.5	.81	.357	<1	12.8	<.01
	26SD	6.7	32.7	16.6	<.5	.73	.330	<1	10.2	.01
	P-A	<5	31.7	25.2	.6	.64	.342	<1	17.9	.01
	P-C	<5	<30	25.0	<.5	.65	.341	<1	12.8	<.01
	IA	13.6	<30	25.4	<.5	.74	.336	<1	7.7	<.01

Pb - Lead - ppb

Cr - Chromium - ppb

Cd - Cadmium - ppb

Hg - Mercury - ppb

NO_3/NO_2 - Nitrate/Nitrite - ppm

TPO_4 - Total Phosphorous - ppm

BOD - Biochemical Oxygen Demand - ppm

COD - Chemical Oxygen Demandd - ppm

NH_3- Ammonia - ppm

ARKANSAS RIVER PROJECT
WATER CHEMICAL MEASUREMENTS
1993

DATE	SITE	Pb	Cr	Cd	Hg	NO_3/NO_2	TPO_4	BOD	COD	NH_3
7/14/93	11A	9.9	30	7.2	<.5	.66	.339	<1	12.2	<.01
	11C	14.6	54	7.0	<.53	.66	.341	<1	12.8	<.01
	11SD	12.5	61.3	13.7	<.5	1.05	.325	6.7	28.2	.07
	21A	<5	74.2	<3	<.5	.62	.316	<1	7.7	.01
	21C	5.3	83.5	<3	<.5	.66	.279	<1	23.1	<.01
	21SD	23.2	85.9	<3	<.5	1.72	.534	<1	106.9	.21
	26SD	13.1	64.9	18.0	<.5	.86	.297	2.5	27.4	.02
	P-A	16.8	<30	<3	<.5	.64	.294	<1	5.5	<.01
	P-C	<5	<30	<3	<.5	.64	.249	<1	8.2	<.01
	I-A	12.9	<30	<3	<.5	.90	.314	4.7	30	.07
8/4/93	11A	6.2	<30	<3	3.6	.02	.210	2.4	16	<.01
	11C	12.6	<30	9.1	.6	.02	.360	2.4	8.2	<.01
	11SD	8.1	<30	9.3	<.5	.41	.364	4.0	40.1	.03
	21A	14.2	<30	14.7	<.5	<.02	.301	3.5	<5	<.01
	21C	<5	<30	<3	1.6	<.02	.340	2.3	5.5	<.01
	21SD	<5	<30	14.0	.8	.89	.354	4.3	24.7	.10
	26SD	6.6	<30	18.1	<.5	<.02	.311	3.8	109.6	.02
	P-A	9.3	<30	29.2	<.5	.155	.349	2.4	<5	<.01
	P-C	<5	<30	15.5	<.5	<.02	.353	2.4	5.1	<.01
	IA	10.6	<30	<3	<.5	<.02	.307	2.6	16.4	.09

Pb - Lead - ppb

Cr - Chromium - ppb

Cd - Cadmium - ppb

Hg - Mercury - ppb

NO_3/NO_2 - Nitrate/Nitrite - ppm

TPO_4 - Total Phosphorous - ppm

BOD - Biochemical Oxygen Demand - ppm

COD - Chemical Oxygen Demand - ppm

NH_3- Ammonia - ppm

ARKANSAS RIVER PROJECT
WATER CHEMICAL MEASUREMENTS
1993

DATE	SITE	Pb	Cr	Cd	Hg	NO_3/NO_2	TPO_4	BOD	COD	NH_3
8/18/93	11A	<5	<30	<3	<.5	<.02	.252	<1	5.5	.03
	11C	10	<30	<3	<.5	<.02	.325	<1	19.3	.02
	11SD	6.8	<30	7.1	<.5	.52	.379	1.3	<5	.06
	21A	6.7	<30	17.6	<.5	<.02	.340	<1	11.0	.02
	21C	<5	<30	9.2	<.5	<.02	.348	<1	<5	.02
	21SD	21.6	<30	7.1	<.5	.65	.252	1.7	13.7	.06
	26SD	9.9	<30	7.4	<.5	<.02	.352	<1	16.4	.04
	P-A	<5	<30	8.9	<.5	<.02	.349	<1	<5	.03
	P-C	6.3	<30	<3	1.7	<.02	.359	<1	8.2	.03
	I-A	<5	<30	6.4	<.5	<.02	.348	<1	13.7	.03
8/25/93	11A	26	<30	16	<.5	.62	.213	<1	10.1	.03
	11C	8.7	30	<3	<.5	.64	.315	<1	12.7	.02
	11SD	6.9	<30	<3	<.5	2.10	2.580	1.6	49.3	.09
	21A	<5	<30	13	<.5	.60	.212	<1	8.2	.04
	21C	7.4	45	<3	<.5	.62	.275	<1	5.5	.02
	21SD	<5	42	<3	<.5	2.0	.326	1.2	35.4	.123
	26SD	5.5	37	<3	<.5	.92	.265	1.0	<5	.04
	P-A	<5	<30	4	<.5	.62	.298	<1	12.7	.02
	P-C	5.7	40	14	<.5	.63	.297	<1	12.7	.03
	IA	<5	<30	<3	<.5	1.40	.237	1.1	20.3	.04

Pb - Lead - ppb

Cr - Chromium - ppb

Cd - Cadmium - ppb

Hg - Mercury - ppb

NO_3/NO_2 - Nitrate/Nitrite - ppm

TPO_4 - Total Phosphorous - ppm

BOD - Biochemical Oxygen Demand - ppm

COD - Chemical Oxygen Demand - ppm

NH_3- Ammonia - ppm

ARKANSAS RIVER PROJECT
WATER CHEMICAL MEASUREMENTS
1993

DATE	SITE	Pb	Cr	Cd	Hg	NO_3/NO_2	TPO_4	BOD	COD	NH_3
9/1/93	11A	7.7	<30	<3	1.4	<.02	.229	1	12.7	.06
	11C	<5	109	10	<.5	1.17	.301	1	7.6	.04
	11SD	5.6	<30	<3	<.5	<.02	.174	1	5	.09
	21A	<5	194	6	<.5	<.02	.221	1	20.3	.06
	21C	8.3	<30	4	<.5	.90	<.04	1	15.2	.03
	21SD	20.8	<30	<3	<.5	<.02	.287	<1	7.6	.08
	26SD	6.8	<30	<3	<.5	<.02	.217	<1	12.7	.06
	P-A	8.8	<30	<3	<.5	.20	.279	<1	5.1	.05
	P-C	<5	<30	<3	<.5	<.02	.307	<1	17.7	.04
	I-A	7.9	<30	<3	<.5	<.02	.309	<1	10.1	.05
9/8/93	11A	5.9	<30	6	<.5	<.02	.280	2.5	10.1	.03
	11C	5.6	<30	<3	<.5	.09	.248	2.4	7.6	.04
	11SD	<5	<30	3	<.5	<.02	.301	3.9	22.8	.11
	21A	<5	<30	5	<.5	<.02	.293	2.0	7.6	<.02
	21C	26	46	<3	<.5	.09	.285	2.0	<5	.06
	21SD	5.8	<30	<3	<.5	<.02	.333	4.0	50.6	.10
	26SD	<5	<30	<3	<.5	<.02	.738	5.5	12.7	.08
	P-A	<5	<30	<3	<.5	<.02	.257	1.6	12.7	.02
	P-C	6.6	<30	<3	<.5	<.02	.207	2.5	5.1	.04
	IA	<5	<30	<3	<.5	<.02	.295	3	12.7	.09

Pb - Lead - ppb

Cr - Chromium - ppb

Cd - Cadmium - ppb

Hg - Mercury - ppb

NO_3/NO_2 - Nitrate/Nitrite - ppm

TPO_4 - Total Phosphorous - ppm

BOD - Biochemical Oxygen Demand - ppm

COD - Chemical Oxygen Demand - ppm

NH_3- Ammonia - ppm

ARKANSAS RIVER PROJECT
WATER CHEMICAL MEASUREMENTS
1993

DATE	SITE	Pb	Cr	Cd	Hg	NO_3/NO_2	TPO_4	BOD	COD	NH_3
9/22/93	11A	11.7	<30	<3	.7	<.02	.261	<1	10.1	.06
	11C	10.9	<30	20	<.5	.76	.259	<1	10.1	.04
	11SD	9.1	30	11	.6	<.02	.065	<1	22.8	.20
	21A	9.9	<30	8	.8	.04	.293	<1	10.1	.04
	21C	30.4	<30	12	<.5	.07	.270	<1	20.3	.04
	21SD	5.1	<30	13	<.5	.06	.270	<1	10.1	.22
	26SD	5.4	<30	<3	<.5	.05	.247	<1	10.1	.13
	P-A	<5	36	12	<.5	.07	<.04	<1	5.1	.03
	P-C	6	<30	7	<.5	.05	.450	<1	12.7	.05
	IA	5.7	51	5	<.5	.04	.325	1.5	<5	.03
9/29/93	11A	6.1	<30	<3	<.5	.60	.259	1.7	7.6	.14
	11C	9.9	<30	<3	<.5	.76	.280	1.8	<5	.04
	11SD	<5	<30	<3	<.5	2.4	.70	<1	<5	.30
	21A	<5	<30	<3	<.5	.56	.663	1.4	7.6	.17
	21C	<5	<30	<3	<.5	.46	.976	1.6	22.8	<.02
	21SD	<5	87	<3	<.5	2.4	.180	2.0	7.6	.32
	26SD	13.5	<30	<3	<.5	1.6	<.04	<1	<5	.10
	P-A	<5	<30	<3	<.5	.50	.190	2.0	12.7	<.01
	P-C	<5	<30	<3	<.5	.25	.170	<1	17.7	.06
	IA	<5	<30	<3	<.5	3.9	.146	<1	17.7	.08

Pb - Lead - ppb

Cr - Chromium - ppb

Cd - Cadmium - ppb

Hg - Mercury - ppb

NO_3/NO_2 - Nitrate/Nitrite - ppm

TPO_4 - Total Phosphorous - ppm

BOD - Biochemical Oxygen Demand - ppm

COD - Chemical Oxygen Demand - ppm

NH_3- Ammonia - ppm

WATER QUALITY REPORT FOR THE ZINK LAKE-RIVER PARKS AREA OF THE ARKANSAS RIVER FOR 1994

PREPARED BY THE TULSA CITY-COUNTY HEALTH DEPARTMENT

SEPTEMBER, 1995

TABLE OF CONTENTS

INTRODUCTION

In 1994, water samples were again collected in the Zink Lake area of the Arkansas River in accordance with the annual study required by the U. S. Army Corps of Engineers Permit for the low water dam. The three areas of concern that were studied included (1) Bacteriological Contamination, (2) Water Chemistry and (3) Contaminants in Fish. Three bridge sites (11th Street, 21st Street, Pedestrian) and four storm drains (11th Street, Indian Avenue, 21st Street, 26th Street) were again used as the sampling locations. In 1994, 252 bacterial samples were collected from the river with an additional 94 bacterial samples collected at the storm drains. For the Water Chemistry study, 168 samples were collected and analyzed. Thus, a total of 514 samples were collected in 1994 for the Zink Lake Project. This level represents a 9% increase in samples collected compared to 1993. The results of the project and the actual data are presented in the following pages.

BACTERIOLOGICAL WATER QUALITY

In 1994 bacteriological samples were collected in the same manner that has been used since the inception of the sampling program. The same three bridge locations and the same four storm drains were utilized as sampling points. The sampling regime was again designed to meet the criteria set forth in the Oklahoma Water Quality Standards (OWQS). The data was analyzed in accordance with the "Primary Body Contact" standards set forth in the OWQS. In addition, we again calculated a "Fecal Coliform/Fecal Streptococcus Ratio (FC/FS)" to use as an indicator of the source of the pollution. "FC/FS Ratios" of 5 or higher are indicative that much of the bacteria is of human origin while ratios of 2 or less are more indicative of animal contamination.

As was the case in all the previous years this study was undertaken, the Arkansas River results indicated that the water quality does not meet the criteria for "Primary Body Contact" standards. Both the Geometric Mean values and the total count values exceeded the required criteria of the OWQS. Each of the river stations will be discussed separately and then a discussion of the storm drains will follow.

11TH STREET BRIDGE

The Geometric Mean criterion (>200 colonies) was exceeded in 4 of the 15 data sets. Three of the exceedances occurred at the east bank substation while the fourth was recorded at the mid-channel substation. Exceedances occurred in June, July and August. The total count criterion (400 colonies in 10% of the samples) was found to have been exceeded in 17% of the samples. The range of values was 9-53,000 for fecal coliform. The range of values for fecal streptococcus was 9-280,000. The "FC/FS Ratio" indicated that in only 1 of the 84 samples collected could the contamination be considered to be of human origin. On the other hand, the ratio indicated that the contamination was from animal origins in 84% of the cases (79/84). This is virtually the same situation we saw in 1993. July was the worst month for this station. Two of the exceedances of the Geometric Mean occurred in this month and 8 of the 14 samples that failed the 400 colony count also occurred in this month. At this station, the east bank substation was the worst collecting locality. This reflects the large deleterious effect the 11th Street storm drain has on the river.

21ST STREET BRIDGE

The Geometric Mean Criterion was exceeded in 4 of the 15 data sets. Three of the four occurred at the three different substations during the month of July. It also exceeded the criterion at the east bank station in August. The total count criterion was exceeded in 14% of the samples collected (12/84). The fecal coliform counts ranged from 9-35,000 while the fecal streptococcus counts ranged from 9-51,000. The "FC/FS ratio" indicated that in 3 of the 84 samples collected the contamination could primarily be related to a human source. Conversely, the ratio indicated that in 89% of the samples (75/84) the source of contamination could be related to animal sources. As with the 11th Street Bridge, July produced the worst results for this sampling point.

Three of the four Geometric Mean exceedances occurred in this month. In addition, 9 of the 12 total count exceedances occurred during July. Again, the east bank substation proved to be the most contaminated sampling point, reflecting the influence of both the 11th Street and Indian Avenue storm drains.

PEDESTRIAN BRIDGE

The Geometric Mean Criterion was exceeded in 2 of the 15 data sets. These both occurred in July and were at the east bank and mid-channel substations. The total count criterion was exceeded in only 6 of the 84 samples (7%). The fecal coliform counts ranged from 9-16,000 while the fecal streptococcus counts ranged from 9-8,700. The "FC/FS Ratio" indicated that in 10 of the 84 (12%) samples collected the contamination could be related to contamination from human sources. In 79% of the samples (67/84), the contamination was related to animal sources. As was evident with the other two bridge sites, July yielded the worst results for this station. Both exceedances of the Geometric Mean occurred in July. Also, 4 of the 6 total count exceedances also occurred in July. Again, the east bank station proved to be the worst substation reflecting some of the effect of all four storm drains studied.

STORM DRAINS

In 1994, bacteriological samples were collected from four major storm drains in the Zink Lake area. In May, the volume of water flowing in the river precluded the taking of samples for most of the month. Storm drain sampling began towards the end of the month and continued on through the rest of the study. Storm drain counts are routinely much higher than those encountered in the in-stream samples. The highest fecal coliform count was 440,000 and this occurred at the 21st Street storm drain. The highest fecal streptococcus count was 2,7000,000 and occurred at the 11 Street storm drain. The range of values for each storm drain is as follows:

11th Street	Fecal Coliform	9 - 300,000
	Fecal Streptococcus	1,700 - 2,700,000
Indian Avenue	Fecal Coliform	100 - 56,000
	Fecal Streptococcus	240 - 54,000
21st Street	Fecal Coliform	500 - 440,000
	Fecal Streptococcus	1,700 - 150,000
26th Street	Fecal Coliform	9 - 90,000
	Fecal Streptococcus	210 - 100,000

This data makes it easy to see that the continuous influx of water from these drains is a major source of bacterial contamination in the river. In only 2 of the 94 samples collected, did the "FC/FS ratio" indicate that most of the contamination was due to human wastes. On the other hand, 84% (79/94) of the samples showed a definite correlation to contamination from animal wastes. The two samples with positive correlation to human waste were from the Indian Avenue and 21st Street storm drains. Compared to 1993, the ratio indicate a decline in the correlation to human contamination and a significant increase to the correlation with animal wastes. Overall, the 11th Street and 21st Street storm drains appear to supply the worst bacterial contamination to the river.

DISCUSSION

Bacterial data from the 1994 project appeared to be somewhat worse when compared to the 1993 data. While exceedances of the Geometric Mean criterion were virtually the same, overall counts appeared to be higher with a few values reaching levels that had never before been observed. In 1994, the month of July produced the worst data from the river samples. Eight of the ten exceedances of the Geometric Mean occurred during that month along with a large number of the total count exceedances. On July 13, counts at all nine river substations exceeded the total count criterion. This indicates that, while the storm drains studied do contribute a large part of the bacterial contamination to the Zink Lake area, there are other upstream sources also contributing a certain amount of bacterial contamination to the river. Again, as in other years, the east bank station produced the worst bacterial data at all three bridge sites. This reflects the strong influence of the storm drains along the east bank. It also indicates that much of the material discharged from these storm drains tends to hug the east bank of the river and does not start mixing well with other currents until it reaches the Pedestrian Bridge. Obviously, the storm drains present the same, if not a worsening, problem that they always have. They are the primary source by which pollutants enter the Arkansas River from the metropolition Tulsa area. In order to achieve better water quality standards in the river, Tulsa will need to take drastic measures in an attempt to control the influx of these materials into the storm drainage system.

ZINK LAKE WATER CHEMISTRY

In 1994, water chemistry samples were collected at three bridge sites and four major storm drains. Because of high flows early in the year, some of the storm drains were not sampled as extensively as the bridge sites. In 1994, 108 sets of in-stream samples (bridge sites) were collected as well as 60 storm drain samples, yielding a total of 168 samples that were collected and analyzed. This represents a 17% increase in the number of samples collected when compared with 1993 figures. The samples were again analyzed for nine parameters. These include Lead (Pb), Chromium (Cr), Cadmium (Cd), Mercury (Hg), Nitrate/Nitrite (NO_3/NO_2), Total Phosphates (TPO_4), Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD) and Ammonia (NH_3). The results obtained for each parameter will be discussed separately.

LEAD (Pb)

Lead was detected (>5.0 ppb) in 57% of all samples collected. In 1993, lead was detectable in 73% of the samples collected. The highest value encountered was 80 ppb and this occurred at the 21st Street storm drain. The highest level encountered in 1993 was 100.2 ppb and also occurred at the 21st Street storm drain. The highest in-stream value was 19 ppb and this occurred at the west bank of the 11th Street Bridge. In all of the samples collected, only two had values greater than 20 ppb. On two sampling occasions (June 29th, July 20th) lead was barely detectable at any station. As in 1993, the 21st Street storm drain had the overall highest lead levels of the four storm drains. Overall, lead was detected in fewer samples and at lower levels than in 1993.

CHROMIUM (Cr)

Chromium was detectable (>30 ppb) in 16% of all samples collected. This is slightly lower than the low 20% values that were found in the previous two years. The highest value encountered was 147 ppb and this occurred at the east bank of the Pedestrian Bridge. The highest storm drain value was 87 ppb and this occurred at the 21st Street storm drain. In 1993, the highest storm drain value was virtually identical (85.9 ppb) and also occurred at the 21st Street storm drain. As was the case in 1993, in-stream values were generally higher than storm drain values. On June 8, 1994 several sites yielded the highest chromium levels encountered all year. Only one storm drain, Indian Avenue, had detectable levels (82 ppb) of chromium. The downstream east bank stations of both the 21st Street Bridge and the Pedestrian Bridge had even higher chromium levels. This may indicate that a slug of chromium waste had been discharged into the Indian Avenue storm drain system and moved down the east bank of the river. While overall chromium levels are not very high, the data does indicate an influx of chromium into the river, some of it from the storm drains being sampled and some from unknown sources.

CADMIUM (Cd)

Cadmium was detected (>3.0 ppb) in 65% of all the samples collected. This is a marked increase over the previous years' data. The highest value encountered was 302 ppb and this was found at the 21st Street storm drain. However, this value is something of an aberration. The next highest value found anywhere was 21.3 ppb and this occurred at the 21st Street storm drain. The highest in-stream value was 16.5 ppb and was found at the west bank of the 21st Street Bridge. While the overall values are not very high, Cadmium appeared to be much more widespread throughout the 1994 study. Unlike Chromium, in-stream Cadmium values did not tend to exceed values encountered in the storm drains.

MERCURY (Hg)

Mercury was undetectable (>.5 ppb) in all 168 samples. While Mercury has never been a very prevalent contaminant, Mercury had always been detectable in at least a few samples. There may be two reasons for this data. The first may be the result of the sampling program itself. Each sample represents a very small, instantaneous picture of the water flowing by the sampling point. In reality, the sampling regime checks only a very small percentage of the volume of water passing in a 24 hour period. Therefore, it is possible to miss contamination events especially when they aren't very prevalent in the first place. The other possibility is that the data actually reflects a decrease in the number or kind of mercury pollution sources.

NITRATE/NITRITE (NO_3/NO_2)

Nitrate/Nitrite radicals were at detectable levels (>.02 ppm) in all but five of the samples collected (97%). This is a much higher percentage of the samples than occurred in 1993. The highest value encountered was 5.92 ppm and occurred at the Indian Avenue storm drain. The highest in-stream value was .85 ppm and this occurred on the east bank of the 21st Street Bridge. The Indian Avenue storm drain also had the highest values in 1993. As in past years, the storm drains had higher levels of nitrates/nitrites than the river stations did. This is a good indication that the storm drains provide a constant, routine source for these materials to enter the river. In order to slow down the enrichment of our surface waters, the City will have to implement techniques to reduce the introduction of fertilizers into its' storm water system.

TOTAL PHOSPHATES ($TP0_4$)

Total Phosphates were detectable (>.02 ppm) in all but eight of the samples collected (95%). The highest value found was 1.4 ppm and this occurred at the 11th Street storm drain. The highest in-stream value was 1.0 ppm and occurred at the east bank of the 21st Street Bridge. Higher values were encountered in the storm drains in 1993 but the river values were much the same in both years. While Total Phosphates were detectable in most samples, levels of .5 ppm or greater were found in only 8.9% of the samples. Of the samples with elevated values, 14 out of 15 came from the storm drains. While phosphate levels in the river and storm drains are not very high, it is apparent that the storm drains are a continuous, routine source of enrichment to surface waters.

BIOCHEMICAL OXYGEN DEMAND (BOD)

BOD represents the measure of various types of organic materials on the oxygen supply dissolved in the water. These materials include living biological organisms, decaying organic matter and the oxidation of organic materials. The BOD was at detectable levels (>1.0 ppm) in 86% of the samples. This is significantly higher than the 1993 data where only 46% of the samples had a measurable BOD. The highest level encountered was 15.7 ppm and this occurred at the 21st Street storm drain. The highest in-stream value was 5.4 ppm and this occurred at the east bank of the 11th Street Bridge. These values are somewhat higher than those found in 1993. In general, the BOD values found in storm drain samples were higher than those ecountered in the river samples. For the most part, the 21st Street storm drain exhibited the highest values of all the storm drains. Obviously, the storm drains are contributing a constant source of materials that tend to deplete the dissolved oxygen content of the river water.

CHEMICAL OXYGEN DEMAND (COD)

The COD determination is a measure of the oxygen equivalent of that portion of the organic matter in a sample that is susceptible to oxidation by a strong oxidant. It does not measure all organic compounds that are readily available to stream organisms and measures some that are not so readily available to biological organisms. It is a useful tool for measuring the oxygen demand of the organic chemicals present in water. Measurable COD values (>5.0 ppm) were found in 71% of all samples collected. In 1993, values were detectable in 92% of the samples. The highest value encountered was 85 ppm and this occurred at the 21st Street storm drain. The highest in-stream value detected was 40 ppm and this occurred at the west bank station of the 21st Street Bridge. These values are somewhat below the worst levels encountered in 1993. For the most part, storm drain values were higher than the in-stream values. This is another indication that the storm drains are a constant source of foreign materials entering the river, leading to further water quality degradation. While these materials may be extremely varied in nature, they tend to deplete the amount of available oxygen in the water.

AMMONIA (NH_3)

Ammonia was detectable (>.01 ppm) in 42% of all samples. This is a significantly lower figure when compared to the 1993 data (79%). The highest value found was 8.2 ppm and this occurred at the 21st Street storm drain. The highest in-stream value was .2 ppm and this occurred at the east bank of the 21st Street Bridge. Again, as with several of the other parameters, storm drain values were routinely higher than those from river samples. In the past, EPA has suggested a criterion of .02 ppm for the protection of aquatic life. Based on this recommendation, 33% of the samples collected exceeded this criteria. This is down significantly from the 1993 level (79%).

DISCUSSION

The 1994 water chemistry data presents us with a mixed bag of results. Several of the contaminants studied seemed to be less of a problem than in previous years. The occurrence of detectable lead levels was lower as were the actual levels themselves. Levels of chromiun contamination were little changed. The problem of cadmium contamination appeared to worsen. No mercury contamination was encountered at all and may really reflect a decrease in mercury pollution sources. Nitrate/Nitrite contamination was more prevalent while total phosphate contamination was about the same. This probably reflects the general use of fertilizers in the urban environment. Measurable levels of Biochemical Oxygen Demand were significantly higher and may reflect either increased organic loading (grass, leaves, animal droppings) or an increase in algal and bacteria growth from the influx of fertilizers. Measurable Chemical Oxygen Demand values appeared to decline slightly. Levels and occurrence of detectable ammonia appeared to be significantly lower.

Urban storm drains present a unique problem for municipalities when they are concerned about improving the quality of surface waters of the state. Increasing population growth means there are more people using more and varied products on their residential property. Increasing urbanization results in greater stormwater flows (larger volume) at greater flow rates (increased velocity) due to more and more land becoming impermeable to rainflow. The increased volume and flow rates mean that materials are more readily washed from residential properties and enter into the storm sewer system. In effect, storm water pollution from urban areas will continue to get worse and will have a greater and greater impact on our lakes, creeks and rivers. Any attempts at reducing these levels of contaminants will be technically difficult and extremely expensive.

FISH TOXOLOGICAL STUDY

In 1994, fish samples were collected in the Arkansas River in order to determine the levels of various toxicants in their tissues. This study was undertaken with the cooperation of Mark Ambler and other personnel of the Oklahoma Department of Wildlife Conservation and with Jimmy Pigg of the Oklahoma Department of Environmental Quality Biomonitoring Survey. The samples were collected in May using an electro-shocking device. They were immediately placed on ice and transported to the ODEQ Laboratory in Oklahoma City where the tissues were prepared and analyzed. As in the past, 24 toxicants were analyzed in the fish tissues. The types of fish studied included (1) Blue Catfish (2) River Carpsucker (3) Small Mouth Buffalo (4) Large Mouth Bass (5) Carp. The results of the analyses for each species follows.

BLUE CATFISH

The mean weight of the catfish collected was 1.79 lbs. Neither PCB's nor any of the 22 pesticides were detectable in the fish tissue. Mercury was detectable at .26 mg/kg and this value is below the "Level of Concern" published in the Oklahoma Water Quality Standards (OWQS).

RIVER CARPSUCKER

The mean weight of the River Carpsucker was 1.72 lbs. Neither PCB's nor any of the 22 pesticides were detectable in the fish tissue. Mercury was detectable at .20 mg/kg.

SMALL MOUTH BUFFALO

The mean weight of the Buffalo was 3.75 lbs. Neither PCB's nor any of the 22 pesticides were detectable in the fish tissue. The level of mercury found was .22 mg/kg.

LARGE MOUTH BASS

The mean weight of the Bass was .81 lbs. Neither PCB's nor any of the 22 pesticides were detectable in the fish tissue. Mercury levels were detectable at .30 mg/kg.

CARP

The ODEQ Laboratory reported that they had a "lab accident" and they were not able to analyze the fish tissue.

DISCUSSION

Obviously, no PCB's or any of the 22 pesticides analyzed were found at detectable levels in the fish that were collected. Mercury was the only contaminant that was detectable and none of the values exceeded the "Concern Level" for mercury (.5 mg/kg) that is contained in OWQS. While this data presents some cause for a certain amount of optimism, it should not be construed to mean that fish in the Arkansas River are contaminant free. None of the fish sampled were very large. This means that they were not very old members of the population and therefore had not been alive long enough to bio-accumulate much in the way of contaminants. Samples in past years have shown traces of PCB's, DDT and its derivaties, Chlordane, Heptachlor and other contaminants from time to time. Therefore, it could be expected that larger and older members of the fish population would still have detectable levels of these contaminants in their tissues. In addition, there is no program in place to analyze for more modern pesticides which are beginning to raise environmental and public health concerns around the country. The general public should not be lulled into believing that fish in the river are totally contaminant free and therefore necessarily safe for consumption.

APPENDIX A - BACTERIOLOGICAL DATA

BACTERIOLOGICAL QUALITY OF THE ARKANSAS RIVER AT ZINK LAKE
MAY - SEPTEMBER 1994

11TH STREET BRIDGE (0A020)

	West Bank (A)			Mid Channel (B)			East Bank (C)		
	FC*	FS*	FC/FS*	FC*	FS*	FC/FS*	FC*	FS*	FC/FS*
09-May-94	18	63	0.29	9	63	0.14	18	72	0.25
11-May-94	18	18	1.00	36	18	2.00	45	140	0.32
16-May-94	18	9	2.00	9	9	1.00	9	18	0.50
18-May-94	9	36	0.25	9	9	1.00	45	9	5.00
23-May-94	27	9	3.00	9	9	1.00	72	140	0.51
25-May-94	9	9	1.00	9	9	1.00	9	9	1.00
G.MEAN*	15.3			11.3			24.4		
13-Jun-94	18	72	0.25	27	130	0.21	270	4000	0.07
15-Jun-94	36	250	0.14	9	360	0.03	100	6200	0.02
20-Jun-94	18	27	0.67	72	36	2.00	810	560	1.45
22-Jun-94	18	230	0.08	54	490	0.11	99	1500	0.07
27-Jun-94	27	3800	0.01	45	670	0.07	120	220	0.55
29-Jun-94	100	350	0.29	54	560	0.10	250	2000	0.13
G.MEAN*	28.8			36.3			200.5		
11-Jul-94	110	3700	0.03	18	1400	0.01	450	520	0.87
13-Jul-94	1600	3600	0.44	4200	5000	0.84	27000	20000	1.35
18-Jul-94	210	140	1.50	330	450	0.73	1600	1900	0.84
20-Jul-94	72	280	0.26	90	460	0.20	12000	99999	0.12
27-Jul-94	45	1900	0.02	1000	2900	0.34	53000	40000	1.33
G.MEAN*	164.3			295.3			6583.1		
01-Aug-94	54	280	0.19	27	260	0.10	2500	280000	0.01
10-Aug-94	27	9	3.00	54	130	0.42	3100	1000	3.10
17-Aug-94	27	36	0.75	54	110	0.49	1800	51000	0.04
22-Aug-94	36	27	1.33	9	9	1.00	54	100	0.54
24-Aug-94	18	800	0.02	18	900	0.02	330	800	0.41
31-Aug-94	54	130	0.42	54	230	0.23	700	1100	0.64
G.MEAN*	33.4			37.7			1263.7		
12-Sep-94	54	63	0.86	18	9	2.00	720	220	3.27
19-Sep-94	72	72	1.00	27	45	0.60	150	240	0.63
21-Sep-94	9	20000	0.00	27	3700	0.01	9	27000	0.00
26-Sep-94	9	81	0.11	9	45	0.20	9	160	0.06
28-Sep-94	45	63	0.71	9	180	0.05	36	1700	0.02
G.MEAN*	26.9			16.0			50.1		

*FC = Fecal Coliform
*FS = Fecal Streptococcus
*FC/FS = Fecal Coliform/Fecal Streptococcus Ratio
*G Mean = Geometric Mean

BACTERIOLOGICAL QUALITY OF THE ARKANSAS RIVER AT ZINK LAKE
MAY - SEPTEMBER 1992

21ST STREET BRIDGE (OA006)

	West Bank (A)			Mid Channel (B)			East Bank (C)		
	FC*	FS*	FC/FS*	FC*	FS*	FC/FS*	FC*	FS*	FC/FS*
09-May-94	27	54	0.50	36	45	0.80	18	72	0.25
11-May-94	18	36	0.50	18	81	0.22	27	18	1.50
16-May-94	9	9	1.00	18	9	2.00	18	18	1.00
18-May-94	9	9	1.00	18	9	2.00	18	63	0.29
23-May-94	9	9	1.00	18	9	2.00	9	45	0.20
25-May-94	9	18	0.50	9	9	1.00	18	36	0.50
G.MEAN*	12.1			18.0			17.2		
13-Jun-94	18	18	1.00	9	45	0.20	120	150	0.80
15-Jun-94	9	36	0.25	27	170	0.16	100	110	0.91
20-Jun-94	18	27	0.67	72	9	8.00	200	45	4.44
22-Jun-94	18	27	0.67	45	63	0.71	320	160	2.00
27-Jun-94	54	1200	0.05	36	470	0.08	180	200	0.90
29-Jun-94	54	140	0.39	54	210	0.26	190	810	0.23
G.MEAN*	23.1			33.9			172.4		
11-Jul-94	27	850	0.03	45	36	1.25	1400	540	2.59
[illegible]-Jul-94	4300	7400	0.58	5200	8300	0.63	35000	51000	0.69
18-Jul-94	229	63	3.63	380	210	1.81	900	500	1.80
20-Jul-94	54	120	0.45	140	230	0.61	900	3800	0.24
27-Jul-94	2000	1500	1.33	2600	1200	2.17	1200	7800	0.15
G.MEAN*	310.2			503.5			1080.1		
01-Aug-94	54	160	0.34	36	63	0.57	310	200	1.55
10-Aug-94	18	18	1.00	18	36	0.50	390	800	0.49
17-Aug-94	45	9	5.00	9	18	0.50	4100	1700	2.41
22-Aug-94	36	36	1.00	9	9	1.00	150	120	1.25
24-Aug-94	18	800	0.02	9	800	0.01	45	800	0.06
31-Aug-94	100	130	0.77	18	150	0.12	1600	3300	0.48
G.MEAN*	37.6			14.3			418.3		
12-Sep-94	100	540	0.19	100	27	3.70	2400	360	6.67
19-Sep-94	9	9	1.00	18	120	0.15	9	27	0.33
21-Sep-94	9	1000	0.01	9	2200	0.00	130	1000	0.13
26-Sep-94	9	18	0.50	9	9	1.00	9	9	1.00
28-Sep-94	9	18	0.50	9	36	0.25	9	130	0.07
G.MEAN*	14.6			16.7			46.9		

*FC = Fecal Coliform
*FS = Fecal Streptococcus
*FC/FS = Fecal Coliform/Fecal Streptococcus Ratio
*G Mean = Geometric Mean

BACTERIOLOGICAL QUALITY OF THE ARKANSAS RIVER AT ZINK LAKE
MAY - SEPTEMBER 1992

PEDESTRIAN BRIDGE (OA005)

	West Bank (A)			Mid Channel (B)			East Bank (C)		
	FC*	FS*	FC/FS*	FC*	FS*	FC/FS*	FC*	FS*	FC/FS*
09-May-94	9	45	0.20	9	9	1.00	63	90	0.70
11-May-94	18	100	0.18	72	27	2.67	160	160	1.00
16-May-94	9	9	1.00	9	9	1.00	9	18	0.50
18-May-94	280	27	10.37	72	9	8.00	27	9	3.00
23-May-94	1200	72	16.67	120	18	6.67	54	90	0.60
25-May-94	18	18	1.00	27	45	0.60	63	18	3.50
G.MEAN*	45.5			33.3			45.0		
13-Jun-94	36	54	0.67	9	9	1.00	27	36	0.75
15-Jun-94	9	45	0.20	27	45	0.60	110	120	0.92
20-Jun-94	210	250	0.84	120	36	3.33	82	54	1.52
22-Jun-94	63	9	7.00	54	9	6.00	72	9	8.00
27-Jun-94	9	72	0.13	9	54	0.17	45	45	1.00
29-Jun-94	81	440	0.18	36	230	0.16	54	330	0.16
G.MEAN*	38.2			28.3			59.1		
11-Jul-94	36	81	0.44	180	45	4.00	430	230	1.87
13-Jul-94	3200	4400	0.73	14000	7000	2.00	16000	8700	1.84
18-Jul-94	110	45	2.44	350	27	12.96	1500	200	7.50
20-Jul-94	63	36	1.75	63	81	0.78	250	250	1.00
27-Jul-94	390	1100	0.35	290	2000	0.15	0	3100	0.00
G.MEAN*	99.3			438.0			1267.4		
01-Aug-94	18	27	0.67	63	36	1.75	150	100	1.50
10-Aug-94	9	9	1.00	9	9	1.00	54	36	1.50
17-Aug-94	54	18	3.00	9	45	0.20	120	90	1.33
22-Aug-94	18	9	2.00	9	18	0.50	180	280	0.64
24-Aug-94	9	800	0.01	9	800	0.01	45	800	0.06
31-Aug-94	90	54	1.67	18	72	0.25	600	610	0.98
G.MEAN*	22.4			14.0			129.5		
12-Sep-94	9	9	1.00	27	18	1.50	82	54	1.52
19-Sep-94	9	45	0.20	9	9	1.00	9	18	0.50
21-Sep-94	9	36	0.25	9	190	0.05	9	72	0.13
26-Sep-94	9	72	0.13	9	72	0.13	9	63	0.14
28-Sep-94	9	63	0.14	54	27	2.00	520	63	8.25
G.MEAN*	9.0			16.0			31.5		

*FC = Fecal Coliform
*FS = Fecal Streptococcus
*FC/FS = Fecal Coliform/Fecal Streptococcus Ratio
*G Mean = Geometric Mean

BACTERIOLOGICAL WATER QUALITY
OF STORM DRAINS
MAY - SEPTEMBER 1994

	11TH ST STORM DRAIN OK 002			INDIAN AVE STORM DRAIN OK 003			21ST ST STORM DRAIN OK 008			26TH ST STORM DRAIN		
DATE	FC*	FS*	FC/FS*	FC*	FS*	FC/FS*	FC*	FS*	FC/FS*	FC*	FS*	FC/FS*
09-May-94	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
11-May-94	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
16-May-94	NA	NA	NA	NA	NA	NA	2800	4000	0.70	NA	NA	NA
18-May-94	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
23-May-94	NA	NA	NA	NA	NA	NA	440000	16000	27.50	NA	NA	NA
25-May-94	14000	83000	0.17	520	200	2.60	91000	150000	0.61	1200	2800	0.43
13-Jun-94	160000	87000	1.84	1000	520	1.92	1400	2900	0.48	730	830	NA
15-Jun-94	22000	2700000	0.01	900	3200	0.28	500	1700	0.29	2500	3400	NA
20-Jun-94	300000	130000	2.31	230	430	0.53	9900	21000	0.47	82000	100000	0.82
22-Jun-94	6000	250000	0.02	680	1500	0.45	10000	5700	1.75	2100	3800	0.55
27-Jun-94	810	1700	0.48	800	810	0.99	4700	2100	2.24	580	550	1.05
29-Jun-94	5300	76000	0.07	1300	1900	0.68	11000	6300	1.75	7200	2000	3.60
11-Jul-94	9000	2700	3.33	2500	730	3.42	4900	2100	2.33	1400	2100	0.67
13-Jul-94	90000	33000	2.73	24000	27000	0.89	49000	41000	1.20	90000	41000	2.20
18-Jul-94	5500	6500	0.85	1400	1000	1.40	2300	6400	0.36	2300	2500	0.92
20-Jul-94	4300	4900	0.88	2200	20000	0.11	4600	7100	0.65	1200	4000	0.30
27-Jul-94	160000	58000	2.76	24000	15000	1.60	14000	60000	0.23	1600	4200	0.38
01-Aug-94	28000	60000	0.47	650	570	1.14	17000	49000	0.35	220	480	0.46
10-Aug-94	17000	9000	1.89	600	1500	0.40	11000	11000	1.00	2700	1900	1.42
17-Aug-94	49000	140000	0.35	2900	3900	0.74	61000	130000	0.47	1200	2600	0.46
22-Aug-94	5800	2000	2.90	220	240	0.92	5600	3500	1.60	90	230	0.39
24-Aug-94	5300	3000	1.77	2600	4800	0.54	4500	3400	1.32	310	2600	0.12
31-Aug-94	1200	37000	0.03	56000	54000	1.04	49000	45000	1.09	2600	26000	0.10
12-Sep-94	4700	5400	0.87	1600	260	6.15	3600	4100	0.88	330	230	1.43
19-Sep-94	9	5600	0.00	1400	3400	0.41	600	15000	0.04	9	16000	0.00
21-Sep-94	120	8000	0.02	100	800	0.13	1700	10000	0.17	18	210	0.09
26-Sep-94	650	23000	0.03	190	2700	0.07	1300	110000	0.01	9	4100	0.00
28-Sep-94	99999	99999	1.00	900	2000	0.45	3800	50000	0.08	63	2800	0.02

NA = No Sample
*FC = Fecal Coliform
*FS = Fecal Streptococcus
*FC/FS = Fecal Coliform/Fecal Streptococcus Ratio

APPENDIX B - WATER CHEMISTRY DATA

ARKANSAS RIVER PROJECT
WATER CHEMICAL MEASUREMENTS
1994

DATE	SITE	Pb	Cr	Cd	Hg	NO_3/NO_2	TPO_4	BOD	COD	NH_3
5/11/94	11th St. A	8	<30	11.3	<.5	.55	.03	2.4	<5	.13
	11th St. B	9	70	<3	<.5	.57	.03	1.9	<5	.14
	11th St. C	12	<30	7.0	<.5	.57	.07	1.6	<5	.13
	21st St. A	13	<30	10.4	<.5	.57	.06	2.1	<5	.15
	21st St. B	8	<30	<3	<.5	.56	.05	1.9	<5	.12
	21st St. C	12	56	<3	<.5	.56	<.02	1.7	<5	.15
	Ped Br A	10	75	5.5	<.5	.55	.03	2.2	<5	.16
	Ped Br B	10	30	10.3	<.5	.56	.05	1.9	<5	.11
	Ped Br C	5	<30	11.0	<.5	.57	.08	2.6	<5	.12
5/18/94	11th St. A	<5	<30	<3	<.5	.58	.05	1.6	<5	.03
	11th St. B	6	<30	<3	<.5	.59	.05	1.6	<5	.03
	11th St. C	<5	<30	<3	<.5	.58	.03	2.3	<5	.05
	21st St. A	<5	<30	<3	<.5	.58	.05	1.4	<5	.04
	21st St. B	7	<30	<3	<.5	.58	.05	1.6	<5	.03
	21st St. C	14	<30	3.3	<.5	.58	.05	2.0	20	.04
	Ped Br A	<5	50	<3	<.5	.59	.04	1.6	<5	.04
	Ped Br B	5	<30	<3	<.5	.59	.04	1.3	<5	.05
	Ped Br C	5	<30	<3	<.5	.59	<.02	1.4	<5	.03
5/25/94	11th St. A	18	55	3.9	<.5	.64	.15	1.2	10	<.01
	11th St. C	13	<30	<3	<.5	.64	.27	1	5	<.01
	11th St. Dr	19	60	7.6	<.5	2.0	.46	2	10	.25
	21st St. A	11	<30	3.0	<.5	.64	.24	1.2	10	<.01
	21st St. C	12	<30	5.2	<.5	.85	.25	<1	10	<.01
	21st St. Dr	10	<30	5.5	<.5	1.96	.42	1.5	20	.22
	26th St. Dr	8	<30	<3	<.5	1.2	.17	<1	10	<.01
	Ped A	6	<30	4.7	<.5	.64	.27	1.4	10	<.01
	Ped C	7	<30	4.2	<.5	.64	.26	1.2	10	<.01
	Ind. Ave. SD	<5	<30	7.9	<.5	.81	.26	2	15	<.01

Pb - Lead - ppb
Cr - Chromium - ppb
Cd - Cadmium - ppb
Hg - Mercury - ppb
NO_3/NO_2 - Nitrate/Nitrite - ppm
TPO_4 - Total Phosphorous - ppm
BOD - Biochemical Oxygen Demand - ppm
COD - Chemical Oxygen Demand - ppm
NH_3- Ammonia - ppm

ARKANSAS RIVER PROJECT
WATER CHEMICAL MEASUREMENTS
1994

DATE	SITE	Pb	Cr	Cd	Hg	NO_3/NO_2	TPO_4	BOD	COD	N
6/8/94	11th St. A	<5	<30	<3	<.5	.64	.12	<1	5	<.01
	11th St. C	<5	33	4.6	<.5	.50	.29	<1	10	<.01
	11th St. Dr	7	<30	<3	<.5	2.59	.32	<1	<5	.02
	21st St. A	<5	101	<3	<.5	.45	.27	<1	14	<.01
	21st St. C	6	107.4	8.7	<.5	.47	.24	<1	<5	<.01
	21st St. Dr	7	<30	4.9	<.5	2.24	.34	<1	8	.01
	26th St. Dr	<5	<30	<3	<.5	1.30	.23	<1	5	.03
	Ped A	<5	44	12.3	<.5	.49	.25	<1	<5	<.01
	Ped C	9	147	4.9	<.5	.47	.25	<1	5	<.01
	Ind. AveSD	8	82	11.8	<.5	5.92	1.0	<1	5	<.01
6/15/94	11th St. A	<5	<30	<3	<.5	.47	.29	<1	15	<.01
	11th St. C	8	<30	<3	<.5	.46	.27	<1	13	<.01
	11th St. Dr	8	<30	5.1	<.5	1.18	.34	8	<5	<.01
	21st St. A	10	<30	4.2	<.5	.46	.28	<1	15	<.01
	21st St. C	9	<30	3.0	<.5	.45	.27	<1	15	[illegible]
	21st St. Dr	9	<30	<3	<.5	2.40	.30	<1	31	.07
	26th St. Dr	7	<30	<3	<.5	1.24	.35	1.5	<5	<.01
	Ped A	<5	<30	<3	<.5	.47	.24	1.4	15	<.01
	Ped C	<5	<30	<3	<.5	.45	.30	1.6	<5	<.01
	Ind. Ave. SD	56	34	8.4	<.5	2.61	.20	1.1	<5	<.01
6/22/94	11th St. A	19	<30	4.0	<.5	.45	.25	2.2	<5	<.01
	11th St. C	7	<30	<3	<.5	.40	.23	1.3	4.6	<.01
	11th St. Dr	12	<30	<3	<.5	2.4	.55	2.6	13.9	.07
	21st St. A	<5	<30	6	<.5	.41	.28	1.17	<5	<.01
	21st St. C	5	<30	<3	<.5	.37	.27	2.0	23.2	<.01
	21st St. Dr	7	87	302	<.5	1.64	.36	14.8	13.9	.14
	26th St. Dr	<5	<30	<3	<.5	.89	.22	1.1	<5	<.01
	Ped A	<5	<30	<3	<.5	.34	.25	1.5	<5	<.01
	Ped C	<5	<30	<3	<.5	.41	.24	1.3	<5	<.01
	Ind. Ave. SD	8	<30	<3	<.5	.47	.26	5.6	9.3	<

