KANSAS INTEGRATED WATER QUALITY ASSESSMENT 2008

April 1, 2008

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EXECUTIVE SUMMARY

This report, the Kansas Integrated Water Quality Assessment (2008), was prepared by the Kansas Department of Health and Environment (KDHE) in response to water quality reporting requirements contained in sections 303(d), 305(b), and 314(a) of the federal Clean Water Act (CWA). Section 303(d) calls for the development of a list of water bodies currently failing to meet established water quality standards, whereas sections 305(b) and 314(a) require information on the overall status of the state's surface waters and the programs responsible for water quality monitoring and pollution abatement.

The Kansas 2008 list of impaired waters (i.e., 303(d) list) was included as an appendix to this report and posted, in its entirety, at http://www.kdheks.gov/tmdl/methodology.htm. This list was based primarily on data collected by the KDHE stream chemistry, stream biological, and lake and wetland monitoring programs and secondarily on information obtained from outside sources. Watersheds containing stream chemistry and/or stream biological monitoring stations represented the assessment units for flowing waters, and monitored lakes and wetlands represented the assessment units for standing water bodies. In all, 492 water quality impairments were identified by KDHE and assigned a high priority for Total Maximum Daily Load (TMDL) development. The 303(d) list also identified all water bodies previously regarded by KDHE as impaired by pollutants but subsequently assigned to other listing categories.

Requirements related to section 305(b) were addressed, in part, using data obtained through a newly implemented stream monitoring program. This program employed a probabilistic survey design to estimate stream mileage failing to support the uses recognized in section 101(a) of the CWA (aquatic life support, food procurement, and recreation). The program's targeted sampling population included all classified streams that contained water during the summer low-flow periods of 2006–2007. Owing largely to the occurrence of a severe drought that extended into 2006, only about 67% of the state's classified stream mileage was represented in the sampling population.

Monitoring data obtained during this reporting cycle indicated that 37% (± 8%) of the state's designated stream mileage fully supported all section 101(a) uses, whereas 63% (± 8%) was impaired for one or more uses (parenthetical values represent 95% confidence intervals). Aquatic life support, contact recreation, and food procurement uses were supported, respectively, in 43% (± 8%), 89% (± 5%), and 80% (± 17%) of the stream miles designated for these uses. Major causes of non-support for streams, in order of prevalence, were nutrient enrichment, weather-related impacts, sedimentation, elevated levels of fecal bacteria, and hydrological modifications. Sources primarily responsible for pollutant loadings and/or use impairment included agriculture (irrigated and non-irrigated crop production, livestock grazing and feeding operations, unrestricted cattle access), natural phenomena (e.g., weather related impacts), and physical habitat degradation.

Additional section 305(b) and 314(a) reporting requirements were addressed using data from the department's lake and wetland monitoring program. This program assessed 322 publicly owned lakes and wetlands during the six-year reporting period, 2002–2007. Physicochemical data obtained from the surveys were compared to established water quality standards to characterize the prevailing

level of use support. Long-term trends in the trophic status of lakes and wetlands were assessed using biological data collected from 1985 through 2007. These data were compared to an existing set of diagnostic thresholds used to interpret narrative water quality criteria for trophic state, nutrient enrichment, and water-column turbidity.

Approximately 17% of the assessed lake acreage fully supported all designated uses, whereas 81% was impaired for one or more designated uses. Sixteen percent of assessed wetland acreage either fully supported all uses or lacked sufficient data to evaluate conditions; the remaining 84% was impaired for one or more designated uses. Major causes of non-support for lakes and wetlands included nutrient enrichment, siltation, elevated turbidity levels, taste and odor problems, and zebra mussel (*Dreissena polymorpha*) infestations. Agriculture, municipal point sources, and natural (e.g., weather-related) phenomena were the primary factors contributing to water quality impairments in lakes and wetlands. Approximately 67% of the assessed lake acreage exhibited little or no recent change in trophic condition, 26% experienced a measurable increase in trophic state, and 4% exhibited some improvement in trophic condition.

Sampling activities during 2006 coincided with one of the worst droughts on record for Kansas. From 2000 to 2006, annual average flows in many streams were lower than the flows reported during all previously recorded droughts. In 2007, major floods in southeastern Kansas scoured many rivers and creeks and produced sustained high stream flows for much of the summer. The combined effects of these dramatic weather-related events contributed to many of the water quality impairments documented during 2006 and 2007.

The renovation of numerous wastewater treatment facilities across the state has produced noticeable improvements in surface water quality. As point source contributions to water quality impairments continue to decline, attention will shift increasingly to nonpoint sources. It is anticipated that watershed pollution control efforts, predicated largely on the development and implementation of total maximum daily loads (TMDLs), will play an increasingly important role in the abatement of nonpoint source pollution in Kansas.

PART A: INTRODUCTION

Purpose

This document fulfills various water quality reporting requirements placed on the State of Kansas by sections 303(d), 305(b), and 314(a) of the federal CWA. Sections 305(b) and 314(a) require a summary of the status of the state's surface waters, whereas section 303(d) calls for the development of a list of water bodies currently failing to meet established water quality standards. Such water bodies are regarded collectively as "impaired waters." Kansas is required under the CWA to take actions that improve the condition of impaired waters. These actions may include the development and implementation TMDLs, water quality-based permit requirements, and/or nonpoint source (NPS) pollution control measures. This report represents Kansas' first integrated response to the requirements of sections 303(d), 305(b), and 314(a). As such, it contains information relevant to upcoming water quality planning, monitoring, permitting, and pollution