Pb - Lead - ppb
Cr - Chromium - ppb
Cd - Cadmium - ppb
Hg - Mercury - ppb
NO_3/NO_2 - Nitrate/Nitrite - ppm
TPO_4 - Total Phosphorous - ppm
BOD - Biochemical Oxygen Demand - ppm
COD - Chemical Oxygen Demand - ppm
NH_3- Ammonia - ppm

ARKANSAS RIVER PROJECT
WATER CHEMICAL MEASUREMENTS
1994

DATE	SITE	Pb	Cr	Cd	Hg	NO_3/NO_2	TPO_4	BOD	COD	NH_3
6/29/94	11th St. A	<5	<30	<3	<.5	.40	<.02	1.3	9.3	.02
	11th St. C	<5	40	9.1	<.5	.36	.02	1.5	<5	<.01
	11th St. Dr	<5	39	<3	<.5	1.97	.35	1.3	<5	.17
	21st St. A	<5	<30	<3	<.5	.35	<.02	1.4	<5	<.01
	21st St. C	<5	<30	5.9	<.5	.32	.17	2.0	<5	<.01
	21st St. Dr	8	30	<3	<.5	1.87	.15	1.5	<5	.03
	26th St. Dr	<5	<30	3.2	<.5	1.05	.06	1.5	<5	<.01
	Ped A	<5	<30	<3	<.5	.35	.17	2.0	9.3	<.01
	Ped C	<5	31	<3	<.5	.37	<.02	1.7	9.3	<.01
	Ind. AveSD	<5	52	6.2	<.5	.70	.18	3.1	9.3	<.01
7/13/94	11th St. A	<5	<30	4.4	<.5	<.01	.20	3.1	17	<.01
	11th St. C	8	<30	6.7	<.5	.33	.25	4.0	26	<.01
	11th St. Dr	9	<30	<3	<.5	1.6	.34	4.6	20	.03
	21st St. A	<5	<30	<3	<.5	<.01	.30	4.7	22	<.01
	21st St. C	7	<30	<3	<.5	.26	.20	4.7	34	<.01
	21st St. Dr	7	<30	4.4	<.5	1.5	.28	4.9	26	.03
	26th St. Dr	12	<30	<3	<.5	.80	.32	5.2	23	.06
	Ped A	<5	<30	9.7	<.5	<.01	.23	4.7	29	<.01
	Ped C	<5	<30	7.7	<.5	<.01	.27	4.4	31	<.01
	Ind. Ave. SD	7	<30	<3	<.5	1.2	.30	7.1	31	.10
7/20/94	11th St. A	<5	<30	8.6	<.5	.20	.28	1	20	.01
	11th St. C	6	<30	<3	<.5	.18	.31	2.5	26	<.01
	11th St. Dr	<5	<30	7.9	<.5	1.7	.20	<1	14	<.01
	21st St. A	<5	<30	16.5	<.5	.20	22	<1	14	<.01
	21st St. C	5	<30	<3	<.5	.20	.20	1.8	17	<.01
	21st St. Dr	<5	<30	<3	<.5	1.6	.22	1.8	11	<.01
	26th St. Dr	<5	<30	4.4	<.5	.74	.24	1.6	11	<.01
	Ped A	<5	<30	8.0	<.5	.18	.20	1.4	11	<.01
	Ped C	<5	<30	4.3	<.5	.20	.23	1.8	11	<.01
	Ind. Ave. SD	<5	<30	8.1	<.5	1.2	.30	3.4	17	<.01

Pb - Lead - ppb
Cr - Chromium - ppb
Cd - Cadmium - ppb
Hg - Mercury - ppb
NO_3/NO_2 - Nitrate/Nitrite - ppm

TPO_4 - Total Phosphorous - ppm
BOD - Biochemical Oxygen Demand - ppm
COD - Chemical Oxygen Demand - ppm
NH_3 - Ammonia - ppm

ARKANSAS RIVER PROJECT
WATER CHEMICAL MEASUREMENTS
1994

DATE	SITE	Pb	Cr	Cd	Hg	NO_3/NO_2	TPO_4	BOD	COD	NI
7/27/94	11th St. A	<5	<30	5.6	<.5	.43	.24	1.4	20	.05
	11th St. C	18	<30	4.7	<.5	.21	.31	5.4	25	.05
	11th St. Dr	13	<30	9.7	<.5	2.2	.74	10.8	30	.73
	21st St. A	<5	<30	6.0	<.5	.19	.20	1.4	8	.08
	21st St. C	16	<30	4.0	<.5	.27	.28	1.9	18	.07
	21st St. Dr	6	43	10.5	<.5	2.3	.80	10.2	30	.76
	26th St. Dr	5	<30	7.8	<.5	1.0	.20	2.2	15	.05
	Ped A	5	<30	10.2	<.5	.20	.22	2.1	15	.05
	Ped C	6	<30	5.6	<.5	.23	.24	1.3	15	.07
	Ind. AveSD	6	<30	6.1	<.5	3.9	.29	1.5	10	<.01
8/10/94	11th St. A	<5	<30	6.1	<.5	.28	.42	1.4	8	<.01
	11th St. C	<5	<30	9.8	<.5	.30	.28	1.03	6	<.01
	11th St. Dr	5	<30	8.6	<.5	.72	.81	10.0	20	2.8
	21st St. A	<5	<30	10.5	<.5	.30	.23	1.0	40	<.01
	21st St. C	<5	<30	10.4	<.5	.22	<.1	1.0	8	<.i
	21st St. Dr	11	<30	18.9	<.5	.75	.81	11.5	18	2.8
	26th St. Dr	5	<30	11.8	<.5	1.20	.20	1.2	5	<.01
	Ped A	<5	<30	13.2	<.5	.24	.25	1.0	20	<.01
	Ped C	<5	<30	14.0	<.5	.27	.26	1	5	<.01
	Ind. Ave. SD	<5	<30	10.4	<.5	.6	.25	1.0	10	<.01
8/17/94	11th St. A	5	<30	6.3	<.5	.12	.30	1.8	<5	<.01
	11th St. C	<5	<30	10.3	<.5	.04	.25	2.4	<5	<.01
	11th St. Dr	15	<30	4.7	<.5	.57	.96	9.6	10	3.0
	21st St. A	<5	<30	12.8	<.5	.05	.20	2.4	<5	<.01
	21st St. C	<5	57	9.1	<.5	.09	1.0	3.2	<5	.20
	21st St. Dr	5	<30	4.1	<.5	.53	.18	9.3	25	2.5
	26th St. Dr	5	<30	7.8	<.5	.93	1.1	2.5	5	<.01
	Ped A	<5	32	9.4	<.5	.01	.26	2.6	20	<.01
	Ped C	<5	<30	9.4	<.5	.04	.26	2.4	30	<.01
	Ind. Ave. SD	9	<30	9.3	<.5	3.9	.31	2.3	<5	<.0'

Pb - Lead - ppb
Cr - Chromium - ppb
Cd - Cadmium - ppb
Hg - Mercury - ppb
NO_3/NO_2 - Nitrate/Nitrite - ppm

TPO_4 - Total Phosphorous - ppm
BOD - Biochemical Oxygen Demand - ppm
COD - Chemical Oxygen Demand - ppm
NH_3- Ammonia - ppm

ARKANSAS RIVER PROJECT
WATER CHEMICAL MEASUREMENTS
1994

DATE	SITE	Pb	Cr	Cd	Hg	NO_3/NO_2	TPO_4	BOD	COD	NH_3
8/24/94	11th St. A	16	<30	<3	<.5	.22	.07	1.3	<5	.07
	11th St. C	9	<30	4.6	<.5	.26	.03	1.2	5	.10
	11th St. Dr	8	<30	<3	<.5	.62	.85	7.7	20	4.3
	21st St. A	<5	<30	6.1	<.5	.17	.09	2.4	10	.05
	21st St. C	<5	<30	6.7	<.5	.15	.12	1.4	5	.06
	21st St. Dr	80	<30	3.6	<.5	.68	<02	11.2	25	5.7
	26th St. Dr	5	<30	7.2	<.5	.80	.12	2.2	5	.12
	Ped A	<5	<30	5.7	<.5	.15	.18	1.0	5	.06
	Ped C	<5	<30	7.7	<.5	.14	.09	<1	<5	.06
	Ind. AveSD	<5	<30	7.2	<.5	2.7	.27	2.8	10	.08
8/31/94	11th St. A	<5	<30	5.5	<.5	.23	.13	1.0	10	.04
	11th St. C	<5	<30	9.9	<.5	.15	.09	1.1	10	.07
	11th St. Dr	10	<30	8.0	<.5	1.4	.26	7.9	36	<.01
	21st St. A	<5	<30	9.15	<.5	.18	.22	1.0	<5	.01
	21st St. C	<5	<30	5.6	<.5	.16	.24	2.0	16	<.01
	21st St. Dr	13	<30	3.9	<.5	<.02	.49	15.7	31.5	.5
	26th St. Dr	5	<30	5.0	<.5	1.0	.37	3.9	10	.06
	Ped A	<5	<30	9.5	<.5	.17	.15	1.3	10	<.01
	Ped C	<5	<30	10.2	<.5	.16	.11	1.5	10	.01
	Ind. Ave. SD	6	<30	6.4	<.5	1.0	.12	4.6	10	.06
9/7/94	11th St. A	11	<30	6.8	<.5	.20	<.02	1.2	10	<.01
	11th St. C	9	<30	<3	<.5	.04	.23	3.3	10	.05
	11th St. Dr	7	<30	21.3	<.5	3.5	.94	2.6	40	<.01
	21st St. A	<5	<30	10.6	<.5	.15	.13	1.2	10	<.01
	21st St. C	<5	<30	7.1	<.5	.09	.13	3.2	10	<.01
	21st St. Dr	5	<30	4.3	<.5	1.1	1.15	17	25	7.1
	26th St. Dr	<5	37	10.2	<.5	1.4	.12	2.7	5	.03
	Ped A	<5	<30	8.3	<.5	.12	.20	2.5	10	<.01
	Ped C	5	<30	9.2	<.5	.11	.12	2.3	10	<.01
	Ind. Ave. SD	6	32	7.5	<.5	.22	.18	6.2	15	<.01

Pb - Lead - ppb
Cr - Chromium - ppb
Cd - Cadmium - ppb
Hg - Mercury - ppb
NO_3/NO_2 - Nitrate/Nitrite - ppm
TPO_4 - Total Phosphorous - ppm
BOD - Biochemical Oxygen Demand - ppm
COD - Chemical Oxygen Demand - ppm
NH_3- Ammonia - ppm

ARKANSAS RIVER PROJECT
WATER CHEMICAL MEASUREMENTS
1994

DATE	SITE	Pb	Cr	Cd	Hg	NO_3/NO_2	TPO_4	BOD	COD	NH
9/21/94	11th St. A	<5	<30	19	<.5	.31	.14	<1	13	<.01
	11th St. C	7	<30	8.0	<.5	.25	.15	1.6	13	<.01
	11th St. Dr	11	38	16	<.5	.1.9	.47	12.9	33	<.01
	21st St. A	9	<30	21	<.5	.28	.14	<1	13	<.01
	21st St. C	5	<30	5	<.5	.24	.17	2.0	13	<.01
	21st St. Dr	7	<30	16	<.5	.58	1.18	13.6	33	8.2
	26th St. Dr	7	<30	21	<.5	1.2	.17	2.0	6	<.01
	Ped A	<5	<30	<3	<.5	.28	.14	<1	<5	<.01
	Ped C	6	<30	<3	<.5	.28	.21	1.0	<5	<.01
	Ind. Ave. SD	6	<30	<3	<.5	6.7	.16	2.0	13	<.01
9/28/94	11th St. A	8	<30	<3	<.5	.31	.10	1.4	5	<.01
	11th St. C	<5	<30	<3	<.5	.40	.20	2.0	6	<.01
	11th St. Dr	24	41	13	<.5	.45	1.4	12.8	50	5.4
	21st St. A	5	<30	<3	<.5	.27	.13	1.3	5	<.01
	21st St. C	8	<30	<3	<.5	.26	.14	2.1	5	<.(
	21st St. Dr	6	<30	13	<.5	.40	.15	16	85	5.4
	26th St. Dr	<5	<30	<3	<.5	1.0	.15	2.6	<5	.01
	Ped A	<5	<30	<3	<.5	.25	.10	1.4	7.5	<.01
	Ped C	5	<30	<3	<.5	.25	<.02	2.0	<5	<.01
	Ind. Ave. SD	<5	<30	<3	<.5	3.7	.5	8.1	<5	<.01

Pb - Lead - ppb
Cr - Chromium - ppb
Cd - Cadmium - ppb
Hg - Mercury - ppb
NO_3/NO_2 - Nitrate/Nitrite - ppm

TPO_4 - Total Phosphorous - ppm
BOD - Biochemical Oxygen Demand - ppm
COD - Chemical Oxygen Demand - ppm
NH_3- Ammonia - ppm

APPENDIX C - ALERT AND CONCERN LEVELS OF TOXICANTS IN FISH TISSUE FROM THE OKLAHOMA WATER QUALITY STANDARDS

TABLE 4. Alert and Concern Levels in Fish Tissue[1]

SUBSTANCE	ALERT LEVEL (mg/kg)	CONCERN LEVEL (mg/kg)
Aldrin	0.3	0.15
Chlordane	0.3	0.15
DDT*	5.0	2.5
Dieldrin	0.3	0.15
Endrin	0.3	0.15
Heptachlor	0.3	0.15
Mercury	1.0	0.5
PCB's*	2.0	1.0
Toxaphene	5.0	2.5

NOTES: [1]Copied directly from OWQS

*DDT = Dichlorodiphenyltrichloroethane

*PCB's = Polychlorinated Biphenyls

APPENDIX D - FISH TOXICOLOGY DATA

SAMPLE NUMBER: 232489
AGENCY NUMBER:
DATE COLLECTED: 05/18/94
TIME COLLECTED:
DATE RECEIVED: 05/19/94
DATE COMPLETED: 06/09/94
STATION: U07164750
COLLECTED BY: JP
DATE REPORTED: 02/23/95

OKLAHOMA DEPARTMENT OF ENVIRONMENTAL QUALITY

FINAL REPORT OF ANALYSIS

STATE ENVIRONMENTAL LAB

CC: FILE COPY

CONCENTRATION IN SAMPLE — PAGE 1

PARAMETER	NUMBER	<	VALUE	UNITS	METHOD
MEAN WEIGHT N POUNDS	00023		1.790	POUNDS	10600D
MEAN LENGTH OF FISH	00024		16.690	INCHES	10600D
FISH CLASS CODE	00093		3.000	NUMBER	10600D
CHLORDANE IN FISH	34682	<	0.020	MG/KG	212.13A
CHLORDANE CIS ISMR F	39063	<	0.020	MG/KG	212.13A
CHLORDANE TRN ISMR F	39066	<	0.020	MG/KG	212.13A
NONACHLOR CIS ISMR F	39069	<	0.020	MG/KG	212.13A
NONACHLOR TRN ISMR F	39072	<	0.020	MG/KG	212.13A
ALPHA BHC IN FISH	39074	<	0.004	MG/KG	212.13A
GAMMA BHC IN FISH	39075	<	0.004	MG/KG	212.13A
P,P' DDT IN FISH	39302	<	40.000	UG/KG	212.13A
O,P DDT IN FISH	39307	<	0.040	MG/KG	212.13A
P,P' DDD IN FISH	39312	<	0.040	MG/KG	212.13A
P,P' DDE IN FISH	39322	<	0.040	MG/KG	212.13A
O,P DDD IN FISH	39325	<	0.040	MG/KG	212.13A
O,P DDE IN FISH	39329	<	0.040	MG/KG	212.13A
ALDRIN IN FISH	39334	<	6.000	UG/KG	212.13A
DDT IN FISH	39358	<	0.040	MG/KG	212.13A
ENDRIN IN FISH	39397	<	6.000	UG/KG	212.13A
DIELDRIN IN FISH	39404	<	0.012	MG/KG	212.13A
TOXAPHENE IN FISH	39407	<	60.000	UG/KG	212.13A
HEPTACHLOR IN FISH	39414	<	6.000	UG/KG	212.13A
HEPTACHLOR EPOXIDE F	39424	<	6.000	UG/KG	212.13A
METHOXYCHLOR IN FISH	39482	<	20.000	UG/KG	212.13A
TOTAL PCBS IN FISH	39520	<	60.000	UG/KG	212.13A
HEXACHLOROBENZENE F	39703	<	4.000	UG/KG	212.13A
MERCURY IN FISH	71930		0.260	MG/KG	245.6
NUMERIC SPECIES CODE	74990		67.000	NUMBER	
FISH TISSUE CODE	74995		86.000	NUMBER	
NUMBER OF INDIVIDUAL	81614		5.000	NUMBER	

SOURCE: ARKANSAS RIVER TULSA
PROGRAM: Water Quality Division
COUNTY: UNKNOWN CITY:

LEGAL DESCRIPTION
/4 NE/4 NW/4 SEC 13 T 09N R 12E IM

SAMPLER'S COMMENTS: 5 OF 10 BLUE CATFISH

ANALYST'S COMMENTS
GC LAB:

Metals LAB:

ANALYST

SAMPLE NUMBER: 232488
AGENCY NUMBER:
DATE COLLECTED: 05/18/94
TIME COLLECTED:
DATE RECEIVED: 05/19/94
DATE COMPLETED: 06/09/94
STATION: U07164750
COLLECTED BY: JP
DATE REPORTED: 02/23/95

OKLAHOMA DEPARTMENT OF ENVIRONMENTAL QUALITY

FINAL REPORT OF ANALYSIS

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STATE ENVIRONMENTAL LAB
OKLA STATE DEPT OF HEALTH
OKLAHOMA CITY OK 73152

	CONCENTRATION IN SAMPLE				PAGE 1
PARAMETER	NUMBER	<	VALUE	UNITS	METHOD
MEAN WEIGHT N POUNDS	00023		1.720	POUNDS	10600D
MEAN LENGTH OF FISH	00024		14.810	INCHES	10600D
FISH CLASS CODE	00093		3.000	NUMBER	10600D
CHLORDANE IN FISH	34682	<	0.020	MG/KG	212.13A
CHLORDANE CIS ISMR F	39063	<	0.020	MG/KG	212.13A
CHLORDANE TRN ISMR F	39066	<	0.020	MG/KG	212.13A
NONACHLOR CIS ISMR F	39069	<	0.020	MG/KG	212.13A
NONACHLOR TRN ISMR F	39072	<	0.020	MG/KG	212.13A
ALPHA BHC IN FISH	39074	<	0.004	MG/KG	212.13A
GAMMA BHC IN FISH	39075	<	0.004	MG/KG	212.13A
P,P' DDT IN FISH	39302	<	40.000	UG/KG	212.13A
O,P DDT IN FISH	39307	<	0.040	MG/KG	212.13A
P,P' DDD IN FISH	39312	<	0.040	MG/KG	212.13A
P,P' DDE IN FISH	39322	<	0.040	MG/KG	212.13A
O,P DDD IN FISH	39325	<	0.040	MG/KG	212.13A
O,P DDE IN FISH	39329	<	0.040	MG/KG	212.13A
ALDRIN IN FISH	39334	<	6.000	UG/KG	212.13A
DDT IN FISH	39358	<	0.040	MG/KG	212.13A
ENDRIN IN FISH	39397	<	6.000	UG/KG	212.13A
DIELDRIN IN FISH	39404	<	0.012	MG/KG	212.13A
TOXAPHENE IN FISH	39407	<	60.000	UG/KG	212.13A
HEPTACHLOR IN FISH	39414	<	6.000	UG/KG	212.13A
HEPTACHLOR EPOXIDE F	39424	<	6.000	UG/KG	212.13A
METHOXYCHLOR IN FISH	39482	<	20.000	UG/KG	212.13A
TOTAL PCBS IN FISH	39520	<	60.000	UG/KG	212.13A
HEXACHLOROBENZENE F	39703	<	4.000	UG/KG	212.13A
MERCURY IN FISH	71930		0.200	MG/KG	245.6
NUMERIC SPECIES CODE	74990		42.000	NUMBER	
FISH TISSUE CODE	74995		86.000	NUMBER	
NUMBER OF INDIVIDUAL	81614		5.000	NUMBER	

SOURCE: ARKANSAS RIVER TULSA
PROGRAM: Water Quality Division
COUNTY: UNKNOWN CITY:

LEGAL DESCRIPTION
/4 NE/4 NW/4 SEC 13 T 09N R 12E IM

SAMPLER'S COMMENTS: 5 OF 13 RIVER CARPSUCKER

ANALYST'S COMMENTS
GC LAB:

Metals LAB:

ANALYST

SAMPLE NUMBER: 232486
AGENCY NUMBER:
DATE COLLECTED: 05/18/94
TIME COLLECTED:
DATE RECEIVED: 05/19/94
DATE COMPLETED: 06/09/94
STATION: U07164750
COLLECTED BY: JP
DATE REPORTED: 02/23/95

OKLAHOMA DEPARTMENT OF ENVIRONMENTAL QUALITY

FINAL REPORT OF ANALYSIS

STATE ENVIRONMENTAL LAB

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CONCENTRATION IN SAMPLE — PAGE 1

PARAMETER	NUMBER	<	VALUE	UNITS	METHOD
MEAN WEIGHT N POUNDS	00023		3.750	POUNDS	10600D
MEAN LENGTH OF FISH	00024		19.100	INCHES	10600D
FISH CLASS CODE	00093		3.000	NUMBER	10600D
CHLORDANE IN FISH	34682	<	0.020	MG/KG	212.13A
CHLORDANE CIS ISMR F	39063	<	0.020	MG/KG	212.13A
CHLORDANE TRN ISMR F	39066	<	0.020	MG/KG	212.13A
NONACHLOR CIS ISMR F	39069	<	0.020	MG/KG	212.13A
NONACHLOR TRN ISMR F	39072	<	0.020	MG/KG	212.13A
ALPHA BHC IN FISH	39074	<	0.004	MG/KG	212.13A
GAMMA BHC IN FISH	39075	<	0.004	MG/KG	212.13A
P,P' DDT IN FISH	39302	<	40.000	UG/KG	212.13A
O,P DDT IN FISH	39307	<	0.040	MG/KG	212.13A
P,P' DDD IN FISH	39312	<	0.040	MG/KG	212.13A
P,P' DDE IN FISH	39322	<	0.040	MG/KG	212.13A
O,P DDD IN FISH	39325	<	0.040	MG/KG	212.13A
O,P DDE IN FISH	39329	<	0.040	MG/KG	212.13A
ALDRIN IN FISH	39334	<	6.000	UG/KG	212.13A
DDT IN FISH	39358	<	0.040	MG/KG	212.13A
ENDRIN IN FISH	39397	<	6.000	UG/KG	212.13A
DIELDRIN IN FISH	39404	<	0.012	MG/KG	212.13A
TOXAPHENE IN FISH	39407	<	60.000	UG/KG	212.13A
HEPTACHLOR IN FISH	39414	<	6.000	UG/KG	212.13A
HEPTACHLOR EPOXIDE F	39424	<	6.000	UG/KG	212.13A
METHOXYCHLOR IN FISH	39482	<	20.000	UG/KG	212.13A
TOTAL PCBS IN FISH	39520	<	60.000	UG/KG	212.13A
HEXACHLOROBENZENE F	39703	<	4.000	UG/KG	212.13A
MERCURY IN FISH	71930		0.220	MG/KG	245.6
NUMERIC SPECIES CODE	74990		48.000	NUMBER	
FISH TISSUE CODE	74995		86.000	NUMBER	
NUMBER OF INDIVIDUAL	81614		5.000	NUMBER	

SOURCE: ARKANSAS RIVER TULSA
PROGRAM: Water Quality Division
COUNTY: UNKNOWN CITY:

LEGAL DESCRIPTION
/4 NE/4 NW/4 SEC 13 T 09N R 12E IM

SAMPLER'S COMMENTS: 5 OF 10 SMALL MOUTH BUFFALO

ANALYST'S COMMENTS
GC LAB:

Metals LAB:

ANALYST

SAMPLE NUMBER: 232484
AGENCY NUMBER:
DATE COLLECTED: 05/18/94
TIME COLLECTED:
DATE RECEIVED: 05/19/94
DATE COMPLETED: 06/09/94
STATION: U07164750
COLLECTED BY:
DATE REPORTED: 02/23/95

STATE ENVIRONMENTAL LAB

OKLAHOMA DEPARTMENT OF ENVIRONMENTAL QUALITY

FINAL REPORT OF ANALYSIS

FEB 27 1995
ENVIRONMENTAL HEALTH
TCCHD

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PARAMETER	CONCENTRATION IN SAMPLE NUMBER <	VALUE	UNITS	PAGE 1 METHOD
MEAN WEIGHT N POUNDS	00023	0.810	POUNDS	10600D
MEAN LENGTH OF FISH	00024	7.750	INCHES	10600D
FISH CLASS CODE	00093	1.000	NUMBER	10600D
CHLORDANE IN FISH	34682 <	0.020	MG/KG	212.13A
CHLORDANE CIS ISMR F	39063 <	0.020	MG/KG	212.13A
CHLORDANE TRN ISMR F	39066 <	0.020	MG/KG	212.13A
NONACHLOR CIS ISMR F	39069 <	0.020	MG/KG	212.13A
NONACHLOR TRN ISMR F	39072 <	0.020	MG/KG	212.13A
ALPHA BHC IN FISH	39074 <	0.004	MG/KG	212.13A
GAMMA BHC IN FISH	39075 <	0.004	MG/KG	212.13A
P,P' DDT IN FISH	39302 <	40.000	UG/KG	212.13A
O,P DDT IN FISH	39307 <	0.040	MG/KG	212.13A
P,P' DDD IN FISH	39312 <	0.040	MG/KG	212.13A
P,P' DDE IN FISH	39322 <	0.040	MG/KG	212.13A
O,P DDD IN FISH	39325 <	0.040	MG/KG	212.13A
O,P DDE IN FISH	39329 <	0.400	MG/KG	212.13A
ALDRIN IN FISH	39334 <	6.000	UG/KG	212.13A
DDT IN FISH	39358 <	0.040	MG/KG	212.13A
ENDRIN IN FISH	39397 <	6.000	UG/KG	212.13A
DIELDRIN IN FISH	39404 <	0.012	MG/KG	212.13A
TOXAPHENE IN FISH	39407 <	60.000	UG/KG	212.13A
HEPTACHLOR IN FISH	39414 <	6.000	UG/KG	212.13A
HEPTACHLOR EPOXIDE F	39424 <	6.000	UG/KG	212.13A
METHOXYCHLOR IN FISH	39482 <	20.000	UG/KG	212.13A
TOTAL PCBS IN FISH	39520 <	60.000	UG/KG	212.13A
HEXACHLOROBENZENE F	39703 <	4.000	UG/KG	212.13A
MERCURY IN FISH	71930	0.300	MG/KG	245.6
NUMERIC SPECIES CODE	74990	31.000	NUMBER	
FISH TISSUE CODE	74995	86.000	NUMBER	
NUMBER OF INDIVIDUAL	81614	4.000	NUMBER	

SOURCE: ARKANSAS RIVER TULSA
PROGRAM: Water Quality Division
COUNTY: UNKNOWN CITY:

LEGAL DESCRIPTION
/4 NE/4 NW/4 SEC 13 T 09N R 12E IM

SAMPLER'S COMMENTS: 4 OF 4 LARGE MOUTH BASS

ANALYST'S COMMENTS
GC LAB:

Metals LAB:

ANALYST

SAMPLE NUMBER: 232487
AGENCY NUMBER:
DATE COLLECTED: 05/18/94
TIME COLLECTED:
DATE RECEIVED: 05/19/94
DATE COMPLETED: 05/27/94
STATION: U07164750
COLLECTED BY: JP
DATE REPORTED: 02/23/95

OKLAHOMA DEPARTMENT OF ENVIRONMENTAL QUALITY

FINAL REPORT OF ANALYSIS

STATE ENVIRONMENTAL LAB

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CONCENTRATION IN SAMPLE — PAGE 1

PARAMETER	NUMBER	<	VALUE	UNITS	METHOD
MEAN WEIGHT N POUNDS	00023		2.590	POUNDS	10600D
MEAN LENGTH OF FISH	00024		17.830	INCHES	10600D
FISH CLASS CODE	00093		3.000	NUMBER	10600D
CHLORDANE IN FISH	34682	R	0.000	MG/KG	212.13A
CHLORDANE CIS ISMR F	39063	R	0.000	MG/KG	212.13A
CHLORDANE TRN ISMR F	39066	R	0.000	MG/KG	212.13A
NONACHLOR CIS ISMR F	39069	R	0.000	MG/KG	212.13A
NONACHLOR TRN ISMR F	39072	R	0.000	MG/KG	212.13A
ALPHA BHC IN FISH	39074	R	0.000	MG/KG	212.13A
GAMMA BHC IN FISH	39075	R	0.000	MG/KG	212.13A
P,P' DDT IN FISH	39302	R	0.000	UG/KG	212.13A
O,P DDT IN FISH	39307	R	0.000	MG/KG	212.13A
P,P' DDD IN FISH	39312	R	0.000	MG/KG	212.13A
P,P' DDE IN FISH	39322	R	0.000	MG/KG	212.13A
O,P DDD IN FISH	39325	R	0.000	MG/KG	212.13A
O,P DDE IN FISH	39329	R	0.000	MG/KG	212.13A
ALDRIN IN FISH	39334	R	0.000	UG/KG	212.13A
DDT IN FISH	39358	R	0.000	MG/KG	212.13A
ENDRIN IN FISH	39397	R	0.000	UG/KG	212.13A
DIELDRIN IN FISH	39404	R	0.000	MG/KG	212.13A
TOXAPHENE IN FISH	39407	R	0.000	UG/KG	212.13A
HEPTACHLOR IN FISH	39414	R	0.000	UG/KG	212.13A
HEPTACHLOR EPOXIDE F	39424	R	0.000	UG/KG	212.13A
METHOXYCHLOR IN FISH	39482	R	0.000	UG/KG	212.13A
TOTAL PCBS IN FISH	39520	R	0.000	UG/KG	212.13A
HEXACHLOROBENZENE F	39703	R	0.000	UG/KG	212.13A
MERCURY IN FISH	71930	I	0.000	MG/KG	245.6
NUMERIC SPECIES CODE	74990		12.000	NUMBER	
FISH TISSUE CODE	74995		86.000	NUMBER	
NUMBER OF INDIVIDUAL	81614		3.000	NUMBER	

SOURCE: ARKANSAS RIVER TULSA
PROGRAM: Water Quality Division
COUNTY: UNKNOWN CITY:

LEGAL DESCRIPTION
/4 NE/4 NW/4 SEC 13 T 09N R 12E IM

SAMPLER'S COMMENTS: 3 OF 3 CARP

ANALYST'S COMMENTS
GC LAB: R = REJECTED: SAMPLE DESTROYED, LAB ACCIDENT.

Metals LAB: NOT ENOUGH FISH FOR SET - THROWN OUT

ANALYST

WATER QUALITY REPORT FOR THE ZINK LAKE-
RIVER PARKS AREA OF THE ARKANSAS RIVER
FOR 1995

PREPARED BY THE TULSA CITY COUNTY

HEALTH DEPARTMENT

SEPTEMBER, 1996

TABLE OF CONTENTS

Introduction

In, 1995, water samples were again collected in the Zink Lake area of the Arkansas River in accordance with the annual study required by the U.S. Army Corps of Engineers Permit for the low water dam. Samples were collected in order to characterize (1) Bacterial Contamination and (2) Water Chemistry in Zink Lake. High spring time flows precluded the collection of fish samples in 1995. Three bridge sites (11th Street, 21st Street, Pedestrian) and four storm drains (11th Street, Indian Avenue, 21st Street, 26th Street) were again used as sampling locations. In 1995, 270 bacteriological samples were collected at these sites. 108 samples were collected for the water chemistry study. A total of 1,800 analyses were run on the 378 total samples collected. Due to increased analytical costs, underfunding and a reduction in laboratory staff, 1995 is the final year of water chemistry analyses for this project.

ZINK LAKE BACTERIOLOGICAL REPORT

As in previous years, a bacteriological study was undertaken in the Zink Lake area of the Arkansas River. The same three bridge sites and the same four storm drains were sampled. High river flows throughout the spring and summer precluded the taking of samples from the storm drains on various dates. From May 1st to September 30th, 234 bacteriological samples were collected from the river itself. An additional 36 samples were collected from the storm drains yielding a total of 270 bacteriological water samples collected in 1995.

The Geometric Mean was calculated for each set of monthly data and compared to the Oklahoma Water Quality Standards. The number of exceedances of the 400 colony count was also tabulated and compared to the water quality standards. A "Fecal Coliform/Fecal Streptococcus" ratio was also calculated for the existing data. This gives an indication whether the bacterial contamination is due to human sources or animal wastes.

11th Street Bridge

At this site the Geometric Mean criterion was exceeded once in 15 data sets. This occurred at the east bank station in the month of September. The 400 colony count criterion was exceeded in 14% of the samples collected and this exceeds the allowable 10% limit. The range of values at this site was 10 - 22,000 for fecal coliform and the range was 10 - 8,200 for fecal streptococcus. The "FC/FS Ratio" indicated that animal wastes were the primary bacterial source in 95% of the samples (74/78). There was no positive correlation indicating that human waste was the specific source of contamination in any of the samples. At this station, September was the worst month for overall contamination. This may simply be the result of a much reduced river flow by that time of year causing a decreased dilution factor for contaminated water flowing from the storm drains. The worst values were encountered against both banks with the middle of the river being relatively clean. As in previous years, the east bank station was the most contaminated site which indicates the influence of the 11th Street storm drain .

21st Street Bridge

The Geometric Mean criterion was exceeded in one of the 15 data sets and this occurred in the month of September at the east bank station. The 400 colony count criterion was exceeded in approximately 17% of the samples collected and this exceeds the 10% allowable limit for all samples. The range of values was 10 - 22,000 for fecal coliform and 10 - 15,000 for fecal streptococcus. The "FC/FS Ratio" indicated that animal wastes were the source of contamination in 92% of the samples (72/78) while one sample showed a positive correlation to contamination from human waste. At this station, September was also the worst month for overall contamination. Again, the worst values were encountered against both banks while the mid-channel station was relatively clean. As at the previous sampling site, the east bank substation was the most highly contaminated point. Both the 11th Street storm drain and the Indian Avenue storm drain have an influence on this station.

Pedestrian Bridge

The Geometric Mean criterion was exceeded in 3 out of 15 data sets at this station. All these occurred in September at the 3 different substations. The 400 colony count criterion was exceeded in 20% of the samples which is twice the allowable limit in the OWQS. The range of values was 10 - 5,600 for fecal coliform and 10 - 10,000 for fecal streptococcus. The "FC/FS Ratio" indicated that in 90% of the samples (71/78) the chief cause of contamination was animal waste. 3 of the samples indicated a positive correlation to contamination from human waste. September was by for the worst month for this station. Both banks were again the worst spots but this site also exhibited the worst mid-channel data. All four storm drains seem to effect this site with more complete mixing resulting in the deteriorated condition of the mid-channel. Overall, the east bank station proved to be the most contaminated site once again.

Storm Drains

Bacteriological sampling at the storm drains was severely curtailed for most of the year due to very high river flows. No samples could be collected for the first 2-1/2 months of the project and subsequent samples were taken sporadically. As has been true in the past, the storm drains still exhibited some very high bacterial counts. The ranges for the four storm drains were:

11th Street Storm Drain	
Fecal Coliform	10 - 310,000
Fecal Streptococcus	90 - 33,000
Indian Avenue Storm Drain	
Fecal Coliform	190 - 22,000
Fecal Streptococcus	230 - 41,000
21st Street Storm Drain	
Fecal Coliform	10 - 160,000
Fecal Streptococcus	27 - 35,000
26th Street Storm Drain	
Fecal Coliform	360-110,000
Fecal Streptococcus	310- 39,000

As can be seen from this data, some fecal coliform counts are very high especially when compared to in-stream values. This would seem to indicate that at least some sewage is entering the storm drain system from time to time. The "Fecal Coliform/Fecal Strepoccoccus Ratio" indicates that in 64% of the samples the contamination is mainly caused by animal waste. Probable human waste as the source of contamination was found in only 8% of the samples. The Indian Avenue storm drain appears to introduce the least amount of bacterial contamination to the river. The 11th Street and 21st Street drains are larger and appear to introduce the most bacterial contamination.

Discussion

The Arkansas River flowing through the metropolitan Tulsa area has been categorized as a "Primary Body Contact" recreational usage area in the Oklahoma Water Quality Standards. This means that the water should be fit for swimming, wading, boating, etc. and that the water should meet the highest standards set forth in the OWQS. Once again the water quality of the river has failed to meet the bacterial standards that have been set forth. Both the Geometric Mean criterion and the total colony count criterion were exceeded during the study. We sample only 4 major storm drains in the Tulsa area. While it is apparent they are a large contributory source to the problem they are only a small number of the sources contributing contamination to the river. The scope of the problem is very large and wide spread and any attempts to improve the bacterial water quality of the river will involve considerable time, effort and expense.

ZINK LAKE WATER CHEMISTRY

In 1995, water samples were again collected from the seven sampling sites in order to at least partially characterize the water chemistry of the River Parks area . A total of 96 samples were collected from the river and 12 samples were collected from the storm drains. Time and monetary constraints combined with high river flows early in the year reduced the number of storm drain samples collected in 1995. Each sample was analyzed for 9 parameters yielding a total of 1,260 tests run on these samples. Each parameter will be discussed separately.

BIOCHEMICAL OXYGEN DEMAND (BOD)

BOD represents the measure of various types of organic materials on the oxygen supply dissolved in the water. This is important because an adequate amount of oxygen is necessary to support an acceptable aquatic community in the river. Living biological organisms, decaying organic matter and the oxidation of organic chemicals all reduce the amount of oxygen available in the aquatic ecosystem. In 1995, BOD levels were at detectable limits (>1.0 ppm) in 71% of all the samples. This was a smaller percentage of the samples than that encountered in 1994 (86%). The highest value (3.9ppm) was found at the 26th Street storm drain. The highest instream value was 3.7 ppm and occurred at the east bank station of the 11th Street Bridge. These values were somewhat lower than the highest values encountered in 1994. The storm drains continue to supply a steady amount of organic loading to the river which tends to deplete it's oxygen content.

AMMONIA (NH3)

Ammonia was detectable in 35% of all samples collected. This was approximately the same level as that encountered in 1994 (41%). The highest value was .16 ppm and was encountered at the east bank station of the 21st Street Bridge. For the most part, ammonia levels were barely detectable when they were detected. When compared with the 1994 levels, the ammonia levels were significantly lower and this appears to continue the trend from 1993. EPA has suggested a criterion of .02 ppm for the protection of aquatic life. Only 17% of the total number of samples collected exceeded that criterion as compared to 33% in 1994. Thus the amounts of ammonia and its' frequency of occurrence were both significantly lower in 1995 as compared to previous years.

NITRATE/NITRITE (NO_3/NO_2)

Detectable levels of this parameter were found in 100% of the samples. The range of values was .10 ppm to 1.98 ppm and this high value occurred at the Indian Avenue storm drain. The highest instream value was .89 ppm and occurred at the east bank station of the 21st street bridge. Values encountered in the storm drain samples were generally higher than those in the river samples. Overall, the values found in 1995 were quite a bit lower in 1995 compared to 1994. The occurrence of detectable levels was virtually the same as in 1994.

TOTAL PHOSPHATE (TPO_4)

Total Phosphates were detectable in 93% of all samples collected in 1995(>.02 ppm). This was virtually the same as in 1994. The highest value encountered was 3.71 ppm and this occurred at the 26th Street storm drain. The highest instream value was 2.457 ppm and occurred at the west bank of the Pedestrian Bridge. The values encountered in 1995 were generally higher than those encountered in 1994.

CHEMICAL OXYGEN DEMAND (COD)

The COD determination is a measure of the oxygen equivalent of that portion of the organic matter in a sample that is susceptible to oxidation by a strong oxidant. It does not measure all organic compounds that are readily available to stream organisms and measures some that are not so readily available to biological organisms. It is a useful tool for measuring the oxygen demand of the organic chemicals present in water. Measurable COD values (>5.0 ppm) were detected in 86% of all the samples collected. This is a larger percentage of samples than was encountered in 1994. The highest value detected was 54 ppm and this was found at the 26th street storm drain. The highest instream value was 39 ppm and this was encountered at the east bank station of the 11th Street Bridge. In general, higher levels were found in the storm drains than in the river. The levels encountered in 1995 were below both 1993 and 1994 levels for the most part. As has been the case in the past, it is obvious that the storm drains provide a continuous flow of materials into the river which help to deplete the oxygen levels in the water, thereby placing greater stress on the aquatic community.

LEAD (Pb)

Lead was detected (>5.0 ppb) in 69% of all samples collected. This is a higher percentage than encountered in 1994 (57%) but almost identical to the 1993 level (73%). The highest value encountered was 33 ppb and this occurred at the 21st Street storm drain. The highest instream value was 23 ppb and it was found at the east bank of the 11th Street Bridge. In general, the storm drains exhibited higher lead levels than the river. Overall, lead values were not much changed from the previous year although detectable levels did exhibit an increase from 1994.

CADMIUM (Cd)

Cadmium was detectable (>3.0 ppb) in 72% of all samples collected. This represents a slight increase from 1994 (65%). The highest value encountered was 22 ppb and this was found at the east bank station of the 11th Street Bridge. The highest storm drain value was 17 ppb and this occurred at the 26th Street storm drain. This storm drain exhibited the highest overall values compared to the other storm drains. Compared to the previous two years, the occurrence of detectable cadmium levels continues to exhibit an increase.

CHROMIUM (Cr)

Chromium was detectable (>30 ppb) in 29% of all the samples collected. This is almost a two fold increase from the occurrence level the previous year. The highest level found was 74 ppb and this occurred at the midstream station of the Pedestrian Bridge. The highest value for a storm drain was 47 ppb and this sample came from the 11th Street storm drain. While the level of occurrence of chromium in the water samples increased, the values found were somewhat lower than those from last year. As in past years, the levels of chromium in the storm drains were less than levels encountered in the river.

MERCURY (Hg)

Mercury was detectable (>.5 ppb) in 17% of all the samples collected. This is a significant increase over the 1994 data when virtually no mercury was detected in any of the samples. The highest value found was 4.2 ppb and this occurred at the midstream station of the 11th Street Bridge. The highest storm drain value was .7 ppb and came from the 11th Street storm drain. While the 1995 data was generally worse than the 1994 data, several sampling sites showed no sign of mercury contamination and the overall occurrence level is still very low when compared to the other parameters studied. This is one contaminant where the storm drains don't seem to be a significant source of contamination.

DISCUSSION

The data from the water chemistry study for 1995 reveals mixed results. The BOD data appeared to be better than the previous year, but the storm drains still appear to be a significant source of biological materials that cause oxygen depletion in our surface waters. The occurrence of and the actual amounts of ammonia that were detectable decreased from 1994. This further continues a downtrend that has been noticeable in the last few years. The occurrence of detectable nitrate/nitrite levels were as ubiquitous as ever but the levels were lower, in general, than in the past. Measurable total phosphate levels were again very high in occurrence and the levels encountered were generally higher than in 1994. The occurrence of detectable COD levels were a little higher but the overall values were lower than in previous years. The lead data was pretty much the same as it has been the last few years. The occurrence of detectable cadmium levels showed a slight increase in 1995. The occurrence of chromium detectable in the samples increased significantly but the overall values were about the same as in previous years. The occurrence of detectable mercury levels in the samples were significantly higher although the actual levels detected were still very low overall.

Our water chemistry study for 1995 indicates that there are still water quality problems in the Arkansas River watershed in the Tulsa area. However, these problems do not appear to be of very great magnitude. Any urbanized area contributes a variety of pollutants to the surface waters in the area, in this case, the Arkansas River. Fertilizers, pesticides, animal wastes, human sewage, organic matter (grass & leaves), household chemicals, commercial and industrial chemicals and a variety of other materials are washed into the watershed through the storm water conveyance system during rain events. As the human population increases and the surrounding urbanized area grows the problems caused by storm water pollution can only increase. Our study shows how only 4 of the major storm drains contribute various types of pollutants to the river. There are many other sources that have gone unstudied. An attempt to control and reduce pollutants in storm water run-off will prove to be a difficult task.

APPENDIX A - BACTERIOLOGICAL DATA

APPENDIX B - WATER CHEMISTRY DATA

11th Street Bridge A (West Bank)

	BOD	NH3	NO3\NO2	T PO4	COD	Pb	Cd	Cr	Hg
Units	ppm	ppm	ppm	ppm	ppm	ppb	ppb	ppb	ppb
5/10/95	3.1	.06	.60	.126	26	5	<3	<30	<.5
5/22/95	1.6	<.20	.10	.009	20	8	10	<30	<.5
6/14/95	2.1	.04	.37	.191	21	5	5	<30	<.5
6/21/95	1.2	<.02	.43	.245	< 5	5	3	60	<.5
7/12/95	1.6	<.02	.48	.300	14	5	<3	<30	<.5
7/19/95	<1	.02	.36	.225	5	<5	4	37	<.5
7/26/95	1.6	.02	.34	.180	8	<5	7	<30	.5
8/2/95	<1	.05	.28	.164	9	5	6	<30	<.5
8/9/95	2.8	.02	.68	.126	10	17	9	<30	.6
8/16/95	<1	.02	.53	<.020	15	<5	7	45	.9
8/30/95	<1	.02	.44	.166	5	<5	8	20	<.5
9/13/95	2.1	.02	.37	.177	34	5	<3	<30	<.5

BOD - Biochemical Oxygen Demand

NH3 - Ammonia

NO3\NO2 - Nitrate Nitrite

COD - Chemical Oxygen Demand

T PO4 - Total Phosphorous

Pb - Lead

Cd - Cadmium

Cr - Chromium

Hg - Mercury

11th Street Bridge B (Mid Stream)

	BOD	NH3	NO3\NO2	T PO4	COD	Pb	Cd	Cr	Hg
Units	ppm	ppm	ppm	ppm	ppm	ppb	ppb	ppb	ppb
5/10/95									
5/22/95	<1	< .02	.52	.164	20	6	8	< 30	4.2
6/14/95	1.8	.03	.37	.173	< 5	6	5	< 30	< .5
6/21/95	2.0	< .02	.45	.128	< 5	7	6	< 30	< .5
7/12/95	1.6	< .02	.47	.225	10	8	< 3	< 30	< .5
7/19/95	<1	.02	.37	.150	8	< 5	5	37	< .5
7/26/95									
8/2/95									
8/9/95	2.5	< .02	.71	.201	10	11	12	40	< .5
8/16/95	<1	< .02	.71	.205	10	7	9	58	1.0
8/30/95	<1	.02	.46	.142	10	< 5	< 3	< 30	1.8
9/13/95									

BOD - Biological Oxygen Demand

NH3 - Ammonia

NO3\NO2 - Nitrate Nitrite

COD - Chemical Oxygen Demand

T PO4 - Total Phosphorous

Pb - Lead

Cd - Cadmium

Cr - Chromium

Hg - Mercury

11th Street Bridge C (East Bank)

	BOD	NH3	NO3\NO2	T PO4	COD	Pb	Cd	Cr	Hg
Units	ppm	ppm	ppm	ppm	ppm	ppb	ppb	ppb	ppb
5/22/95	1.7	<.02	.54	.097	22	9	8	< 30	< .5
6/14/95	3.7	.04	.38	.162	13	10	6	33	< .5
6/21/95	1.3	<.02	.44	.128	6	5	5	< 30	< .5
7/12/95	1.6	<.02	.47	.211	14	8	< 3	< 30	< .5
7/19/95	<1	<.02	.38	.219	10	< 5	9	< 30	< .5
7/26/95	<1	.04	.35	.131	12	6	< 3	< 30	< .5
8/2/95	1.8	<.02	.27	.334	13	23	5	< 30	< .5
8/9/95	2.4	.02	.78	.201	5	14	9	< 30	.6
8/16/95	<1	<.02	.69	.215	10	6	6	< 30	1.7
8/30/95	<1	<.02	.44	.041	10	< 5	9	< 30	< .5
9/13/95	1.7	<.02	.43	.147	39	8	22	< 30	< .5

BOD - Biological Oxygen Demand

NH3 - Ammonia

NO3\NO2 - Nitrate Nitrite

COD - Chemical Oxygen Demand

T PO4 - Total Phosphoroue

Pb - Lead

Cd - Cadmium

Cr - Chromium

Hg - Mercury

21st Street Bridge A (West Bank)

	BOD	NH3	NO3\NO2	COD	T PO4	Pb	Cd	Cr	Hg
Units	ppm	ppm	ppm	ppm	ppm	ppb	ppb	ppb	ppb
5/10/95	2.8	.08	.58	21	< .02	< 5	< 3	< 30	< .5
5/22/95	1.6	< .02	.52	25	.056	6	6	31	< .5
6/14/95	2.0	< .02	.36	< 5	.068	8	4	< 30	< .5
6/21/95	2.0	< .02	.43	8	.107	< 5	3	37	< .5
7/12/95	1.8	< .02	.45	5	.289	6	< 3	< 30	1.0
7/19/95	<1	< .02	.39	8	.244	< 5	7	35	< .5
7/26/95	1.3	.02	.34	5	.178	6	3	< 30	< .5
8/2/95	<1	< .02	.27	18	.258	11	8	< 30	.6
8/9/95	2.3	.04	.71	10	.077	15	12	< 30	< .5
8/16/95	<1	< .02	.62	10	.051	5	9	31	< .5
8/30/95	2.4	< .02	.46	20	< .02	6	10	< 30	< .5
9/13/95	2.4	< .02	.41	34	.164	7	15	< 30	< .5

BOD - Biological Oxygen Demand

NH3 - Ammonia

NO3\NO2 - Nitrate Nitrite

COD - Chemical Oxygen Demand

T PO4 - Total Phosphorous

Pb - Lead

Cd - Cadmium

Cr - Chromium

Hg - Mercury

21st Street Bridge B (MId Stream)

	BOD	NH3	NO3\NO2	T PO4	COD	Pb	Cd	Cr	Hg
Units	ppm	ppm	ppm	ppm	ppm	ppb	ppb	ppb	ppb
5/10/95									
5/22/95	1.7	< .02	.56	.156	20	5	10	33	< .5
6/14/95	1.9	.03	.37	.219	< 5	8	4	< 30	< .5
6/21/95	1.2	< .02	.43	.148	< 5	< 5	4	< 30	.6
7/12/95	2.2	< .02	.47	.263	14	5	< 3	< 30	< .5
7/19/95	1.1	< .02	.37	.258	8	< 5	6	< 30	< .5
7/26/95									
8/2/95									
8/9/95	2.6	.03	.77	< .02	5	13	9	< 30	< .5
8/16/96	< 1	< .02	.66	.200	5	8	11	< 30	< .5
8/30/95	< 1	< .02	.43	.090	10	< 5	16	< 30	< .5
9/13/95									

BOD - Biological Oxygen Demand

NH3 - Ammonia

NO3\NO2 - Nitrate Nitrite

COD - Chemical Oxygen Demand

T PO4 - Total Phosphorous

Pb - Lead

Cd - Cadmium

Cr - Chromium

Hg - Mercury

21st Street Bridge C (East Bank)

	BOD	NH3	NO3\NO2	T PO4	COD	Pb	Cd	Cr	Hg
Units	ppm	ppm	ppm	ppm	ppm	ppb	ppb	ppb	ppb
5/24/95	1.7	< .02	.54	.101	10	9	12	30	1.6
6/14/95	1.9	< .02	.37	.255	< 5	8	< 3	30	< .5
6/21/95	1.1	< .02	.44	.170	9	< 5	< 3	38	< .5
7/12/95	1.7	< .02	.48	.262	5	10	< 3	< 30	< .5
7/19/95	< 1	< .02	.37	.255	12	< 5	6	62	< .5
7/26/95	1.3	< .02	.34	.299	10	< 5	5	< 30	< .5
8/2/95	< 1	.02	.30	.367	18	16	10	< 30	< .5
8/9/95	2.3	.05	.78	2.275	20	16	10	< 30	< .5
8/16/95	< 1	.16	.89	.145	10	8	10	< 30	< .5
8/30/96	< 1	< .02	.45	.177	5	< 5	9	< 30	< .5
9/13/95	1.9	< .02	.47	.164	39	5	21	< 30	< .5

BOD - Biological Oxygen Demand

NH3 - Ammonia

NO3\NO2 - Nitrate Nitrite

COD - Chemical Oxygen Demand

T PO4 - Total Phosphorous

Pb - Lead

Cd - Cadmium

Cr - Chromium

Hg - Mercury

Pedestrian Bridge A (West Bank)

	BOD	NH3	NO3\NO2	T PO4	COD	Pb	Cd	Cr	Hg
Units	ppm	ppm	ppm	ppm	ppm	ppb	ppb	ppb	ppb
5/10/95	3.2	.05	.59	.110	18	6	3	< 30	< .5
5/22/95	1.5	< .02	.54	.063	17	7	10	< 30	< .5
6/14/95	1.1	.03	.37	.131	< 5	7	3	49	< .5
6/21/95	1.1	< .02	.43	.242	< 5	7	4	53	< .5
7/12/95	1.6	< .02	.46	.296	14	9	< 3	< 30	< .5
7/19/95	< 1	< .02	.47	.099	8	< 5	7	< 30	< .5
7/26/95	2.3	< .02	.35	.206	10	< 5	< 3	< 30	< .5
8/2/95	< 1	< .02	.29	.178	18	8	10	< 30	< .5
8/9/95	2.3	.40	.70	.138	5	< 5	12	< 30	< .5
8/16/95	1.3	.02	.70	.312	20	13	12	< 30	< .5
8'30'95	1.2	< .02	.60	.207	10	< 5	< 3	< 30	< .5
9/13/95	1.6	< .02	.32	2.457	39	8	< 3	< 30	< .5

BOD - Biological Oxygen Demand

NH3 - Ammonia

NO3\NO2 - Nitrate Nitrite

COD - Chemical Oxygen Demand

T PO4 - Total Phosphorous

Pb - Lead

Cd - Cadmium

Cr - Chromium

Hg - Mercury

Pedestrian Bridge B (Mid Stream)

	BOD	NH3	NO3\NO2	T PO4	COD	Pb	Cd	Cr	Hg
Units	ppm	ppm	ppm	ppm	ppm	ppb	ppb	ppb	ppb
5/10/95									
5/22/95	< 1	< .02	.57	.065	22	< 5	9	52	< .5
6/14/95	1.9	< .02	.36	.161	13	8	4	< 30	< .5
6/21/95	1.1	< .02	.43	.140	< 5	< 5	< 3	< 30	< .5
7/12/95	1.3	< .02	.48	.037	< 5	9	< 3	34	< .5
7/19/95	< 1	< .02	.36	.184	5	< 5	5	< 30	< .5
7/26/95									
8/2/95									
8/9/95	2.5	.03	.68	.274	5	< 5	15	74	< .5
8/16/95	1.0	< .02	.62	.145	5	6	12	< 30	< .5
8/30/95	1.2	< .02	.34	.133	5	< 5	< 3	< 30	< .5
9/13/95									

BOD - Biological Oxygen Demand

NH3 - Ammonia

NO3\NO2 - Nitrate Nitrite

COD - Chemical Oxygen Demand

T PO4 - Total Phosphorous

Pb - Lead

Cd - Cadmium

Cr - Chromium

Hg - Mercury

Pedestrian Bridge C (EastBank)

	BOD	NH3	NO3\NO2	T PO4	COD	Pb	Cd	Cr	Hg
Units	ppm	ppm	ppm	ppm	ppm	ppb	ppb	ppb	ppb
5/10/95	3.2	.07	.56	.054	24	11	4	< 30	< .5
5/22/95	< 1	< .02	.54	.063	25	9	12	< 30	< .5
6/14/95	1.9	< .02	.39	.144	< 5	6	< 3	< 30	< .5
6/21/95	1.1	< .02	.44	.178	9	6	4	< 30	< .5
7/12/95	2.3	< .02	.47	.210	10	10	3	< 30	< .5
7/19/95	< 1	< .02	.40	.169	5	< 5	8	34	< .5
7/26/95	1.7	< .02	.36	.171	< 5	< 5	6	< 30	< .5
8/2/95	1.6	< .02	.30	.281	18	11	14	31	< .5
8/9/95	2.5	< .02	.76	.228	5	< 5	12	< 30	.5
8/16/95	< 1	< .02	.67	.270	5	5	11	< 30	< .5
8/30/95	< 1	.03	.43	.206	20	< 5	9	31	< .5
9/13/95	2.7	< .02	.38	.176	20	6	8	< 30	< .5

BOD - Biological Oxygen Demand

NH3 - Ammonia

NO3\NO2 - Nitrate Nitrite

COD - Chemical Oxygen Demand

T PO4 - Total Phosphorous

Pb - Lead

Cd - Cadmium

Cr - Chromium

Hg - Mercury

11th Street Storm Drain

	BOD	NH3	NO3\NO2	T PO4	COD	Pb	Cd	Cr	Hg
UNITS	ppm	ppm	ppm	ppm	ppm	ppb	ppb		ppb
5/10/95									
5/24/95									
6/14/95									
6/21/95									
7/12/95									
7/19/95									
7/26/95	< 1	.04	.92	.315	30	8	5	47	< .5
8/2/95	1.3	< .02	1.47	< .02	9	9	10	< 30	< .5
8/9/95									
8/16/95									
8/30/95									
9/13/95	1.5	< .02	.89	.167	4	17	< 3	33	.7

BOD - Biological Oxygen Demand

NH3 - Ammonia

NO3\NO2 - Nitrate Nitrite

COD - Chemical Oxygen Demand

T PO4 - Total Phosphoroue

Pb - Lead

Cd - Cadmium

Cr - Chromium

Hg - Mercury

21st Street Storm Drain

	BOD	NH3	NO3\NO2	T PO4	COD	Pb	Cd	Cr	Hg
Units	ppm	ppm	ppm	ppm	ppm	ppb	ppb	ppb	ppb
5/10/95									
5/22/95									
6/14/95									
6/21/95									
7/12/95									
7/19/95									
07/26/96	1.2	< .02	1.59	< .02	5	5	3	< 30	< .5
8/2/95	< 1	< .02	1.47	.047	< 5	< 5	10	34	< .5
8/9/95									
8/16/95									
8/30/95									
9/13/95	1.3	.02	.88	.031	39	33	11	< 30	< .5

BOD - Biological Oxygen Demand

NH3 - Ammonia

NO3\NO2 - Nitrate Nitrite

COD - Chemical Oxygen Demand

T PO4 - Total Phosphorous

Pb - Lead

Cd - Cadmium

Cr - Chromium

Hg - Mercury

26th Street Storm Drain

	BOD	NH3	NO3\NO2	T PO4	COD	Pb	Cd	Cr	HG
Units	ppm	ppm	ppm	ppm	ppm	ppb	ppb	ppb	ppb
5/10/95									
5/22/95									
6/14/95									
6/21/95									
7/12/95									
7/19/95									
07/26/96	2.4	< .02	.60	.385	8	24	6	< 30	< .5
8/2/95	1.8	.04	.49	.424	58	9	11	< 30	< .5
8/9/95									
8/16/95									
8/30/95									
9/13/95	3.9	.03	1.11	3.710	54	< 5	17	< 30	< .5

BOD - Biological Oxygen Demand

NH3 - Ammonia

NO3\NO2 - Nitrate Nitrite

COD - Chemical Oxygen Demand

T PO4 - Total Phosphorous

Pb - Lead

Cd - Cadmium

Cr - Chromium

Hg - Mercury

Indian Avenue Storm Drain

	BOD	NH3	NO3\NO2	T PO4	COD	Pb	Cd	CR	HG
Units	ppm	ppm	ppm	ppm	ppm	ppb	ppb	ppb	ppb
5.10.95									
5.22.95									
6/14/95									
6/21/95									
7/12/95									
7/19/95									
07/26/96	1.1	< .02	.45	.232	12	< 5	4	< 30	< .5
8/2/95	1.8	< .02	.39	.263	18	10	8	36	< .5
8/9/95									
8/16/95									
8/30/95									
9/13/95	1.8	< .02	1.98	.271	49	8	< 3	< 30	< .5

BOD - Biological Oxygen Demand

NH3 - Ammonia

NO3\NO2 - Nitrate Nitrite

COD - Chemical Oxygen Demand

T PO4 - Total Phosphorous

Pb - Lead

Cd - Cadmium

Cr - Chromium

Hg - Mercury

BACTERIOLOGICAL REPORT

FOR ZINK LAKE ON THE

ARKANSAS RIVER FOR 1996

PREPARED BY THE TULSA CITY/COUNTY

HEALTH DEPARTMENT

AUGUST, 1997

INTRODUCTION

In, 1996, water samples were collected in the Zink Lake area of the Arkansas River in accordance with the annual study required by the U.S. Army Corps of Engineers Permit for the low water dam. Samples were collected in order to characterize Bacterial contamination in this area. Three bridge sites (11th Street, 21st Street, Pedestrian) and four storm drains (11th Street, Indian Avenue, 21st Street, 26th Street) were again used as sampling locations. Samples were analyzed for both fecal coliform bacteria and fecal streptococcus bacteria. The Oklahoma Water Quality Standards (OWQS) developed by the Oklahoma Water Resources Board set forth desired bacterial standards to allow primary body contact recreation (swimming, etc.) in Oklahoma waters. Our results are compared to these standards. These bacterial contaminants are only a general indicator of contamination by human waste and do not necessarily mean someone would get ill from swimming in these areas.

In 1996, 234 river samples were collected along with 104 storm drain samples for a total of 338 samples collected during the five month study. 676 bacterial tests were run on these samples. The Oklahoma Water Quality Standards require that 5 sets of samples be collected within a 30 day period and this was achieved each month.

The OWQS require that the Geometric Mean of the counts should be calculated for each 30 day period. To meet the standard, the Geometric mean should not exceed a value of 200. In addition, the standard requires that no more than 10% of the samples exceed a total count of 400. Besides these standards, we have also calculated a "Fecal Coliform/Fecal Streptococcus Ratio." This gives us an indication of whether or not the source of contamination was human waste or animal waste. The results of the findings for each sampling location are discussed separately.

11^{TH} STREET BRIDGE

At this site, the Geometric Mean criterion was exceeded in 7 of 15 data sets. All three substations exceeded the Geometric Mean during the months of May and June. This data is much worse than what has been experienced in recent years. In 1995, the Geometric Mean was exceeded only once at this bridge site. The 400 colony count was exceeded in approximately 28% of the samples which is significantly higher than the allowable 10% limit. The percentages of samples exceeding this limit was double the amount of last year's samples. The range in values at this site was 9-72,000 for fecal coliform and the range was 9-120,000 for fecal streptococcus. The 'FC/FS Ratio" indicated that 90% (70/78) of the contamination was caused by animal wastes. The ratio indicated that in 2 of the samples the likely source was human waste. As was mentioned earlier, May and June were the worst months for this site. 6 of the 7 exceedances of the Geometric Mean occurred during those months as well as 16 of the 22 exceedances of the 400 count criterion. The other 3 months of the study had relatively few problems. As has been the case in the past, the east bank station yielded the worst data due to the influence of the 11^{th} street storm drain. However, we also experienced much more contamination at the mid-channel station than is normally the case. We are not cognizant of any particular reason why the results at this site were so much worse than in previous years.

21^{st} Street Bridge

The Geometric Mean criterion was exceeded in 4 of the 15 data sets. This criterion was exceeded only once in 1995. All 4 exceedances occurred in the months of May and June with two occurring on the east bank and two occurring on the west bank. The 400 colony count was exceeded in approximately 28% of the samples (22/78) and this greatly exceeds the 10% allowable limit. The percentage of samples exceeding the limit in 1995 was 17%. The range of values for fecal coliform at this site was 9-61,000. The range of values for fecal streptococcus was 9-38,000. The 'FC/FS Ratio" indicated that 83% (65/78) of the contamination was caused by animal waste. However, it also indicated that in 8 of the samples, the contamination might be correlated with human waste. This is by far the largest number of samples in which we have ever encountered such a correlation. As with the first bridge site, the months of May and June produced the worst data for this site. All exceedances of the Geometric Mean and 16 of the 22 exceedances of the 400 colony count occurred during these months. The east bank station yielded the worst data, reflecting the influence of both the 11^{th} Street and Indian Avenue storm drains. The mid-channel station at this site yielded few violations as compared to the mid-channel station at the 11^{th} Street Bridge.

Pedestrian Bridge

The Geometric Mean criterion was exceeded in 3 of the 15 data sets. These all occurred in the month of June at all 3 substations. The 400 colony count criterion was exceeded in approximately 17% of the samples. This was about the same percentage as encountered in 1995. The range of values was 9-27,000 for fecal coliform and 9-23,000 for fecal streptococcus. These values were much higher than those encountered in 1995. The 'FC/FS' Ratio" indicated that in 86% of the samples, the contamination was caused by animal sources. Only 2 samples indicated that the contamination source was primarily of human origin. June was by far the worst month for this station since all 3 Geometric Mean exceedances and 11 of 13 exceedances of the 400 colony count occurred during this month. In general, the east bank station was the worst sampling point since it yielded virtually the highest Geometric Mean calculation of all 3 substations. In general, this station normally has the least number of violations of any type because much of the bacterial contaminants have been diluted out due to better mixing with the river flow.

Storm Drains

Only four of the many storm drains that enter the Arkansas River are studied in this project. These are the 11th Street, Indian Avenue, 21st Street and 26th Street storm drains. These four are studied mainly because they are the largest that drain the downtown areas along the river and because they produce a constant low water flow even when it isn't raining. The data shows that on some occasions, the bacterial counts can be extremely high in the storm drains. The range of values for the storm drains were:

11th Street Storm Drain	
Fecal Coliform	9-110,000
Fecal Streptococcus	30-270,000
Indiana Avenue Storm Drain	
Fecal Coliform	70-110,000
Fecal Streptococcus	110-260,000
21st Street Storm Drain	
Fecal Coliform	9-99,000
Fecal Streptococcus	36-98,000
26th Street Storm Drain	
Fecal Coliform	180-96,000
Fecal Streptococcus	590-60,000

As can be seen from this data, some fecal coliform counts are very high especially when compared to in-stream values. This seems to indicate that at least some human generated sewage is entering the storm drainage system from time to time. Compared to the 1995 data, it is also apparent that fecal streptococcus counts were significantly higher for 1996.

The "Fecal Coliform/ Fecal Streptococcus Ratio" indicates that in 78% of the storm drain samples, the contamination is mainly caused by animal waste. The ratio also indicated that in only six of the 104 samples could the contamination be related to mainly human waste. For the most part, the highest values were found in May and June and extended through mid-July. This corresponds well with the exceedances of the Geometric Mean in the river samples. On average, fecal streptococcus values were much higher over this same period. While fecal coliform numbers were roughly the same for all 4 storm drains, fecal streptococcus numbers greatly increased in the 11th Street and Indian Avenue storm drainages.

DISCUSSION

The Arkansas River flowing through the metropolitan Tulsa area has been categorized as a "Primary Body Contact" recreational usage area by the Oklahoma Water Quality Standards. This means that the water should be fit for swimming, wading, boating, etc., and that the water quality should meet the highest standards set forth in the OWQS. As has been the case in every year since the study began in 1983, the bacterial water quality of the Arkansas River could not measure up to the criterion set forth in the OWQS. However, the 1996 data yielded some dramatic results when compared to that of recent years. In 1995, the Geometric Mean criterion was exceeded in a total of 5 of 45 data sets. In 1994 it was 10 of 45 data sets and it was 11 of 45 data sets in 1993. In 1996, 14 of 45 dates sets exceeded the Geometric Mean criterion. In 1995, the "FC/FS Ratio" indicated that in only 4 samples could the source be considered as human waste. In 1996, that number jumped to 12 in-stream samples. Obviously it appears that bacterial contamination of the river may be worsening. While the storm drains sampled in this study obviously have a strong effect on the east bank of the river, it is also apparent that other unknown and unsampled sources also contribute bacteria to the river. The Geometric Mean exceedances at the west bank and mid-river stations of the 11st Street bridge are an indication of unknown upstream sources since they are not effected by the 11th Street storm drain.

Bacterial contamination of the river is caused by "non-point" sources because it comes from a widespread, geographical area that includes many varied sources. Bacteria are contributed by pastureland, farmland, storm water discharges, illicit sanitary sewer connections and other varied sources. Since bacterial contamination is such a pervasive problem, it will be a difficult task to reduce the sources of contamination and achieve the criterion of the OWQS.

BACTERIOLOGICAL WATER QUALITY
OF THE ARKANSAS RIVER AT ZINK LAKE
MAY - SEPTEMBER 1996

11TH STREET BRIDGE (OAO2O)

	WEST BANK (A)			MID CHANNEL (B)			EAST BANK (C)		
DATE	FC	FS	FC/FS	FC	FS	FC/FS	FC	FS	FC/FS
05/06/96	2500	2300	1.09	2100	2900	0.72	340	460	0.74
05/08/96	340	100	3.40	63	81	0.78	460	370	1.24
05/13/96	290	190	1.53	80	69	1.16	340	890	0.38
05/15/96	720	420	1.71	80	50	1.60	190	270	0.70
05/22/96	2800	260	10.77	2500	57	43.86	450	230	1.96
G MEAN	869.48			291.83			340.04		
DATE	FC	FS	FC/FS	FC	FS	FC/FS	FC	FS	FC/FS
06/03/96	4300	19000	0.23	330	230	1.43	16000	15000	1.07
06/12/96	10	54	0.19	30	10	3.00	27	36	0.75
06/17/96	130	140	0.93	140	300	0.47	30000	6200	4.84
06/19/96	6600	5600	1.18	13000	13000	1.00	72000	55000	1.31
06/24/96	42000	33000	1.27	620	1300	0.48	34000	120000	0.28
06/26/96	20	850	0.02	140	350	0.40	10	1600	0.01
G MEAN	560.45			340.70			2611.58		
DATE	FC	FS	FC/FS	FC	FS	FC/FS	FC	FS	FC/FS
07/01/96	72	1800	0.04	30	2500	0.01	160	7200	0.02
07/08/96	30	2200	0.01	20	930	0.02	470	330	1.42
07/10/96	300	790	0.38	1300	800	1.63	4300	3500	1.23
07/15/96	10	160	0.06	70	140	0.50	6800	180	37.78
07/17/96	30	140	0.21	150	90	1.67	50	150	0.33
G MEAN	45.47			96.09			643.03		
DATE	FC	FS	FC/FS	FC	FS	FC/FS	FC	FS	FC/FS
08/05/96	190	160	1.19	320	80	4.00	550	470	1.17
08/13/96	9	9	1.00	9	20	0.45	9	20	0.45
08/19/96	9	10	0.90	10	10	1.00	70	250	0.28
08/21/96	20	30	0.67	20	20	1.00	150	230	0.65
08/28/96	10	40	0.25	20	54	0.37	230	540	0.43
G MEAN	19.85			25.84			103.63		
DATE	FC	FS	FC/FS	FC	FS	FC/FS	FC	FS	FC/FS
09/04/96	10	20	0.50	20	9	2.22	20	50	0.40
09/09/96	9	80	0.11	9	80	0.11	10	3800	0.00
09/16/96	200	180	1.11	410	560	0.73	15000	1900	7.89
09/18/96	9	180	0.05	10	120	0.08	80	100	0.80
09/30/96	20	340	0.06	9	140	0.06	9	220	0.04
G MEAN	20.05			23.15			73.60		

FC = FECAL COLIFORM
FS = FECAL STREPTOCOCCUS
FC/FS = FECAL COLIFORM / FECAL STREPTOCOCCUS RATIO
G MEAN = GEOMETRIC MEAN

BACTERIOLOGICAL WATER QUALITY
OF THE ARKANSAS RIVER AT ZINK LAKE
MAY - SEPTEMBER 1996

21ST STREET BRIDGE (OAOO6)

	WEST BANK (A)			MID CHANNEL (B)			EAST BANK (C)		
DATE	FC	FS	FC/FS	FC	FS	FC/FS	FC	FS	FC/FS
05/06/96	130	120	1.08	3700	2300	1.61	43000	37000	1.16
05/08/96	420	100	4.20	54	36	1.50	700	200	3.50
05/13/96	64	23	2.78	47	29	1.62	460	580	0.79
05/15/96	280	400	0.70	130	140	0.93	570	400	1.43
05/22/96	3500	190	18.42	120	80	1.50	3900	310	12.58
G MEAN	321.31			171.07			1984.51		
DATE	FC	FS	FC/FS	FC	FS	FC/FS	FC	FS	FC/FS
06/03/96	4100	1600	2.56	440	260	1.69	25000	21000	1.19
06/12/96	20	10	2.00	10	40	0.25	81	160	0.51
06/17/96	170	240	0.71	230	80	2.88	55000	2200	25.00
06/19/96	8800	9700	0.91	8200	9800	0.84	61000	38000	1.61
06/24/96	390	580	0.67	10	1400	0.01	2200	3500	0.63
06/26/96	30	380	0.08	10	610	0.02	260	2300	0.11
G MEAN	335.86			96.94			3965.08		
DATE	FC	FS	FC/FS	FC	FS	FC/FS	FC	FS	FC/FS
07/01/96	150	1400	0.11	45	1300	0.03	80	5500	0.01
07/08/96	20	800	0.03	200	190	1.05	5200	5200	1.00
07/10/96	60	600	0.10	3400	450	7.56	5700	720	7.92
07/15/96	60	81	0.74	20	10	2.00	20	40	0.50
07/17/96	60	10	6.00	9	30	0.30	170	100	1.70
G MEAN	57.85			88.76			381.32		
DATE	FC	FS	FC/FS	FC	FS	FC/FS	FC	FS	FC/FS
08/05/96	45	27	1.67	1200	63	19.05	450	480	0.94
08/14/96	9	9	1.00	9	9	1.00	9	90	0.10
08/19/96	20	50	0.40	9	10	0.90	30	20	1.50
08/21/96	9	20	0.45	9	9	1.00	9	150	0.06
08/28/96	10	10	1.00	40	50	0.80	260	470	0.55
G MEAN	14.88			32.27			49.06		
DATE	FC	FS	FC/FS	FC	FS	FC/FS	FC	FS	FC/FS
09/04/96	9	60	0.15	9	10	0.90	10	150	0.07
09/09/96	9	50	0.18	9	40	0.23	20	70	0.29
09/16/96	2700	220	12.27	60	220	0.27	310	1800	0.17
09/18/96	40	150	0.27	100	90	1.11	80	260	0.31
09/30/96	9	230	0.04	9	220	0.04	50	230	0.22
G MEAN	37.95			21.29			47.74		

FC = FECAL COLIFORM
FS = FECAL STREPTOCOCCUS
FC/FS = FECAL COLIFORM / FECAL STREPTOCOCCUS RATIO
G MEAN = GEOMETRIC MEAN

BACTERIOLOGICAL WATER QUALITY
OF THE ARKANSAS RIVER AT ZINK LAKE
MAY - SEPTEMBER 1996

PEDESTRIAN BRIDGE (OAOO5)

	WEST BANK (A)			MID CHANNEL (B)			EAST BANK (C)		
DATE	FC	FS	FC/FS	FC	FS	FC/FS	FC	FS	FC/FS
05/06/96	9	18	0.50	36	9	4.00	81	100	0.81
05/08/96	130	64	2.03	96	32	3.00	270	470	0.57
05/13/96	63	430	0.15	75	57	1.32	58	39	1.49
05/15/96	140	210	0.67	210	110	1.91	230	260	0.88
05/22/96	340	58	5.86	110	61	1.80	170	110	1.55
G MEAN	81.10			90.25			137.75		
DATE	FC	FS	FC/FS	FC	FS	FC/FS	FC	FS	FC/FS
06/03/96	4900	6000	0.82	3400	5600	0.61	5800	3500	1.66
06/12/96	30	10	3.00	10	20	0.50	30	50	0.60
06/17/96	600	280	2.14	680	340	2.00	320	220	1.45
06/19/96	3500	2100	1.67	16000	19000	0.84	27000	23000	1.17
06/24/96	630	380	1.66	11000	8300	1.33	4800	5300	0.91
06/26/96	70	100	0.70	60	250	0.24	72	740	0.10
G MEAN	488.65			790.57			896.62		
DATE	FC	FS	FC/FS	FC	FS	FC/FS	FC	FS	FC/FS
07/01/96	36	1800	0.02	72	1400	0.05	63	7400	0.01
07/08/96	10	140	0.07	250	590	0.42	300	310	0.97
07/10/96	340	2200	0.15	70	1200	0.06	660	870	0.76
07/15/96	9	10	0.90	9	10	0.90	20	9	2.22
07/17/96	72	40	1.80	250	20	12.50	36	81	0.44
G MEAN	38.01			77.72			97.87		
DATE	FC	FS	FC/FS	FC	FS	FC/FS	FC	FS	FC/FS
08/05/96	30	10	3.00	9	20	0.45	63	90	0.70
08/14/96	9	10	0.90	9	10	0.90	10	10	1.00
08/19/96	10	9	1.11	9	10	0.90	10	36	0.28
08/21/96	9	10	0.90	9	9	1.00	20	50	0.40
08/28/96	20	20	1.00	20	36	0.56	380	200	1.90
G MEAN	13.72			10.56			34.36		
DATE	FC	FS	FC/FS	FC	FS	FC/FS	FC	FS	FC/FS
09/04/96	9	10	0.90	9	10	0.90	10	10	1.00
09/09/96	20	110	0.18	9	20	0.45	60	20	3.00
09/16/96	480	210	2.29	150	150	1.00	210	390	0.54
09/18/96	200	150	1.33	63	72	0.88	30	210	0.14
09/30/96	9	230	0.04	9	190	0.05	40	250	0.16
G MEAN	43.49			23.31			43.24		

FC = FECAL COLIFORM
FS = FECAL STREPTOCOCCUS
FC/FS = FECAL COLIFORM / FECAL STREPTOCOCCUS RATIO
G MEAN = GEOMETRIC MEAN

BACTERIOLOGICAL REPORT
FOR ZINK LAKE ON THE
ARKANSAS RIVER FOR 1997

PREPARED BY THE TULSA CITY/COUNTY
HEALTH DEPARTMENT

APRIL, 1998

INTRODUCTION

In 1997, water samples were collected in the Zink Lake area of the Arkansas River in accordance with the annual study required by the U. S. Army Corps of Engineers Permit for the low water dam. The samples were collected in order to characterize bacterial contamination in this area of the river. Three bridge sites (11th Street, 21st Street, Pedestrian) were sampled along with four storm drain sites (11th Street, Indian Avenue, 21st Street, 26th Street). Each bridge site had 3 sampling points, the east and west banks along with a mid-stream substation. Samples were analyzed for both fecal coliform bacteria as well as fecal streptococcus bacteria.

The Oklahoma Water Quality Standards (OWQS) developed by the Oklahoma Water Resources Board set forth desired bacterial standards to allow primary body contact recreation (swimming, wading, etc.) in Oklahoma waters. Our results are compared to these standards. While we have always had trouble meeting the bacterial water quality standards, it does not necessarily mean someone would get ill from swimming in these areas.

In 1997, 225 river samples were collected during the 5 month sampling period. A total of 450 bacterial analyses were performed on these samples. In addition, a total of 92 samples were collected from the 4 storm drains and 184 analyses were performed on these samples. The Oklahoma Water Quality Standards require that a set of 5 samples be collected at each site during a 30 day period and this requirement was achieved each month.

The OWQS require that the Geometric Mean of the counts be calculated for each 30 day period. To meet the standard, the Geometric Mean should not exceed a value of 200. In addition, the standard requires that no more than 10% of the samples exceed a count of 400. These standards only apply to the in-stream (river) samples and do not apply to the storm drains. Besides these standards, we have also calculated a "Fecal Coliform/ Fecal Streptococcus Ratio". This gives us an indication of whether or not the source of contamination is more likely to be from human waste or from animal waste. An "FC/FS Ratio" of 2 or less implies that contamination is primarily of animal origin. An "FC/FS Ratio" of 5 or greater implies that the source of contamination is mainly human waste. Values in between the two numbers are considered to be inconclusive as an indicator. The results of the findings for each sampling location will be discussed separately.

11th Street Bridge

For the first time since the inception of this study (1983) there where no exceedances of the Geometric Mean criterion at this sampling site. This means that all 15 data sets had Geometric Means less than 200. This is somewhat remarkable since the 1996 results were some of the worst ever encountered. Only 4% of the samples exceeded the 400 count criteria. The range of fecal coliform values was 9-3,000. The range of fecal streptococcus values was 9-22,000. These values are extremely low when compared to previous years' data. The "FC/FS Ratio" indicated that in 4% of the samples the contamination could be attributed to human sewage. On the other hand, it appears that animal waste contributed most of the contamination in 88% of the samples. As in past years, the east bank station proved to be the most troublesome sampling point, mainly due to the influence of the 11th Street storm drain.

21st Street Bridge

As with the 11th Street Bridge, the Geometric Mean criterion was not exceeded in any of the 15 data sets obtained in 1997. This is the first time this has ever occurred at this station also. The 400 count criterion was exceeded in 4% of the samples, the same result encountered at the 11st Street Bridge. The range of values for fecal coliform was 9-4,800 while the range for fecal streptococcus was 9-9,500. These values are all fairly low when compared to past years. The " FC/FS Ratio" indicates that the contamination was most likely related to human waste in only 4% of the samples. Animal wastes appeared to be the major contributing factor in 87% of the samples. In general, the east bank station was the worst sampling point although the highest fecal coliform and fecal streptococcus readings were obtained from the mid-stream station (on the same day).

Pedestrian Bridge

The Geometric Mean criterion was exceeded once in the 15 data sets obtained from this site. The actual value was 218.49. This was the only time the criterion was exceeded during the 1997 sampling period. The exceedance occurred in June and was located at the east bank station. Overall however, the data was pretty benign for this site also. The 400 count criterion was exceeded in only 4% of the samples. This was exactly the same results as at the other two bridge sites. The range of values for fecal coliform were 9-3,500 and the range of values for fecal streptococcus was 9-11,000. These numbers are also generally lower than those that have been encountered in the past. The "FC/FS Ratio" indicates that the contamination was most likely contributed by human waste in 8% of the samples. This is twice the occurrence at the other two bridge sites. In addition, most of these occurrences were at the west bank station and three of them occurred on the same day (6-2-97). It would appear likely that on that date, human derived wastewater had been released to the river, possibly from one of the storm drains. All three bridge sites exhibited high ratios on that date which might indicate that the unknown source might have been upstream from Tulsa. The "FC/FS Ratio" also indicated that the main contributory source was animal waste in 81% of the samples. In general, the east bank station yielded the highest values. This is due to the influence of the major storm drains.

Storm Drains

Four major urban storm drains are sampled for this study. These are the 11th Street, Indian Avenue, 21st Street and 26th Street storm drains. These drains are used because, besides conveying stormwater flows from the downtown Tulsa area, they also produce a constant 24 hours a day low flow from various sources. Some of these sources contribute highly to the bacterial counts in these drains. This low water flow is generated from activities such as car washes, lawn watering, external cleaning operations, broken and illicit sewer line connections, and other varied sources. The range of values for the storm drains were:

11 Street Storm Drain	
Fecal Coliform	10-52,000
Fecal Streptococcus	20-100,000
Indian Avenue Storm Drain	
Fecal Coliform	9-130,000
Fecal Streptococcus	9-150,000
21st Street Storm Drain	
Fecal Coliform	10-47,000
Fecal Streptococcus	110-160,000
26th Street Storm Drain	
Fecal Coliform	130-1,100,000
Fecal Streptococcus	120-260,000

As can be seen from the data, some fecal coliform counts are very high especially when compared to in-stream values. In fact, we encountered the highest fecal coliform count ever on May 6, 1997. This was the 1,100,000 count at the 26th Street storm drain. That same sample also yielded the highest fecal streptococcus count for the study period (260,000). While the specific source of these high bacterial counts could not specifically be determined, this is a good example of what the City of Tulsa faces in trying to reduce bacterial contamination of the river. The "FC/FS Ratio" indicated that in only 4 of the 92 samples could the contamination be related to human sources of sewage. Conversely, 84% of the samples (77/92) indicated that the main contributory factor was animal wastes. While the range of storm drain values is very wide, an arbitrary value of a 10,000 colony count was chosen to exhibit another point. Using this value, we see that only 15% of the samples exceeded this figure (14/92). When we look at this value for each storm drain, we see that it was exceeded 8 of the 14 times (57%) at the 26th Street storm drain. Obviously it appears that the 26th Street storm drainage area added much of the bacterial contamination problem to the Arkansas River during 1997.

DISCUSSION

For the most part, the 1997 data appears to be improved compared to previous years. Only one sample in 45 data sets exceeded the Geometric Mean criterion of 200. None of the sites had 10% of the samples exceed the 400 count criterion. These are virtually the best results we've had since the inception of the study. The real question, therefore, is whether or not this data reflects a real improvement in conditions or has some other explanation for the results. While we would like to think that the number reflects an improvement in overall water quality, there are reasons to be skeptical. First and foremost of these is that the contributory sources of bacterial contamination are basically unchanged. The storm drains and other stormwater outflows are still there. Bacterial counts for the storm drains, although somewhat lower, still yield the occasional astronomical count. The City of Tulsa, while striving to detect and prevent sanitary waste from entering the storm drainage system, has not been able to detect and remove all of these sources as of yet. In addition, many upstream sources have no control measures whatsoever. In addition, the "Fecal Coliform/Fecal Streptococcus Ratio" on June 2, 1997 indicated that the river received a slug of untreated sewage from some source upstream of Tulsa. A possible source might be a by-pass condition at the Sand Springs sewage treatment plant due to a malfunction. There could be various other sources, too. Since we know, in general, that stormwater flow to the river is generally on the increase (more and more land is built upon) and we know the increased volume carries more nutrients and bacteria into the river, how can we explain the more innocuous results of 1997? It can probably be related to two main factors. These are high river flows and pure chance. The river had higher than average flows for a longer period of time. This tends to dilute the samples that are collected. In addition, while the sampling protocol meets the requirements of the Oklahoma Water Quality Standards, we are in reality sampling only a very tiny amount of the volume of the water flowing in the river day in and day out. Chance alone would dictate that we are not truly getting a real view of the daily water quality problems in the Arkansas River. Barring excessive rains, I would fully expect the results to return to more normal levels in 1998.

BACTERIOLOGICAL WATER QUALITY
OF THE ARKANSAS RIVER AT ZINK LAKE
MAY - SEPTEMBER 1997

11TH STREET BRIDGE (OAO2O)

	WEST BANK (A)			MID CHANNEL (B)			EAST BANK (C)		
DATE	FC	FS	FC/FS	FC	FS	FC/FS	FC	FS	FC/FS
05/06/97	18	18	1.00	9	10	0.90	10	54	0.19
05/07/97	81	27	3.00	10	18	0.56	10	72	0.14
05/13/97	9	10	0.90	9	27	0.33	100	63	1.59
05/14/97	45	9	5.00	9	9	1.00 *	18	9	2.00
05/20/97	100	150	0.67	18	18	1.00	370	300	1.23
G MEAN	35.83			10.56			36.70		
DATE	FC	FS	FC/FS	FC	FS	FC/FS	FC	FS	FC/FS
06/02/97	130	10	13.00	170	9	18.89	170	54	3.15
06/04/97	10	9	1.11	10	27	0.37	10	45	0.22
06/11/97	10	54	0.19	160	130	1.23	100	72	1.39
06/16/97	1900	4300	0.44	30	40	0.75	36	20	1.80
06/18/97	110	72	1.53	9	9	1.00	180	220	0.82
G MEAN	77.06			37.43			64.33		
DATE	FC	FS	FC/FS	FC	FS	FC/FS	FC	FS	FC/FS
07/07/97	10	30	0.33	9	9	1.00	10	45	0.22
07/15/97	10	30	0.33	9	10	0.90	9	40	0.23
07/16/97	280	790	0.35	10	10	1.00	1600	490	3.27
07/22/97	40	50	0.80	30	140	0.21	20	110	0.18
07/23/97	50	70	0.71	10	72	0.14	10	60	0.17
G MEAN	35.45			11.94			31.04		
DATE	FC	FS	FC/FS	FC	FS	FC/FS	FC	FS	FC/FS
08/06/97	9	30	0.30	9	9	1.00	9	10	0.90
08/12/97	9	270	0.03	9	260	0.03	9	240	0.04
08/13/97	10	20	0.50	9	40	0.23	30	330	0.09
08/19/97	220	1300	0.17	20	160	0.13	3000	22000	0.14
08/20/97	20	180	0.11	9	20	0.45	60	310	0.19
G MEAN	20.44			10.56			53.48		
DATE	FC	FS	FC/FS	FC	FS	FC/FS	FC	FS	FC/FS
09/03/97	10	20	0.50	9	20	0.45	20	90	0.22
09/08/97	20	9	2.22	9	20	0.45	80	80	1.00
09/10/97	10	10	1.00	10	3400	0.00	150	300	0.50
09/15/97	10	120	0.08	10	50	0.20	20	50	0.40
09/30/97	60	30	2.00	40	9	4.44	120	30	4.00
G MEAN	16.44			12.65			56.50		

FC = FECAL COLIFORM
FS = FECAL STREPTOCOCCUS
FC/FS = FECAL COLIFORM / FECAL STREPTOCOCCUS RATIO
G MEAN = GEOMETRIC MEAN

BACTERIOLOGICAL WATER QUALITY
OF THE ARKANSAS RIVER AT ZINK LAKE
MAY - SEPTEMBER 1997

21ST STREET BRIDGE (OAOO6)

	WEST BANK (A)			MID CHANNEL (B)			EAST BANK (C)		
DATE	FC	FS	FC/FS	FC	FS	FC/FS	FC	FS	FC/FS
05/06/97	54	36	1.50	27	18	1.50	36	110	0.33
05/07/97	18	10	1.80	10	18	0.56	45	210	0.21
05/13/97	10	36	0.28	10	10	1.00	63	54	1.17
05/14/97	23	9	2.56	9	18	0.50	10	10	1.00
05/20/97	72	27	2.67	45	9	5.00	63	81	0.78
G MEAN	27.63			16.13			36.45		
DATE	FC	FS	FC/FS	FC	FS	FC/FS	FC	FS	FC/FS
06/02/97	100	9	11.11	110	81	1.36	190	27	7.04
06/04/97	9	10	0.90	18	10	1.80	36	36	1.00
06/11/97	18	10	1.80	91	27	3.37	9	18	0.50
06/16/97	10	40	0.25	4800	9500	0.51	290	950	0.31
06/18/97	120	81	1.48	10	10	1.00	270	510	0.53
G MEAN	28.69			97.14			86.42		
DATE	FC	FS	FC/FS	FC	FS	FC/FS	FC	FS	FC/FS
07/07/97	20	54	0.37	30	9	3.33	20	90	0.22
07/15/97	10	36	0.28	9	9	1.00	20	30	0.67
07/16/97	310	1700	0.18	10	70	0.14	1800	5400	0.33
07/22/97	10	72	0.14	20	80	0.25	20	50	0.40
07/23/97	40	91	0.44	30	50	0.60	50	70	0.71
G MEAN	30.12			17.45			59.08		
DATE	FC	FS	FC/FS	FC	FS	FC/FS	FC	FS	FC/FS
08/06/97	9	50	0.18	9	10	0.90	10	9	1.11
08/12/97	9	320	0.03	9	400	0.02	9	160	0.06
08/13/97	9	210	0.04	9	40	0.23	30	60	0.50
08/19/97	60	560	0.11	40	100	0.40	2500	4500	0.56
08/20/97	10	210	0.05	9	10	0.90	30	430	0.07
G MEAN	13.43			12.13			45.84		
DATE	FC	FS	FC/FS	FC	FS	FC/FS	FC	FS	FC/FS
09/03/97	9	20	0.45	9	9	1.00	60	1600	0.04
09/08/97	40	40	1.00	9	10	0.90	60	50	1.20
09/10/97	20	20	1.00	9	20	0.45	130	30	4.33
09/15/97	20	140	0.14	9	9	1.00	110	70	1.57
09/30/97	50	20	2.50	40	10	4.00	110	70	1.57
G MEAN	23.52			12.13			89.25		

FC = FECAL COLIFORM
FS = FECAL STREPTOCOCCUS
FC/FS = FECAL COLIFORM / FECAL STREPTOCOCCUS RATIO
G MEAN = GEOMETRIC MEAN

BACTERIOLOGICAL WATER QUALITY
OF THE ARKANSAS RIVER AT ZINK LAKE
MAY - SEPTEMBER 1997

PEDESTRIAN BRIDGE (OAOO5)

	WEST BANK (A)			MID CHANNEL (B)			EAST BANK (C)		
DATE	FC	FS	FC/FS	FC	FS	FC/FS	FC	FS	FC/FS
05/06/97	260	54	4.81	36	9	4.00	340	280	1.21
05/07/97	36	63	0.57	9	18	0.50	18	230	0.08
05/13/97	54	10	5.40	10	18	0.56	120	27	4.44
05/14/97	10	9	1.11	9	9	1.00	9	9	1.00
05/20/97	110	10	11.00	18	9	2.00	36	72	0.50
G MEAN	56.11			13.93			47.35		
DATE	FC	FS	FC/FS	FC	FS	FC/FS	FC	FS	FC/FS
06/02/97	130	10	13.00	2600	280	9.29	190	27	7.04
06/04/97	10	27	0.37	27	18	1.50	260	250	1.04
06/11/97	18	9	2.00	27	10	2.70	9	9	1.00
06/16/97	9	54	0.17	9	20	0.45	3500	11000	0.32
06/18/97	70	9	7.78	10	27	0.37	320	520	0.62
G MEAN	27.15			44.30			218.49		
DATE	FC	FS	FC/FS	FC	FS	FC/FS	FC	FS	FC/FS
07/07/97	9	9	1.00	9	9	1.00	60	200	0.30
07/15/97	9	9	1.00	9	9	1.00	40	50	0.80
07/16/97	390	720	0.54	10	40	0.25	2400	3900	0.62
07/22/97	40	63	0.63	20	40	0.50	40	110	0.36
07/23/97	10	100	0.10	10	100	0.10	10	100	0.10
G MEAN	26.32			11.01			74.56		
DATE	FC	FS	FC/FS	FC	FS	FC/FS	FC	FS	FC/FS
08/06/97	9	20	0.45	9	10	0.90	9	50	0.18
08/12/97	9	480	0.02	9	40	0.23	9	1600	0.01
08/13/97	10	40	0.25	10	20	0.50	9	30	0.30
08/19/97	20	210	0.10	20	50	0.40	240	3200	0.08
08/20/97	10	100	0.10	9	20	0.45	10	460	0.02
G MEAN	11.01			10.78			17.73		
DATE	FC	FS	FC/FS	FC	FS	FC/FS	FC	FS	FC/FS
09/03/97	9	20	0.45	9	40	0.23	20	200	0.10
09/08/97	9	9	1.00	9	20	0.45	380	110	3.45
09/10/97	70	9	7.78	9	9	1.00	50	40	1.25
09/15/97	9	50	0.18	20	10	2.00	130	70	1.86
09/30/97	90	30	3.00	80	20	4.00	100	1100	0.09
G MEAN	21.50			16.34			86.85		

FC = FECAL COLIFORM
FS = FECAL STREPTOCOCCUS
FC/FS = FECAL COLIFORM / FECAL STREPTOCOCCUS RATIO
G MEAN = GEOMETRIC MEAN

BACTERIOLOGICAL WATER QUALITY
OF STORM DRAINS
MAY - SEPTEMBER 1997

	11TH ST STORM DRAIN OK 022			INDIAN AVE. STORM DRAIN OK 003			21ST ST STORM DRAIN OK 008			26TH ST STORM DRAIN OK		
DATE	FC	FS	FC/FS	FC	FS	FC/FS	FC	FS	FC/FS	FC	FS	FC/FS
05/06/97	750	460	1.63	45	170	0.26	1300	600	2.17	1100000	260000	4.23
05/07/97	350	630	0.56	330	1500	0.22	420	590	0.71	10000	8100	1.23
05/13/97	240	650	0.37	9	9	1.00	54	600	0.09	36000	3200	11.25
05/14/97	560	570	0.98	81	320	0.25	45	110	0.41	510	120	4.25
05/20/97	490	460	1.07	9	10	0.90	320	340	0.94	6800	3400	2.00
DATE	FC	FS	FC/FS	FC	FS	FC/FS	FC	FS	FC/FS	FC	FS	FC/FS
06/02/97	970	210	4.62	2600	280	9.29	210	100	2.10	19000	4500	4.22
06/04/97	100	220	0.45	290	400	0.73	400	460	0.87	5400	11000	0.49
06/11/97	18000	15000	1.20	500	250	2.00	440	380	1.16	3900	2500	1.56
06/16/97	52000	100000	0.52	10000	21000	0.48	47000	84000	0.56	22000	40000	0.55
06/18/97	320	370	0.86	460	1500	0.31	220	390	0.56	5700	4000	1.43
DATE	FC	FS	FC/FS	FC	FS	FC/FS	FC	FS	FC/FS	FC	FS	FC/FS
07/07/97	140	220	0.64	81	170	0.48	130	150	0.87	7500	11000	0.68
07/15/97	110	120	0.92	54	54	1.00	30	150	0.20	1200	390	3.08
07/16/97	3100	2000	1.55	2600	4100	0.63	1900	1700	1.12	28000	5800	4.83
DATE	FC	FS	FC/FS	FC	FS	FC/FS	FC	FS	FC/FS	FC	FS	FC/FS
08/06/97	190	780	0.24	9	10	0.90	160	690	0.23	130	6200	0.02
08/12/97	10	18000	0.00	30	14000	0.00	20	14000	0.00	620	5500	0.11
08/13/97	80	490	0.16	450	900	0.50	90	800	0.11	620	7400	0.08
08/19/97	2300	69000	0.03	130000	150000	0.87	25000	160000	0.16	13000	73000	0.18
08/20/97	720	9200	0.08	10	950	0.01	2800	13000	0.22	6700	3000	2.23
DATE	FC	FS	FC/FS	FC	FS	FC/FS	FC	FS	FC/FS	FC	FS	FC/FS
09/03/97	40	370	0.11	900	4700	0.19	10	320	0.03	900	500	1.80
09/08/97	660	1400	0.47	350	390	0.90	1000	1500	0.67	1600	7100	0.23
09/10/97	410	20	20.50	230	380	0.61	2600	3000	0.87	1600	2400	0.67
09/15/97	1000	490	2.04	400	470	0.85	700	390	1.79	1700	600	2.83
09/30/97	1700	920	1.85	110	280	0.39	900	1500	0.60	29000	2300	12.61

NA = NO SAMPLE
FC = FECAL COLIFORM
FS = FECAL STREPTOCOCCUS
FC/FS = FECAL COLIFORM / FECAL STREPTOCOCCUS RATIO

BACTERIOLOGICAL REPORT
FOR ZINK LAKE ON THE
ARKANSAS RIVER FOR 1998

PREPARED BY THE TULSA CITY/COUNTY

HEALTH DEPARTMENT

APRIL, 1999

INTRODUCTION

In 1998, water samples were collected in the Zink Lake area of the Arkansas River in accordance with the annual study required by the U. S. Army Corps of Engineers Permit for the low water dam. The samples were collected in order to characterize bacterial contamination in this area of the river. Three bridge sites (11th Street, 21st Street, Pedestrian) were sampled along with four storm drain sites (11th Street, Indian Avenue, 21st Street, 26th Street). Each bridge site had 3 sampling points, the east and west banks along with a mid-stream substation. Samples were analyzed for both fecal coliform bacteria as well as fecal streptococcus bacteria.

The Oklahoma Water Quality Standards (OWQS) developed by the Oklahoma Water Resources Board set forth desired bacterial standards to allow primary body contact recreation (swimming, wading, etc.) in Oklahoma waters. Our results are compared to these standards. While we have always had trouble meeting the bacterial water quality standards, it does not necessarily mean someone would get ill from swimming in these areas.

In 1998, 225 river samples were collected during the 5 month sampling period. A total of 450 bacterial analyses were performed on these samples. In addition, a total of 96 samples were collected from the 4 storm drains and 192 analyses were performed on these samples. The Oklahoma Water Quality Standards require that a set of 5 samples be collected at each site during a 30 day period and this requirement was achieved each month.

The OWQS require that the Geometric Mean of the counts be calculated for each 30 day period. To meet the standard, the Geometric Mean should not exceed a value of 200. The standards only apply to the in-stream (river) samples and do not apply to the storm drains. Besides these standards, we have also calculated a "Fecal Coliform/ Fecal Streptococcus Ratio". This gives us an indication of whether or not the source of contamination is more likely to be from human waste or from animal waste. An "FC/FS Ratio" of 2 or less implies that contamination is primarily of animal origin. An "FC/FS Ratio" of 5 or greater implies that the source of contamination is mainly human waste. Values in between the two numbers are considered to be inconclusive as an indicator. The results of the findings for each sampling location will be discussed separately.

11^{th} Street Bridge

Data from the 11^{th} Street Bridge indicates that this site did not meet the bacterial standard in 6 of 15 data sets. All six exceedances occurred in the months of August and September and were found at all 3 sampling sites on the bridge. The range of fecal coliform values was 9-12,000 while the range of fecal streptococcus values was 9-24,000. The "FC/FS Ratio" indicated that in 9.3% of the samples the source of contamination could be attributed to human waste. In 73% of the samples, the contamination could be attributed to animal waste. The data indicates that August and September were obviously the worst months for this site. As in past years, the east bank station proved to be the most troublesome sampling point, mainly due to the influence of the 11^{th} street storm drain.

21^{st} Street Bridge

As with the 11^{th} Street Bridge, the bacterial standard was exceeded in 6 of 15 data sets. All of these exceedances also occurred in the months of August and September and were found at all 3 sampling points along the bridge. Obviously, this correlates nicely with the data from the 11^{th} Street Bridge. The range of fecal coliform values was 9-100,000 while the range of fecal streptococcus values was 9-8,000. The "FC/FS Ratio" indicated that in 9.3% of the samples, the contamination could be attributed to human waste while in 81% of the samples the contamination could be attributed to animal waste. In general, the months of August and September yielded the highest counts for this station. Again, the east bank sampling point had the highest bacterial counts, again due to the influence of the major storm drains on the east side of the river.

Pedestrian Bridge

The bacterial criterion was exceeded in 3 of 15 data sets. Two of the exceedances occurred at the east and west bank sampling points in the month of September. The other exceedance occurred in June at the east bank station. This was the only one of all the exceedances that did not occur in August or September. The range of fecal coliform values was 9-12,000. The range of fecal streptococcus values was 9-7,000. The "FC/FS Ratio" reveals that 10.6% of the samples were contaminated by human waste while in 73% of the samples, the contamination can be attributed to animal wastes. In general, the month of September yielded the worst data at this site while the east bank station again proved to be the worst sampling point. The data from this site is never quite as bad as that from the other two bridge sites. This is mainly due to the fact that the storm drain water has had more time to mix with the normal river flow, thereby becoming more diluted by the time it reaches this sampling point.

Storm Drains

Four major urban storm drains are sampled for this study. These are the 11th Street, Indian Avenue, 21st Street and 26th Street storm drains. These drains are used because, besides conveying stormwater flows from the downtown Tulsa area, they also produce a constant 24 hours a day low flow from various sources. Some of these sources contribute highly to the bacterial counts in these drains. This low water flow is generated from activities such as car washes, lawn watering, external cleaning operations, broken and illicit sewer line connections, and other varied sources. The range of values for the storm drains were:

11 Street Storm Drain	
Fecal Coliform	9-56,000
Fecal Streptococcus	9-54,000
Indian Avenue Storm Drain	
Fecal Coliform	9-30,000
Fecal Streptococcus	9-40,000
21st Street Storm Drain	
Fecal Coliform	9-47,000
Fecal Streptococcus	9-63,000
26th Street Storm Drain	
Fecal Coliform	20-150,000
Fecal Streptococcus	70-160,000

As can be seen from the data, some fecal coliform counts are very high especially when compared to in-stream values. It should also be noted, however, that we also get some barely detectable counts. This is a good indication of just how variable the contaminant loading can be from time to time. The storm drain data also shows that, in general, fecal streptococcus counts are greater than fecal coliform counts. The "FC/FS Ratio" of the storm drains indicated that the contamination in 16% of the samples might be attributed to human waste. Conversely the ratio indicates that animal wastes are the primary contaminant in 67% of the samples. If an arbitrary figure of 10,000 colonies is applied to the data we see that it would be exceeded in only 11.5% (11/96) of the samples collected. Of those 11 samples exceeding the value, 7 of them were encountered at the 26th Street storm drain. Once again, the 26th Street storm drain appears to be a major source of bacterial contamination.

DISCUSSION

The bacterial counts encountered in 1998 yielded some of the worst results found in recent years. Fully 33% of the data sets did not meet the Geometric Mean Criteria of 200 colonies (15/45). Most of these exceedances occurred in the months of August and September. In 1998, both the 11th Street and 21st Street bridges exhibited equally poor data. In addition, the east bank station of the sites continue to exhibit the highest values encountered. The data from the storm drains again illustrates the great impact they have on the water quality of the Arkansas River. When you take into consideration the fact that we are sampling only a small amount of the bacterial sources entering the river, the scope of the problem becomes more evident. With continued growth of the city and a burgeoning population, it is apparent that the stormwater drainage system will carry an ever increasing pollutant load to the Arkansas River making it more and more difficult to attain desirable water quality criteria for the river.

BACTERIOLOGICAL WATER QUALITY OF STORM DRAINS MAY - SEPTEMBER 1998

11TH STREET BRIDGE (0A020)

	WEST BANK (A)			MID CHANNEL (B)			EAST BANK (C)		
DATE	FC	FS	FC/FS	FC	FS	FC/FS	FC	FS	FC/FS
05/04/98	190	30	6.33	20	9	2.22	200	90	2.22
05/11/98	20	9	2.22	9	9	1.00	140	10	14.00
05/18/98	9	9	1.00	9	9	1.00	36	54	0.67
05/20/98	10	10	1.00	10	10	1.00	10	10	1.00
05/27/98	160	220	0.73	81	80	1.01	530	970	0.55
G MEAN	35.29			16.73			88.22		
DATE	FC	FS	FC/FS	FC	FS	FC/FS	FC	FS	FC/FS
06/01/98	10	9	1.11	9	9	1.00	9	9	1.00
06/08/98	9	150	0.06	30	190	0.16	50	2800	0.02
06/15/98	9	300	0.03	40	1000	0.04	50	50	1.00
06/22/98	1400	40	35.00	2800	130	21.54	12000	2700	4.44
06/29/98	80	20	4.00	20	50	0.40	120	290	0.41
G MEAN	39.04			57.06			126.51		
DATE	FC	FS	FC/FS	FC	FS	FC/FS	FC	FS	FC/FS
07/13/98	30	10	3.00	20	20	1.00	160	200	0.80
07/21/98	40	50	0.80	9	27	0.33	60	370	0.16
07/22/98	9	54	0.17	130	110	1.18	180	180	1.00
07/27/98	10	30	0.33	9	9	1.00	10	45	0.22
07/29/98	30	230	0.13	20	420	0.05	220	1500	0.15
G MEAN	20.05			21.13			82.41		
DATE	FC	FS	FC/FS	FC	FS	FC/FS	FC	FS	FC/FS
08/10/98	600	140	4.29	800	100	8.00	700	30	23.33
08/18/98	3500	2300	1.52	4200	2600	1.62	4100	2400	1.71
08/20/98	3300	2800	1.18	3200	3300	0.97	5200	3800	1.37
08/24/98	360	480	0.75	310	370	0.84	430	340	1.26
08/27/98	6000	9000	0.67	6000	10000	0.60	6500	7300	0.89
G MEAN	1718.06			1820.54			2108.89		
DATE	FC	FS	FC/FS	FC	FS	FC/FS	FC	FS	FC/FS
09/08/98	130	80	1.63	120	70	1.71	280	50	5.60
09/14/98	12000	22000	0.55	10000	22000	0.45	8000	24000	0.33
09/21/98	1800	700	2.57	1300	800	1.63	1700	500	3.40
09/23/98	5000	2300	2.17	5200	2400	2.17	5000	2400	2.08
09/28/98	420	290	1.45	620	260	2.38	600	340	1.76
G MEAN	1426.01			1193.14			1627.66		

FC = FECAL COLIFORM
FS = FECAL STREPTOCOCCUS
FC/FS = FECAL COLIFORM / FECAL STREPTOCOCCUS RATIO
G MEAN = GEOMETRIC MEAN

BACTERIOLOGICAL WATER QUALITY OF STORM DRAINS MAY - SEPTEMBER 1998

21ST STREET BRIDGE (0A006)

	WEST BANK (A)			MID CHANNEL (B)			EAST BANK (C)		
DATE	FC	FS	FC/FS	FC	FS	FC/FS	FC	FS	FC/FS
05/04/98	140	70	2.00	9	10	0.90	230	70	3.29
05/11/98	40	20	2.00	9	10	0.09	110	80	1.38
05/18/98	10	10	1.00	9	9	1.00	30	20	1.50
05/20/98	9	9	1.00	9	9	1.00	20	10	2.00
05/27/98	390	300	1.30	120	200	0.60	640	1300	0.49
G MEAN	45.57			15.11			99.42		
DATE	FC	FS	FC/FS	FC	FS	FC/FS	FC	FS	FC/FS
06/01/98	20	10	2.00	10	9	1.11	9	10	0.90
06/08/98	800	560	1.43	9	130	0.07	72	180	0.40
06/15/98	30	280	0.11	9	240	0.04	170	410	0.41
06/22/98	210	70	3.00	2100	240	8.75	5200	700	7.43
06/29/98	50	9	5.56	40	80	0.50	150	110	1.36
G MEAN	87.19			36.86			153.75		
DATE	FC	FS	FC/FS	FC	FS	FC/FS	FC	FS	FC/FS
07/13/98	60	120	0.50	54	60	0.90	80	330	0.24
07/21/98	60	50	1.20	30	100	0.30	60	260	0.23
07/22/98	50	40	1.25	10	27	0.37	110	190	0.58
07/27/98	10	36	0.28	9	9	1.00	20	30	0.67
07/29/98	110	330	0.33	100	410	0.24	100	1700	0.06
G MEAN	45.64			27.09			63.79		
DATE	FC	FS	FC/FS	FC	FS	FC/FS	FC	FS	FC/FS
08/10/98	2000	300	6.67	1300	340	3.82	2100	430	4.88
08/18/98	380	220	1.73	290	240	1.21	370	330	1.12
08/20/98	390	210	1.86	370	230	1.61	330	180	1.83
08/24/98	80	120	0.67	160	120	1.33	110	120	0.92
08/27/98	220	210	1.05	180	220	0.82	160	140	1.14
G MEAN	349.52			331.73			339.54		
DATE	FC	FS	FC/FS	FC	FS	FC/FS	FC	FS	FC/FS
09/08/98	160	70	2.29	120	60	2.00	90	30	3.00
09/14/98	56000	8000	7.00	50000	6000	8.33	100000	7000	14.29
09/21/98	710	1400	0.51	550	1100	0.50	540	1200	0.45
09/23/98	14000	8000	1.75	13000	3000	4.33	15000	3700	4.05
09/28/98	600	580	1.03	620	450	1.38	500	500	1.00
G MEAN	2216.00			1927.39			2052.77		

FC = FECAL COLIFORM
FS = FECAL STREPTOCOCCUS
FC/FS = FECAL COLIFORM / FECAL STREPTOCOCCUS RATIO
G MEAN = GEOMETRIC MEAN

BACTERIOLOGICAL WATER QUALITY OF STORM DRAINS
MAY - SEPTEMBER 1998

PEDESTRIAN BRIDGE (0A005)

	WEST BANK (A)			MID CHANNEL (B)			EAST BANK (C)		
DATE	FC	FS	FC/FS	FC	FS	FC/FS	FC	FS	FC/FS
05/04/98	40	20	2.00	40	10	4.00	110	30	3.67
05/11/98	20	10	2.00	9	9	1.00	130	30	4.33
05/18/98	10	9	1.11	10	9	1.11	40	90	0.44
05/20/98	10	9	1.11	9	9	1.00	10	9	1.11
05/27/98	260	210	1.24	90	110	0.82	350	690	0.51
G MEAN	29.08			19.63			72.49		
DATE	FC	FS	FC/FS	FC	FS	FC/FS	FC	FS	FC/FS
06/01/98	9	9	1.00	9	9	1.00	9	9	1.00
06/08/98	300	120	2.50	110	40	2.75	12000	1400	8.57
06/15/98	40	210	0.19	60	140	0.43	250	130	1.92
06/22/98	1400	230	6.09	2000	240	8.33	2400	400	6.00
06/29/98	50	40	1.25	20	100	0.20	120	230	0.52
G MEAN	94.56			75.02			378.57		
DATE	FC	FS	FC/FS	FC	FS	FC/FS	FC	FS	FC/FS
07/13/98	20	60	0.33	63	54	1.17	800	360	2.22
07/21/98	10	10	1.00	10	20	0.50	120	300	0.40
07/22/98	10	50	0.20	10	20	0.50	220	250	0.88
07/27/98	40	63	0.63	20	40	0.50	9	110	0.08
07/29/98	20	1300	0.02	9	800	0.01	30	1300	0.02
G MEAN	17.41			16.25			89.37		
DATE	FC	FS	FC/FS	FC	FS	FC/FS	FC	FS	FC/FS
08/10/98	50	20	2.50	320	40	8.00	80	60	1.33
08/18/98	50	40	1.25	30	20	1.50	180	130	1.38
08/20/98	20	9	2.22	54	60	0.90	63	80	0.79
08/24/98	30	30	1.00	10	20	0.50	40	10	4.00
08/27/98	9	10	0.90	9	30	0.30	60	100	0.60
G MEAN	26.67			34.18			73.72		
DATE	FC	FS	FC/FS	FC	FS	FC/FS	FC	FS	FC/FS
09/08/98	140	10	14.00	20	10	2.00	80	40	2.00
09/14/98	3300	4000	0.83	5100	5000	1.02	6500	7000	0.93
09/21/98	30	9	3.33	10	9	1.11	9	40	0.23
09/23/98	800	160	5.00	1000	160	6.25	1000	280	3.57
09/28/98	40	60	0.67	20	9	2.22	80	200	0.40
G MEAN	213.49			115.33			206.38		

FC = FECAL COLIFORM
FS = FECAL STREPTOCOCCUS
FC/FS = FECAL COLIFORM / FECAL STREPTOCOCCUS RATIO
G MEAN = GEOMETRIC MEAN

BACTERIOLOGICAL WATER QUALITY
OF STORM DRAINS
MAY - SEPTEMBER 1992

DATE	11TH ST STORM DRAIN OK 002 FC*	FS*	FC/FS*	INDIAN AVE STORM DRAIN OK 003 FC*	FS*	FC/FS*	21ST ST STORM DRAIN OK 008 FC*	FS*	FC/FS*	26TH ST STORM DRAI FC*	FS*	FC/FS
04-May-92	7700	1600	4.81	6100	162	37.65	620	9	68.89	440	117	3.7
06-May-92	3500	520	6.73	550	410	1.34	1500	2000	0.75	360	400	0.9
11-May-92	23000	57000	0.40	17000	47000	0.36	40000	180000	0.22	37000	75000	0.4
13-May-92	3400	600	5.67	820	2600	0.32	21000	3000	7.00	910	470	1.9
18-May-92	29000	630000	0.05	530	930	0.57	6400	1500	4.27	2000	4200	0.4
20-May-92	33000	4900	6.73	1400	2100	0.67	29000	5500	5.27	2100	2400	0.8
27-May-92	220	1700	0.13	1100	3700	0.30	820	540	1.52	820	3900	0.2
03-Jun-92	10000	4700	2.13	4100	2800	1.46	4800	3800	1.26	1500	5600	0.27
08-Jun-92	18000	21000	0.86	3900	4400	0.89	6000	2600	2.31	5600	2500	2.2
10-Jun-92	60001	97001	0.62	28000	79000	0.35	60001	100001	0.60	12000	38000	0.32
15-Jun-92	1400	6900	0.20	9	27	0.33	2200	1400	1.57	450	6100	0.0
17-Jun-92	1500	16000	0.09	10000	15000	0.67	60001	100001	0.60	1300	25000	0.05
22-Jun-92	2100	5600	0.38	3600	2600	1.38	4300	5200	0.83	1500	3100	0.4
24-Jun-92	910	2900	0.31	460	750	0.61	12000	100001	0.12	3800	47000	0.08
29-Jun-92	60001	100001	0.60	60001	100001	0.60	60001	100001	0.60	60001	100001	0.6
06-Jul-92	570	620	0.92	610	490	1.24	1200	870	1.38	380	550	0.69
08-Jul-92	290	210	1.38	170	380	0.45	530	560	0.95	170	490	0.35
13-Jul-92	270	160	1.69	270	170	1.59	60001	21000	2.86	350	390	0.90
15-Jul-92	22000	4900	4.49	1800	430	4.19	2300	140	16.43	21000	1600	13.13
20-Jul-92	730	440	1.66	1200	490	2.45	640	860	0.74	910	460	1.98
22-Jul-92	730	970	0.75	730	780	0.94	60001	1600	37.50	730	950	0.77
29-Jul-92	5100	5300	0.96	410	880	0.47	2100	480	4.38	9000	2600	3.46
05-Aug-92	60001	100001	0.60	60001	100001	0.60	80000	140000	0.57	760000	93000	8.17
10-Aug-92	580	320	1.81	560	300	1.87	460	300	1.53	480	300	1.60
17-Aug-92	290	480	0.60	380	190	2.00	72	140	0.51	250	90	2.78
19-Aug-92	560	490	1.14	380	250	1.52	280	310	0.90	450	370	1.22
24-Aug-92	470	2100	0.22	2300	1600	1.44	1900	1300	1.46	490	1500	0.33
26-Aug-92	430	530	0.81	100	140	0.71	8000	3100	2.58	360	350	1.03
31-Aug-92	23000	3800	6.05	72000	100000	0.72	110000	72000	1.53	5900	3200	1.84
02-Sep-92	46000	9000	5.11	250000	250000	1.00	200000	77000	2.60	46000	37000	1.24
09-Sep-92	370	500	0.74	2900	3500	0.83	3600	1200	3.00	200	2000	0.10
14-Sep-92	31000	42000	0.74	2200	570	3.86	1500	340	4.41	240	210	1.14
16-Sep-92	4000	20000	0.20	3800	2400	1.58	440	150	2.93	230	200	1.15
21-Sep-92	1400	520	2.69	22000	8000	2.75	1600	390	4.10	2500	470	5.32
23-Sep-92	2900	6100	0.48	25000	7600	3.29	2700	5200	0.52	220	420	0.52
28-Sep-92	2500	580	4.31	4800	720	6.67	4700	630	7.46	1400	370	3.78

C = Fecal Coliform
*FS = Fecal Streptococcus
*FC/FS = Fecal Coliform/Fecal Streptococcus Ratio

BACTERIOLOGICAL WATER QUALITY
OF STORM DRAINS
MAY - SEPTEMBER 1998

	11th Street SD OK 022			Indian Ave. SD OK 003			21st Street SD OK 008			26th Street SD OK		
DATE	FC	FS	FC/FS	FC	FS	FC/FS	FC	FS	FC/FS	FC	FS	FC/FS
05/04/98	10	2	5.00	130	10	13.00	10	10	1.00	580	300	1.93
05/11/98	20	60	0.33	9	100	0.09	27	36	0.75	25000	2300	10.87
05/18/98	240	90	2.67	9	9	1.00	72	80	0.90	2800	3000	0.93
05/20/98	320	1800	0.18	120	1300	0.09	500	400	1.25	10000	1300	7.69
05/27/98	320	150	2.13	9	10	0.90	140	170	0.82	5200	2300	2.26
DATE	FC	FS	FC/FS	FC	FS	FC/FS	FC	FS	FC/FS	FC	FS	FC/FS
06/08/98	56000	54000	1.04	30000	40000	0.75	47000	63000	0.75	40000	50000	0.80
06/15/98	350	340	1.03	9	200	0.05	40	240	0.17	3100	6500	0.48
06/22/98	9	9	1.00	2700	60	45.00	9	9	1.00	13000	2800	4.64
06/29/98	9	9	1.00	100	9	11.11	9	9	1.00	9000	4400	2.05
DATE	FC	FS	FC/FS	FC	FS	FC/FS	FC	FS	FC/FS	FC	FS	FC/FS
07/13/98	700	90	7.78	9	9	1.00	580	83	6.99	9000	3800	2.37
07/21/98	1000	230	4.35	220	220	1.00	900	210	4.29	4000	1000	4.00
07/22/98	840	160	5.25	9	27	0.33	700	240	2.92	2900	320	9.06
07/27/98	140	220	0.64	81	700	0.12	130	150	0.87	1200	390	3.08
07/29/98	250	2000	0.13	430	1300	0.33	1100	530	2.08	4000	7700	0.52
DATE	FC	FS	FC/FS	FC	FS	FC/FS	FC	FS	FC/FS	FC	FS	FC/FS
08/10/98	1200	380	3.16	1300	150	8.67	1200	450	2.67	22000	3400	6.47
08/18/98	1700	2300	0.74	410	530	0.77	1400	1100	1.27	380	230	1.65
08/20/98	3800	1000	3.80	300	180	1.67	420	500	0.84	520	90	5.78
08/24/98	200	390	0.51	280	900	0.31	150	360	0.42	20	70	0.29
08/27/98	1500	2700	0.56	8000	6000	1.33	1200	2700	0.44	600	2100	0.29
DATE	FC	FS	FC/FS	FC	FS	FC/FS	FC	FS	FC/FS	FC	FS	FC/FS
09/08/98	350	1500	0.23	240	320	.075	210	70	3.00	150000	160000	0.94
09/14/98	2700	10000	0.27	12000	12000	1.00	2100	8000	0.26	8000	4000	2.00
09/21/98	610	2200	0.28	940	180	5.22	700	1900	0.37	310	400	0.78
09/23/98	700	800	0.88	2700	600	4.50	6000	330	18.18	3000	1800	1.67
09/28/98	410	2700	0.15	150	330	0.45	520	2700	0.19	12000	20000	0.60

FC = FECAL COLIFORM
FS = FECAL STREPTOCOCCUS
FC/FS = FECAL COLIFORM / FECAL STREPTOCOCCUS RATIO

BACTERIOLOGICAL REPORT

FOR ZINK LAKE ON THE

ARKANSAS RIVER FOR 1999

PREPARED BY THE TULSA CITY/COUNTY

HEALTH DEPARTMENT

MARCH, 2000

INTRODUCTION

In 1999, water samples were collected in the Zink Lake area of the Arkansas River in accordance with the annual study required by the U. S. Army Corps of Engineers Permit for the low water dam. The samples were collected in order to characterize bacterial contamination in this area of the river. Three bridge sites (11th Street, 21st Street, Pedestrian) were sampled along with four storm drain sites (11th Street, Indian Avenue, 21st Street, 26th Street). Each bridge site had 3 sampling points, the east and west banks along with a mid-stream substation. Samples were analyzed for both fecal coliform bacteria as well as fecal streptococcus bacteria.

The Oklahoma Water Quality Standards (OWQS) developed by the Oklahoma Water Resources Board set forth desired bacterial standards to allow primary body contact recreation (swimming, wading, etc.) in Oklahoma waters. Our results are compared to these standards. While we have always had trouble meeting the bacterial water quality standards, it does not necessarily mean someone would get ill from swimming in these areas.

In 1999, 225 river samples were collected during the 5 month sampling period. A total of 450 bacterial analyses were performed on these samples. In addition, a total of 32 samples were collected from the 4 storm drains and 64 analyses were performed on these samples. The Oklahoma Water Quality Standards require that a set of 5 samples be collected at each site during a 30 day period and this requirement was achieved each month.

The OWQS require that the Geometric Mean of the counts be calculated for each 30 day period. To meet the standard, the Geometric Mean should not exceed a value of 200. The standards only apply to the in-stream (river) samples and do not apply to the storm drains. Besides these standards, we have also calculated a "Fecal Coliform/ Fecal Streptococcus Ratio". This gives us an indication of whether or not the source of contamination is more likely to be from human waste or from animal waste. An "FC/FS Ratio" of 2 or less implies that contamination is primarily of animal origin. An "FC/FS Ratio" of 5 or greater implies that the source of contamination is mainly human waste. Values in between the two numbers are considered to be inconclusive as an indicator. The results of the findings for each sampling location will be discussed separately.

11th Street Bridge

Data from the 11th street bridge site indicates that this site did not meet the bacterial standard in 4 of 15 data sets. Three of the four exceedances occurred during the month of September at each substation. The other occurred in the month of June at the west bank substation. The range of fecal coliform values was 9 to 12,000 while the range of Fecal Streptococcus was 9 to 140,000. This high FS value occurred at the mid-river substation during the month of September when river flows were minimal. The "FC/FS Ratio" indicated that in 98% of the samples the source of contamination was animal wastes. There was not one instance where "The Ratio" indicated any confirmed contamination due to human wastes. This is probably the first time in all the years of the program that this has happened. As is usually the case, August and September were the worst months for this station. Again, the east bank substation produced the worst values for this site, most likely due to the influence of the storm drains.

21st Street Bridge

Data from the 21st Street Bridge site indicates that this site did not meet bacterial standards in 3 of the 15 data sets. All of these exceedance occurred in the month of September at each of the 3 substations. The range of Fecal Coliform values was 9 to 3,200. The highest values were considerably lower than in past years. The range of Fecal Streptococcus values was 9 to 9,300. These FS values are also generally low for river samples. The "FC/FS Ratio" indicates that in 96% of the samples the main source of contamination was animal waste. The "FC/FS Ratio" had no values high enough to indicate contamination strictly from human waste. As with the previous site, August and September were the worst months for this site. Again, the east bank sampling site generally had the worst values.

Pedestrian Bridge

Data from the Pedestrian Bridge site indicates that this site did not meet the bacterial standard in 1 of 15 data sets. This excedance occurred in the month of June at the east bank substation. The range of values for Fecal Coliform bacteria was 9 to 4,200. The range of values for the Fecal Streptococcus bacteria was 9 to 10,000. These ranges were also low compared to most previous years. The "FC/FS Ratio" indicated that the contamination in 96% of the samples was from animal sources. There were no instances where the ratio indicated that contamination was due to human sources. This is the same result that occurred at the other two bridge sites. The data from this site indicates that there was really very little problem with samples taken at this downstream location during 1999.

Storm Drains

Four major urban storm drains are sampled for this study. These are the 11th Street, Indian Avenue, 21st Street and 26th Street storm drains. These drains are used because, besides conveying stormwater flows from the downtown Tulsa area, they also produce a constant 24 hours a day low flow from various sources. Some of these sources contribute highly to the bacterial counts in these drains. This low water flow is generated from activities such as car washes, lawn watering, external cleaning operations, broken and illicit sewer line connections, and other varied sources. The range of values for the storm drains were:

11 Street Storm Drain	
Fecal Coliform	9-35,000
Fecal Streptococcus	90-68,000
Indian Avenue Storm Drain	
Fecal Coliform	200-70,000
Fecal Streptococcus	210-100,000
21st Street Storm Drain	
Fecal Coliform	9-29,000
Fecal Streptococcus	80-60,000
26th Street Storm Drain	
Fecal Coliform	9-10,000
Fecal Streptococcus	9-32,000

As can be seen from the data, less storm drain samples were collected in 1999 than in previous years. This was due to the extremely high river flows that occurred during the first three months of the project. During high flows, the storm drains are flooded with river water and would essentially consist of river water instead of the normal flow of the storm drain. Therefore, storm drain samples cannot be collected. While this usually occurs for short periods every year, it lasted for a much longer period in 1999. Even though less storm drain samples were collected in 1999, some things were still rather evident. All of the results from all four storm drains were much higher, on average, than values found in the river samples. Next, we can see that there were some very high counts from all four storm drains from time to time. It is also apparent that fecal streptococcus counts are routinely higher than fecal coliform counts. The Fecal Coliform/Fecal Streptococcus Ratio indicated that in 84% of the samples, the contamination was primarily caused by animal wastes. The 'FC/FS Ratio" of one sample indicated the contamination was most likely due to human waste. This one occurrence was on 9/14/99 at the Indian Avenue storm drain. On 9/27/99 a moderate rain storm occurred in the early morning hours which scoured the debris and stagnant water from the drains and carried it into the river. This resulted in the highest bacterial counts encountered at all 4 storm drains for the entire project.

Discussion

As has been the case since the inception of the program, the Arkansas River in Metro Tulsa could not met the Oklahoma Water Quality standard for bacterial contamination. In 1999, the criteria was not met in 8 out of 45 data sets. In reality, it might have exceeded the criterion more often if not for the diluting factor of the high river flows for an extended period of time. Most of the exceedances occurred during the months of August and September when flows had diminished. A favorable statistic was that virtually all of the contamination was contributed by animal wastes and very little was contributed by human waste. This may be a sign that the City's program to eliminate illicit sewage discharges to the storm drains may be reaching fruition.

However, it is apparent that little has changed. The storm drains are obviously contributing large quantities of bacteria to the Arkansas River. With an ever increasing population and more and more impervious cover in the metropolitan area, storm flows to the Arkansas River will continue to increase in volume. This means that levels of organic matter and bacterial concentrations will also be on the increase. These occurrences will have a greater negative impact on the quality of the stormwater entering the river. It will therefore be much more difficult to achieve the desired water quality conditions to meet the State standards for our stretch of the Arkansas River.

BACTERIOLOGICAL WATER QUALITY
OF ARKANSAS RIVER
MAY - SEPTEMBER 1999

11^{TH} STREET BRIDGE (0A020)

	WEST BANK (A)			MID CHANNEL (B)			EAST BANK (C)		
DATE	FC	FS	FC/FS	FC	FS	FC/FS	FC	FS	FC/FS
05/10/99	45	100	0.45	10	10	1.00	140	210	0.67
05/12/99	10	30	0.33	18	60	0.30	18	80	0.23
05/18/99	310	800	0.39	280	600	0.47	400	800	0.50
05/24/99	100	180	0.56	40	200	0.20	63	220	0.29
05/26/99	27	190	0.14	54	170	0.32	20	200	0.10
G MEAN	51.90			40.49			66.19		
DATE	FC	FS	FC/FS	FC	FS	FC/FS	FC	FS	FC/FS
06/07/99	110	100	1.10	100	90	1.11	54	50	1.08
06/14/99	130	250	0.52	110	200	0.55	120	100	1.20
06/16/99	3300	10000	0.33	2100	9500	0.22	3300	9700	0.34
06/21/99	190	180	1.06	190	170	1.12	100	180	0.56
06/28/99	50	300	0.17	30	330	0.09	20	210	0.10
G MEAN	213.95			167.45			133.73		
DATE	FC	FS	FC/FS	FC	FS	FC/FS	FC	FS	FC/FS
07/13/99	9	160	0.06	20	200	0.10	10	280	0.04
07/14/99	40	80	0.50	10	120	0.08	10	40	0.25
07/19/99	10	90	0.11	9	9	1.00	10	70	0.14
07/20/99	54	90	0.60	9	10	0.90	10	60	0.17
07/27/99	310	1700	0.18	340	1200	0.28	250	800	0.31
G MEAN	35.98			22.29			19.04		
DATE	FC	FS	FC/FS	FC	FS	FC/FS	FC	FS	FC/FS
08/09/99	50	600	0.08	60	450	0.13	60	490	0.12
08/16/99	60	250	0.24	40	200	0.20	20	150	0.13
08/23/99	140	160	0.88	100	130	0.77	180	260	0.69
08/24/99	170	350	0.49	100	310	0.32	140	170	0.82
08/30/99	30	70	0.43	30	50	0.60	110	40	2.75
G MEAN	73.48			59.08			80.24		
DATE	FC	FS	FC/FS	FC	FS	FC/FS	FC	FS	FC/FS
09/14/99	420	320	1.31	300	320	0.94	400	370	1.08
09/20/99	150	410	0.37	120	300	0.40	1300	3200	0.41
09/21/99	40	60	0.67	45	30	1.50	380	220	1.73
09/27/99	10000	130000	0.08	12000	140000	0.09	10000	100000	0.10
09/28/99	90	120	0.75	100	130	0.77	50	90	0.56
G MEAN	295.89			286.91			629.44		

FC = FECAL COLIFORM
FS = FECAL STREPTOCOCCUS
FC/FS = FECAL COLIFORM / FECAL STREPTOCOCCUS RATIO
G MEAN = GEOMETRIC MEAN

BACTERIOLOGICAL WATER QUALITY OF ARKANSAS RIVER MAY - SEPTEMBER 1999

21ST STREET BRIDGE (0A006)

	WEST BANK (A)			MID CHANNEL (B)			EAST BANK (C)		
DATE	FC	FS	FC/FS	FC	FS	FC/FS	FC	FS	FC/FS
05/10/99	63	180	0.35	9	9	1.00	140	280	0.50
05/12/99	50	100	0.50	20	80	0.25	20	100	0.20
05/18/99	400	900	0.44	400	500	0.80	470	800	0.59
05/24/99	60	180	0.33	50	150	0.33	130	210	0.62
05/26/99	130	170	0.76	50	180	0.28	54	210	0.26
G MEAN	99.65			44.78			98.43		
DATE	FC	FS	FC/FS	FC	FS	FC/FS	FC	FS	FC/FS
06/07/99	40	50	0.80	45	50	0.90	81	110	0.74
06/14/99	90	250	0.36	30	250	0.12	90	150	0.60
06/16/99	3200	9200	0.35	3100	9300	0.33	2200	7600	0.29
06/21/99	190	220	0.86	190	320	0.59	150	260	0.58
06/28/99	45	1700	0.03	60	900	0.07	70	850	0.08
G MEAN	158.01			136.68			175.90		
DATE	FC	FS	FC/FS	FC	FS	FC/FS	FC	FS	FC/FS
07/13/99	30	200	0.15	20	200	0.10	20	160	0.13
07/14/99	9	90	0.10	10	90	0.11	10	130	0.08
07/19/99	9	40	0.23	9	50	0.18	9	60	0.15
07/20/99	90	100	0.90	9	40	0.23	20	80	0.25
07/27/99	120	1200	0.10	60	1400	0.04	200	1000	0.20
G MEAN	30.47			15.76			23.52		
DATE	FC	FS	FC/FS	FC	FS	FC/FS	FC	FS	FC/FS
08/09/99	110	240	0.46	100	250	0.40	80	160	0.50
08/16/99	20	60	0.33	9	70	0.13	30	170	0.18
08/23/99	50	20	2.50	50	60	0.83	40	20	2.00
08/24/99	130	600	0.22	170	460	0.37	260	450	0.58
08/30/99	210	260	0.81	110	180	0.61	40	270	0.15
G MEAN	78.62			60.96			63.08		
DATE	FC	FS	FC/FS	FC	FS	FC/FS	FC	FS	FC/FS
09/14/99	1600	1000	1.60	1900	1200	1.58	1800	700	2.57
09/20/99	130	420	0.31	70	180	0.39	560	890	0.63
09/21/99	40	150	0.27	120	54	2.22	270	200	1.35
09/27/99	600	700	0.86	800	1000	0.80	600	1500	0.40
09/28/99	130	210	0.62	150	800	0.19	190	900	0.21
G MEAN	230.38			286.05			499.28		

FC = FECAL COLIFORM
FS = FECAL STREPTOCOCCUS
FC/FS = FECAL COLIFORM / FECAL STREPTOCOCCUS RATIO
G MEAN = GEOMETRIC MEAN

BACTERIOLOGICAL WATER QUALITY
OF ARKANSAS RIVER
MAY - SEPTEMBER 1999

PEDESTRIAN BRIDGE (0A005)

	WEST BANK (A)			MID CHANNEL (B)			EAST BANK (C)		
DATE	FC	FS	FC/FS	FC	FS	FC/FS	FC	FS	FC/FS
05/10/99	20	80	0.25	9	30	0.30	180	220	0.82
05/12/99	9	9	1.00	9	9	1.00	20	20	1.00
05/18/99	150	900	0.17	9	80	0.11	300	500	0.60
05/24/99	20	81	0.25	9	10	0.90	91	200	0.46
05/26/99	9	54	0.17	9	20	0.45	10	170	0.06
G MEAN	21.74			9.00			62.88		
DATE	FC	FS	FC/FS	FC	FS	FC/FS	FC	FS	FC/FS
06/07/99	30	20	1.50	9	30	0.30	150	150	1.00
06/14/99	110	70	1.57	10	40	0.25	100	100	1.00
06/16/99	100	170	0.59	20	36	0.56	4200	10000	0.42
06/21/99	81	150	0.54	10	140	0.07	200	260	0.77
06/28/99	90	290	0.31	60	280	0.21	150	420	0.36
G MEAN	75.21			16.09			285.29		
DATE	FC	FS	FC/FS	FC	FS	FC/FS	FC	FS	FC/FS
07/13/99	90	82	1.10	9	10	0.90	10	120	0.08
07/14/99	9	20	0.45	10	20	0.50	9	90	0.10
07/19/99	9	60	0.15	9	20	0.45	9	60	0.15
07/20/99	90	90	1.00	9	40	0.23	9	120	0.08
07/27/99	9	60	0.15	9	50	0.18	80	90	0.89
G MEAN	22.61			9.19			14.23		
DATE	FC	FS	FC/FS	FC	FS	FC/FS	FC	FS	FC/FS
08/09/99	10	120	0.08	9	80	0.11	30	200	0.15
08/16/99	9	60	0.15	9	40	0.23	90	40	2.25
08/23/99	9	9	1.00	9	9	1.00	10	40	0.25
08/24/99	50	180	0.28	30	220	0.14	20	320	0.06
08/30/99	10	40	0.25	2	110	0.18	60	70	0.86
G MEAN	13.23			13.43			31.78		
DATE	FC	FS	FC/FS	FC	FS	FC/FS	FC	FS	FC/FS
09/14/99	170	80	2.13	100	30	3.33	620	320	1.94
09/20/99	100	230	0.43	20	70	0.29	100	200	.050
09/21/99	45	60	0.75	10	100	0.10	45	36	1.25
09/27/99	160	220	0.73	480	600	0.80	260	350	0.74
09/28/99	10	120	0.08	10	30	0.33	100	130	.077
G MEAN	65.70			39.49			148.63		

FC = FECAL COLIFORM
FS = FECAL STREPTOCOCCUS
FC/FS = FECAL COLIFORM / FECAL STREPTOCOCCUS RATIO
G MEAN = GEOMETRIC MEAN

BACTERIOLOGICAL WATER QUALITY
OF STORM DRAINS
MAY - SEPTEMBER 1999

	11th Street SD OK 022			Indian Ave. SD OK 003			21st Street SD OK 008			26th Street SD OK		
DATE	FC	FS	FC/FS	FC	FS	FC/FS	FC	FS	FC/FS	FC	FS	FC/FS
05/10/99	NONE	NONE		NONE	NONE		NONE	NONE		NONE	NONE	
05/12/99	NONE	NONE		NONE	NONE		NONE	NONE		NONE	NONE	
05/18/99	NONE	NONE		NONE	NONE		NONE	NONE		NONE	NONE	
05/24/99	NONE	NONE		NONE	NONE		NONE	NONE		NONE	NONE	
05/26/99	NONE	NONE		NONE	NONE		NONE	NONE		NONE	NONE	
DATE	FC	FS	FC/FS	FC	FS	FC/FS	FC	FS	FC/FS	FC	FS	FC/FS
06/07/99	NONE	NONE		NONE	NONE		NONE	NONE		NONE	NONE	
06/14/99	NONE	NONE		NONE	NONE		NONE	NONE		NONE	NONE	
06/16/99	NONE	NONE		NONE	NONE		NONE	NONE		NONE	NONE	
06/21/99	NONE	NONE		NONE	NONE		NONE	NONE		NONE	NONE	
06/28/99	NONE	NONE		NONE	NONE		NONE	NONE		NONE	NONE	
DATE	FC	FS	FC/FS	FC	FS	FC/FS	FC	FS	FC/FS	FC	FS	FC/FS
07/13/99	NONE	NONE		NONE	NONE		NONE	NONE		NONE	NONE	
07/14/99	NONE	NONE		NONE	NONE		NONE	NONE		NONE	NONE	
07/19/99	NONE	NONE		NONE	NONE		NONE	NONE		NONE	NONE	
07/20/99	NONE	NONE		NONE	NONE		NONE	NONE		NONE	NONE	
07/27/99	NONE	NONE		NONE	NONE		NONE	NONE		NONE	NONE	
DATE	FC	FS	FC/FS	FC	FS	FC/FS	FC	FS	FC/FS	FC	FS	FC/FS
08/09/99	2000	3500	0.57	200	410	0.49	90	3000	0.03	3800	1200	3.17
08/16/99	1200	5000	0.24	800	330	2.42	1600	4200	0.38	700	150	4.67
08/23/99	220	410	0.54	600	650	0.92	200	450	0.44	9	9	1.00
08/24/99	250	600	0.42	800	500	1.60	300	650	0.46	60	50	1.20
08/30/99	2500	6000	0.42	230	210	1.10	2100	8000	0.26	80	20	4.00
DATE	FC	FS	FC/FS	FC	FS	FC/FS	FC	FS	FC/FS	FC	FS	FC/FS
09/14/99	9	90	0.10	9000	1500	6.00	9	80	0.11	100	250	0.40
09/20/99	NONE	NONE		NONE	NONE		NONE	NONE		NONE	NONE	
09/21/99	NONE	NONE		NONE	NONE		NONE	NONE		NONE	NONE	
09/27/99	35000	68000	0.51	70000	100000	0.70	29000	60000	0.48	10000	32000	0.31
09/28/99	130	180	0.72	600	1400	0.43	200	800	0.25	1600	1800	0.89

FC = FECAL COLIFORM
FS = FECAL STREPTOCOCCUS
FC/FS = FECAL COLIFORM / FECAL STREPTOCOCCUS RATIO

BACTERIOLOGICAL REPORT
FOR ZINK LAKE ON THE
ARKANSAS RIVER FOR 2000

PREPARED BY THE TULSA CITY/COUNTY

HEALTH DEPARTMENT

FEBRUARY, 2001

INTRODUCTION

In 2000, water samples were collected in the Zink Lake area of the Arkansas River in accordance with the annual study required by the U. S. Army Corps of Engineers Permit for the low water dam. The samples were collected in order to characterize bacterial contamination in this area of the river. Three bridge sites (11th Street, 21st Street, Pedestrian) were sampled along with four storm drain sites (11th Street, Indian Avenue, 21st Street, 26th Street). In the year 2000, the City of Tulsa undertook major street repairs on Riveside Drive in the area of the Indian Avenue storm drain. This caused the Indian Avenue storm drain to be inaccessible for the entire sampling period, so very few samples were collected at this site. Each bridge site had 3 sampling points, the east and west banks along with a mid-stream substation. Samples were analyzed for both fecal coliform bacteria as well as fecal streptococcus bacteria.

The Oklahoma Water Quality Standards (OWQS) developed by the Oklahoma Water Resources Board set forth desired bacterial standards to allow primary body contact recreation (swimming, wading, etc.) in Oklahoma waters. Our results are compared to these standards. While we have always had trouble meeting the bacterial water quality standards, it does not necessarily mean someone would get ill from swimming in these areas.

In 2000, 225 river samples were collected during the 5 month sampling period. A total of 450 bacterial analyses were performed on these samples. In addition, a total of 75 samples were collected from the 4 storm drains and 150 analyses were performed on these samples. The Oklahoma Water Quality Standards require that a set of 5 samples be collected at each site during a 30 day period and this requirement was achieved each month.

The OWQS require that the Geometric Mean of the counts be calculated for each 30 day period. To meet the standard, the Geometric Mean should not exceed a value of 200. The standards only apply to the in-stream (river) samples and do not apply to the storm drains. Besides these standards, we have also calculated a "Fecal Coliform/ Fecal Streptococcus Ratio". This gives us an indication of whether or not the source of contamination is more likely to be from human waste or from animal waste. An "FC/FS Ratio" of 2 or less implies that contamination is primarily of animal origin. An "FC/FS Ratio" of 5 or greater implies that the source of contamination is mainly human waste. Values in between the two numbers are considered to be inconclusive as an indicator. The results of the findings for each sampling location will be discussed separately.

11th Street Bridge

Data from the 11th street bridge site indicates that this site did not meet the bacterial standard in 7 of 15 data sets. All three substations failed to meet the criteria during the months of May and September. The seventh exceedance occurred at the east bank substation during the month of June. The range of fecal coliform values was 9 -39,000 . The range of Fecal Streptococcus values was 10 -16,000. Both of the high values occurred at the east bank substation. The "FC/FS Ratio" indicated that in 84% of the samples the contamination was due to animal wastes. It also indicated that in 14.7% of the samples the contamination was caused by human wastes. May and September turned out to be the worst months for this station. The east bank substation was the worst of the three, which is usually the case. This is due to the influence of the storm drains along the east bank.

21st Street Bridge

Data from the 21st Street Bridge site indicates that this site did not meet bacterial standards in 10 of the 15 data sets. This is a much higher level of exceedances than we've ever experienced before. There were exceedances at all 3 substations during the months of May and September and the only month where there were no exceedances was July. The range of Fecal Coliform counts was 9 - 43,000. The range of Fecal Streptococcus counts was 9 - 42,000. The highest values were encountered at the east bank substation during the month of June. The "FC/FS Ratio" indicated that in 87% of the samples, the main source of contamination was animal wastes. In only one sample of 75 did it appear that the main source of contamination was human waste. During the study, both the east bank and mid-river substations exhibited the most exceedances. While the exceedances were fairly well spread out over the entire sampling period, May and September had the most with September being the worst month.

Pedestrian Bridge

Data from the Pedestrian Bridge site indicates that this site did not meet the bacterial standard in 3 of 15 data sets. All exceedances occurred at the east bank substation for 3 different months. The range of Fecal Coliform values was 9 to 18,000. The range of Fecal Streptococcus values was 9 - 35,000. These values were pretty much in line with the other substations. The "FC/FS Ratio" indicated that in 90% of the samples the main source of contamination was animal waste. The "FC/FS Ratio" indicated that the main source of contamination was human waste in 4% of the samples. The highest values for this site all pretty much occurred during the month of June. Overall, however, this site exhibited the least problems of the three sites which is normally the case.

Storm Drains

Four major urban storm drains are sampled for this study. These are the 11th Street, Indian Avenue, 21st Street and 26th Street storm drains. These drains are used because, besides conveying stormwater flows from the downtown Tulsa area, they also produce a constant 24 hours a day low flow from various sources. Some of these sources contribute highly to the bacterial counts in these drains. This low water flow is generated from activities such as car washes, lawn watering, external cleaning operations, broken and illicit sewer line connections, and other varied sources. Physical inaccessibility prevented the sampling of the Indian Avenue storm drain during the year 2000. The range of values for the storm drains were:

11th Street Storm Drain	
Fecal Coliform	650-320,000
Fecal Streptococcus	230-310,000
21st Street Storm Drain	
Fecal Coliform	800-260,000
Fecal Streptococcus	280-280,000
26th Street Storm Drain	
Fecal Coliform	200-52,000
Fecal Streptococcus	160-84,000

In reviewing the data from the storm sewers, it can be seen that bacterial counts were relatively high during the entire sampling period. In fact, they appear to be about the highest counts ever encountered since the river study began. This may partly be due to a more moderate river flow during 2000, resulting in less dilution of the storm drain flows entering the river. However, many of the numbers were so high on a routine basis that one must consider the possibility that routine flows were carrying greater loads of bacterial contaminants than in the past. Whether or not these are the results of increased run-off from animal droppings or illicit sanitary sewer discharges cannot be determined. However, the "FC/FS Ratio", indicates that in 90.7% of the samples, the contamination was due to animal wastes while in 6.7% of the samples the contamination source would be considered human waste. While 6.7% is not a very high rate, it is a higher rate than is normally encountered. Both the 11th Street and 21st Street storm drains had routinely high bacterial levels throughout the sampling period.

DISCUSSION

Once again, the Arkansas River in the metropolitan Tulsa area did not meet bacterial standards in the year 2000. The criterion was not met in 20 of the 45 data sets. This was a much higher rate of failure than is usually encountered. During the last few years, the number of exceedances was fairly low. The obvious reason for this is pretty evident. The storm drain data indicates that high bacterial counts routinely occur in the storm drain flows. High river flows during the early part of the year normally dilute the storm drain flows enough so that almost no exceedances occur in the early months of the sampling period. During the spring of 2000, the Arkansas River never did have very high flows so flows from the storm drains were not as diluted. Therefore, we ended up with a higher number of exceedances than usual. The "FC/FS Ratio" indicated that in 86.5% of all samples, the main contributing factor was animal wastes. In 6.7% of all samples the source of contamination could be attributed to human waste.

The old saying says that "Dilution is the Solution to Pollution." In this case, it appears that dilution is the reason the bacterial data from the Arkansas River aren't any worse than they are. The storm drain data clearly indicates (as usual) that non-point source pollution from the metropolitan Tulsa area has a highly detrimental impact on the water quality of the Arkansas River. The 24 hour-a-day influx of bacterially contaminated water to the Arkansas River severely degrades the water quality of the river. Until the City of Tulsa takes some serious steps to ameliorate the problem of the major storm drains, the goal of attaining "fishable, swimmable" standards for the river will not be reached any time soon.

BACTERIOLOGICAL WATER QUALITY
OF STORM DRAINS
MAY - SEPTEMBER 2000

11TH STREET BRIDGE (0A020)

	WEST BANK (A)			MID CHANNEL (B)			EAST BANK (C)		
DATE	FC	FS	FC/FS	FC	FS	FC/FS	FC	FS	FC/FS
05/01/00	2900	5800	0.50	3600	6200	0.58	3300	5600	0.59
05/15/00	150	3600	0.04	1300	3200	0.41	820	3600	0.23
05/16/00	72	130	0.55	72	140	0.51	27	72	0.38
05/22/00	580	180	3.22	250	180	1.39	620	82	7.56
05/23/00	1500	260	5.77	2300	280	8.21	1700	270	6.30
G MEAN	567.45			720.19			598.83		
DATE	FC	FS	FC/FS	FC	FS	FC/FS	FC	FS	FC/FS
06/05/00	9	36	0.25	63	10	6.30	36	54	0.67
06/12/00	10	45	0.22	10	63	0.16	310	160	1.94
06/14/00	36	120	0.30	150	230	0.65	6500	16000	0.41
06/19/00	63	230	0.27	63	150	0.42	36	150	0.24
06/26/00	5200	5200	1.00	5400	5200	1.04	5200	5300	0.98
G MEAN	63.85			126.31			423.23		
DATE	FC	FS	FC/FS	FC	FS	FC/FS	FC	FS	FC/FS
07/10/00	35	45	0.78	18	36	0.50	27	81	0.33
07/17/00	36	63	0.57	27	72	0.38	27	110	0.25
07/18/00	72	210	0.34	90	260	0.35	90	330	0.27
07/24/00	270	540	0.50	360	640	0.56	310	450	0.69
07/25/00	1500	2600	0.58	1700	2500	0.68	1200	3400	0.35
G MEAN	129.73			121.77			119.54		
DATE	FC	FS	FC/FS	FC	FS	FC/FS	FC	FS	FC/FS
08/07/00	90	810	0.11	45	300	0.15	81	410	0.20
08/14/00	240	470	0.51	200	570	0.35	280	390	0.72
08/21/00	370	3500	0.11	410	3000	0.14	360	2800	0.13
08/28/00	36	36	1.00	10	54	0.19	200	270	0.74
08/29/00	72	290	0.25	130	420	0.31	54	340	0.16
G MEAN	115.68			86.34			154.55		
DATE	FC	FS	FC/FS	FC	FS	FC/FS	FC	FS	FC/FS
09/11/00	620	520	1.19	650	480	1.35	520	390	1.33
09/18/00	280	27	10.37	220	18	12.22	260	27	9.63
09/19/00	110	63	1.75	36	54	0.67	45	45	1.00
09/25/00	34000	5100	6.67	37000	4800	7.71	39000	4600	8.48
09/26/00	1700	1600	1.06	1800	1500	1.20	1800	1200	1.50
G MEAN	1019.94			807.28			843.54		

FC = FECAL COLIFORM
FS = FECAL STREPTOCOCCUS
FC/FS = FECAL COLIFORM / FECAL STREPTOCOCCUS RATIO
G MEAN = GEOMETRIC MEAN

BACTERIOLOGICAL WATER QUALITY OF STORM DRAINS MAY - SEPTEMBER 2000

21ST STREET BRIDGE (0A006)

	WEST BANK (A)			MID CHANNEL (B)			EAST BANK (C)		
DATE	FC	FS	FC/FS	FC	FS	FC/FS	FC	FS	FC/FS
05/01/00	2800	7800	0.36	4500	6700	0.67	5100	6600	0.77
05/15/00	100	170	0.59	110	200	0.55	63	130	0.48
05/16/00	140	130	1.08	110	170	0.65	130	130	1.00
05/22/00	310	430	0.72	370	280	1.32	300	240	1.25
05/23/00	290	220	1.32	360	190	1.89	310	200	1.55
G MEAN	323.15			373.34			329.51		
DATE	FC	FS	FC/FS	FC	FS	FC/FS	FC	FS	FC/FS
06/05/00	10	81	0.12	18	54	0.33	27	27	1.00
06/12/00	45	270	0.17	36	150	0.24	420	560	0.75
06/14/00	36	120	0.30	640	1400	0.46	43000	42000	1.02
06/19/00	1000	3500	0.29	1100	3700	0.30	1100	3300	0.33
06/26/00	6800	6400	1.06	6500	6100	1.07	5800	5800	1.00
G MEAN	161.59			312.19			1254.82		
DATE	FC	FS	FC/FS	FC	FS	FC/FS	FC	FS	FC/FS
07/10/00	18	110	0.16	10	180	0.06	10	110	0.09
07/17/00	45	160	0.28	56	190	0.29	27	210	0.13
07/18/00	210	340	0.62	160	320	0.50	200	530	0.38
07/24/00	240	380	0.63	230	280	0.82	150	340	0.44
07/25/00	1600	3300	0.48	2600	3300	0.79	2000	4000	0.50
G MEAN	145.55			139.89			110.13		
DATE	FC	FS	FC/FS	FC	FS	FC/FS	FC	FS	FC/FS
08/07/00	280	620	0.45	280	270	1.04	210	280	0.75
08/14/00	180	190	0.95	200	290	0.69	150	220	0.68
08/21/00	720	5600	0.13	1600	1500	1.07	1500	1800	0.83
08/28/00	9	9	1.00	27	10	2.70	72	54	1.33
08/29/00	230	210	1.10	240	210	1.14	220	280	0.79
G MEAN	149.67			225.31			237.05		
DATE	FC	FS	FC/FS	FC	FS	FC/FS	FC	FS	FC/FS
09/11/00	1500	310	4.84	1800	390	4.62	1500	360	4.17
09/18/00	420	450	0.93	580	400	1.45	440	400	1.10
09/19/00	380	360	1.06	390	220	1.77	520	300	1.73
09/25/00	17000	3800	4.47	14000	3800	3.68	15000	3100	4.84
09/26/00	2200	380	5.79	1400	400	3.50	1300	360	3.61
G MEAN	1550.24			1514.97			1462.57		

FC = FECAL COLIFORM
FS = FECAL STREPTOCOCCUS
FC/FS = FECAL COLIFORM / FECAL STREPTOCOCCUS RATIO
G MEAN = GEOMETRIC MEAN

BACTERIOLOGICAL WATER QUALITY OF STORM DRAINS MAY - SEPTEMBER 2000

PEDESTRIAN BRIDGE (0A005)

	WEST BANK (A)			MID CHANNEL (B)			EAST BANK (C)		
DATE	FC	FS	FC/FS	FC	FS	FC/FS	FC	FS	FC/FS
05/01/00	1100	1000	1.10	210	5300	0.04	2600	4800	0.54
05/15/00	120	430	0.28	9	36	0.25	350	920	0.38
05/16/00	36	27	1.33	18	27	0.67	220	200	1.10
05/22/00	18	45	0.40	10	18	0.56	72	81	0.89
05/23/00	45	110	0.41	27	72	0.38	81	45	1.80
G MEAN	82.62			24.70			259.09		
DATE	FC	FS	FC/FS	FC	FS	FC/FS	FC	FS	FC/FS
06/05/00	9	81	0.11	10	54	0.19	10	18	0.56
06/12/00	18	36	0.50	9	10	0.90	250	170	1.47
06/14/00	7500	4800	1.56	15000	35000	0.43	8300	18000	0.46
06/19/00	27	130	0.21	10	63	0.16	460	2600	0.18
06/26/00	5600	7800	0.72	81	300	0.27	4800	5100	0.94
G MEAN	178.99			64.23			539.76		
DATE	FC	FS	FC/FS	FC	FS	FC/FS	FC	FS	FC/FS
07/10/00	9	36	0.25	9	54	0.17	10	54	0.19
07/17/00	10	18	0.56	9	36	0.25	10	72	0.14
07/18/00	10	240	0.04	9	130	0.07	160	300	0.53
07/24/00	10	140	0.07	9	91	0.10	150	280	0.54
07/25/00	100	390	0.26	27	370	0.07	990	2300	0.43
G MEAN	15.52			11.21			75.02		
DATE	FC	FS	FC/FS	FC	FS	FC/FS	FC	FS	FC/FS
08/07/00	27	280	0.10	45	560	0.08	100	1700	0.06
08/14/00	54	18	3.00	18	10	1.80	72	280	0.26
08/21/00	250	8500	0.03	230	2600	0.09	300	360	0.83
08/28/00	10	36	0.28	18	18	1.00	54	36	1.50
08/29/00	36	63	0.57	27	54	0.50	90	160	0.56
G MEAN	42.03			39.03			100.98		
DATE	FC	FS	FC/FS	FC	FS	FC/FS	FC	FS	FC/FS
09/11/00	72	54	1.33	72	54	1.33	220	240	0.92
09/18/00	63	110	0.57	18	72	0.25	81	45	1.80
09/19/00	18	9	2.00	10	10	1.00	36	63	0.57
09/25/00	1900	280	6.79	4800	380	12.63	7600	870	8.74
09/26/00	140	63	2.22	190	54	3.52	560	180	3.11
G MEAN	116.78			103.40			307.07		

FC = FECAL COLIFORM
FS = FECAL STREPTOCOCCUS
FC/FS = FECAL COLIFORM / FECAL STREPTOCOCCUS RATIO
G MEAN = GEOMETRIC MEAN

BACTERIOLOGICAL WATER QUALITY
OF STORM DRAINS
MAY - SEPTEMBER 2000

	11th Street SD OK 022			Indian Ave. SD OK 003			21st Street SD OK 008			26th Street SD OK		
DATE	FC	FS	FC/FS	FC	FS	FC/FS	FC	FS	FC/FS	FC	FS	FC/FS
05/01/00	280000	200000	1.40	210000	320000	0.66	58000	260000	0.22	4200	12000	0.35
05/15/00	58000	270000	0.21	***	***	***	98000	280000	0.35	52000	84000	0.62
05/16/00	320000	310000	1.03	***	***	***	260000	260000	1.00	1800	1700	1.06
05/22/00	42000	180000	0.23	***	***	***	43000	56000	0.77	1400	11000	0.13
05/23/00	4800	15000	0.32	***	***	***	2500	19000	0.13	580	1600	0.36
DATE	FC	FS	FC/FS	FC	FS	FC/FS	FC	FS	FC/FS	FC	FS	FC/FS
06/05/00	650	560	1.16	***	***	***	800	580	1.38	230	450	0.51
06/12/00	***	***	***	***	***	***	1400	1300	1.08	1400	2200	0.64
06/14/00	5800	15000	0.39	***	***	***	130000	82000	1.59	42000	63000	0.67
06/19/00	24000	96000	0.25	***	***	***	33000	93000	0.35	18000	53000	0.34
06/26/00	30000	59000	0.51	***	***	***	43000	68000	0.63	11000	25000	0.44
DATE	FC	FS	FC/FS	FC	FS	FC/FS	FC	FS	FC/FS	FC	FS	FC/FS
07/10/00	2100	21000	0.10	***	***	***	2000	23000	0.09	570	580	0.98
07/17/00	22000	230	95.65	***	***	***	19000	280	67.86	520	490	[illegible]
07/18/00	58000	36000	1.61	***	***	***	63000	54000	1.17	3000	3700	[illegible]
07/24/00	22000	18000	1.22	***	***	***	14000	9400	1.49	680	850	0.80
07/25/00	56000	220000	0.25	***	***	***	68000	180000	0.38	38000	82000	0.46
DATE	FC	FS	FC/FS	FC	FS	FC/FS	FC	FS	FC/FS	FC	FS	FC/FS
08/07/00	28000	180000	0.16	***	***	***	29000	170000	0.17	2700	4700	0.57
08/14/00	34000	38000	0.89	***	***	***	29000	40000	0.73	35000	5600	6.25
08/21/00	8800	18000	0.49	***	***	***	14000	21000	0.67	20000	13000	1.54
08/28/00	4000	2100	1.90	***	***	***	8900	5300	1.68	200	160	1.25
08/29/00	4500	3700	1.22	***	***	***	6300	4700	1.34	4600	3800	1.21
DATE	FC	FS	FC/FS	FC	FS	FC/FS	FC	FS	FC/FS	FC	FS	FC/FS
09/11/00	2800	2000	1.40	***	***	***	3600	2600	1.38	8600	1400	6.14
09/18/00	5600	13000	0.43	***	***	***	5200	16000	0.33	490	550	0.89
09/19/00	5600	5800	0.97	***	***	***	6300	6900	0.91	1900	1500	1.27
09/25/00	58000	25000	2.32	***	***	***	65000	23000	2.83	16000	3000	5.33
09/26/00	12000	18000	0.67	***	***	***	12000	8200	1.46	1500	5300	0.28

*** = No Sample
FC = FECAL COLIFORM
FS = FECAL STREPTOCOCCUS
FC/FS = FECAL COLIFORM / FECAL STREPTOCOCCUS RATIO

Appendix E

USEPA NPDES/OPDES Facility Data

Two (2) pages

LAT/LONG	FACILITY NAME & ODEQ PERMIT NUMBER	Dis-charge Pipe Design-ation	AV Flow in Conduit or thru Treatment Plant, (GPD)	AV pH	General Fecal Coliform (#/100 mL)	AV BOD, 5-Day (20 deg. C), (mg/L)	AV COD, (High Level), (mg/L)	AV TSS, (mg/L)	AV Total Solids Dis-solved, (mg/L)	AV Oil and Grease, (mg/L)	AV TOC, (mg/L)	AV Total Ammonia as Nitrogen, (mg/L)	AV Total Phenolics, Recoverable, (mg/L)	AV Total Sulfate, (mg/L)	AV Total Sulfide as S, (mg/L)	AV Total Hexa-valent Chromium, (mg/L)	AV Total Chromium, (mg/L)	AV Total Chloride as Chlorine (mg/L)	AV Total Chlorine Residual, (mg/L)	AV Free Avail-able Chlor-ine, (mg/L)	AV Total Fluo-ide as Fluor-ine, (mg/L)	AV Total Oxid-ants Residual (mg/L)	AV Free Oxid-ants Avail-able (mg/L)	AV Total Antimony as SB, (mg/L)	AV Total Tin as SN, (mg/L)	AV Total Lead as PB, (mg/L)	AV Total Mer-cury as HG, (mg/L)
35.971667 95.919444	KIMBERLY-CLARK CORP-JENKS MILL, OK0040827	001	1,937,143	6.636		3.008		3.946																			
35.969167 95.917778	KIMBERLY-CLARK CORP-JENKS MILL, OK0040827	002	103,500	7.836			12.433 av dly max	3.957 av dly max		5.167 av dly max																	
35.966944 95.928056	KIMBERLY-CLARK CORP-JENKS MILL, OK0040827	003	54,357	7.65			24.698 av dly max	9.421 av dly max		5.167 av dly max																	
36.129667 96.098972	BAKER PETROLITE, SAND SPRINGS, OK0000388	001	3,735,556	8.434				8.857		5.144	0.5																
36.137444 96.05325	OZARK FLUORINE SPECIALTIES,INC, OK0000655	001	3987.594	7.267				< 5.7													1.196			0.0185	< .036		
36.13375 96.054167	CHEMTRADE REFINERY SERV. INC., OK0036439	001	70,600	7.451		3.428		9.664	665					245.613				187.25									
36.143889 96.013333	SUNOCO, INC.-TULSA REFINERY, OK0000876	001	1,985,214	7.081		6.321	55.071	17.214		5		0.882	0.031		0.021	0.016	0.014										
36.119722 95.995000	SINCLAIR TULSA REFINING CO., OK0001309	01A	1,253,857	7.386		6.157	51	11.414		4.457		2.006	0.05		0.055	0.011	0.01										
36.12000 95.994722	SINCLAIR TULSA REFINING CO., OK0001309	01B	10,772,250	8.738				6.188		4.162	5.25																
36.133664 96.029403	MAGELLAN PIPELINE CO, LLC, OK0043206	1	2936	7.75																							
35.959167 95.887278	HOLLIDAY SAND & GRAVEL-BIXBY#1, OK0035319	001	2,166,667	7.978				25.222 av dly max																			
35.957694 95.881528	HOLLIDAY SAND & GRAVEL-BIXBY#1, OK0035319	002	2,166,667	7.773				31.444 av dly max																			
36.122222 96.118889	SAND SPRINGS SAND & GRAVEL CO., OK0040096	001	260,077.50	8.198				13.825 av dly max																			
36.122222 96.120833	SAND SPRINGS SAND & GRAVEL CO., OK0040096	002	121,682	8.263				10.717 av dly max																			
35.995833	ANCHOR STONE CO.-DELAWARE SAND, OK0042404	001A	no discharge																								
35.923611 95.759722	J & J SAND COMPANY, OK0043893	001	927,192	7.53				36.769																			
36.048056 95.9775	ANCHOR STONE - 81ST SAND PLANT, OK0044415	001	no discharge																								
36.042306 95.972611	ANCHOR STONE CO. - JENKS SAND, OK0044547	001	no discharge																								
36.230556 95.843889	ANCHOR STONE CO.-36th STREET, OKG950035	001	no discharge																								

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35.958333 95.895556	MID-CONTINENT CONCRETE CO - BIXBY	001A																									
36.133639 95.996306	MID-CONTINENT CONCRETE CO - TULSA, OKG110054	001	no discharge																								
35.98305695.931944	GREEN COUNTRY ENG-COGENTRIX EN, OK0043869	001	201,000	6.984															<0.099	<0.099						<0.005	
35.98305695.931944	GREEN COUNTRY ENG-COGENTRIX EN, OK0043869	01A	52,571					4.625		<5																	
35.998444 95.956306	PUBLIC SERVICE CO - RIVERSIDE, CTRL PSO JENKS, OK0002429	2	0.331	7.476				21.369		< 5.00																	
35.996389 95.955833	PUBLIC SERVICE CO - RIVERSIDE, CTRL PSO JENKS, OK0002429	1	1.061	7.762															<0.09 av dly max	<0.09 av dly max							
36.116833 95.990222	PUBLIC SERVICE CO - TULSA POWER PSO, OK0000108	1	361,428	7.889																		<0.05 dly max	<0.05				
36.117778 95.991389	PUBLIC SERVICE CO - TULSA POWER PSO, OK0000108	01A	36,428					10.916		<5.00																	
35.948278 95.869528	BIXBY PUBLIC WORKS AUTH-SOUTH, OK0026913	001	349,607	7.989	351.318	18.432		15.161																			
35.987667 95.937972	JENKS PUBLIC WORKS AUTHORITY, OK0037401	001	1,190,000	7.05		4.714		7.586																			
36.131222 96.089917	SAND SPRINGS MUNICIPAL AUTH WASTE WATER TRT, OK0030864	001	1,878,643	7.478	8.1	21.357		11.643											0.0578 av dly max								
35.961944 95.781722	BROKEN ARROW SEWAGE TRT, OK0040053	1	3,602,000	7.25		13.1		9.3	491																		1E-04
36.087694 95.991722	TMUA SOUTH, OK0026239	1	21,309,333	6.98	8.1	12.36	10.61125		0.062 av dly max																		
36.087611 95.991444	TMUA SOUTH, OK0026239	2	no measurements																								
35.941694 95.853917	RMUA-HAIKEY CREEK, OK0034363	1	9,955,333	7.207	10.4	12.44	6.803125		0.025 av dly max																		

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Figures, Tables & Appendices

Acronyms

ARC	Arkansas River Corridor
ASL	Above Sea Level
AVG	Average
BUMP	Beneficial Use Monitoring Program
C	Celsius
CWA	Clean Water Act
F	Fahrenheit
FIPS	Federal Information Processing Standard
GIS	Geographical Information System
GPD	Gallons Per Day
HUC	Hydrologic Unit Code
INCOG	Indian Nations Council of Governments
MG/L	milligrams per liter
N	Nitrogen
NAD83	North American Horizontal Datum
NAVD88	North American Vertical Datum
NPDES	National Pollution Discharge Elimination System
NTU	Nephelometric Turbidity Units
ODEQ	Oklahoma Department of Environmental Quality
OK	Oklahoma
OPDES	Oklahoma Pollution Discharge Elimination System
OWRB	Oklahoma Water Resources Board
PCS	Permit Compliance System
S	Sulfate
SDSFIE	Spatial Data Standards for Facilities, Infrastructure, and the Environment
TMDL	Total Maximum Daily Loading
UG/L	micrograms per liter
USAP	Use Support Assessment Protocols
USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey
USACE	United States Army Corps of Engineers
WQS	Water Quality Standards

Abstract

The Arkansas River's natural water quality has caused it to be largely abandoned as a source of municipal/industrial and public water supply. In general, the river's water quality is greatly influenced by the mineral and salt concentrations of the Salt Fork, Cimarron and Canadian tributaries draining into it from across western Oklahoma. However, within the 42-mile long study area from the Keystone Dam to the Tulsa/Wagoner County line certain physical and chemical constituents of the river are typical of other streams' water quality within the United States. This would include pH, temperature, alkalinity, hardness, chloride, sulfate, total dissolved solids, heavy metal concentrations and others. In addition, the Oklahoma Water Resources Board's beneficial use determinations and the US Environmental Protection Agency's Drinking Water Quality Standards for the river are being supported and/or met, respectively. This is substantiated by three Oklahoma Water Resources Board's monitoring stations, five City of Tulsa monitoring stations, and seven years of recent water quality data. Throughout most of the study area, the river is supported for the Oklahoma Water Resources Board's designated beneficial uses that include; Emergency Water Supply, Warm Water Aquatic Community, Agriculture, and Aesthetic Quality. This also includes the river not being Nutrient Threatened. The water quality of the river is also influenced by anthropogenic (manmade) sources of pollution mostly in the form of biological constituents. Thus, the Oklahoma Water Resources Board's beneficial use for Primary Body Contact—Recreation is not supported throughout most of the study area because of fecal coliform, E. Coli and Enterococci bacteriological concentrations and number of occurrences. The industrial facilities located along the river within the study area includes; six (6) wastewater treatment plants, three (3) public electricity generation utilities, nine (9) sand & gravel operations or concrete batch operations, two (2) petroleum refineries, one (1) petroleum pipeline, one (1) paper product manufacturer, and three (3) chemical product manufacturers or processors. These industrial facilities are permitted under the US Environmental Protection Agency's National Pollution Discharge Elimination System or the Oklahoma Pollution Discharge Elimination System. In general, despite the physical and chemical constituents discharged into the river by these permitted facilities the Oklahoma Water Resources Board's beneficial use criteria and the US Environmental Protection Agency's Primary and Secondary Water Quality Standards (where applicable) are still being met within the 42-mile study area.

Arkansas River Corridor (ARC) Water Quality Data Report

Purpose of Study

The Greater Tulsa Area communities recognized that the Arkansas River Corridor (ARC) is an important natural resource that could be developed to stimulate immense private investment and greatly improve the quality of life for current and future generations. A Tulsa County, one-penny, 13-year sales tax was approved to support this vision (Vision 2025) with a portion of the tax devoted to studies and improvements along the ARC. The Indian Nations Council of Government (INCOG) directed and oversaw the development of a ARC Master Plan/Phase I Vision Plan that was completed in August 2004. The US Army Corps of Engineers (USACE), Tulsa District and INCOG developed a Phase II Master Plan and Pre-Reconnaissance Study in October of 2005. Some of the objectives of the Phase II Plan involved addressing potential environmental initiatives. This led to a letter agreement between Tulsa County, the Oklahoma Water Resources Board (OWRB) and the USACE Tulsa District to inventory, assess and evaluate environmental data for the Arkansas River from the Keystone Dam to the Tulsa/Wagoner County line, a 42 mile long corridor. The environmental initiatives included a: 1) faunal and floral inventory; 2) fish community structure and composition assessment; 3) aquatic macro-invertebrate structure and composition; 4) water quality data assessment, and; 5) cultural resource evaluation. This report is specific to the water quality data assessment.

This ARC water quality data assessment conducted in 2006/07 included the compilation, analysis and synopsis of existing water quality data. The water quality data was compiled from available published reports and scientific literature produced by municipal agencies, county agencies, state agencies, federal agencies, and private industry. A thorough analysis of the existing water quality data produced a synopsis (report) of the current water quality conditions within the study area. The study area was defined as the 42 mile long corridor of the Arkansas River within Tulsa County from the Keystone Dam to the Tulsa/Wagoner County line **(Figure 1)**. In addition to the analysis and synopsis of the water quality data, the study included a supporting GIS database for mapping. The GIS database and mapping format was designed to be compatible with the USACE and county agency mapping formats. The GIS database and mapping format used for the study was based on state of Oklahoma's FIPS 3501 (feet), NAD83 horizontal datum plane and NAVD88 vertical datum plane coordinate system. The GIS database format also included all of the appropriate features that can support the USACE's Spatial Data Standards for Facilities, Infrastructure, and the Environment (SDSFIE) Release 2.5 requirements.

Introduction

In order to adequately assess the ARC (42-mile study area) one must first understand the basics of water quality measurements as well as the natural chemistry of surface water. It is also important to understand the basic characteristics of the Arkansas River as a whole. Secondly, it is important to understand the specific characteristics of the river in the study area. These specific characteristics include the climate, physiography, geology, soils, natural vegetation, hydrology, and watersheds. Another characteristic to understand is the impact to the river by man (anthropogenic influences). So, it is important to identify the demographic characteristics within the study area. These demographic characteristics include the population distribution, municipalities, land use, water use, man-made structures, and environmental influences.

See Figure 1 PDF file

oxidation/reduction potential. Dissolved oxygen concentrations around 2-3 mg/l pose a threat to aquatic life. Turbidity is a measurement of the fine suspended matter in water. The turbidity is measured in units that measure the light-scattering and absorbing properties of the suspended matter. Turbidity levels greater than 25 Nephelometric Turbidity Units (NTU) for extended periods of time cannot sustain aquatic life **(Hem, 1986)**.

The specific conductance (conductivity) of surface water or its ability to conduct an electrical current is dependent upon the concentration of cations (hydrogen, sodium, calcium, magnesium) and anions (hydroxide, chloride, sulfate, bicarbonate, carbonate, phosphate) in solution. Natural waters have specific conductances that are much less than one mmho/cm (mS/cm) so the values are expressed in umho/cm (uS/cm). The measurement of Total Dissolved Solids is a measure of the ions plus the dissolved solids (inorganic acids, bases and salts). The USGS classifies fresh water as having 500 mg/l or less of Total Dissolved Solids which is also the preferable concentrations for domestic use and many industrial processes **(Hem, 1986)**.

The occurrence of ions in surface waters also predicates the degree of salinity which is usually measured as sodium chloride. Chloride (anion) occurs in all natural waters but is typically low. Chloride concentrations of 10 mg/l are commonly found in natural waters in humid regions. A maximum of 50 mg/l is allowable for industrial use and 100 mg/l for irrigation use. The USEPA secondary drinking water standard for sulfate is 250 mg/l. Another anion (sulfate) is found in natural waters as oxidized sulfides, sulfites and thiosulfates or in organic matter. It can also occur as industrial pollution (detergents, tanneries). The USEPA secondary drinking water standard is 250 mg/l **(Hem, 1986)**.

Alkalinity is almost entirely a measurement of bicarbonate and carbonate anions expressed as an equivalent amount of calcium carbonate. It has the capacity to neutralize acid or maintain the pH at a certain level. Values ranging from 5 to 125 mg/l are expected in surface waters and concentrations greater than 20 mg/l can impact aquatic life. Hardness is also expressed as an equivalent of calcium carbonate, but is a measurement of calcium and magnesium cations in the water. Concentrations from 0 to 50 mg/l are considered soft, 50 to 150 mg/l is moderately hard, 150 to 300 mg/l is hard, and above 330 mg/l is very hard. The degree of hardness can adversely impact industry processes and build up deposits in piping **(Hem, 1986)**.

The chemical and biological processes that transfer nitrogen to form the lithosphere, atmosphere, hydrosphere and biosphere are referred to as the nitrogen cycle. Nitrogen is an essential nutrient for plant growth. Man's influence on the nitrogen cycle includes production and of synthetic fertilizers such as ammonia and other nitrogen compounds. It can be measured as total nitrogen, Kjeldahl nitrogen, nitrate minus nitrite, or ammonia. Water from many small and medium-sized rivers in agricultural areas has nitrate concentrations exceeding 10 mg/l. Excessive concentrations of nitrate in drinking water, greater than 10 mg/l, can cause health problems especially in small children **(Hem, 1986)**.

Phosphorous in its elemental form is insoluble in water and soils. It is found in detergents, animal waste, sewage and commercial fertilizers. In its anionic form, it is called phosphate and in water occurs as orthophosphate, polyphosphate and organically bound phosphate. Total phosphate is a measurement of all three forms. Orthophosphate is the most likely to occur in natural water **(Hem, 1986)**. When present in water phosphates are capable of supporting excessive growth, high densities of plants and algae. The state of Oklahoma has a numerical criteria limit value of 0.037 mg/l for scenic rivers.

Trace metals and/or heavy metals in surface water occur naturally and have anthropogenic sources. Anthropogenic sources can include agricultural runoff, industrial operations, electroplating, leachate from landfills, chemicals, galvanizing operations and others. As a minor constituent in surface water, concentrations for arsenic, cadmium, lead, nickel, and zinc range from 0.0001 to 0.1 mg/l or parts per million. Also as minor constituents in surface water, other concentration values and ranges are; mercury (0.5 ug/l in 32% of surface waters sampled), thallium (1.0 ug/l), silver (0.1 to 4 ug/l), selenium (less than 10 ug/l), copper (less than 20 ug/l), and chromium (1 to 100 ug/l) **(Hem, 1986)**. A microgram per liter (ug/l) equivalent expression is parts per billion.

The biological characteristics include fecal coliform, Escherichia coli (E. coli) and Enterococci. All three forms are bacteria and are present in the intestine and/or feces of warm-blooded animals. Fecal coliform generally do not pose a danger to people or animals but they indicate the presence of other disease-causing bacteria, such as those that cause typhoid, dysentery, hepatitis A, and cholera. Unlike fecal coliform, disease-causing bacteria generally do not survive long enough in the water, outside the body of animals, to be detected. This makes their direct monitoring difficult. So scientists and public health officials consider the presence of fecal coliform as an indicator of disease causing bacteria in the water. The presence of fecal coliform, E. coli and Enterococci bacteria in water can be an indication of recent sewage or animal waste contamination and are limited to 400 colonies/100ml, 126 colonies/100 ml and 33 colonies /100 ml, respectively for recreational **(OWRB, 2004)**.

Arkansas River

The Arkansas River's headwaters begin near Leadville, central Colorado. The river flows 1,450 miles across Colorado, Kansas, north-central Oklahoma, east-central Oklahoma and through Arkansas before it reaches the confluence with the Mississippi River. It is the fourth longest river in the United States. With a drainage basin of nearly 195,000 miles, the Arkansas River is the largest tributary of the Mississippi-Missouri River System. It enters Oklahoma near Arkansas City on the Kansas border above Kaw Lake (Kay County, Oklahoma), then flows generally southeast through Tulsa and Muskogee before turning east and flowing across the Arkansas State Line into Fort Smith. In Oklahoma, the Arkansas River is fed by the Salt Fork, Black Bear, Cimarron, Illinois, Verdigris and Canadian Rivers along with several other smaller rivers, creeks and streams. Numerous dams including the Keystone Dam west of Tulsa have created very large lakes on the Arkansas River **(McCord, 2007)**.

The Arkansas River's natural water quality has caused it to be largely abandoned as a source of municipal/industrial and public water supply. In general, the river's water quality is greatly influenced by the mineral and salt concentrations of tributaries draining into it from across western Oklahoma. These rivers include the Salt Fork, Black Bear, Cimarron and Canadian. Above Keystone Dam (beginning of the study area) is the tributary inflow from the Salt Fork, Black Bear and Cimarron Rivers. The mineral and salt concentrations from these rivers greatly influence the Arkansas River's natural water quality throughout the 42 mile study area and to the confluence of the Verdigris, Neosho and Arkansas Rivers some 30 miles below the study area. These eastern Oklahoma Rivers are significantly less mineralized and provide a large volume of water to dilute the mineralized (total dissolved solid) concentrations transported by the Arkansas River. It is not until the tributary inflow of the Canadian River another 30 miles further downstream of the eastern Oklahoma rivers' confluence that the dissolved solid concentrations increase again because of the western Oklahoma tributary influence.

Climate

The climate of Tulsa County is temperate. The normal annual temperature is 60.3 degrees Fahrenheit (F). The average annual maximum and minimum temperatures are 71° and 49° F, respectively. The highest recorded temperature was 115° F and the lowest recorded temperature was -15° F. On the average, the relative humidity ranges between 47% and 92%. The normal annual precipitation is 41.91 inches and there are approximately 83 days per year with precipitation. The majority of the annual rainfall (64%) occurs between April and September. Thunderstorms occur predominantly in the spring and summer for about 50 days out of the year. The prevailing winds across Tulsa County are predominantly from the south to southeast and the wind speeds average nearly seven miles per hour on an annual basis **(Bennison, Knight, Creath, Dott & Hayes, 1972)**. The mean annual pan evaporation rate for Tulsa County is between 70 and 80 inches **(Watson & Burnett, 1993)**.

Physiography

There are two geomorphic provinces identified in Tulsa County. They are called the Eastern Sandstone Cuesta Plain and the Claremore Cuesta Plain. The Eastern Sandstone Cuesta Plain forms rugged hills with one steep face (cuesta) on top of broad shale plains (river floodplain) in the most western arm of the county. The Claremore Cuesta Plain produces less pronounced and less frequent hills, but is composed of sandstone and limestone on top of the broad shale plains. The Claremore Cuesta Plain occurs throughout the rest of the county **(Johnson, et al., 1979)**. These hills form the topographic highs (elevations) while the Arkansas River itself forms the topographic lows. These topographic highs and lows define the watersheds and drainage basin boundaries for the Arkansas River within the study area. The relief (elevation differences) ranges from 180 to 300 feet when the cuestas are in close proximity to the river and 20 to 60 feet when the floodplains dominate the landscape.

Geology

Some of the hills (cuestas) that outcrop next to the river are Pennsylvanian rock formations. The hills along the upper reaches of the river are composed of the Dewey Limestone and Nellie Bly Formation. Progressing downriver the rock formations become older and include the Coffeyville, Checkerboard Limestone, Seminole, Holdenville, and Nowata Shale. These formations represent ancient river and sea deposits: delta; prodelta; subtidal clastics & marine shell banks; shallow marine banks; platform shallow marine, and; marine basinal shales **(Bennison, et al., 1972; Marcher & Bingham, 1988)**.

Quaternary river deposits cover the younger Pennsylvanian formations on the broad floodplains when the hills are not encountered next to the river. These river deposits predominate along the river and study area. The younger Holocene deposits represent modern floodplain alluvium that overly older Pleistocoene terrace deposits. The deposits consist of unconsolidated gravels, sands, silts and clays **(Bennison, et al., 1972; Marcher & Bingham, 1988)**.

Watersheds

There are five USGS, eight-digit Hydrologic Unit Codes (HUC) for the Arkansas River Basin in Oklahoma. One of these HUCs is located in the Lower Arkansas River Basin and is called the Polecat-Snake (11110101) Watershed. The Polecat-Snake Watershed extends throughout southern Tulsa County and northeastern Muskogee County. The Arkansas River and approximately twenty-one tributaries make up the Polecat-Snake watershed (OK 11110101) which has a drainage area of 280 square miles.

There are four, state of Oklahoma watershed basins identified for the 42-mile study area. They include portions of Tulsa, Creek, Muskogee, Okmulgee, Osage, Rogers and Wagoner Counties. The Oklahoma Water Body Identification System identifies these eight-digit watersheds as OK120410-01, OK120410-03, OK120420-01, and OK120420-02.

The Arkansas River tributaries from the upper reach to the lower reach of the study area (42 miles long) and in sequential order, include; Brush Creek (north side of river), Little Sand Creek (north), Sand Creek (north), Mud Creek (south side of river), Shell Creek (north), Fisher Creek (south), Euchee Creek (north), Anderson Creek (south), Blackboy Creek (north), Berryhill Creek (south), Harlow Creek (north), Crow Creek (north, 31st), Cherry Creek (south), Mooser Creek (south), Joe Creek (north), Fred Creek (north), Polecat Creek (south), Posey Creek (south), Haikey Creek (north), Snake Creek (south), and Broken Arrow Creek (north) **(Figure 1a)**.

Demographics

Tulsa County has a total population of 563,299 people. The population density is 988 persons per square mile. As a contrast, the state of Oklahoma has a population density of 50 persons per square mile **(University of Oklahoma Urban Design Studio [OUUDS], 2003)**. The cities and towns along the Arkansas River from the upper reaches to the lower reaches of the study area include Sand Springs, Tulsa, Jenks, Bixby and Broken Arrow and they have a total population of 518,047 persons. The specific populations are Sand Springs (17,667), Tulsa (382,457), Jenks (13,095), Bixby (18,600) and Broken Arrow (86,228) **(U.S. Census Bureau, 2005)**. There are some smaller communities along the river such as Lotsee, Wekiwa, Fisher, Bend, Prattville, Shirk, Gray, Price, Kengle, and Garden City all of which are located in Oklahoma and are included in the census population.

Land Use

One method for identifying land use within the ARC study area involves measuring the percentage of urbanized development verses non-urbanized along the north and south banks. Urbanization being defined as developed land that is used for residential, commercial, industrial and other non-agricultural uses with a population density typically greater than 500 persons per square mile and/or possessing significant civic infrastructure **(OUUDS, 2003).** The non-urbanization would be defined as all other land uses. In these terms, the river corridor is approximately 62.5% urbanized along the north bank verses 37.5% which is non-urbanized. And, 51% is urbanized along the south bank verses 49% which is non-urbanized.

See Figure 1A PDF file

Another method for identifying land use within the ARC study area is to look at the percentage of urbanization verses agricultural development and non-urbanization throughout the entire 42 square mile area (slightly under 26,880 acres). The urbanization definition is expanded to include developed lands used for residential, commercial, industrial, transportation/communication utilities, strip mines/quarries/gravel pits and other built-up areas. The agricultural development definition includes cropland/pasture, and orchards/groves/vineyards/nurseries/horticultural areas. The non-urbanized definition includes deciduous forest land, streams/canals, reservoirs, beaches, other sandy areas, and transitional areas **(C.H. Guernsey & Company, 2005).** In these terms, the urbanized development percentage is 22.9%, the agricultural development percentage is 35.6% and the non-urbanized percentage is 41.6%. The deciduous forest lands make-up 14.5% of the total study area acreage and 34.9% of the non-urbanized percentage.

Water Use

The urban/suburban, industrial and agricultural/horticulture development in Tulsa County and along the ARC has led to anthropogenic (manmade) uses for the river and sources of discharge into the river. Uses have included recreation (boating, fishing & hunting), industrial, utility, municipal, agriculture/horticulture and structure building along the river.

There are significant recreational areas (parkways) located along the east bank of Tulsa from 11th Street to 101st Street. Industrial areas are concentrated along the north bank of Sand Springs, the north & west bank of Tulsa, and sporadically south of Tulsa on either bank of the river. There are five major municipalities with significant commercial and residential areas developed along the center two-thirds of the study area. In the southern portion of the study area (Bixby & Broken Arrow), there is significant agriculture/horticulture development along both banks of the river. There is a major dam (Keystone), a low-water dam (Zink Lake) , and fifteen bridges spanning the Arkansas River within the study area.

USEPA Water Quality Regulations

The Water Quality Standards (WQS) are the foundation of the Water Quality-Based Pollution Control Program mandated by the federal Clean Water Act (CWA). The WQS define the goals for a water body by: 1) designating its uses (e.g., recreation, water supply, aquatic life, agriculture, etc.); 2) setting water quality criteria (e.g., numeric pollutant concentrations & narrative requirements); 3) establishing anti-degradation policies to maintain and protect existing uses and high quality waters, and; 4) establishing general policies (e.g., low flows, variances, mixing zones, etc.) **(USEPA, WQS, 2007).**

The WQS regulations require the states to specify appropriate water uses to be achieved and protected. The appropriate uses are identified by taking into consideration the use and value of the water body for public water supply, for protection of fish, shellfish, and wildlife, and for recreational, agricultural, industrial, and navigational purposes. In designating the uses for a water body, states examine the suitability of a water body for the uses based on the physical, chemical, and biological characteristics of the water body, its geographical setting and scenic qualities, as well as economic considerations **(USEPA, WQS, 2007).**

The CWA also provided a statutory basis for regulating the discharge of pollutants from point sources into waters of the United States. The CWA gives the USEPA the authority to set effluent limits on an industry-wide (technology-based) basis and on a water-quality basis to ensure the protection of the receiving water. This was done through the National Pollution Discharge Elimination System (NPDES) Permit Program. The CWA also allowed the USEPA to authorize the NPDES Permit Program to state governments, enabling states like Oklahoma to perform many of the permitting, administrative, and enforcement aspects for the federal program through its own permit program, the Oklahoma Pollution Discharge Elimination System (OPDES). The USEPA still retains oversight responsibilities in the states that have been authorized to implement the CWA programs **(USEPA, WQS, 2007)**.

The key sections of the CWA that directly relate to the NPDES Permit Program include Titles I, II, III and IV. Title I is research and related programs and Title II is grants for construction of treatment works. Title III is the standards and enforcement which includes; effluent standards (§301), water quality-related effluent limitations (§302), water quality standards and implementation plan (§303), information and guidelines (§304), water quality inventory (§305), and the toxic and pretreatment effluent standards (§307). Title IV is the permitting and licensing, specifically the NPDES (§402) **(USEPA, Permit Compliance System [PCS], 2007)**.

Oklahoma Water Quality Regulations

The Oklahoma WQS are set forth under statutory authority of the OWRB which is authorized under 82 O.S. § 1085.30 **(OWRB, Rules, 2007)**. The rules adopted by the state of Oklahoma are in accordance with the federal CWA, applicable federal regulations, and state pollution control and administrative procedure statutes. The WQS serve a dual role: 1) they establish water quality benchmarks, and; 2) provide a basis for developing water-quality based pollution control programs **(Oklahoma Department of Environmental Quality [ODEQ], 2004)**.

The state's surface waters receive broad and explicit protection through the WQS. Furthermore, the implementation rules contain Use Support Assessment Protocols (USAP) for Oklahoma's water bodies and are developed in coordination with all of the state's environmental agencies. The USAP establish a consistent and scientific decision methodology for determining whether a water body's beneficial uses are being supported, and they outline the minimum data requirements for the decision methodology **(OWRB, 2004)**. This scientific decision methodology or USAP involve collecting and analyzing the physical, chemical and biological characteristics of a particular water body in various numeric criteria and narrative assessment combinations.

Created in 1998, the Beneficial Use Monitoring Program (BUMP) is a comprehensive statewide compilation of water quality data. The BUMP main goals are to document beneficial use impairments, identify impairment sources, detect water quality trends, provide needed information for the Oklahoma WQS, and provide critical information for the prioritization of pollution control activities by state and local entities. The current recognized beneficial uses for some or all of the waters in Oklahoma include public and private water supply, fish and wildlife propagation, agriculture, hydropower, municipal and industrial process and cooling water, primary body contact recreation (such as swimming), secondary body contact recreation (such as boating or fishing), navigation, and aesthetics. **(OWRB, 2004)**. The Arkansas River within the 42-mile study area does have identified beneficial use impairments.

The ODEQ also has statutory authority under Title 27A O.S., § 2.6.101 et. seq. for water quality in the state. The state statutes allow the ODEQ to: issue permits; conduct water quality assessments, listings, and reports; manage point source and non-point sources of pollution; establish Total Maximum Daily Loading (TMDL) restrictions and modeling for streams; conduct toxicity & biomonitoring, and; implement a water quality management plan (208 Plan).

The ODEQ issues municipal point source discharge permits (OKG58), municipal stormwater MS4 permits (Tulsa), small municipal stormwater MS4 permits (Sand Springs, Jenks, Bixby, Broken Arrow), industry specific point source discharge permits, industrial stormwater permits (multi-sector general permit, OKR05, MSGP), and construction stormwater discharge permits (OKR10).

The CWA 303(d) regulations require states to develop lists of water bodies that do not meet the water quality standards and submit an updated list to the USEPA every two years. For water bodies on the 303(d) list, the CWA requires that a pollutant load reduction plan or TMDL be developed to correct each impairment. TMDLs must document the nature of the water quality impairment, determine the maximum amount of a pollutant which can be discharged and still meet the standard requirements, and identify allowable loads from the contributing sources **(ODEQ, 2004)**. Currently, there are no TMDL requirements for the Arkansas River within the 42-mile study area.

The CWA 305(b) regulations requires a state to develop an inventory of the water quality of all state water bodies and submit an updated report to the USEPA every two years. The 305(b) report includes: 1) analysis and compliance of the water bodies "fishable/swimmable" goal; 2) analysis and elimination process of pollutant discharges and the water quality related to the "fishable/swimmable" goal; 3) the environmental impact; 4) economic and social cost/benefit analysis, and; 5) the estimated date of such achievement. It also entails a description of the nature and extent of non-point sources of pollutants, recommendations of programs needed to control them, and an estimate of the costs of implementing such programs **(ODEQ, 2004)**.

Water Quality Reports & Data

Most of the available water quality data for Oklahoma has been generated by local, county, regional, state and federal agencies. These agencies have included the City of Tulsa, Tulsa County Health Department, Oklahoma Conservation Commission, ODEQ, Department of Agriculture Food and Forestry, OWRB, USACE, and the USGS.

There are older water quality data reports and studies that have been conducted for the Arkansas River in general, near the study area, and within the study area. There are also former and existing USGS and USACE gauging stations that have water quality data for the Arkansas River in or near the identified study area. While some of these studies and gauging stations do provide data with some insight on the water quality of the Arkansas River, they are either to general in nature, temporally (time) non-relevant or spatially (distance) non-relevant for the goals of this report. The general, temporal and spatial non-relevant studies and data included, but were not limited to:

- Dover, T.B. (1957). Water Quality- A Factor in Arkansas River Development. USGS. Presented before the Tulsa Chamber of Commerce, July 22, 1957.
- Cox, W. R., Wright, M. D., & Woodruff, G. D. (1981). The Importance of Intense Trend Bacteriological Monitoring for Evaluating a Recreational Water Quality Enhancement Program. Water Quality Control Section, Office of Planning & Research, Tulsa City-County Health Department. Oklahoma Academy Science, Volume 61: 58-61.

- USACE. (2001). Water Quality Report; Keystone Lake Oklahoma 1996. Southwestern Division, Tulsa District.
- USGS. (2005). Water Resources Data, Oklahoma Water Year 2005. Volume 1. Arkansas River Basin. Water-Data Report OK-05-1.
- USGS. (1978). Water Type And Suitability of Oklahoma Surface Waters For Public Supply And Irrigation, Part 1: Arkansas River Mainstem and Verdigris, Neosho, and Illinois River Basins Through 1978. Water-Resources Investigations 81-83.

Two reports that begin to relate to the ARC study area in terms of specific, temporal and spatial terms include a five year period from 1976-1980, and a twelve year period from 1989-2000. While they are relevant to the study area they do not represent the most recent data. However, for the purposes of this report, they will be used to support the most recent data and water quality trends within the study area. The Zink Lake Water Quality Assessment is referenced in Appendix A and the Arkansas River Water Quality Reports are included in Appendix D. The two reports are:

- Tulsa County Health Department. (1989-2000). Arkansas River Water Quality Reports.
- Woodruff, Gary D. (1983). Zink Lake Water Quality Assessment. Office of Planning and Research and Water Quality Section. Tulsa City-County Health Department.

The more recent reports and data which will be used to establish the water quality baseline for the study area reflect an eight year period from 1999-2006. The reports are:

- City of Tulsa, Department of Public Works. (2005). 1992-2004 Stream Monitoring Sampling Plan and Data. Tulsa, Oklahoma.
- City of Tulsa, Department of Public Works. (2006). 2005/06 Stream Monitoring Sampling Plan and Data. Tulsa, Oklahoma.
- Oklahoma Water Resources Board. (2004). Beneficial Use Monitoring Program (BUMP) Streams Report. State of Oklahoma.
- Oklahoma Water Resources Board. (2007). Water Information Mapping System (WIMS). Internet Based Mapping Server. State of Oklahoma. http://www.owrb.ok.gov/maps/server/wims.php.
- USEPA. (2007). Permit Compliance System (PCS). Water Discharge Permits. http://www.epa.gov/enviro/html/pcs/index.html.

Water Quality Data Monitoring Stations

There are three fixed, OWRB, BUMP monitoring stations that are used to characterize the beneficial use impairments for the Arkansas River (Polecat-Snake Watershed, Hydrologic Unit Code [HUC] 11110101) and the 42-mile study area **(Figure 2)**. These monitoring stations are used to collect physical, biological and chemical data. The first two locations are in Tulsa County near Sand Springs (S.H. 97 Bridge) and Bixby (S.H. 64 Bridge). A third station is in northeastern Muskogee County east of Haskell (S.H. 104 Bridge). The USAP and the CWA 305 (b) guidelines limit the spatial coverage of a BUMP monitoring station(s) to 25 stream miles on a non-wadable stream like the Arkansas River. In addition, the spatial coverage for a monitoring station(s) cannot extend outside the eight-digit HUC watershed unless it is determined reasonable to do so.

The Sand Springs BUMP station is representative of the Arkansas River from Keystone Reservoir (36.1504, -96.2528) downstream west of Tulsa (36.1392, -96.0569). Within this segment the water enters the river system from Keystone Lake and from several tributaries including; Shell Creek, Fisher Creek, Euchee Creek, Anderson Creek, Blackboy Creek, and Berryhill Creek. The Bixby BUMP station is representative of the Arkansas River from west of Tulsa (36.1392, -96.0569) downstream to the confluence of the Arkansas River and Snake Creek (35.9305, -95.8344). Within this segment tributary waters enter the river system from Harlow Creek, Crow Creek, Cherry Creek, Mooser Creek, Joe Creek, Fred Creek, Polecat Creek, Posey Creek, Haikey Creek, and Snake Creek. The Haskell BUMP station is representative of the Arkansas River from the confluence of Snake Creek (35.9305, -95.8344) downstream to the confluence of the Arkansas River and Pecan Creek (35.7990, -95.4348). Within this segment the tributary water entering the river system is from the Broken Arrow Creek.

There are five City of Tulsa surface water monitoring stations on the Arkansas River and within the 42-mile study area. In downstream order, they are AR1, 11th Street Bridge at Tulsa (36.1434, -96.9870), AR3, I-44 Bridge at Tulsa (36.0968, -95.9854), AR4, 68th & Riverside at Tulsa (36.0640, -95.9796), AR6, Highway 64 Bridge at Bixby (35.9587, -95.8869), and AR8, Indian Springs Sports Complex at Broken Arrow (35.9620, -95.8080) **(Figure 2)**. These monitoring stations are used to collect physical, biological and chemical data throughout the year to meet, support and supplement the ODEQ Permit reporting requirements. These permits include the City of Tulsa's Municipal Point Source Discharges (OKG58) and Municipal Separate Storm Sewer System Discharges (MS4).

There are four USGS surface water stations for the Arkansas River (Polecat-Snake Watershed, HUC 11110101). In downstream order, they are the Arkansas River at Tulsa (36.1406, -96.0061), Joe Creek at 61st Street at Tulsa (36.0756, -95.9603), Haikey Creek at 101stst Street South at Tulsa (36.0170, -95.8486), and Little Haikey Creek at 101st Street at Tulsa (36.0175, -95.8606). These stations measure discharge at all of the locations and temperature at one location. Since the BUMP stations measure discharge (flow) and temperature at all of their locations, the USGS stations will be identified for the purposes of this report, but will not be used in the evaluation of the water quality. In addition, all of the BUMP stations are located on the Arkansas River itself and not on tributaries that feed into the river.

Water Quality Data (OWRB) & Conclusions

The CWA 305(b) and USAP limit the spatial coverage of the state's BUMP monitoring locations to 25 stream miles on non-wadable streams. In addition, the spatial coverage for the monitoring locations cannot extend outside the eight-digit HUC watershed unless it is determined reasonable to do so. The USAP establishes two temporal coverage limitations. First, the collected data cannot be biased towards critical-flow, base-flow or high-flow conditions. Second, stream data that is more than five years old cannot be used to assess support unless no other data exists or a scientifically defensible reason can be used to justify using the older data. The 2004 BUMP Report uses data collected during all of the seasons and does not use data collected before November of 1998 **(OWRB, 2004)**.

The minimum number of samples required to assess the use support for all general water quality variables is ten (10). The BUMP program collects at least ten samples per year on all general water quality parameters with the exception of bacteria, organics and metals. Toxicants (metals and organics) require a minimum of five (5) samples to determine use support, however, less than five (5) samples can be used to determine if a use is partially supported or not supported. The metals are sampled on a biannual basis. Typically, the samples collected from a monitoring station for the

See Figure 2 PDF file

beneficial use determinations are averaged over one year which produce geometric mean values. These values are in turn compared to a screening level values, long-term averaging values, and/or average sample standards for all of the monitoring stations in a specific watershed. The percentage of exceedences determines the beneficial use status. The prescribed percent exceedences are: 1) less than or equal to ten percent are supporting; 2) greater than ten percent (10%), but less than twenty-five percent (25%) are partially supporting, and; 3) greater than or equal to twenty-five percent (25%) are not supporting **(OWRB, 2004)**.

The following table **(Table 1)** identifies the OWRB, Beneficial Use Determination Program's criteria for determining whether or not a particular stream is supported, partially supported, not supported or threatened. It should be noted that the OWRB values presented in Table 1 are limited to the average sample standard, geometric mean and constituent units in mg/l. There are several other numerical caveats and supporting narrative criteria that are used in determining the beneficial use determinations. For example, the beneficial use determinations can be based on the percentage of samples exceeding an average sample standard or geometric mean. And, the heavy metal concentrations utilize a hardness (calcium carbonate) concentration as a multiplication factor to determine the final concentration. However, the average sample standards, geometric means and mg/l concentrations in Table 1 do provide invaluable information for the baseline comparison. Table 1 also includes typical stream water quality mean and range values and the USEPA Primary and/or Secondary Drinking Water Quality Standard values as a baseline comparison to the BUMP data **(Tables 2, 3 & 4)**.

The OWRB water quality data identified in Tables 2, 3 & 4 are yearly mean values and range values (lowest to highest) for the physical, chemical and biological water constituents and measurements collected in 2006. This data was tabulated and averaged from the OWRB's website (a public domain) and data viewer tables **(Appendix B)** for specific BUMP monitoring stations. The OWRB has a disclaimer pertaining to the public domain data and states, "all data viewed through the data viewer is not fully quality assured and is provisional. The January thru September 2006 data was validated for use in October 2006. The October thru December 2006 data was validated for use in June-July 2007. The OWRB 2006 data was utilized to provide the most current, full year of data for the ARC, 42-mile study area (Tables 2, 3 & 4). It augments the City of Tulsa data **(Tables 5, 6, 7, 8 & 9)** which provides full year data for years 2000, 2001, 2002, 2003, 2004 and 2005. Thus, full year data has been provided for the last seven years. For comparative purposes, both the OWRB and City of Tulsa have analyzed similar physical, chemical and biological constituents or parameters.

The Sand Springs monitoring station has been active for all of the water quality variables since September of 1999. The following assessment of beneficial uses is based on data collected from October of 1999 through October of 2004. The following designated beneficial uses for this segment are: 1) Emergency Water Supply; 2) Fish and Wildlife Propagation, Warm Water Aquatic Community; 3) Agriculture—Class I Irrigation; 4) Secondary Body Contact— Recreation, and; 5) Aesthetic. All of the listed beneficial uses are supported and/or not threatened. The Aesthetic beneficial use is not threatened. The Public & Private Water Supply does not apply to this water body segment. And, this segment of the river is not nutrient-threatened **(OWRB, 2004)**.

Table 1
Applicable Criteria & Standards for Water Quality Data Comparison

Constituent/Measurement	USGS. Water-Supply Paper 2254 Typical Streams	OWRB BUMP Criteria	USEPA Primary/Secondary Drinking Water Standards
Arsenic, mg/l	0.0001-0.10	0.04	**0.010**
Barium, mg/l	---	1.00	**2.0**
Cadmium, mg/l	0.0001-0.10	0.020	**0.005**
Chromium, mg/l	0.001-0.10	0.050	**0.1**
Copper, mg/l	<0.020	1.000	**1.0**
Cyanide	---	0.200	**0.2**
Fluoride (@ 90° C), mg/l	---	4.0	**4.0, 2.0**
Lead, mg/l	0.0001-0.10	0.100	**0.015 action level**
Mercury, mg/l	0.00050	0.002	**0.002**
Nickel, mg/l	0.0001-0.10	---	---
Selenium, mg/l	< 0.010	0.010	**0.05**
Silver, mg/l	0.0001-0.0040	0.050	**0.10**
Thallium, mg/l	0.0010	---	**0.002**
Zinc, mg/l	0.0001-0.10	5.000	**5.0**

Table 1
Applicable Criteria & Standards for Water Quality Data Comparison

Constituent/Measurement	USGS. Water-Supply Paper 2254 Typical Streams	OWRB BUMP Criteria	USEPA Primary/Secondary Drinking Water Standards
Temperature C°	---	18-32	---
pH	6.5-8.5	6.5-9.0	6.5-8.5
Dissolved Oxygen, mg/l	---	4.0-5.0	---
Total Alkalinity, mg/l	5-125 mg/l	---	---
Total Hardness, as CaCO3, mg/l	---	---	---
Total Dissolved Solids (TDS), mg/l	---	1,782 & 1,868 avg. sample standard	500
Turbidity, NTU	---	50	---
Chloride, mg/l	10	810 & 925 avg. sample standard	250
Sulfate, mg/l	---	172 & 178 sample standard	250
Fecal Coliform, count/100 ml	---	400 geometric mean	---
E. Coli, Quanti-Tray, count/100 ml	---	126 geometric mean	---
Enterococci, count/100 ml	---	33 geometric mean	---
Nitrogen, Nitrate/Nitrite as N, mg/l	---	5.0	10.000
Nitrogen, Nitrite, mg/l	---	---	1.0
Phosphorous, Total, mg/l	---	0.36	---

For 1999 through 2004 data, Warm Water Aquatic Community beneficial use is supported because the dissolved oxygen, pH, turbidity and toxicant samples met the criteria prescribed for this beneficial use. The Agriculture beneficial use is supported for total dissolved solids, chlorides, and sulfates even though twelve percent (12%) of the sulfate concentrations exceeded the sample standard of 178.0 mg/l. The sulfate concentration values are also below the prescribed minimum standard of 250 mg/l. The Primary Body Contact—Recreation beneficial use is supported for fecal coliform, Enterococci and E. coli concentrations. This particular segment of the Arkansas River is not nutrient-threatened because the total phosphorus and nitrate/nitrite median values were below the threshold medians of 0.36 mg/l and 5.0 mg/l, respectively **(OWRB, 2004)**.

The 2006 OWRB data identified in Table 2 represents the most recent water quality sampling for a full year at the Sand Springs monitoring station. The mean values trend very similar to the 1999 through 2004 water quality data suggesting that this segment of the river will have similar results for its beneficial use determinations. In addition, the physical and chemical mean and range values generally reflect typical conditions found in other streams in the United States **(Hem, 1986)**.

The Bixby monitoring station has been active for all water quality variables since November of 1998. The following assessment of beneficial uses is based on data collected from October of 1999 through October of 2004. The following designated beneficial uses for this segment are: 1) Emergency Water Supply; 2) Fish & Wildlife Propagation, Warm Water Aquatic Community; 3) Agriculture—Class I Irrigation; 4) Secondary Body Contact—Recreation, and; 5) Aesthetic. All of the listed beneficial uses are supported with one exception. The exception is the Secondary Body Contact—Recreation beneficial use which is not supported because the fecal coliform counts exceed the limit of 400/100ml. The Aesthetic beneficial use is not threatened. The Public & Private Water Supply does not apply to this water body segment. And, this segment of the river is not nutrient-threatened **(OWRB, 2004)**.

For 1999 through 2004 data, the Warm Water Aquatic Community beneficial use is supported because the dissolved oxygen, pH, turbidity, and toxicant samples met the criteria prescribed for this beneficial use. The Agriculture beneficial use is supported for total dissolved solids, chlorides, and sulfates even though eleven percent (11%) of the sulfate concentrations exceeded the sample standard of 178.0 mg/l. The sulfate concentration values are also below the prescribed minimum standard of 250 mg/l. The Primary Body Contact—Recreation beneficial use is not supported. Of the seventeen (17) fecal coliform concentrations, seven (7) samples or forty-one percent (41%) exceeded the prescribe screening level of 400 cfu/ml, and the geometric mean of 884.8 cfu/ml exceeded the prescribed mean standard of 400 cfu/ml. Of the seventeen (17) E. coli concentrations, three (3) samples exceeded the prescribed screening level of 406 cfu/ml, and the geometric mean of 141.8 cfu/ml exceeded the prescribed mean standard of 126 cfu/ml. Finally, of the seventeen (17) Enterococci concentrations, three (3) samples exceeded the prescribed screening level of 406 cfu/ml, and the geometric mean of 415 cfu/ml exceeded the prescribed mean standard of 33 cfu/ml. This particular segment of the Arkansas River is not nutrient-threatened because the total phosphorus and nitrate/nitrite median values were below the threshold medians of 0.36 mg/l and 5.0 mg/l, respectively **(OWRB, 2004)**.

Table 2
OWRB, Beneficial Use Monitoring Plan (BUMP)
AT164400 (Sand Springs) State Highway 97, 36.12393866/-96.115783427

2006 Mean & Range Data

Constituent/Measurement	Mean	Range
Stream width, meters	659.29	60-1,680
Stream stage, feet	16.34	2.01-45.22
Flow (instantaneous), cubic feet per second	7,553	12.75-33,309
Sample depth, meters	0.38	0.1-0.8
Temperature C°	18.38	4.42-27.33
Oxidation/Reduction Potential, MV	411	253-478
Specific Conductance, umhos/cm	2,361.43	1430-3,306
Dissolved Oxygen, mg/l	7.97	4.61-12.87
Dissolved Oxygen Saturation, %	84.32	57.7-121.5
pH	7.96	7.48-8.32
Total Alkalinity, mg/l	139	125-164
P-Alkalinity, mg/l		
Total Hardness, as $CaCO_3$, mg/l	264	168-384
Total Dissolved Solids (TDS), mg/l	1,508	915-2,116
Salinity, g/l	2.10	0.80-7.73
Turbidity, NTU	13	5-34
Chloride, mg/l	572.5	313-1,100
Sulfate, mg/l	119.39	43.4-195
Fecal Coliform, count/100 ml	20.0	10-30
E. Coli, Quanti-Tray	25.5	10-41
Enterococci	28.5	10-63

Table 2
OWRB, Beneficial Use Monitoring Plan (BUMP)
AT164400 (Sand Springs) State Highway 97, 36.12393866/-96.115783427

2006 Mean & Range Data

Constituent/Measurement	Mean	Range
Nitrogen, Ammonia, mg/l	0.073	0.05-0.18
Nitrogen, Kjeldahl, mg/l	0.579	0.47-0.69
Nitrogen, Nitrate/Nitrite as N, mg/l	0.185	0.05-0.27
Phosphorous, Total, mg/l	0.106	0.068-0.220
Phosphorous, Ortho, mg/l	0.067	0.019-0.180

The 2006 OWRB data identified in Table 3 represents the most recent water quality sampling for a full year at the Bixby monitoring station. The mean values trend very similar to the 1999 through 2004 water quality data suggesting that this segment of the river will have similar results for its beneficial use determinations. This would include the biological mean and range values which currently will not support the Primary Body Contact—Recreation beneficial use for this segment of the river **(OWRB, WIMS, 2007)**. The physical and chemical mean and range values generally reflect typical conditions found in other streams in the United States **(Hem, 1986)**.

The Haskell monitoring station has been active for all water quality variables since November of 1998. The following assessment of beneficial uses is based on data collected from October of 1999 through September of 2004. The following designated beneficial uses for this segment are: 1) Emergency Water Supply; 2) Fish & Wildlife Propagation, Warm Water Aquatic Community; 3) Agriculture—Class I Irrigation; 4) Secondary Body Contact—Recreation, and; 5) Aesthetic. The Fish & Wildlife Propagation, Warm Water Aquatic Community beneficial use is supported. The Agriculture—Class I Irrigation beneficial use is partially supported. The Secondary Body Contact—Recreation beneficial use is not supported. The Aesthetic beneficial use is not threatened. The Public & Private Water Supply does not apply to this water body segment. And, this segment of the river is not nutrient-threatened **(OWRB, 2004)**.

For 1999 through 2004 data, the Warm Water Aquatic Community beneficial use is supported because the dissolved oxygen, pH, turbidity, and toxicant samples met the criteria prescribed in the WWAC beneficial use. The Agriculture beneficial use is partially supported. Of the forty-five (45) total dissolved solids concentrations, nine (9) of the samples or twenty percent (20%) exceeded the minimum sample standard of 1,168 mg/l. The chlorides and sulfates are within the prescribed sample standards and yearly means. The Primary Body Contact—Recreation beneficial use is not supported. Of the twenty-two (22) Enterococci concentrations, one (1) sample exceeded the prescribed screening level of 406 cfu/ml, and the geometric mean of 36.0 cfu/ml. This particular segment of the Arkansas River is not nutrient-threatened because the total phosphorus and nitrate/nitrite median values were below the threshold medians of 0.36 mg/l and 5.0 mg/l, respectively **(OWRB, 2004)**.

The 2006 OWRB data identified in Table 4 represents the most recent water quality sampling for a full year at the Haskell monitoring station. The mean values trend very similar to the 1999 through 2004 water quality data suggesting that this segment of the river will have similar results for its beneficial use determinations. The exception is the biological mean and range values which currently indicate a support for the Primary Body Contact—Recreation beneficial use for this segment of the river **(OWRB, WIMS, 2007)**. The physical and chemical mean and range values generally reflect typical conditions found in other streams in the United States **(Hem, 1986)**.

Table 3
OWRB, Beneficial Use Monitoring Plan (BUMP)
AT165520 (Bixby) State Highway 64, 35.955853074/-95.886225622

2006 Mean & Range Data

Constituent/Measurement	Mean	Range
Stream width, meters	721.43	100-1,920
Stream stage, feet	6.67	4.94-10.40
Flow (instantaneous), cubic feet per second	2,372	379-9,569
Sample depth, meters	0.56	0.40-0.90
Temperature C°	19.96	6.66-32.11
Oxidation/Reduction Potential, MV	398	275-465
Specific Conductance, umhos/cm	2,130	1,361-3,031
Dissolved Oxygen, mg/l	10.71	5.93-16.70
Dissolved Oxygen Saturation, %	115.64	75.3-166.1
pH	8.28	7.89-8.50
Total Alkalinity, mg/l	147	121-183
P-Alkalinity, mg/l	----	----
Total Hardness, as CaCO3, mg/l	248	182-368
Total Dissolved Solids (TDS), mg/l	1,364	871-1,940
Salinity, g/l	1.12	0.72-1.56
Turbidity, NTU	18	5-58
Chloride, mg/l	466.9	249-840
Sulfate, mg/l	118.68	69.5-164
Fecal Coliform, count/100 ml	546	200-1,190
E. Coli, Quanti-Tray	95.6	10-235
Enterococci	215.6	10-471

Table 3
OWRB, Beneficial Use Monitoring Plan (BUMP)
AT165520 (Bixby) State Highway 64, 35.955853074/-95.886225622

2006 Mean & Range Data

Constituent/Measurement	Mean	Range
Nitrogen, Ammonia, mg/l	0.086	0.05-0.33
Nitrogen, Kjeldahl, mg/l	0.990	0.66-1.83
Nitrogen, Nitrate/Nitrite as N, mg/l	0.619	0.05-1.72
Phosphorous, Total, mg/l	0.317	0.20-0.835
Phosphorous, Ortho, mg/l	0.217	0.11-0.646

Table 4
OWRB, Beneficial Use Monitoring Plan (BUMP)
AT165570 (Haskell) State Highway 104 35.820955487/-95.639952643

2006 Mean & Range Data

Constituent/Measurement	Mean	Range
Stream width, meters	890.00	300-2,400
Stream stage, feet	4.03	2.54-7.1
Flow (instantaneous), cubic feet per second	4,198	553-11,400
Sample depth, meters	0.40	0.1-0.6
Temperature C°	20.26	7.55-32.04
Oxidation/Reduction Potential, MV	398	366-444
Specific Conductance, umhos/cm	2,126	856-2,918
Dissolved Oxygen, mg/l	9.40	6.42-12.84
Dissolved Oxygen Saturation, %	105.64	58.0-167.8
pH	8.34	7.83-8.88
Total Alkalinity, mg/l	150	123-191
P-Alkalinity, mg/l	----	----
Total Hardness, as CaCO3, mg/l	232	160-304
Total Dissolved Solids (TDS), mg/l	1,360	548-1,867
Salinity, g/l	1.14	0.45-1.58
Turbidity, NTU	27	5-76
Chloride, mg/l	422.4	10-820
Sulfate, mg/l	105.41	10-158
Fecal Coliform, count/100 ml	40.0	10-130
E. Coli, Quanti-Tray	13.5	10-52
Enterococci	23.3	10-74

Table 4
OWRB, Beneficial Use Monitoring Plan (BUMP)
AT165570 (Haskell) State Highway 104 35.820955487/-95.639952643

2006 Mean & Range Data

Constituent/Measurement	Mean	Range
Nitrogen, Ammonia, mg/l	0.092	0.05-0.32
Nitrogen, Kjeldahl, mg/l	0.776	0.05-2.18
Nitrogen, Nitrate/Nitrite as N, mg/l	0.360	0.05-1.09
Phosphorous, Total, mg/l	0.204	0.009-0.650
Phosphorous, Ortho, mg/l	0.140	0.005-0.367

Water Quality Data (City of Tulsa) & Conclusions

The water quality data provided in **Tables 5, 6, 7, 8 & 9** is the City of Tulsa's 2000-05 water quality data which is used to supplement their Stormwater Management Plan requirements **(Appendix C)**. It is also used in accordance with the ODEQ 252: 605-7-31(e) regulations to support the City's NPDES/OPDES Waste Water Treatment Plant Permits. The City of Tulsa's water quality data was used because: 1) there were five additional monitoring stations within the study area to obtain information; 2) four of the five City of Tulsa monitoring stations represented different sampling points in the study area; 3) water quality data was available for multiple years and current, and; 4) the City of Tulsa's water quality data was similar to the constituents sampled by the OWRB. The City's water quality data comes from five monitoring stations **(Figure 2)** and involves six years of monitoring data, 2000, 2001, 2002, 2003, 2004 & 2005. A geometric mean was calculated for each monitoring station and water year's physical, chemical and biological constituents. The geometric mean was calculated to allow for a comparative analysis to the OWRB's water quality data. The most comprehensive data is represented by monitoring station AR1 (11th St. Bridge, Tulsa) and monitoring station AR6 (U.S. Highway 64 Bridge, Bixby).

All of the monitoring station's physical and chemical constituents sampled over the six year period reflect water quality typical of water quality found in other streams in the United States. It should be noted that the water is generally found to be hard due to calcium carbonate concentrations between 250 and 330 mg/l. The majority of the physical, chemical and biological constituents support the OWRB's 2004 BUMP Report findings for the particular beneficial use and also support the 2006 trend concentration analysis identified by **Tables 2, 3 & 4**. This would include the Warm Water Aquatic Community, Primary Body Contact—Recreation, and Nutrient-Threatened beneficial use determinations.

The fecal coliform, geometric mean concentration values for all five of the monitoring stations and most of the monitoring years reflect concentrations that would make them not-supported for the OWRB Primary Body Contact—Recreation beneficial use. The City of Tulsa fecal coliform values are similar to the OWRB monitoring station fecal coliform results in that they are occurring downstream from Tulsa. The OWRB's Sand Springs monitoring station is located at the State Highway 97 Bridge and the segment it represents is from the Keystone Dam to just west of downtown Tulsa. This segment of the river does support the Primary Body Contact—Recreation Beneficial Use. However, the City of Tulsa's monitoring stations begin at AR1 (11th St. Bridge, Tulsa) and are all located downstream as are the two remaining OWRB monitoring stations. Thus, the City of Tulsa and the two other OWRB monitoring stations reflect relatively high levels for fecal coliform.

Only four of the five OWRB monitoring stations included metal analysis. Most of the metal analysis from these four monitoring stations (AR1, AR3, AR6 & AR8) reflect concentrations that meet either the OWRB requirements or the USEPA Primary and Secondary Drinking Water requirements with the exception of arsenic, mercury and selenium. At AR1 (11th St. Bridge, Tulsa), arsenic concentrations were just above the OWRB criteria limit of 0.04 mg/l in 2000 and 2001. And, approximately four times the USEPA Primary Drinking Water Quality Standard of 0.01 mg/l in the same years (Table 5). At AR3 (I-44 Bridge, Tulsa), arsenic concentrations were at the OWRB criteria and also four times the USEPA Primary Drinking Water Quality Standard in years 2000 and 2001 (Table 6). At AR6 (U.S. Highway 64 Bridge, Bixby), the arsenic concentration in 2001 was at the OWRB criteria limit and four times the USEPA Primary Drinking Water Quality Standard (Table 8). In 2002, the mercury concentration of 0.004 mg/l was twice the OWRB criteria limit and the USEPA Primary Drinking Water

Quality Standard of 0.002 mg/l which are the same value. In 2001, the selenium concentration was approximately twice the OWRB criteria limit of 0.01 mg/l, but below the USEPA Primary Drinking Water Quality Standard of 0.05 mg/l (Table 8). At AR8 (Indian Springs Sports Complex, Broken Arrow), the arsenic concentrations were just above the OWRB criteria limit of 0.04 mg/l in 2000 and 2001. And, approximately four to five times the USEPA Primary Drinking Water Quality Standard of 0.01 mg/l in the same years (Table 5).

Water Quality (Tulsa City—County Health Department) & Conclusions

The Tulsa County Health Department conducted water quality assessments from 1976-1980 **(Woodruff, 1983)** and 1989-2000 **(Tulsa County Health Department, 1989-2000)**. The monitoring station transects were located along the 11th Street Bridge, 21st Street Bridge and Pedestrian Bridge, and at the 11th Street Storm Drain, Indian Avenue Sanitary Drain, 21St Street Storm Drain and 26th Street Sanitary Drain. The monitoring included the collection of physical and chemical parameters 1976-1980 and 1991-95 **(Appendix D, Table 1 & Reports)**. The monitoring also included the collection of biological parameters 1976-1980 and 1989-2000 **(Appendix D, Tables 2 & 3 & Water Quality Reports)**. For comparative analysis, the monitoring stations would include all of the Tulsa County Health Department transects, the City of Tulsa's 11th Street transect and the OWRB's Bixby station. As a caveat, the Bixby station represents water quality to almost Sand Springs.

There are significant correlations and trends when the earlier Tulsa County Health Department data is compared to the more recent OWRB and City of Tulsa data. In general, the physical parameter monitoring correlated to the OWRB and City of Tulsa data with little to no significant variations. Again, the physical mean and range values reflect typical conditions found in other streams in the United States **(Hem, 1986)**.

The chemical (heavy metal) parameters, specifically cadmium, chromium, lead and mercury showed a significant decrease in concentrations from the earlier data to the more recent data. The decreases ranged from two to four times lower for cadmium, four to eight times lower for chromium, four to 10 times lower for lead, and one order of magnitude lower for mercury. The other chemical parameters correlated to the OWRB and City of Tulsa data with little to no significant variations. The chemical mean and range values reflect typical conditions found in other streams in the United States **(Hem, 1986)**.

The Tulsa County Health Department biological parameters (fecal coliform) were sampled in-stream at the bridges or from the direct measurement of the effluent at the sanitary storm drains. These results continue to confirm the OWRB and City of Tulsa sampling results. The number of exceedences and concentrations greater than 400/100 ml would not allow the Primary Body Contact—Recreation beneficial use to be supported or partially supported under the OWRB BUMP. The direct effluent concentrations for fecal coliform ranged from 10,000/100 ml to 1,100,000/100 ml at the sanitary storm drains. **(Appendix D, Tables 2 & 3 & Water Quality Reports)**.

Water Quality (NPDES Permitted Industrial Facilities) & Conclusions

There are 38 issued NPDES/OPDES permits throughout the 42-mile study area **(Appendix E)**. Of the 38 issued permits, there are 28 active discharge points for 25 different facilities **(Figure 3)**. There are six (6) wastewater treatment plants, three (3) public electricity generation utilities, nine (9) sand & gravel operations or concrete batch operations, two (2) petroleum refineries, one (1) petroleum pipeline, one (1) paper product manufacturer, and three (3) chemical product manufacturers or processors. These facilities are permitted by the ODEQ under the OPDES. Permits are issued under the Industrial (specific) Point Source Discharge categories and the Storm Water Discharge (OKR05) if applicable **(USEPA, PCS, 2007)**.

The most common, measured constituents for the permitted facilities are flow (gpd), pH, biological oxygen demand (BOD), total suspended solids (TSS) and oil and grease. The least measured constituents are chemical oxygen demand (COD), total dissolved solids (TDS), total chloride, total chlorine residual, total fluoride, total sulfate, total sulfide, total antimony, total tin, total mercury, total hexavalent chromium, total chromium, total ammonia, fecal coliform and total phenolics (Table 10). Some of these constituents have USEPA specified effluent limits, relevant USEPA Primary and Secondary Drinking Water Quality Standards, and others have no applicable water quality standards **(USEPA, NPDES, 2007)**.

The effluent limits for each type of industry have established numeric criteria and narrative (qualitative) standards. The effluent limits are established to meet the water quality standards of the state and not degrade (antidegradation policy) the water quality. In addition, the effluent limits and other requirements are specific to the type of industry. If a particular stream/river's water quality is threatened by a industrial facility's discharge a limit will be set on the concentration and amount of discharge. This is better known as a TMDL limit. Currently there are no TMDLs established within the Arkansas River along the 42-mile study area **(USEPA, NPDES, 2007)**.

In general, the physical, chemical and biological constituents identified in Table 10 fall within the typical stream characteristics of other streams in the United States, meet the OWRB BUMP criteria and meet the USEPA Primary and Secondary Water Quality Standards where applicable (Table 1). There are no USEPA Primary and/or Secondary Water Quality Standards established for biological oxygen demand, chemical oxygen demand, total suspended solids, total organic carbon, phenolics and/or oil and grease.

City of Tulsa 1992-2004 Data																								
	DATE	TEMP	pH	DO	BOD	NH4	N03	NO2	NO2+NO3	HRDNSS	COLIF F	TSS	PO4	PHENO	AS	CD	CR	CU	PB	HG	SE	AG	ZN	Kjaldahl
		(°C)	(std.)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/L)	(mg/l)	(mg/l)	(#/100ml)	(mg/l)	(mg/l)	(mg/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)
AR-1	01/03/00	8.90	7.80	11.00	10.0	0.18	0.99	0.03	1.02	252														
AR-1	01/11/00	8.90	7.90	11.00	2.0	0.14	1.02	0.02	1.04	276														
AR-1	01/19/00	8.40	8.30	11.00	2.0	0.11	1.06	0.02	1.08	275					40.0	4.0	10.0	20.0	2.0	0.2	2.0	0.5	20.0	
AR-1	01/24/00	4.40	8.20	12.00	11.0	0.23	0.99	0.02	1.01	304														
AR-1	02/01/00	4.60	8.10	12.00	2.2	0.13	1.03	0.01	1.03	302														
AR-1	02/07/00	7.20	8.30	13.00	2.0	0.11	0.98	0.02	1.00	337														
AR-1	02/17/00	13.00	8.10	12.00	17.0	0.06	1.01	0.01	1.02	330														
AR-1	02/22/00	12.00	8.30	12.00	2.0	0.05	0.79	0.02	0.80	346					60.0	4.0	10.0	20.0	2.0	0.2	2.0	0.5	20.0	
AR-1	03/01/00	11.00	8.50	12.00	2.0	0.12	0.91	0.01	0.91	294														
AR-1	03/07/00	13.00	8.20	10.00	2.0	0.13	1.05	0.02	1.07	280														
AR-1	03/13/00	14.00	8.10	9.70	2.0	0.16	1.06	0.02	1.08	275					86.0	4.0	10.0	20.0	2.0	0.2	2.0	0.5	54.0	
AR-1	03/22/00	11.00	7.90	11.00	2.0	0.13				223														
AR-1	04/06/00	15.00	7.80	10.00	2.0	0.18	0.81	0.02	0.83	199														
AR-1	04/11/00	15.00	8.00	9.90	2.0	0.08	0.76	0.02	0.79	225					40.0	4.0	10.0	20.0	2.0	0.2	2.0	0.5	20.0	
AR-1	04/19/00	18.00	8.00	8.10	2.0	0.07	1.70	0.03	1.73	349														
AR-1	04/27/00	18.00	8.10	7.90	2.0	0.10	0.55	0.01	0.55	329														
AR-1	05/08/00	24.00	7.60	7.10	2.0	0.14	0.31	0.03	0.34	138	1,005													
AR-1	05/16/00	21.00	8.00	6.50	2.2	0.11	0.37	0.03	0.40	259	23													
AR-1	05/24/00	24.00	7.60	6.70	3.0	0.03	0.48	0.01	0.49	285	82													
AR-1	06/06/00	23.00	7.70	8.00	2.00	0.05	0.49	0.01	0.50	239	80													
AR-1	06/15/00	24.00	8.00	7.90	2.00	0.02	0.49	0.01	0.49	227	109													
AR-1	06/19/00	24.00	7.90	6.40	2.00	0.29	0.52	0.01	0.52	261	10				40.00	4.00	10.00	20.00	2.00	0.20	2.00	0.50	20.00	
AR-1	06/27/00	25.00	7.80	7.40	2.00	0.05	0.40	0.01	0.40	246	2,000													
AR-1	07/06/00	26.00	7.90	7.30	2.00	0.07	0.50	0.01	0.50	215	10													
AR-1	07/11/00	27.00	7.70	6.20	2.00	0.02	0.42	0.01	0.43	203	90													
AR-1	07/19/00	28.00	7.80	5.30	2.00	0.09	0.27	0.01	0.29	216	10				50.00	4.00	10.00	20.00	2.00	0.20	2.00	0.50	20.00	
AR-1	07/27/00	27.00	7.90	7.30	7.30	0.07				250	13													
AR-1	08/03/00	27.00	7.50	6.40	2.00	0.09	0.40	0.03	0.43	228	10													
AR-1	08/07/00	28.00	8.10	6.10	2.00	0.02	0.30	0.01	0.32	235	23													
AR-1	08/15/00	27.00	7.90	7.30	2.00	0.06	0.23	0.01	0.24	239	52													
AR-1	08/23/00	29.10	8.2	9.30	2.7	0.0840	0.121	0.01	0.121		80				52	4.00	10.00	10.00	1.0	0.20	2.00	1.00	10.00	
AR-1	09/07/00	26.00	7.9	8.60	2.00	0.0600				251	58													
AR-1	09/11/00	27.20	8.40	9.90	3.7	0.09	0.04	0.01	0.04	262	33													
AR-1	09/19/00	21.70		11.00	4.1	0.02	0.029	0.01	0.0290	258	40				40.00	4.00	10.00	10.00	1.00	0.20	2.00	1.00	190.00	
AR-1	09/26/00	19.40	8.10	9.20	2.00	0.02	0.116	0.01	0.116	248	560													
AR-1	10/02/00	20.50	8.30	9.20	4.0	0.107	0.036	0.0130	0.0490	267														
AR-1	10/10/00	14.80	8.20	9.70	2.00	0.210	0.125	0.01	0.125	260														
AR-1	10/18/00	18.70	7.90	8.80	2.00	0.0580	0.269	0.0140	0.283	256					49.00	4.00	10.00	10.00	1.00	0.20	2.00	1.00	45	
AR-1	10/26/00	18.40	7.80	8.10	4.00	0.152	0.986	0.0280	1.01	265														
AR-1	11/01/00	19.2	7.9	8.0	2.00		0.187	0.0730	0.260	280														
AR-1	11/07/00	15.5	7.9	8.3	2.00		0.419	0.0210	0.440	265														
AR-1	11/13/00	12.4	8.0	9.20	2.00	0.060	0.66	0.021	0.68	256					40.00	4.00	10.00	10.00	1.00	0.20	2.00	1.00	38.00	
AR-1	11/28/00	8.20	8.0	11	2.00	0.078	0.91	0.01	0.92	338														
AR-1	12/05/00	7.40	8.0	9.2	2.00	0.059	0.92	0.01	0.92	328														
AR-1	12/20/00	5.40	8.00	10.10	2.00	0.11	0.87	0.01	0.87	274														
AR-1	01/04/01	3.40	7.70		2.00	0.05	1.00	0.01	1.00	311														
AR-1	01/11/01	4.10	7.90	8.10	2.00	0.14				289														
AR-1	01/17/01	7.40	7.70	8.00	2.00	0.12	1.10	0.02	1.10	270					48.00	4.00	10.00	10.00	1.00	0.20	2.00	1.00	10.00	
AR-1	01/23/01	5.80	7.70	7.20	2.00	0.05	0.89	0.02	0.91	350														
AR-1	02/05/01	5.60	8.80	12.00	2.70	0.05	0.65	0.02	0.67	288														

City of Tulsa 1992-2004 Data																								
	DATE	TEMP	pH	DO	BOD	NH4	N03	NO2	NO2+NO3	HRDNSS	COLIF F	TSS	PO4	PHENOL	AS	CD	CR	CU	PB	HG	SE	AG	ZN	Kjaldahl
		(°C)	(std.)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/L)	(mg/l)	(mg/l)	(#/100ml)	(mg/l)	(mg/l)	(mg/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)
AR-1	02/15/01	4.80	8.50	13.00	2.30	0.05	0.96	0.03	0.99	345														
AR-1	02/20/01	7.10	8.20	12.10	2.00	0.17	1.10	0.04	1.20	323														
AR-1	02/28/01	8.10	7.90	9.40	4.70	0.13	1.40	0.02	1.40															
AR-1	03/05/01	7.20	8.20	8.50	2.00	0.20	1.15	0.04	1.18	258														
AR-1	03/15/01	10.40	7.90	7.80	2.00	1.29	0.02	0.45	0.03	243														
AR-1	03/20/01	9.60	8.20	11.00	2.00	0.18	1.50	0.03	1.50	230					40.00	4.00	10.00	10.00	2.00		2.00	3.00	21.10	
AR-1	03/28/01	10.00	7.80	7.60	2.00	0.22	1.40	0.03	1.40	239														
AR-1	04/02/01	11.70	7.70	8.10	2.40	0.23	1.20	0.03	1.20	347														
AR-1	04/12/01	17.00	8.10	8.60	2.00	0.14	1.26	0.04	1.30	272														
AR-1	04/18/01	14.50	8.10	8.30	2.00	0.19	1.10	0.03	1.20	290														
AR-1	04/24/01	16.90	8.00	8.40	2.00	0.14	1.20	0.03	1.20	173					70	4.00	10.00	10.00	2.00	0.20	2.00	3.00	10.00	
AR-1	05/10/01	21.40	8.10	9.10	2.00	0.05	0.73	0.11	0.83	320	18													
AR-1	05/16/01	22.20	7.70	8.00	2.00	0.13	0.66	0.03	0.69	360	19				40.00	4.00	10.00	10.00	2.00		2.00	3.00	10.00	
AR-1	05/22/01	21.50	8.20	7.40	2.90	0.17	0.45	0.05	0.50	299														
AR-1	06/06/01	23.70	8.10	7.20	2.00	0.05	0.79	0.03	0.82	219	1													
AR-1	06/11/01	27.40	7.80	7.10	2.00	0.05	0.79	0.02	0.81	189					40.00	4.00	10.00	10.00	2.00	0.20	4.40	3.00	16.10	
AR-1	06/19/01	27.10	8.00	7.80	2.00	0.09	0.84	0.02	0.84		32													
AR-1	06/25/01	26.60	7.30	6.90	2.00	0.11	0.77	0.02	0.77	235														
AR-1	07/02/01	26.80	7.90	6.70	2.00	0.57	0.72	0.02	0.75	264	1				40.00	4.00	10.00	14.50	2.00	0.06	2.00	3.00	53.50	
AR-1	07/10/01	28.10	8.20	6.50	2.10	0.16	0.66	0.02	0.66	244	13													
AR-1	07/18/01	28.30	8.00	6.30	2.00	0.25	0.40	0.02	0.42	234	8													
AR-1	07/26/01	29.50	8.30	9.30	4.60	0.05	0.14	0.02	0.15	250	47													
AR-1	08/01/01	28.90	7.80	8.10	2.00	0.09	0.24	0.03	0.27	233	69				40.00	4.00	10.00	10.00	2.00		2.00	3.00	10.00	
AR-1	08/09/01	28.60	7.90	6.70	2.10	0.18	0.21	0.02	0.21	237	100													
AR-1	08/14/01	24.50	7.60	7.10	2.40	0.07	0.09	0.02	0.11	240	58													
AR-1	08/23/01	26.30	7.90	7.20	2.00	0.25	0.21	0.03	0.23	240	144													
AR-1	09/05/01	27.20	8.10	6.60	2.00	0.09	0.10	0.02	0.12	243	2,000				40.00	4.00	10.00	15.10	5.60	0.20	2.00	3.00	14.30	
AR-1	09/19/01	23.00	8.00	6.60	2.00	0.05	0.41	0.02	0.42	230	82													
AR-1	10/01/2001	20.60	8.30	8.60	2.00	0.05	0.42	0.02	0.43	236	29					4.00		10.00	2.00				214.00	
AR-1	11/05/2001	18.10	8.00	8.90	2.00	0.27	0.79	0.02	0.80	192	646					4.00		10.00	2.00				51.00	
AR-1	12/03/2001	13.20	8.30	10.00	2.00	0.18	0.94	0.02	0.95		206					4.00		10.00	2.00	0.20			21.00	
AR-1	01/07/02	5.00	8.50	NR	2.20	0.11	0.93	0.04	0.96	240	75					4.00		10.00	2.00				10.00	0.72
AR-1	01/28/02	14.00	8.00	10.00																				
AR-1	02/04/02	6.50	8.40	12.00	2.00	0.12	0.57	0.02	0.59	253	60					4.00		10.00	2.00				36.00	0.63
AR-1	03/08/02	15.00	8.20	10.00	2.00	0.14	0.52	0.02	0.54	270	44					4.00		5.00	2.00				20.00	0.66
AR-1	04/15/02	21.50	8.40	7.60	2.50	0.09	0.27	0.02	0.3	280	208					4.10		5.00	2.00				46.00	0.72
AR-1	05/13/02	20.20	7.69	7.52	2.10	0.14	2.38	0.05	2.44	290	26					4.50		5.00	2.00				93.00	3.00
AR-1	06/04/02	22.70	7.70	6.70	2.00	0.09	0.40	0.02	0.42	250	63					4.00		5.00	2.00				10.00	0.63
AR-1	07/03/02	25.90	8.22	4.76	2.00	0.25	0.74	0.02	0.75	180	1					4.00		5.00	2.00				20.00	0.64
AR-1	08/01/02	28.10	8.00	6.90	2.00	0.11	0.22	0.02	0.24	190	13					4.00		5.00	2.00				24.00	0.79
AR-1	09/05/02	27.60	8.00	6.60	2.00	0.10	0.47	0.02	0.48	160	38					4.00		5.00	2.00				29.00	0.55
AR-1	10/03/02	22.70	7.45	6.74	2.00	0.03	1.05	0.02	1.07	148	81					4.00		5.00	2.26				47.00	0.64
AR-1	11/04/02	11.30	7.60	9.80	2.00	0.03	1.22	0.02	1.23	180	651					4.00		6.20	2.00				49.00	0.57
AR-1	12/02/02	10.10	8.11	12.39	2.00	0.17	1.23	0.07	1.30	290	290					4.00		7.20	2.00				27.00	0.41
AR-1	01/06/03	6.50	8.27	10.96	2.30	0.14	1.02	1.10	1.10	320	113					**1.00**		5.00	2.00				40.00	1.15
AR-1	02/05/03	5.10	8.40	11.10	2.00	0.04	0.84	0.09	0.93	380	189		0.11			**1.00**		6.30	2.00	**0.20**			10.00	0.74
AR-1	03/05/03	3.70	8.52	11.09	2.00	0.04	0.43	0.01	0.43	380	19		0.02			1.00		5.40	2.00				10.00	0.76
AR-1	04/02/03	15.00	8.00	7.80	2.00	0.22	0.73	0.01	0.74	280.00	22.00		0.21			1.00		5.70	2.00	0.20			120.00	1.32
AR-1	05/05/03	20.00	8.20	6.80	2.00	0.09	0.09	0.09	0.95	250	2		0.14			1.00		6.60	2.00				150.00	1.22
AR-1	06/02/03	23.00	7.70	5.90	2.00	0.04	0.92	0.01	0.92	230	550		0.17			1.40		5.00	2.00				120.00	1.96

City of Tulsa 1992-2004 Data																								
	DATE	TEMP	pH	DO	BOD	NH4	N03	NO2	NO2+NO3	HRDNSS	COLIF F	TSS	PO4	PHENO	AS	CD	CR	CU	PB	HG	SE	AG	ZN	Kjaldahl
		(°C)	(std.)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/L)	(mg/l)	(mg/l)	(#/100ml)	(mg/l)	(mg/l)	(mg/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)
AR-1	07/02/03	26.00	7.90	6.60	2.00	0.05	0.53	0.01	0.53	250	25		0.14			1.00		5.00	2.00				160.00	0.60
AR-1	08/04/03	26.00	7.90	5.80	2.00	0.12	0.23	0.02	0.26	220.00	78.00		0.12			1.00		5.20	2.18				160.00	0.44
AR-1	09/04/03	25.00	7.80	6.70	2.00	0.08	0.11	0.04	0.16	200.00	7000.00		0.12			1.00		5.00	2.00				0.13	0.70
AR-1	10/06/03	19.00	7.70	7.90	2.00	0.22	0.61	0.03	0.63	200	874		0.12			1.50		5.60	2.00				240.00	0.55
AR1	11/04/03	19.00	7.50	8.60	2.40	0.12	1.01	0.02	1.03	180	118		0.13			1.00			2.00		2.00	2.00	120.00	
AR1	12/03/03	9.30	7.20	11.00	2.00	0.11	0.95	0.02	0.98	190	36		0.13			1.50		5.00	2.00				18.00	0.28
AR1	01/05/04	4.20	8.00	10.00	2.00	0.24	0.76	0.01	0.78	230	513		0.23			1.00		5.60	5.30				150.00	0.91
AR1	02/03/04	4.10	8.20	9.50	2.10	0.08	0.70	0.01	0.71	230	560		0.10			2.20		5.00	2.00				210.00	0.67
AR1	03/03/04	8.30	8.20	8.10	2.90	0.09	0.94	0.01	0.96	230	213		0.12			2.20		5.00	3.07				45.00	1.01
AR1	04/05/04	16.00	7.80	7.70	2.00	0.19	0.73	0.05	0.78	250	38		0.15			1.00		5.00	2.00				BDL(10)	0.75
AR1	04/19/04	17.00	7.90	6.60																				
AR1	05/03/04	17.00	7.80	6.30	2.00	0.04			0.85	180	6		0.19			3.80		5.00	2.00				21.00	0.68
AR1	06/07/04	25.00	8.30	7.70	2.00	0.04			0.47	230	570		0.13			1.00		5.00	2.00				17.00	0.54
AR1	07/01/04	23.00	7.70	5.80	2.00	0.04			0.87	190	22		0.15			2.00		23.00	2.00				43.00	0.97
AR1	08/02/04	25.00	7.80	6.60	2.00	0.04			0.77	200	19		0.20			2.50		6.90	2.00				24.00	0.50
AR1	09/01/04	22.00	7.80	6.20		0.11			0.75	160	75		0.18			1.30		5.00	2.00				25.00	0.58
AR1	09/08/04	23.00	8.10	7.90	2.00																			
AR1	10/06/04	20.00	8.20	8.30	2.00	0.04			0.57	200	260		0.13			1.00		5.00	2.00				BDL(10)	0.57
AR1	11/04/04	16.00	8.00	9.90	2.00	0.84			0.61	210	773		0.13			1.20		5.00	2.00				14.00	0.53
AR1	12/06/04	11.00	7.80	11.00	2.00	0.23			0.90	250	1,650		0.22			1.00		5.00	2.00				99.00	0.78
	Avg.1992																							
	Avg.1993																							
	Avg.1994																							
	Avg.1995																							
	Avg.1996																							
	Avg.1997																							
	Avg.1998																							
	Avg.1999																							
	Avg. 2000	18.47	7.99	9.06	2.99	0.10	0.69	0.02	0.71	261.66	251.21				49.44	4.00	10.00	16.00	1.67	0.20	2.00	0.70	43.56	
	Avg. 2001	17.68	8.00	8.29	2.23	0.17	0.75	0.04	0.77	263.42	204.29				41.14	4.00	10.00	10.87	2.24	0.18	2.30	2.75	39.18	
	Avg. 2002	17.74	8.02	8.42	2.07	0.11	0.83	0.03	0.86	227.58	129.17					4.05		6.12	2.02				34.25	0.83
	Avg. 2003	16.47	7.92	8.35	2.06	0.11	0.62	0.12	0.72	256.67	752.17		0.13			1.12		5.44	2.02	0.20	2.00	2.00	95.68	0.88
	Avg. 2004	16.54	7.97	7.97	2.08	0.17	0.78	0.02	0.75	213.33	391.58		0.16			1.68		6.71	2.36				64.80	0.71

City of Tulsa 1992-2004 Data																							
AREA	DATE	TEMP	pH	DO	BOD	NH4	NO3	N02	NO2+NO3	HARDNESS	COLIF F	TSS	PO4	PHENOL	AS	CD	CR	CU	PB	HG	SE	AG	ZN
		(°C)	(std.)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	0	(mg/l)	(mg/l)	(N/100ml)	(mg/l)	(mg/l)	(mg/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)
AR3	1/3/2000	10.00	7.50	10.00																			
AR3	1/11/2000	10.00	8.00	11.00																			
AR3	1/19/2000	9.00	8.00	12.00											40.0	4.0	10.0	20.0	2.0	0.2	2.0	0.5	20.0
AR3	1/24/2000	5.20	8.20	12.00																			
AR3	2/1/2000	3.50	8.00	13.00																			
AR3	2/7/2000	9.70	7.90	16.00																			
AR3	2/17/2000	8.50	7.70	12.00															2.0		2.0	0.5	20.0
AR3	2/22/2000	14.00	8.10	18.00																			
AR3	3/1/2000	11.00	8.50	12.00										10.0									
AR3	3/7/2000	13.00	8.30	11.00																			
AR3	4/11/2000	16.00	7.70	8.70																			
AR3	4/19/2000	21.00	8.10	8.50																			
AR3	4/27/2000	18.00	8.20	8.00																			
AR3	5/8/2000	25.00	8.10	8.10							200												
AR3	5/16/2000	20.00	8.00	7.60							891			10.0		4.0	10.0	20.0	2.0	0.2	2.0	0.5	20.0
AR3	5/24/2000	26.00	7.90	6.90							95												
AR3	6/6/2000	23.00	7.90	8.60							214												
AR3	6/15/2000	24.00	8.00	7.00							210												
AR3	6/19/2000	24.00	8.00	6.70							3,000												
AR3	6/27/2000	24.00	7.40	7.60							4,000												
AR3	7/6/2000	27.00	8.00	7.10							34												
AR3	7/11/2000	27.00	7.80	6.20							1,880												
AR3	7/19/2000	29.00	7.80	5.20							560			10.00						0.20	2.00	0.50	20.00
AR3	7/27/2000	26.00	8.00	8.40							600												
AR3	8/3/2000	27.00	7.90	8.40							31												
AR3	8/7/2000	30.00	8.20	6.70							24												
AR3	8/15/2000	28.00	7.90	7.60							51												
AR3	8/23/2000	30.40	8.20	8.70							83			5.00	50	4.00	10.00	10.00	1.00	0.20	2.00	1.00	15.00
AR3	9/7/2000	26.00	7.40	10.4							390												
AR3	9/11/2000	26.70	7.80	10.5							173												
AR3	9/19/2000	21.70	7.40	11.4							28												
AR3	9/26/2000	18.70	7.50	10.3							20,000												
AR3	10/2/2000	19.70	8.00	9.80																			
AR3	10/10/2000	12.90	8.20	11.2																			
AR-3	11/1/2000	20.0	8.0	8.60																			
AR-3	11/13/2000	10.3	8.2	10.6											40.00	4.00	10.00	11	1.1	0.20	2.00	1.00	12
AR-3	11/28/2000	10.3	7.4	13.4																			
AR-3	11/7/2000	14.6	8.1	9.30																			
AR-3	12/5/2000	9.20	7.90	9.41																			
AR-3	12/20/2000	4.10	8.10	9.80											40.00	4.00	10.00	10.00	1.00	0.20	2.00	1.00	17
AR-3	1/4/2001	4.90	7.60																				
AR-3	1/11/2001	5.40	7.90	8.00																			
AR-3	1/17/2001	7.00	7.70	7.70																			
AR-3	1/23/2001	5.40	7.70	8.40																			
AR-3	2/5/2001	8.00	8.60	12.60																			
AR-3	2/15/2001	4.00	8.50	12.60																			
AR-3	2/20/2001	7.00	8.50	12.60																			
AR-3	2/28/2001	7.40	8.20	9.20																			
AR-3	3/5/2001	8.00	8.00	9.20																			
AR-3	3/15/2001	9.70	8.00	8.20																			
AR-3	3/20/2001	10.10	8.30	11.40																			
AR-3	3/28/2001	9.70	7.70	8.00																			
AR-3	4/2/2001	12.90	8.00	7.20																			
AR-3	4/12/2001	17.40	8.20	10.60																			

City of Tulsa 1992-2004 Data																							
AREA	DATE	TEMP	pH	DO	BOD	NH4	NO3	N02	NO2+NO3	HARDNESS	COLIF F	TSS	PO4	PHENOL	AS	CD	CR	CU	PB	HG	SE	AG	ZN
		(°C)	(std.)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	0	(mg/l)	(mg/l)	(N/100ml)	(mg/l)	(mg/l)	(mg/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)
AR-3	4/18/2001	16.30	7.80	8.55																			
AR-3	4/24/2001	16.90	7.40	9.53																			
AR-3	5/10/2001	23.30	7.50	8.01							45,000												
AR-3	5/16/2001	22.30	7.90	7.70							938				40.00	4.00	10.00	10.00	2.00		2.00	3.00	10.00
AR-3	5/22/2001	22.70	8.10	7.05							780												
AR-3	6/6/2001	23.00		7.05							3,000												
AR-3	6/11/2001	27.40	8.20	9.44							65				40.00	4.00	10.00	10.00	2.00	0.20	3.50	3.00	11.90
AR-3	6/19/2001	26.40	8.00	7.75							560												
AR-3	6/25/2001	26.40	7.80	9.21							227												
AR-3	7/2/2001	27.10	7.80	8.93							1,570												
AR-3	7/10/2001	28.80	8.10	9.22							210												
AR-3	7/18/2001	29.00	7.90	10.10							447												
AR-3	7/26/2001	32.00	7.50	8.52							53												
AR-3	8/1/2001	29.70	7.60	6.08						258	1,160				40.00	4.00	10.00	10.00	2.00		2.00	3.00	10.00
AR-3	8/9/2001	28.90	7.60	8.46							12,300												
AR-3	8/15/2001	26.80	8.10	10.80							125												
AR-3	9/5/2001	27.20	7.90	10.00																			
AR-3	9/19/2001	22.90	8.00	7.40							580												
AR-3	10/1/2001	20.50	8.20	6.60							440												
AR-3	10/22/2001	18.70	8.20	1.00							163												
AR-3	11/5/2001	18.40	8.70	19.10							520					4.00		10.00	2.00				21.00
AR-3	11/26/2001	13.50	9.10	17.40							214												
AR-3	12/3/2001	14.60	7.40	14.40							192												
AR-3	12/18/2001	14.60	7.60	11.40							260												
AR-3	1/7/2002	8.20	7.70	NR							1,080												
AR-3	1/28/2002	15.3	9.5	12.8							15												
AR-3	2/4/2002	8.70	8.50	13.50						250	60			5.00		4.00		1.00	2.00	0.20	2.00	2.00	30.00
AR-3	2/18/2002	13.10	9.00	10.30																			
AR-3	3/8/2002	16.00	8.80	16.00							22												
AR-3	3/28/2002	17.20	8.70	16.00						100													
AR-3	4/15/2002	23.50	9.00	12.50							16												
AR-3	4/29/2002	16.70	8.00	8.60							224												
AR-3	5/13/2002	23.50	7.91	10.57						290	490			5.00	2.00	4.00		5.00	2.00		2.00	2.00	16.00
AR-3	5/28/2002	18.30	7.93	8.27							11,000												
AR-3	6/4/2002	26.90	7.90	8.10																			
AR-3	6/18/2002	23.20	8.00	7.80							420												
AR-3	7/3/2002	26.50	8.28	7.73							1,580												
AR-3	7/17/2002	25.90	7.50	6.30							960												
AR-3	8/1/2002	29.30	8.00	10.00							2,600			5.00		4.00		5.00	2.00		2.00	2.00	11.00
AR-3	8/15/2002	25.80	7.60	7.40							2,200												
AR-3	9/5/2002	30.00	8.20	11.40							164												
AR-3	9/19/2002	24.50	7.81	NR							270												
AR-3	10/3/2002	23.80	7.49	7.59							800												
AR-3	10/17/2002	14.90	7.56	8.79							31												
AR-3	11/4/2002	11.60	7.70	10.20						180	593			5.00		4.00		**20.00**	2.00		2.00	**5.00**	71.00
AR-3	11/18/2002	13.20	8.19	12.57							200												
AR-3	12/2/2002	10.30	8.58	14.75							26												
AR-3	12/16/2002	11.50	7.94	14.48							120												
AR-3	1/6/2003	7.60	7.61	12.13							78												
AR-3	1/22/2003	3.30	8.44	14.83							130												
AR-3	2/5/2003	6.20	8.50	10.00	1.00					370	10		0.09	5.00		**1.00**		6.70	2.00	**0.20**	2.00	2.00	10.00
AR-3	2/19/2003	10.70	8.80	14.40							250		0.10										
AR-3	3/5/2003	4.20	8.57	12.93							260		0.02										
AR-3	3/19/2003	11.90	8.20	7.95							2,800		0.47										

City of Tulsa 1992-2004 Data																							
AREA	DATE	TEMP	pH	DO	BOD	NH4	NO3	N02	NO2+NO3	HARDNESS	COLIF F	TSS	PO4	PHENOL	AS	CD	CR	CU	PB	HG	SE	AG	ZN
		(ºC)	(std.)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	0	(mg/l)	(mg/l)	(N/100ml)	(mg/l)	(mg/l)	(mg/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)
AR-3	4/2/2003	16.00	8.00	7.60							120		0.24										
AR-3	4/16/2003	15.80	8.00	8.30							6,550		0.18										
AR-3	5/5/2003	20.00	8.00	6.70						240	100		0.14	5.00					2.00		2.00	2.00	140.00
AR-3	5/19/2003	25.30	8.10	8.06							7,450		0.11										
AR-3	6/2/2003	21.00	7.70	6.60							2,400		0.50										
AR-3	6/16/2003	27.00	8.00	6.20							667		0.23										
AR-3	7/2/2003	27.00	7.60	8.40							400		0.13										
AR-3	7/17/2003	27.00	8.00	6.50							440		0.14										
AR-3	8/4/2003	26.00	7.60	6.20						200	636		0.15			1.00		5.00	2.00		2.00	2.00	180
AR-3	8/20/2003	29.00	8.00	8.20						455			0.11										
AR-3	9/4/2003	25.00	7.70	7.00						5000			0.14										
AR-3	9/22/2003	25.00	7.90	10.00						919			0.12										
AR-3	10/6/2003	19.00	8.40	14.00						1200			0.05										
AR-3	10/20/2003	21.00	7.30	8.00						330			0.16										
AR-3	11/4/2003	21.00	7.60	9.00						230	193		0.12						2.00		2.00	2.00	10.00
AR-3	11/18/2003	12.00	7.50	10.00							56000		0.1										
AR-3	12/3/2003										15500		0.12										
AR-3	1/5/2004	4.10	8.40	14.00																			
AR-3	1/20/2004	5.50	8.20	7.60																			
AR-3	2/3/2004	6.20	8.30	10.00																			
AR-3	2/17/2004	7.00	8.30	11.00																			
AR-3	3/3/2004	11.00	7.50	9.30																			
AR-3	3/17/2004	12.00	7.70	7.50																			
AR-3	4/5/2004	15.00	8.00	7.60																			
AR-3	4/19/2004	17.00	8.20	7.40																			
AR-3	5/3/2004	17.00	8.00	7.70							520												
AR-3	5/17/2004	22.00	7.80	6.10							11,400												
AR-3	6/7/2004	25.00	7.50	7.50							280												
AR-3	6/24/2004	24.00	7.80	5.10							600												
AR-3	7/1/2004	25.00	7.80	6.00							80												
AR-3	7/19/2004	26.00	7.40	7.20							325												
AR-3	8/2/2004	25.00	7.80	6.80							109												
AR-3	8/16/2004	25.00	7.90	7.70							1,540												
AR-3	9/1/2004	24.00	7.50	6.30							200												
AR-3	9/22/2004	25.00	7.80	9.60							91												
AR-3	10/6/2004	21.00	8.20	11.00							240												
AR-3	10/21/2004	23.00	8.00	8.60																			
AR-3	11/4/2004	17.00	8.00	14.00																			
AR-3	11/18/2004	16.00	8.00	11.00																			
AR-3	12/6/2004	12.00	7.90	12.00																			
AR-3	12/20/2004	6.90	8.10	15.00																			

City of Tulsa 1992-2004 Data																							
AREA	DATE	TEMP	pH	DO	BOD	NH4	NO3	N02	NO2+NO3	HARDNESS	COLIF F	TSS	PO4	PHENOL	AS	CD	CR	CU	PB	HG	SE	AG	ZN
		(°C)	(std.)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	0	(mg/l)	(mg/l)	(N/100ml)	(mg/l)	(mg/l)	(mg/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)
	Avg.1992																						
	Avg.1993																						
	Avg.1994																						
	Avg.1995																						
	Avg.1996																						
	Avg.1997																						
	Avg.1998																						
	Avg.1999																						
	Avg. 2000	18.84	7.93	9.43							2119.33			8.75	40.00	4.00	10.00	15.00	1.60	0.20	2.00	0.75	19.00
	Avg. 2001	17.74	7.98	9.44						258.00	3276.38				40.00	4.00	10.00	10.00	2.00	0.20	2.50	3.00	13.23
	Avg. 2002	19.08	8.16	10.71						205.00	1089.10			5.00	2.00	4.00		7.75	2.00	0.20	2.00	2.75	32.00
	Avg. 2003	18.23	7.98	9.23						993.78	5221.33		0.16	5.00		1.00		5.85	2.00	0.20	2.00	2.00	85.00
	Avg. 2004	17.94	7.91	8.48							1398.64												

City of Tulsa 1992-2004 Data																							
AREA	DATE	TEMP	pH	DO	BOD	NH4	N03	NO2	NO2+NO3	HARDNESS	COLIF F	TSS	PO4	PHENOL	AS	CD	CR	CU	Pb	HG	SE	AG	ZN
		(°C)	(std.)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/L)	mg/l	(mg/l)	(n/100ml)	(mg/l)	(mg/l)		(ug/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)
AR4	1/3/2000	9.20	7.80	11.00																			
AR4	1/11/2000	9.20	7.70	12.00																			
AR4	1/19/2000	8.50	8.00	11.00																			
AR4	1/24/2000	4.80	8.10	13.00																			
AR4	2/1/2000	4.20	8.10	13.00																			
AR4	2/7/2000	9.30	8.10	15.00																			
AR4	2/17/2000	8.30	8.00	12.00																			
AR4	2/22/2000	13.00	8.00	15.00																			
AR4	3/1/2000	11.00	8.40	12.00																			
AR4	3/7/2000	13.00	8.20	10.00																			
AR4	4/11/2000	15.00	7.90	9.80																			
AR4	4/19/2000	19.00	8.00	8.50																			
AR4	4/27/2000	18.00	8.10	9.00																			
AR4	5/8/2000	24.00	7.40	7.30							927												
AR4	5/16/2000	20.00	8.00	7.80							709												
AR4	5/24/2000	25.00	7.80	7.20							280												
AR4	6/6/2000	23.00	7.60	7.60							89												
AR4	6/15/2000	25.00	7.80	7.40							691												
AR4	6/19/2000	24.00	7.90	6.60							27												
AR4	6/27/2000	25.00	7.50	6.40							605												
AR4	7/6/2000	27.00	7.90	7.10							10												
AR4	7/11/2000	26.00	7.80	6.30							490												
AR4	7/19/2000	28.00	7.90	5.20							300												
AR4	7/27/2000	26.00	8.00	7.70							4,000												
AR4	8/3/2000	27.00	7.80	8.30							1,120												
AR4	8/7/2000	28.00	8.10	6.80							290												
AR4	8/15/2000	29.00	8.00	7.90							627												
AR4	8/23/2000	27.80	8.30	8.90							500												
AR4	9/7/2000	25.70	8.00	9.18							430												
AR4	9/11/2000	27.10	7.90	10.4							45												
AR4	9/19/2000	21.00	8.00	10.9							36												
AR4	9/26/2000	18.70	8.10	9.00							370												
AR4	10/2/2000	20.00	8.30	9.40																			
AR4	10/10/2000	13.60	8.30	10.8																			
AR4	11/7/2000	14.4	8.1	9.30																			
AR4	11/13/2000	11.1	8.3	10.4																			
AR4	11/28/2000	8.90	8.1	11.7																			
AR4	12/5/2000	7.70	8.00	8.22																			
AR4	12/20/2000	5.90	8.10	7.90																			
AR-4	1/4/2001	3.60	7.60																				
AR-4	1/11/2001	4.60	7.90	7.70																			
AR-4	1/17/2001	7.70	7.60	8.40																			
AR-4	1/23/2001	6.10	7.70	8.90																			
AR-4	2/5/2001	5.50	8.90	12.20																			

City of Tulsa 1992-2004 Data																							
AREA	DATE	TEMP	pH	DO	BOD	NH4	N03	NO2	NO2+NO3	HARDNESS	COLIF F	TSS	PO4	PHENOL	AS	CD	CR	CU	Pb	HG	SE	AG	ZN
		(°C)	(std.)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/L)	mg/l	(mg/l)	(n/100ml)	(mg/l)	(mg/l)		(ug/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)
AR-4	2/15/2001	4.10	8.60	13.20																			
AR-4	2/20/2001	7.10	8.50	12.40																			
AR-4	2/28/2001	7.20	8.20	8.70																			
AR-4	3/5/2001	7.30	8.10	9.00																			
AR-4	3/15/2001	9.60	7.90	8.70																			
AR-4	3/20/2001	10.00	8.30	10.20																			
AR-4	3/28/2001	10.10	7.90	8.20																			
AR-4	4/2/2001	12.00	7.70	8.00																			
AR-4	4/12/2001	15.50	7.70	10.70																			
AR-4	4/18/2001	15.30	7.90	9.41																			
AR-4	4/24/2001	17.40	7.80	9.81																			
AR-4	5/10/2001	22.90	8.00	8.05							171												
AR-4	5/16/2001	23.90	7.90	7.30							157												
AR-4	5/22/2001	22.00	8.20	7.22							407												
AR-4	6/6/2001	24.80	8.10	7.40							1,450												
AR-4	6/11/2001	26.50	7.90	7.64							32												
AR-4	6/19/2001	25.90	8.00	7.43							220												
AR-4	6/25/2001	26.20	7.80	8.01							20												
AR-4	7/2/2001	26.90	8.00	8.24							413												
AR-4	7/10/2001	28.80	8.20	8.71							119												
AR-4	7/18/2001	28.70	8.00	8.14							160												
AR-4	7/26/2001	30.50	7.70	8.68							107												
AR-4	8/1/2001	28.20	7.70	6.25						243	2,000												
AR-4	8/9/2001	28.40	7.70	6.72							5,100												
AR-4	8/15/2001	27.30	8.50	8.88							94												
AR-4	8/23/2001	25.70	8.30	8.10							400												
AR-4	9/5/2001	27.40	8.20	8.10							94												
AR-4	9/19/2001	23.90	8.00	6.60																			
AR-4	10/01/2001	21.60	8.30	6.60							200												
AR-4	10/22/2001	18.90	8.30	1.00							144												
AR-4	11/05/2001	19.80	7.90	8.35							1,610												
AR-4	11/26/2001	14.40	8.50	12.00							2,800												
AR-4	12/03/2001	14.00	8.30	9.70							4,000												
AR-4	12/18/2001	11.90	8.30	11.50							627												
AR-4	1/7/2002	3.10	7.90	NR							81												
AR-4	1/28/2002	12.70	8.70	13.90							29												
AR-4	2/4/2002	7.00	8.50	13.30							24												
AR-4	2/18/2002	8.80	8.50	7.60							2												
AR-4	3/8/2002	15.20	7.00	10.30																			
AR-4	3/28/2002	15.50	8.50	11.00							99												
AR-4	4/15/2002	22.20	8.40	8.50							580												

City of Tulsa 1992-2004 Data																							
AREA	DATE	TEMP	pH	DO	BOD	NH4	N03	NO2	NO2+NO3	HARDNESS	COLIF F	TSS	PO4	PHENOL	AS	CD	CR	CU	Pb	HG	SE	AG	ZN
		(°C)	(std.)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/L)	mg/l	(mg/l)	(n/100ml)	(mg/l)	(mg/l)		(ug/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)
AR-4	4/29/2002	18.00	8.30	8.40							36												
AR-4	5/13/2002	21.10	7.29	9.26							470												
AR-4	5/28/2002	18.30	7.44	8.06							20,000												
AR-4	6/4/2002	24.70	7.90	7.30							148												
AR-4	6/18/2002	22.60	8.10	7.60							450												
AR-4	7/3/2002	26.30	8.29	7.01							400												
AR-4	7/17/2002	25.50	7.90	6.90							233												
AR-4	8/1/2002	28.60	8.30	8.80							63												
AR-4	8/15/2002	26.30	8.30	7.40							367												
AR-4	9/5/2002	28.60	8.00	7.30							40												
AR-4	9/19/2002	25.30	8.20	NA							720												
AR-4	10/3/2002	24.10	7.95	6.98							93												
AR-4	10/17/2002	15.60	7.68	9.23							75												
AR-4	11/4/2002	11.80	7.70	10.40							530												
AR-4	11/18/2002	13.00	8.05	10.84							373												
AR-4	12/2/2002	11.50	7.55	13.51							94												
AR-4	12/16/2002	12.20	7.51	13.62							88												
AR-4	1/6/2003	7.30	7.72	12.55							50												
AR-4	1/22/2003	3.10	8.74	11.95							255												
AR-4	2/5/2003	6.30	8.30	11.30							420												
AR-4	2/19/2003	8.70	8.80	12.30							NR		0.12										
AR-4	3/5/2003	4.30	8.58	11.32							240		0.02										
AR-4	3/19/2003	11.90	8.20	8.17							5,500		0.36										
AR-4	4/2/2003	15.00	8.00	7.70							160		0.24										
AR-4	4/16/2004	15.70	8.20	8.20							3,700		0.16										
AR-4	5/5/2003	20.00	8.00	6.60							84		0.14										
AR-4	5/19/2003	24.80	8.00	8.10							2,700		0.35										
AR-4	6/2/2003	22.00	7.80	6.60							3,700		0.14										
AR-4	6/16/2003	26.00	7.80	5.50							621		0.14										
AR-4	7/2/2003	26.00	8.00	7.70							50		0.16										
AR-4	7/17/2003	27.00	8.10	6.80							14		0.14										
AR-4	8/4/2003	26.00	8.00	6.8							127		0.13										
AR-4	8/20/2003	28.00	8.00	6.8							96		0.13										
AR-4	9/4/2003	24.00	7.80	7.2							2,600		0.10										
AR-4	9/22/2003	24.00	8.00	8.6							818		0.13										
AR-4	10/6/2003	20.00	8.00	8.50							2,700		0.48										
AR-4	10/20/2003	20.00	7.50	7.70							75		0.15										
AR-4	11/4/2003	21.00	7.80	9.10							124		0.13										
AR-4	11/18/2003	15.00	8.00	9.20							581		0.00										
AR-4	12/3/2003										11,400		0.11										
AR-4	1/5/2004	3.90	8.20	12.00																			
AR-4	1/20/2004	4.10	8.30	10.00																			
AR-4	2/3/2004	5.20	8.30	10.00																			

City of Tulsa 1992-2004 Data																							
AREA	DATE	TEMP	pH	DO	BOD	NH4	N03	NO2	NO2+NO3	HARDNESS	COLIF F	TSS	PO4	PHENOL	AS	CD	CR	CU	Pb	HG	SE	AG	ZN
		(°C)	(std.)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/L)	mg/l	(mg/l)	(n/100ml)	(mg/l)	(mg/l)		(ug/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)
AR-4	2/17/2004	7.50	8.30	10.00																			
AR-4	3/3/2004	9.90	8.00	8.40																			
AR-4	3/17/2004	11.00	7.80	8.40																			
AR-4	4/5/2004	16.00	8.00	7.20																			
AR-4	4/19/2004	18.00	8.10	7.40																			
AR-4	5/3/2004	17.00	7.90	7.00							410												
AR-4	5/17/2004	22.00	7.60	6.50							440												
AR-4	6/7/2004	23.00	7.70	7.30							162												
AR-4	6/24/2004	24.00	8.00	5.30							119												
AR-4	7/1/2004	22.00	7.50	6.00							58												
AR-4	7/19/2004	26.00	7.20	7.40							152												
AR-4	8/2/2004	25.00	7.80	6.60							127												
AR-4	8/16/2004	25.00	7.90	7.50							1,320												
AR-4	9/1/2004	24.00	7.70	6.40							200												
AR-4	9/22/2004	23.00	8.00	7.50							127												
AR-4	10/6/2004	20.00	8.40	10.00							260												
AR-4	10/21/2004	21.00	8.10	7.90																			
AR-4	11/4/2004	15.00	8.20	11.00																			
AR-4	11/18/2004	17.00	8.10	10.00																			
AR-4	12/6/2004	12.00	7.60	14.00																			
AR-4	12/20/2004	5.60	8.10	15.00																			
	Avg.1992																						
	Avg.1993																						
	Avg.1994																						
	Avg.1995																						
	Avg.1996																						
	Avg.1997																						
	Avg.1998																						
	Avg.1999																						
	Avg.2000	18.53	7.97	9.21							726.07												
	Avg.2001	17.74	8.05	8.58						243.00	923.86												
	Avg.2002	18.25	8.00	9.42							1086.74												
	Avg.2003	18.00	8.06	8.85							1637.05		0.17										
	Avg.2004	16.55	7.95	8.70							306.82												

City of Tulsa 1992-2004 Data																								
AREA	DATE	TEMP	pH	DO	BOD	NH4	NO3	NO2	NO2+NO3	HARDNS	COLIF F	TSS	PO4	PHENOL	AS	CD	CR	CU	PB	HG	SE	AG	ZN	N-Kjel
		(^{o}C)	(std.)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(N/100ml)	(mg/l)	(mg/l)	(mg/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)	(mg/l)
AR6	1/3/2000	9.30	7.90	11.00																				
AR6	1/11/2000	8.70	8.00	11.00																				
AR6	1/19/2000	8.10	8.00	11.00																				
AR6	1/24/2000	4.60	8.30	12.00																				
AR6	2/1/2000	5.40	8.00	13.00																				
AR6	2/7/2000	8.50	7.90	13.00																				
AR6	2/17/2000	8.10	8.20	11.00																				
AR6	2/22/2000	13.00	8.00	11.00																				
AR6	3/1/2000	10.00	8.30	12.00																				
AR6	3/7/2000	13.00	8.10	10.00																				
AR6	4/11/2000	16.00	8.00	9.10																				
AR6	4/19/2000	22.00	8.00	8.00																				
AR6	4/27/2000	19.00	8.20	9.10																				
AR6	5/8/2000	23.00	7.50	6.80							809													
AR6	5/16/2000	20.00	7.80	7.50							736													
AR6	5/24/2000	26.00	8.00	7.20							100													
AR6	6/6/2000	23.00	7.80	8.00							680													
AR6	6/15/2000	24.00	7.70	7.60							727													
AR6	6/19/2000	25.00	8.00	6.70							480													
AR6	6/27/2000	24.00	8.00	6.90							1,300													
AR6	7/6/2000	27.00	8.10	6.80							206													
AR6	7/11/2000	28.00	7.80	6.30							90													
AR6	7/19/2000	29.00	8.00	5.80							35													
AR6	7/27/2000	24.00	8.10	8.40							4,000													
AR6	8/3/2000	28.00	8.10	8.90							650													
AR6	8/7/2000	28.00	8.10	6.70							470													
AR6	8/15/2000	28.00	8.20	8.10							493													
AR6	8/23/2000	27.40	8.00	7.50	3.6						88				46									
AR6	9/7/2000	13.70	8.20	9.40							400													
AR6	9/11/2000	28.00	8.40	10.0							164													
AR6	9/19/2000	23.00	8.30	10.7																				
AR6	9/26/2000	19.00	8.10	9.40							220													
AR6	10/2/2000	22.70	8.50	9.50																				
AR6	10/10/2000	13.20	8.40	11.00																				
AR-6	11/7/2000	13.5	8.2	9.40																				
AR-6	11/13/2000	9.70	8.3	10.8																				
AR-6	11/28/2000	8.70	8.2	11.4																				
AR-6	12/5/2000	8.30	8.10	7.95																				
AR-6	12/20/2000	5.20	8.00	9.40																				
AR-6	1/4/2001	3.40	7.80																					
AR-6	1/11/2001	5.00	7.80	8.40																				
AR-6	1/17/2001	6.80	7.80	7.50																				
AR-6	1/23/2001	5.90	7.90	8.60																				
AR-6	2/5/2001	7.30	8.00	9.58																				
AR-6	2/15/2001	6.60	8.30	11.70																				
AR-6	2/20/2001	8.30	8.40	12.70																				

City of Tulsa 1992-2004 Data																								
AREA	DATE	TEMP	pH	DO	BOD	NH4	NO3	NO2	NO2+NO3	HARDNS	COLIF F	TSS	PO4	PHENOL	AS	CD	CR	CU	PB	HG	SE	AG	ZN	N-Kjel
		(°C)	(std.)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(N/100ml)	(mg/l)	(mg/l)	(mg/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)	(mg/l)
AR-6	2/28/2001	8.40	8.10	8.10																				
AR-6	3/20/2001	10.40	8.30	10.10																				
AR-6	3/28/2001	9.60	7.90	8.40																				
AR-6	4/2/2001	11.60	7.70	8.20																				
AR-6	4/12/2001	18.10	8.00	8.91																				
AR-6	4/18/2001	13.90	8.10	9.63																				
AR-6	4/24/2001	16.20	8.10	9.18																				
AR-6	5/10/2001	22.40	8.10	7.98							45													
AR-6	5/16/2001	24.20	7.70	7.10							220													
AR-6	5/22/2001	22.10	8.10	7.49							400													
AR-6	6/6/2001	24.70	8.10	7.28							986													
AR-6	6/11/2001	26.40	8.10	8.60							88													
AR-6	6/19/2001	26.20	7.90	7.89							393													
AR-6	6/25/2001	27.50	7.80	8.29							63													
AR-6	7/2/2001	27.80	8.20	8.52							510													
AR-6	7/10/2001	29.00	8.40	7.38							88													
AR-6	7/18/2001	29.10	8.90	8.95							310													
AR-6	7/26/2001	32.40	8.60	6.19							103													
AR-6	8/1/2001	28.40	8.10	6.36						251.00	317													
AR-6	8/9/2001	28.20	8.10	7.32							14,400													
AR-6	8/15/2001	27.30	8.30	7.69							177													
AR-6	8/23/2001	25.30	8.30	7.50							250													
AR-6	9/5/2001	27.90	8.10	8.40	2.90	0.13	0.11	0.02	0.12		240				40.00	4.00	10.00	10.00	4.50	0.20	22.00	3.00	10.00	
AR-6	9/19/2001	23.40	8.10	6.80	2.00	0.05	0.39	0.02	0.41		3,300													
AR-6	10/1/2001	20.90	8.20	6.20	47.00	0.05	0.74	0.02	0.75		300					4.00		13.50	2.00				10.50	
AR-6	10/22/2001	20.10	8.00	1.00							4,400													
AR-6	11/5/2001	20.30	7.50	6.71	3.30	0.17	0.89	0.02	0.90		4,500					4.00		10.00	4.90				40.00	
AR-6	11/26/2001	13.40	8.30	10.70							320													
AR-6	12/03/2001	14.00	8.40	10.20	2.00	0.12	0.72	0.02	0.73		119					4.00		10.00	2.00	0.20			26.00	
AR-6	12/18/2001	11.00	8.00	10.70							1,210													
AR-6	1/7/2002	5.00	8.50	NR	2.00	0.21	0.82	0.03	0.86		113					4.00		10.00	2.00				10	0.74
AR-6	1/28/2002	12.40	8.70	11.40							28													
AR-6	2/4/2002	7.30	8.40	12.40	2.00	0.12	0.56	0.020	0.58		32					4.00		10	2.00	4.00			10	0.74
AR-6	2/18/2002	12.40	8.50	8.80	4.30	0.77	0.44	0.022	0.46		15													1.68
AR-6	3/8/2002	14.80	7.60	9.10	2.10	0.29	0.59	0.025	0.62	280	54					4.00		5.8	2.00				16	1.18
AR-6	3/28/2002	13.80	7.80	9.30							100													
AR-6	4/15/2002	22.10	8.20	7.40	3.40	0.35	0.29	0.033	0.32	210	61					4.1		5	2.5				43	1.5
AR-6	4/29/2002	19.10	7.90	8.00							64													
AR-6	5/13/2002	18.30	7.00	7.65	4.30	0.25	0.14	0.027	0.16	250	1,420					4.00		11	8.28				54	1.77
AR-6	5/28/2002	20.80	7.70	7.08							1,020													
AR-6	6/4/2002	25.80	8.00	7.60	3.00	0.09	0.19	0.020	0.21	260	440					4.00		5	2.34				31	0.92
AR-6	6/18/2002	23.80	8.20	7.80							2,100													
AR-6	7/3/2002	26.10	8.24	6.98	2.00	0.19	0.69	0.015	0.69	190	2,770					4.00		10	6.1				60	0.91
AR-6	7/17/2002	25.60	8.00	6.80							83													

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AREA	DATE	TEMP	pH	DO	BOD	NH4	NO3	NO2	NO2+NO3	HARDNS	COLIF F	TSS	PO4	PHENOL	AS	CD	CR	CU	PB	HG	SE	AG	ZN	N-Kjel
		(^{o}C)	(std.)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(N/100ml)	(mg/l)	(mg/l)	(mg/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)	(mg/l)
AR-6	8/1/2002	29.40	8.60	9.40	2.00	0.03	0.11	0.015	0.12	190	520					4.00		5	2.01				21	0.87
AR-6	8/15/2002	26.70	8.30	7.20							2,500													
AR-6	9/5/2002	29.50	8.40	8.80	4.30	0.06	0.22	0.018	0.24		1,180					4.00		6.4	2.4				33	0.92
AR-6	9/19/2002	24.40	8.10	NR						165	4,700													
AR-6	10/3/2002	24.30	7.91	6.89	2.00	0.13	0.97	0.020	0.99	150	920					4.00		5	3.56				31	0.82
AR-6	10/17/2002	15.20	7.74	9.40							131													
AR-6	11/4/2002	12.30	7.70	10.20	2.00	0.05	1.17	0.015	1.18	180	490					4		**20**	2.6				83	1.06
AR-6	11/18/2002	12.40	8.10	10.94							197													
AR-6	12/2/2002	10.00	7.99	11.92	2.00	0.16	1.12	0.057	1.18	250	71					4		5.8	2.00				10	0.46
AR-6	12/16/2002	12.10	7.72	10.58							98													
AR-6	1/6/2003	7.80	7.65	9.65	2.00	0.28	0.87	0.026	0.9	370	28					1		5	2.00				75	1.08
AR-6	1/22/2003	3.00	8.71	11.27							180													
AR-6	2/5/2003	6.30	8.30	10.20	2.00	0.07	0.65	0.047	0.7	380	88		0.13			1		6.1	2.00	**0.2**			13	1.08
AR-6	2/19/2003	9.10	8.60	11.00							300		0.052											
AR-6	3/5/2003	5.00	8.65	11.29	2.00	0.04	0.29	0.018	0.31	380	50		0.02			1		8.4	2.00				120	1.05
AR-6	3/19/2003	14.50	7.59	6.40							2,100		0.41											
AR-6	4/2/2003	16.00	8.10	7.70	2.00	0.25	0.72	**0.010**	0.72	270	96		0.26			1		7.4	2.21				95	1.27
AR-6	4/16/2003	16.20	8.20	8.20							270		0.13											
AR-6	5/5/2003	21.00	8.10	6.80	2.00	0.10	0.82	0.094	0.91	250	535		0.14			1		5	2.00				200	0.83
AR-6	5/19/2003	25.00	7.70	6.88							2,000		0.14											
AR-6	6/2/2003	22.00	7.80	6.40	3.20	0.10	0.89	0.035	0.92	190	21,000		0.22						3.83					
AR-6	6/16/2003	25.00	7.90	5.60							250		0.15											
AR-6	7/2/2003	28.00	8.20	7.90	2.00	0.04	0.45	0.011	0.457	240	18		0.16			1		5	2.33				150	0.74
AR-6	7/17/2003	28.00	8.40	6.80							280		0.17											
AR-6	8/4/2003	27.00	7.90	6.20	2.00	0.04	0.26	0.021	0.22	220	900		0.17			1		5	2.00				170	0.82
AR-6	8/20/2003	29.00	8.30	6.80							160		0.15											
AR-6	9/4/2003	26.00	7.80	7.40	2.00	0.04	..16	0.026	0.18	190	15,000		0.13			0.005		5	2.00				0.012	0.7
AR-6	9/22/2003	24.00	8.00	8.10							2,100		0.15											
AR-6	10/6/2003	20.00	7.80	7.80	2.00	0.20	0.62	0.025	0.65	200			0.12			1.5		5	2.00				230	0.46
AR-6	10/20/2003	20.00	7.60	8.00							400		0.18											
AR-6	11/4/2003	21.00	8.20	9.10	2.00	0.04	0.95	0.022	0.98	190	260		0.2			1		5	2.00				10	0.68
AR-6	11/18/2003	16.00	7.80	9.10							766		0.17											
AR-6	12/3/2003	8.70	7.60	12.00	2.00	0.04	1.03	0.024	1.06	200	4,300		0.38			1.4		5	2.00				10	0.28
AR-6	1/5/2004	3.10	7.90	10.00	2.00	0.40	0.65	0.033	0.68	240	350		0.15			1		5.6	2.00				180	0.69
AR-6	1/20/2004	3.50	8.30	10.00																				
AR-6	2/3/2004	4.90	8.20	9.50	2.00	0.09	0.67	0.033	0.68	230	230		0.11			2.4		5	2.00				140	0.7
AR-6	2/17/2004	6.10	8.20	8.70																				
AR-6	3/3/2004	10.00	8.30	8.20	2.80	0.19	0.74	0.033	0.77	250	700		0.16			1.7		5	2.00				16	1.08
AR-6	3/17/2004	11.00	7.80	7.40																				
AR-6	4/5/2004	15.00	7.90	7.20	2.00	0.13	0.87	0.053	0.92	220	156		0.17			1		5	2.21				20	0.77
AR-6	4/19/2004	18.00	8.00	7.50																				
AR-6	5/3/2004	18.00	8.00	7.40	2.30	0.04			0.81	200	274		0.35			1.8		5	2.89				19	0.91
AR-6	5/17/2004	22.00	8.00	6.30							950													

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AREA	DATE	TEMP	pH	DO	BOD	NH4	NO3	NO2	NO2+NO3	HARDNS	COLIF F	TSS	PO4	PHENOL	AS	CD	CR	CU	PB	HG	SE	AG	ZN	N-Kjel
		(°C)	(std.)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(N/100ml)	(mg/l)	(mg/l)	(mg/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)	(mg/l)
AR-6	6/7/2004	23.00	8.00	6.30	2.00	0.04			0.49	220	490		0.21			1		7.2	2.00				10	0.27
AR-6	6/24/2004	24.00	7.80	5.50							220													
AR-6	7/1/2004	25.00	7.80	5.40	2.00	0.04			0.64	210	182					1.5		11					20	0.78
AR-6	7/19/2004	26.00	7.50	6.80							77													
AR-6	8/2/2004	26.00	7.90	6.80															2.00					
AR-6	8/16/2004	25.00	7.90	7.40							425													
AR-6	9/1/2004	24.00	7.90	6.50		0.04			0.59	170	250		0.027			1.4		5					14	0.054
AR-6	9/8/2004	23.00	8.50	8.90	7.10																			
AR-6	9/22/2004	23.00	8.10	7.30							109													
AR-6	10/6/2004	19.00	8.40	9.10	2.10	0.04	0.54		0.54	250	420		0.3			1		5	2.00				10	0.67
AR-6	10/21/2004	21.00	8.10	7.80																				
AR-6	11/4/2004	13.00	7.90	11.00	2.00	0.12			0.52	140			0.2			1.1		5.2	3.25				22	0.68
AR-6	12/6/2004	11.00	7.90	11.00	2.00	0.04			0.15	150	1,800		0.21			1		5	2.00				140	0.79
AR-6	12/20/2004	6.20	8.10	14.00																				
	Avg.1992																							
	Avg.1993																							
	Avg.1994																							
	Avg.1995																							
	Avg.1996																							
	Avg.1997																							
	Avg.1998																							
	Avg.1999																							
	Avg. 2000	18.42	8.06	9.06							724													
	Avg. 2001	17.97	8.09	8.25	11.44	0.10	0.57	0.02	0.58	251.00	1,423				40.00	4.00	10.00	10.88	3.35	0.20	22.00	3.00	21.63	
	Avg. 2002	18.48	8.05	8.89	2.72	0.21	0.56	0.02	0.59	212.50	796.13					4.01		8.25	3.15	4.00			33.50	1.04
	Avg. 2003	18.20	8.04	8.29	2.10	0.10	0.69	0.03	0.67	256.67	2321.86		0.17			0.99		5.63	2.20	0.20			97.55	0.82
	Avg. 2004	17.29	8.02	8.09	2.63	0.08	0.71	0.04	0.61	204.00	448.79		0.19			1.39		5.84	2.26				41.10	0.67

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SITE	DATE	TEMP ("C)	pH (std.)	DO (mg/l)	BOD (mg/l)	NH4 (mg/l	N03 (mg/l)	NO2 (mg/l)	NO2+NO3 (mg/l)	HARDNESS (mg/l)	COLIF F (N/100ml)	TSS (mg/l)	P04 (mg/l)	PHENOL (mg/l)	AS (ug/l)	CD (ug/l)	CR (ug/l)	CU (ug/l)	PB (ug/l)	HG (ug/l)	SE (ug/l)	AG (ug/l)	Zn (ug/l)	Kjeldahl (ug/l)
AR8	1/3/2000	9.80	7.90	10.00	20.00	0.17	0.94	0.02	0.96	238														
AR8	1/11/2000	9.40	8.10	10.00	2.00	0.19	1.08	0.02	1.10	275														
AR8	1/19/2000	8.50	8.00	11.00	2.00	0.08	1.04	0.02	1.06	280					< 40.0	< 4.0	10.0	20.0	2.0	0.2	2.0	0.5	20.0	
AR8	1/24/2000	5.20	8.30	12.00	12.00	0.13	< 0.03	< 0.00	< 0.03	280														
AR8	2/1/2000	4.90	7.70	13.00	2.40	0.07	0.91	< 0.01	0.91	286														
AR8	2/7/2000	9.80	8.00	12.00	2.00	0.10	0.91	0.02	0.93	288														
AR8	2/17/2000	8.00	8.30	12.00	17.00	0.07	1.00	< 0.01	1.01	322					74.0	4.0	10.0	20.0	2.0	0.2	2.0	0.5	20.0	
AR8	2/22/2000	14.00	8.50	12.00	2.20	0.03	0.73	0.01	0.75	314														
AR-8	3/1/2000	10.00	8.30	11.00	20.00	0.05	0.92	< 0.01	0.92	206														
AR-8	3/7/2000	13.00	8.10	10.00	2.10	0.15	1.00	0.02	1.02	278														
AR-8	3/13/2000	13.00	8.10	10.00	2.00	0.14	1.08	0.02	1.10	264														
AR-8	3/22/2000	13.00	8.10	10.00	2.00	0.14				245					61	< 4	10	20	2	0.2	2	0.5	44	
AR-8	4/6/2000	15.00	7.80	9.60	2.00	0.12	0.84	0.02	0.87	201														
AR-8	4/11/2000	15.00	7.90	9.20	2.00	0.08	0.70	0.02	0.72	257														
AR-8	4/19/2000	21.00	8.00	8.20	2.00	0.05	0.71	0.02	0.73	332					78	< 4	10	20	2	0.2	2	0.5	20	
AR-8	4/27/2000	19.00	8.10	8.80	2.10	0.03	0.57	< 0.01	0.57	328														
AR8	5/8/2000	23.00	7.20	6.50	2.00	0.18	0.35	0.03	0.39	108	164													
AR8	5/16/2000	20.00	8.00	7.40	2.50	0.13	0.48	0.03	0.51	260	430				< 40.0	< 4.0	10.0	20.0	2.0	0.2	2.0	0.5	20.0	
AR8	5/24/2000	27.00	8.10	7.20	2.70	0.02	0.33	0.02	0.35	273	64													
AR8	6/6/2000	23.00	7.90	7.80	2.70	0.06	0.48	< 0.13	0.48	231.00	100													
AR8	6/15/2000	24.00	7.70	7.20	2.00	< 0.02	0.50	< 0.13	0.50	230.00	5,600													
AR8	6/19/2000	25.00	8.00	6.80	2.00	0.07	0.55	< 0.13	0.55	254.00	515				<40	< 4.00	10.00	20.00	2.00	0.20	2.00	0.50	20.00	
AR8	6/27/2000	26.00	7.70	7.00	3.40	0.05	0.35	0.03	0.38	116.00	500													
AR8	7/6/2000	30.00	8.30	7.10	2.00	0.04	0.10	< 0.01	0.10	224.00	88													
AR8	7/11/2000	29.00	8.10	6.40	3.20	< 0.02	0.23	< 0.01	0.23	194.00	450													
AR8	7/19/2000	29.00	8.10	6.00	2.00	0.05	0.31		0.32	219.00	165				47.00	< 4.00	10.00	20.00	2.00	0.20	2.00	0.50	20.00	
AR8	7/27/2000	25.00	8.00	8.30	5.20	0.18				205.00	4,000													
AR8	8/3/2000	29.00	7.90	10.00	2.30	0.08	0.18	< 0.01	0.19	192.00	355													
AR8	8/7/2000	29.00	8.20	7.20	3.10	< 0.02	0.06	< 0.01	0.07	254.00	217													
AR8	8/15/2000	30.00	8.50	8.10	5.20	< 0.02	1.56	0.06	1.62	235.00	455													
AR8	8/23/2000	27.30	8.30	7.90		0.0450	0.134	< 0.01	0.134		55					< 4.00	10.00		1.00	0.20	2.00	1.00	33	
AR8	9/7/2000	25.40	8.30	9.6	2.0	0.06				250	530													
AR8	9/11/2000	28.50	8.20	10.00	3.2	0.0640	0.274	< 0.01	0.274	269	250													
AR8	9/19/2000		8.00	10.8	3.6	0.0660	0.219	< 0.01	0.219	245	148				< 40.00	< 4.00	10.00	10.00	1.00	0.20	2.00	1.00	10.00	
AR8	9/26/2000	20.80	7.60	8.40	< 2.00	0.157	0.509	0.02	0.529	176	> 2,000													
AR8	10/2/2000	22.30	8.30	9.50	4.20	0.06	0.22	< 0.01	0.22	228														
AR8	10/10/2000	14.00	8.40	11.00	3.10	0.05	0.32	0.02	0.33	262														
AR8	10/18/2000	19.30	7.80	7.80	2.50	0.13	0.40	0.02	0.42	178					60	< 4.0	< 10	11	1.5	0.20	2.00	1.00	44.00	
AR8	10/26/2000	18.90	7.80	7.70	8.70	0.13	0.61	0.04	0.65	66.0														
AR-8	11/1/2000	21.3	8.2	8.5	2.8		0.170	0.0410	0.211	255														
AR-8	11/7/2000	13.2	8.2	9.4	< 2.00		0.440	0.0190	0.459	242														
AR-8	11/13/2000	11.0	7.9	10.5	< 2.00	0.095	0.65	0.018	0.67	248					< 40.00	< 4.00	10.00	10.00	1.0	0.20	2.00	1.00	48	
AR-8	11/28/2000	9.70	8.2	11	< 2.00	0.16	0.84	0.027	0.87	307														
AR-8	12/5/2000	8.10	8.00	8.10	< 2.00	0.05	0.96	< 0.01	0.97	311.00														
AR-8	12/20/2000	5.40	8.20	10.10	< 2.00	0.15	0.87	< 0.01	0.87	244.00														
AR-8	1/4/2001	3.40	7.80		< 2.00	< 0.05	1.00	0.01	1.00	256.00														
AR-8	1/11/2001	4.90	7.70	9.10	< 2.00	0.13				271.00														
AR-8	1/17/2001	8.10	7.90	8.30	< 2.00	0.12	1.00	0.01	1.00	258.00					51.00	< 4.00	10.00	10.00	1.00	0.20	2.00	1.00	10.00	
AR-8	1/23/2001	5.40	8.00	7.80	2.40	< 0.05	0.85	0.02	0.87	356.00														
AR-8	2/5/2001	6.10	8.80	11.00	2.90	< 0.05	0.56	0.01	0.57	271.00														
AR-8	2/15/2001	6.70	8.60	12.00	4.00	0.17	0.97	0.02	0.99	316.00														
AR-8	2/20/2001	8.60	8.50	12.30	< 2.00	0.18	1.00	< 0.02	1.00	294.00														
AR-8	2/28/2001	7.00	8.00	9.00	< 2.00	0.16	1.30	< 0.02	1.30															
AR-8	3/5/2001	7.60	8.30	8.90	< 2.00	2.85	1.19	0.04	1.23	256.00														
AR-8	3/15/2001	10.90	7.90	9.30	3.50	0.18	< 0.02	0.03	0.03	296.00														
AR-8	3/20/2001	10.10	8.10	11.00	2.30	0.34	1.40	0.03	1.40	254.00					< 40.00	< 4.00	10.00	11.80	2.00		2.00	3.00	21.20	
AR-8	3/28/2001	9.40	8.00	7.70	< 2.00	0.26	1.20	0.04	1.30	251.00														

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SITE	DATE	TEMP ("C)	pH (std.)	DO (mg/l)	BOD (mg/l)	NH4 (mg/l	N03 (mg/l)	NO2 (mg/l)	NO2+NO3 (mg/l)	HARDNESS (mg/l)	COLIF F (N/100ml)	TSS (mg/l)	P04 (mg/l)	PHENOL (mg/l)	AS (ug/l)	CD (ug/l)	CR (ug/l)	CU (ug/l)	PB (ug/l)	HG (ug/l)	SE (ug/l)	AG (ug/l)	Zn (ug/l)	Kjeldahl (ug/l)
AR-8	4/2/2001	12.20	7.90	7.90	< 2.00	0.18	1.20	0.04	1.20	328.00														
AR-8	4/12/2001	19.60	8.00	9.10	3.20	0.18	0.97	0.04	1.01	275.00														
AR-8	4/18/2001	14.60	8.20	9.60	2.90	0.15	1.20	0.03	1.20	270.00														
AR-8	4/24/2001	18.10	7.80	9.30	4.80	0.23	1.00	0.07	1.10	112.00					42	< 4.00	10.00	12	4.3	0.20	2.00	3.00	29	
AR-8	5/10/2001	22.10	8.00	8.40	2.10	< 0.05	0.63	0.06	0.69		54													
AR-8	5/16/2001	23.00	7.90	7.80	2.40	0.08	0.54	0.03	0.57	372.00	200				< 40.00	< 4.00	10.00	10.00	2.00		2.00	3.00	10.00	
AR-8	5/22/2001	20.60	8.20	7.40	3.80	0.10	0.48	0.04	0.51	286.00	613													
AR-8	6/6/2001	24.40	8.00	7.40	< 2.00	< 0.05	0.75	0.03	0.78	217.00	829													
AR-8	6/11/2001	26.70	8.00	8.40	3.80	< 0.05	0.79	< 0.02	0.79	197.00	113				< 40.00	< 4.00	10.00	10.00	5.20	0.20	2.00	3.00	10.80	
AR-8	6/19/2001	27.10	7.50	8.60	2.40	0.08	0.74	< 0.02	0.74	194.00	320													
AR-8	6/25/2001	27.50	7.70	8.40	< 2.00	0.34	0.66	< 0.02	0.66	231.00	91													
AR-8	7/2/2001	28.60	7.70	7.40	2.90	0.14	0.49	0.04	0.54	160.00	1,360				< 40.00	4.10	10.00	18.00	2.00	0.03	2.00	3.00	48.50	
AR-8	7/10/2001	29.20	8.00	7.40	2.30	0.16	0.54	< 0.02	0.54	244.00	550													
AR-8	7/18/2001	30.20	8.90	11.00	35.00	0.10	< 0.02	< 0.02	< 0.02	224.00	> 4,000													
AR-8	7/26/2001	29.90	8.60	9.70	6.40	< 0.05	0.07	< 0.02	0.08	294.00	330													
AR-8	8/1/2001	28.60	8.30	7.80	4.90	< 0.05	0.15	< 0.02	0.17	252.00	220				< 40.00	< 4.00	10.00	10.00	2.00		2.00	3.00	42.4	
AR-8	8/9/2001	27.10	8.20	8.10	4.20	0.12	0.28	< 0.02	0.26	242.00	125													
AR-8	8/14/2001	26.60	8.50	8.40	4.30	0.06	0.12	< 0.02	0.13	249.00	96													
AR-8	8/23/2001	25.10	8.50	8.90	5.20	0.06	0.09	0.02	0.11	249.00	50													
AR-8	9/5/2001	28.20	8.70	10.00						244.00	131													
AR-8	10/01/2001	22.20	8.30	9.30							72													
AR-8	10/22/2001	20.10	8.20							223.00	500													
AR-8	11/05/2001	20.10	7.80	7.90							1,820													
AR8	11/26/2001	14.00	8.00	10.00							310													
AR-8	12/18/2001	11.30	7.50	10.00							> 2,000													
AR8	1/7/2002	1.70	8.00	NR							106													
AR8	1/28/2002	14.00	8.00	10.00							69													
AR-8	2/4/2002	6.80	8.00	12.00							1,610													
AR8	2/18/2002	12.60	7.70	7.00							69													
AR8	3/8/2002	15.80	7.40	10.50							76													
AR8	3/28/2002	15.40	7.80	9.40							124													
AR8	4/15/2002	21.90	7.90	8.10							183													
AR8	4/29/2002	19.50	7.30	7.00							280													
AR8	5/13/2002	17.40	7.25	7.27							> 2,000													
AR8	5/28/2002	19.40	7.22	7.57							> 20,000													
AR8	6/4/2002	28.00	8.40	9.00							1,360													
AR8	6/18/2002	24.20	8.30	8.00							< 1													
AR8	7/3/2002	27.20	8.27	6.84							1,000													
AR8	7/17/2002	25.80	8.20	7.40							333													
AR8	8/1/2002	31.10	8.80	11.40							560													
AR8	8/15/2002	27.00	8.30	7.30							2,800													
AR8	9/5/2002	30.80	8.60	10.90							180													
AR8	9/19/2002	24.00	7.40	NR							2,170													
AR8	10/3/2002	25.10	7.98	7.13							200													
AR8	10/17/2002	15.70	7.83	9.40							290													
AR8	11/4/2002	12.50	7.40	9.60							1,370													
AR8	11/18/2002	13.70	8.01	9.85							547													
AR8	12/2/2002	12.30	7.34	10.39							110													
AR8	12/16/2002	12.20	7.24	9.34							176													
AR8	1/6/2003	8.00	7.80	10.12							58													
AR8	1/22/2003	3.00	8.59	11.71							400													
AR8	2/5/2003	6.00	8.40	11.20							124		0.13											
AR8	2/19/2003	9.10	7.80	9.20							NR		0.13											
AR8	3/5/2003	5.00	8.68	11.43							167													
AR8	3/19/2003	13.50	7.81	7.04							10,000													
AR8	4/2/2003	17.00	8.10	7.60							246		0.48											
AR8	4/16/2004	16.40	8.30	8.20							470		0.19											

City of Tulsa 1992-2004 Data

SITE	DATE	TEMP (°C)	pH (std.)	DO (mg/l)	BOD (mg/l)	NH4 (mg/l	N03 (mg/l)	NO2 (mg/l)	NO2+NO3 (mg/l)	HARDNESS (mg/l)	COLIF F (N/100ml)	TSS (mg/l)	P04 (mg/l)	PHENOL (mg/l)	AS (ug/l)	CD (ug/l)	CR (ug/l)	CU (ug/l)	PB (ug/l)	HG (ug/l)	SE (ug/l)	AG (ug/l)	Zn (ug/l)	Kjeldahl (ug/l)
AR8	5/5/2003	22.00	8.10	6.70							350		0.18											
AR8	5/19/2003	25.00	7.70	6.27							7,270		0.08											
AR8	6/2/2003	23.00	7.70	5.90							28,000		0.62											
AR8	6/16/2003	27.00	8.00	5.80							127		0.20											
AR8	7/2/2003	29.00	8.20	9.00							220		0.18											
AR8	7/17/2003	29.00	8.60	7.60							400		0.16											
AR8	8/4/2003	27.00	8.0	6.4							2,000		0.20											
AR8	8/20/2003	31.00	8.5	8.3							1,330		0.15											
AR8	9/4/2003	26.00	7.7	7.3							1,360		0.18											
AR8	9/22/2003	25.00	7.8	8.5							3,000		0.15											
AR8	10/6/2003	19.00	7.6	7.5							1,140		0.16											
AR8	10/20/2003	21.00	7.6	7.9							143		0.19											
AR8	11/4/2003	22.00	8.1	7.9							780		0.49											
AR8	11/18/2003	15.00	7.5	8.2							3,400		0.16											
AR8	12/3/2003										1,420		0.14											
AR8	1/5/2004	5.70	7.7	9.6																				
AR8	1/20/2004	3.70	8.30	10.00																				
AR8	2/3/2004	4.90	8.10	9.60																				
AR8	2/17/2004	6.70	8.20	8.30																				
AR8	3/3/2004	11.00	7.80	8.20																				
AR8	3/17/2004	11.00	7.80	7.90																				
AR8	4/5/2004	16.00	7.90	7.30																				
AR8	4/19/2004	19.00	7.90	6.40																				
AR8	5/3/2004	18.00	8.00	7.40							440													
AR8	5/17/2004	22.00	8.10	6.40																				
AR8	6/7/2004	24.00	7.60	5.40							360													
AR8	6/24/2004	25.00	7.90	5.60							200													
AR8	7/1/2004	25.00	7.50	5.90							136													
AR8	7/19/2004	27.00	7.60	6.90																				
AR8	8/2/2004	27.00	7.90	6.60							183													
AR8	8/16/2004	25.00	7.90	7.50							270													
AR8	9/1/2004	25.00	8.10	7.30							117													
AR8	9/22/2004	23.00	8.20	8.10							109													
AR8	10/6/2004	10.00	8.20	20.00							230													
AR8	10/21/2004	22.00	8.10	8.00																				
AR8	11/4/2004	15.00	7.80	10.00																				
AR8	11/18/2004	17.00	8.00	9.80																				
AR8	12/6/2004	11.00	7.70	4.70																				
AR8	12/20/2004	9.10	7.70	12.00																				

City of Tulsa 1992-2004 Data

SITE	DATE	TEMP ("C)	pH (std.)	DO (mg/l)	BOD (mg/l)	NH4 (mg/l	N03 (mg/l)	NO2 (mg/l)	NO2+NO3 (mg/l)	HARDNESS (mg/l)	COLIF F (N/100ml)	TSS (mg/l)	P04 (mg/l)	PHENOL (mg/l)	AS (ug/l)	CD (ug/l)	CR (ug/l)	CU (ug/l)	PB (ug/l)	HG (ug/l)	SE (ug/l)	AG (ug/l)	Zn (ug/l)	Kjeldahl (ug/l)
	Avg.1992																							
	Avg.1993																							
	Avg.1994																							
	Avg.1995																							
	Avg.1996																							
	Avg.1997																							
	Avg.1998																							
	Avg.1999																							
	Avg.1999																							
	Avg. 2000	18.69	8.04	9.06	4.12	0.09	0.63	0.03	0.64	248.25	1,007				52.50	4.00	10.00	17.78	1.78	0.20	2.00	0.68	24.22	
	Avg. 2001	17.98	8.11	8.99	4.05	0.22	0.71	0.03	0.73	256.19	656				41.83	4.01	10.00	11.63	2.37	0.16	2.00	2.71	20.10	
	Avg. 2002	18.92	7.86	8.88							1483.92													
	Avg. 2003	19.05	8.13	8.41							2836.59		0.22											
	Avg. 2004	16.80	7.93	8.23							227.22													

City of Tulsa 2005-10 Data

DATE	TEMP	pH	DO		BOD		NH4		NO2+NO3	HRDNSS		COLIF F		PO4		CD		CU		PB		HG		ZN		Kjaldahl
AR-1B	(oC)	(std.)	(mg/l)		(mg/l)		(mg/l)		(mg/l)	(mg/l)		(#/100ml)		(mg/l)		(ug/l)		(ug/l)		(ug/l)		(ug/l)		(ug/l)		(ug/l)
05-Jan-05	7	8.1	13		2		0.092		0.88	290		740		0.15		1		5		2				17		0.78
03-Feb-05	5	8	7.8		2		0.16		1.03	300		8		0.15		1		5		4.19				14		0.2
07-Mar-05	11	8.2	15	<	3		0.053		0.87	320		156		0.16		1.0	<	5	<	2				19		0.76
04-Apr-05	15	8.2	9.6	<	3		0.040		0.71	310		50		0.093		1.3	<	5	<	2				14		0.55
02-May-05	14	8.3	9.2	<	3		0.21		0.38	340		3000		0.091		1.8	<	5	<	2				20		0.92
01-Jun-05	22	8.1	7.1	<	3		0.057		0.27	290		600		0.13		1.8		6.4	<	2				21		0.72
06-Jul-05	26	7.6	4.7	<	3		0.097		0.44	220	<	1		0.19		1		7.4	<	2				12		0.38
04-Aug-05	nr	nr	nr	<	3		0.077		0.32	230				0.2		1.6		5.7	<	2			<	10		0.68
01-Sep-05	26	7.6	6.8									561														
03-Oct-05	24	7.9	6.7									156														
03-Nov-05	15	8	9.1	<	3	<	0.05		0.7	230		112		0.15		1.2	<	5	<	2				15		0.76
07-Dec-05	4	8.1	nr	<	3	<	0.05		0.63	300		183		0.13		1.6	<	5		0.44				30		110
16-Dec-05	4	8.3	13																							
04-Jan-06	10	8.2	11		8.8		0.064		0.76	360		64		0.12		1.5	<	5	<	2				14		73
06-Feb-06	6	8.2	13	<	3		0.076		0.66	340		44		0.067		1.6	<	5	<	1				19		1.42
27-Mar-06	13	8.2	9.6	<	3		0.099		0.71	330		5		0.19		5.1		5.5		6.77				19		0.64
10-Apr-06	15	8.4	10	<	3	<	0.05		0.11	340		150		0.065		1.2		1.2	<	1				12		0.71
08-May-06	19	8	7.1	<	3		0.089		0.27	280		780		0.11		2.5		6		1.76				20		1.02
07-Jun-06	24	7.9	7.1	<	3	<	0.05		0.47	240		860		0.13		2.6		13		19.6				59		1.15
06-Jul-06	24	7.9	7.1	<	3		0.08		0.15	220		1950		0.2		1.3		6.6	<	1			<	10		1.18
07-Aug-06	27	7.8	4.8	<	3		0.066		0.2	240		36000		0.16		1.4		7.4	<	1				12		1.18
07-Sep-06	23	7.7	6.6									180														

City of Tulsa 2005-10 Data

DATE	TEMP	pH	DO	BOD	NH4	NO2+NO3	HRDNSS	COLIF F	PO4	CD	CU	PB	HG	ZN	Kjaldahl
AR-3	(oC)	(std.)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(#/100ml)	(mg/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)
05-Jan-05	5.0	8	14												
19-Jan-05	5.0	8	13												
03-Feb-05	5.7	8	7.4												
17-Feb-05	7.9	7.8	8.1												
07-Mar-05	11.0	8.1	15												
22-Mar-05	13.0	8.2	18												
04-Apr-05	15.0	8	9.7												
18-Apr-05	24.0	8.3	13												
02-May-05	13.0	8.3	16					60							
16-May-05	21.0	8.3	15					57							
01-Jun-05	23.0	8	9												
15-Jun-05	24.0	7.8	5.8					3980							
20-Jun-05	26.0	7.7	6.3					840							
06-Jul-05	25.0	7.7	6.1					3900							
20-Jul-05	26.0	7.7	6.3					840							
03-Aug-05	27.0	7.3	6.7					450							
17-Aug-05	26.1	7.5	6.1					4100							
1-Sep-05	28.6	7.7	6.2					697							
19-Sep-05	25.0	7.5	6.3					1720							
17-Oct-05	19.0	7.9	7.7												
03-Nov-05	15.0	7.9	12												
17-Nov-05	9.0	7.5	11												
07-Dec-05	3.8	7.6													
16-Dec-05	11.0	8.3	15												
21-Dec-05	4.9	8.1	13					570							
	414.0	197.2	246.7					13117							
04-Jan-06	11.0	8.3	17					22							
19-Jan-06	9.1	7.1	9.4					130							
06-Feb-06	2.8	8.3	15					23							
24-Feb-06	7.9	8	7.9					165							
13-Mar-06	9.0	7	15					387							
27-Mar-06	13.0	8.1	12					144							
10-Apr-06	14.0	8.1	13					818							
24-Apr-06	22.0	8	7.2					7500							
08-May-06	18.0	7.9	7.7					2700							
22-May-06	23.0	7.8	8.5					467							
07-Jun-06	31.0	8.2	9					300							
21-Jun-06	24.0	7.9	7.5					1700							
06-Jul-06	25.0	7.8	8.3					1150							
21-Jul-06	28.0	7.9	6.4					800							
07-Aug-06	27.0	8	7					901							
21-Aug-06	26.0	7.7	4.9					2100							
07-Sep-06	22.0	7.9	7.6					400							

City of Tulsa 2005-10 Data

DATE	TEMP	pH	DO	BOD	NH4	NO2+NO3	HRDNSS		COLIF F	PO4	CD	CU	PB	HG	ZN	Kjaldahl
AR-4	(oC)	(std.)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)		(#/100ml)	(mg/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)	(ug/l)
05-Jan-05	5.2	8.2	14													
19-Jan-05	5.7	8	12													
03-Feb-05	5.1	8.1	9.4													
17-Feb-05	8.1	7.8	8.2													
07-Mar-05	11.0	8.2	16													
22-Mar-05	15.0	8.2	15													
04-Apr-05	15.0	8.3	11													
18-Apr-05	21.0	8.1	10													
02-May-05	15.0	7.4	12						9							
16-May-05	21.0	7.6	10					<	20000							
01-Jun-05	23.0	8.1	8.1						675							
15-Jun-05	24.0	7.8	6						2400							
20-Jun-05	27.0	7.7	6.5						186							
06-Jul-05	26.0	7.7	6						2000							
20-Jul-05	27.0	7.7	6.5						186							
03-Aug-05	27.0	7.7	6.4						240							
17-Aug-05	26.5	7.8	6.1						3500							
1-Sep-05	29.1	7.8	6.5						872							
19-Sep-05	25.0	7.9	6.4						1000							
17-Oct-05	19.0	7.9	8.1													
03-Nov-05	15.0	8.2	10													
17-Nov-05	10.0	8.1	11													
07-Dec-05	1.6	8.4	nr													
16-Dec-05	7.0	8.5	15													
21-Dec-05	4.4	8.1	13						124							
	413.7	199.3	233.2						28108							
04-Jan-06	10.0	8.2	14						25							
19-Jan-06	8.8	8.4	11						240							
06-Feb-06	7.3	7.6	14						720							
24-Feb-06	7.8	8.3	12						28							
13-Mar-06	10.0	7	11						280							
27-Mar-06	12.0	7.9	12						6500							
10-Apr-06	15.0	8.5	11						410							
24-Apr-06	19.0	8	8.1						267							
08-May-06	18.0	8	7.7						620							
23-May-06	23.0	7.9	6.9						360							
07-Jun-06	27.0	8.1	84						1700							
21-Jun-06	24.0	8	7.6						2220							
06-Jul-06	25.0	8	7.8						960							
21-Jul-06	28.0	8	6.2						420							
07-Aug-06	27.0	8	7.3						545							
21-Aug-06	27.0	8	5.6						1910							
07-Sep-06	23.0	8	7.7						200							

City of Tulsa 2005-10 Data

DATE	TEMP	pH	DO		BOD		NH4		NO2+NO3		HRDNSS		COLIF F		PHOS		CD		CU		PB		HG		ZN		Kjaldahl
AR-6	(oC)	(std.)	(mg/l)		(mg/l)		(mg/l)		(mg/l)		(mg/l)		(#/100ml)		(mg/l)		(ug/l)		(ug/l)		(ug/l)		(ug/l)		(ug/l)		(ug/l)
05-Jan-05	5.4	8.1	15		2		0.15		0.77		230		2330		0.33		1		5.6		2.04				13		1.02
19-Jan-05	5.7	8	13																								
03-Feb-05	5.2	8.1	9.1		2		0.3		1.02		270		96		0.33		1.1		5.9						27		2.62
17-Feb-05	7.8	7.9	8.2																								
22-Mar-05	14.0	8.4	13																								
04-Apr-05	16.0	8.3	11	<	3		0.052		0.61		300		56		0.10		1.1		BDL(5.0)	<	2				19		0.81
18-Apr-05	21.0	8.7	11																								
02-May-05	15.0	7.7	7.9		3.2		0.13		0.57		390		42		0.16		1.6		BDL(5.0)	<	2				12		0.84
16-May-05	21.0	7.7	7										982														
01-Jun-05	23.0	8.2	7.8		3.8	<	0.03		0.16		300		1200		0.26		1.7		7.5		2.84				22		1.40
15-Jun-05	24.0	7.8	6.1										980														
20-Jun-05	27.0	7.9	6.4										2900														
06-Jul-05	26.0	7.8	6.3	<	3	<	0.03		0.44		220		900		0.25		1		8.6	<	2				12		0.46
20-Jul-05	27.0	7.9	6.4										2900														
03-Aug-05	29.0	8	6.3	<	3	<	0.03		0.21		230				0.21		1.6	<	5	<	2			<	10		0.84
17-Aug-05	26.6	7.8	6.3										3000														
1-Sep-05	28.5	7.8	6.7										628														
19-Sep-05	28.0	8.1	7.2										1300														
03-Oct-05	25.0	7.3	7									<	1														
17-Oct-05	20.0	7.8	8																								
03-Nov-05	16.0	8.2	10	<	3	<	0.05		0.63		220		210		0.15		1.2		33	<	2				10	<	0.2
17-Nov-05	9.0	8	12																								
07-Dec-05	1.6	8.4	nr	<	3		0.19		0.65		270		226		0.23		1.1	<	5		1.24			<	10		1.42
16-Dec-05	6.1	8.5	16																								
21-Dec-05	3.8	8.2	13										3300														
	17.3	**8.024**	**9.195833**		**2.714286**		**0.111429**		**0.62**		**240**		**1482.583**		**0.25**		**1.166667**		**10.08**		**1.9**				**13.66667**		**1.093333**
04-Jan-06	11.0	8.2	12		8		0.38		0.69		380		189		0.22		1.5	<	5	<	2				11		1.36
19-Jan-06	8.1	8.4	11										112														
06-Feb-06	5.9	8.2	12	<	3		0.58		0.74		350		224		0.36		1.9		5		1.93				14		1.75
24-Feb-06	8.2	8.3	11										112														
13-Mar-06	12.0	7.2	9.6										176														
27-Mar-06	13.0	8	9		0.38		1.2		0.50		310		112		0.61		2.8		9.5		3.98				24	<	0.1
10-Apr-06	15.0	8.4	10	<	3		0.51		0.21		360		64		0.93	<	1		15		7.69				43		2.8
24-Apr-06	21.0	7.9	7.1										764														
08-May-06	20.0	8	8.1	<	3		0.16		0.30		290		1600		0.46		2.6		6.7		4.71				18		1.51
23-May-06	23.0	7.9	6.5										580														
07-Jun-06	25.0	8	7.8		3	<	0.05		0.39		250		180		0.21		1.2		7.2		1.16				10		0.87
21-Jun-06	25.0	8.1	6.9										4100														
06-Jul-06	26.0	8.1	7.9	<	3	<	0.05		0.10		220		348		0.16		1.4		12		3.82				16		1.37
21-Jul-06	30.0	8.1	6.3										455														
07-Aug-06	29.0	8	7		3.3		0.066		0.12		240		455		0.2		1.5		13	<	1				13		1.26
21-Aug-06	28.0	7.9	5.8										11000														
07-Sep-06	23.0	8.1	7.8									<	1														

City of Tulsa 2005-10 Data

DATE	TEMP	pH	DO		BOD		NH4		NO2+NO3		HRDNSS		COLIF F		PO4		CD		CU		PB		HG		ZN		Kjaldahl
AR-8	(°C)	(std.)	(mg/l)		(mg/l)		(mg/l)		(mg/l)		(mg/l)		(#/100ml)		(mg/l)		(ug/l)		(ug/l)		(ug/l)		(ug/l)		(ug/l)		(ug/l)
05-Jan-05	5.5	7.8	15																								
19-Jan-05	5.8	8	13																								
03-Feb-05	5.4	8	8.9																								
17-Feb-05	7.7	7.9	8.1																								
07-Mar-05	12	8	15																								
22-Mar-05	13	8.3	13																								
04-Apr-05	16	8.2	10																								
18-Apr-05	21	8.6	9.7																								
02-May-05	15	8.4	11										26														
16-May-05	21	7.5	6.8										1430														
01-Jun-05	23	8.2	7.3										1620														
15-Jun-05	25	7.9	6.2										1710														
20-Jun-05	28	8.1	7.4										2950														
06-Jul-05	26	7.8	6.3										553														
20-Jul-05	28	8.1	7.4										2950														
03-Aug-05	29	8.2	7.8										440														
17-Aug-05	26.8	7.9	6.6										580														
1-Sep-05	28.7	7.7	6.4										864														
19-Sep-05	29	8	7.9										983														
17-Oct-05	20	7.6	7.6																								
03-Nov-05	16	8.2	9.9																								
17-Nov-05	9.7	8.3	12																								
07-Dec-05	0.3	8.3	nr																								
16-Dec-05	8.5	7.6	14																								
21-Dec-05	3.3	7.6	12										263														
	16.948	**8.008**	**9.554167**										**1197.88**														
04-Jan-06	13	8.2	11										3300														
19-Jan-06	8.4	8.5	11										400														
06-Feb-06	6.3	7.8	11										86														
13-Mar-06	13	6.9	9.6										290														
27-Mar-06	14	7.7	9.2										240														
10-Apr-06	17	7.6	9.4										380														
24-Apr-06	7.1	7.9	7.1										519														
08-May-06	20	8	8.1										740														
23-May-06	25	8	7.2										960														
07-Jun-06	24	7.4	5.7									>	10000														
21-Jun-06	26	7.6	7.1										5700														
06-Jul-06	26	8	8.3										870														
21-Jul-06	31	8.3	8.4										460														
07-Aug-06	30	8	6.4										818														
21-Aug-06	27	7.6	5.4										22000														
07-Sep-06	23	7.6	8.4										131														

LAT/LONG	FACILITY NAME & ODEQ PERMIT NUMBER	Dis-charge Pipe Design-ation	AV Flow in Conduit or thru Treatment Plant, (GPD)	AV pH	General Fecal Coliform (#/100 mL)	AV BOD, 5-Day (20 deg. C), (mg/L)	AV COD, (High Level), (mg/L)	AV TSS, (mg/L)	AV Total Solids Dis-solved, (mg/L)	AV Oil and Grease, (mg/L)	AV TOC, (mg/L)	AV Total Ammonia as Nitrogen, (mg/L)	AV Total Phenolics, Recoverabl e, (mg/L)	AV Total Sulfate, (mg/L)	AV Total Sulfide as S, (mg/L)	AV Total Hexa-valent Chromium, (mg/L)	AV Total Chromi um, (mg/L)	AV Total Chloride as Chlorine (mg/L)	AV Total Chlorine Residual, (mg/L)	AV Free Avail-able Chlor-ine, (mg/L)	AV Total Fluo-ide as Fluor-ine, (mg/L)	AV Total Oxid-ants Residual (mg/L)	AV Free Oxid-ants Avail-able (mg/L)	AV Total Anti-mony as SB, (mg/L)	AV Total Tin as SN, (mg/L)	AV Total Lead as PB, (mg/L)	AV Total Mer-cury as HG, (mg/L)
35.9716679 5.919444	KIMBERLY-CLARK CORP-JENKS MILL, OK0040827	001	1,937,143	6.636		3.008		3.946																			
35.9691679 5.917778	KIMBERLY-CLARK CORP-JENKS MILL, OK0040827	002	103,500	7.836			12.433 av dly max	3.957 av dly max		5.167 av dly max																	
35.9669449 5.928056	KIMBERLY-CLARK CORP-JENKS MILL, OK0040827	003	54,357	7.65			24.698 av dly max	9.421 av dly max		5.167 av dly max																	
36.1296679 6.098972	BAKER PETROLITE, SAND SPRINGS, OK0000388	001	3,735,556	8.434				8.857		5.144	0.5																
36.1374449 6.05325	OZARK FLUORINE SPECIALTIES,INC, OK0000655	001	3987.594	7.267				< 5.7													1.196			0.0185	< .036		
36.1337596. 054167	CHEMTRADE REFINERY SERV. INC., OK0036439	001	70,600	7.451		3.428		9.664	665					245.613				187.25									
36.1438899 6.013333	SUNOCO, INC.-TULSA REFINERY, OK0000876	001	1,985,214	7.081		6.321	55.071	17.214		5		0.882	0.031		0.021	0.016	0.014										
36.1197229 5.995000	SINCLAIR TULSA REFINING CO., OK0001309	01A	1,253,857	7.386		6.157	51	11.414		4.457		2.006	0.05		0.055	0.011	0.01										
36.1200000 95.994722	SINCLAIR TULSA REFINING CO., OK0001309	01B	10,772,250	8.738				6.188		4.162	5.25																
36.1336649 6.029403	MAGELLAN PIPELINE CO, LLC, OK0043206	1	2936	7.75																							
35.9591679 5.887278	HOLLIDAY SAND & GRAVEL-BIXBY#1, OK0035319	001	2,166,667	7.978				25.222 av dly max																			
35.9576949 5.881528	HOLLIDAY SAND & GRAVEL-BIXBY#1, OK0035319	002	2,166,667	7.773				31.444 av dly max																			
36.1222229 6.118889	SAND SPRINGS SAND & GRAVEL CO., OK0040096	001	260,077.50	8.198				13.825 av dly max																			
36.1222229 6.120833	SAND SPRINGS SAND & GRAVEL CO., OK0040096	002	121,682	8.263				10.717 av dly max																			
35.995833	ANCHOR STONE CO.-DELAWARE SAND, OK0042404	001A	no discharge																								
35.9236119 5.759722	COMPANY, OK0043893	001	927,192	7.53				36.769																			
36.0480569 5.9775	ANCHOR STONE - 81ST SAND PLANT, OK0044415	001	no discharge																								
36.0423069 5.972611	ANCHOR STONE CO. - JENKS SAND, OK0044547	001	no discharge																								
36.2305569 5.843889	ANCHOR STONE CO.-36th STREET, OKG950035	001	no discharge																								
35.9583339 5.895556	CONCRETE CO - BIXBY	001A																									

LAT/LONG	FACILITY NAME & ODEQ PERMIT NUMBER	Dis-charge Pipe Design-ation	AV Flow in Conduit or thru Treatment Plant, (GPD)	AV pH	General Fecal Coliform (#/100 mL)	AV BOD, 5-Day (20 deg. C), (mg/L)	AV COD, (High Level), (mg/L)	AV TSS, (mg/L)	AV Total Solids Dis-solved, (mg/L)	AV Oil and Grease, (mg/L)	AV TOC, (mg/L)	AV Total Ammonia as Nitrogen, (mg/L)	AV Total Phenolics, Recoverable, (mg/L)	AV Total Sulfate, (mg/L)	AV Total Sulfide as S, (mg/L)	AV Total Hexa-valent Chromium, (mg/L)	AV Total Chromium, (mg/L)	AV Total Chloride as Chlorine (mg/L)	AV Total Chlorine Residual, (mg/L)	AV Free Avail-able Chlor-ine, (mg/L)	AV Total Fluo-ide as Fluor-ine, (mg/L)	AV Total Oxid-ants Residual (mg/L)	AV Free Oxid-ants Avail-able (mg/L)	AV Total Anti-mony as SB, (mg/L)	AV Total Tin as SN, (mg/L)	AV Total Lead as PB, (mg/L)	AV Total Mer-cury as HG, (mg/L)
36.1336399 5.996306	MID-CONTINENT CONCRETE CO - TULSA, OKG110054	001	no discharge																								
35.9830569 5.931944	GREEN COUNTRY ENG-COGENTRIX EN, OK0043869	001	201,000	6.984															<0.099	<0.099						<0.005	
35.9830569 5.931944	GREEN COUNTRY ENG-COGENTRIX EN, OK0043869	01A	52,571					4.625		<5																	
35.9984449 5.956306	CO - RIVERSIDE, CTRL PSO JENKS, OK0002429	2	0.331	7.476				21.369		< 5.00																	
35.9963899 5.955833	CO - RIVERSIDE, CTRL PSO JENKS, OK0002429	1	1.061	7.762															<0.09 av dly max	<0.09 av dly max							
36.1168339 5.990222	CO - TULSA POWER PSO, OK0000108	1	361,428	7.889																		<0.05 dly max	<0.05				
36.1177789 5.991389	CO - TULSA POWER PSO, OK0000108	01A	36,428					10.916		<5.00																	
35.9482789 5.869528	BIXBY PUBLIC WORKS AUTH-SOUTH, OK0026913	001	349,607	7.989	351.318	18.432		15.161																			
35.9876679 5.937972	WORKS AUTHORITY, OK0037401	001	1,190,000	7.05		4.714		7.586																			
36.1312229 6.089917	SAND SPRINGS MUNICIPAL AUTH WASTE WATER TRT, OK0030864	001	1,878,643	7.478	8.1	21.357		11.643											0.0578 av dly max								
35.9619449 5.781722	BROKEN ARROW SEWAGE TRT, OK0040053	1	3,602,000	7.25		13.1		9.3	491																		1E-04
36.0876949 5.991722	TMUA SOUTH, OK0026239	1	21,309,333	6.98	8.1	12.36	10.61125		0.062 av dly max																		
36.0876119 5.991444	TMUA SOUTH, OK0026239	2	no measurements																								
35.9416949 5.853917	RMUA-HAIKEY CREEK, OK0034363	1	9,955,333	7.207	10.4	12.44	6.803125		0.025 av dly max																		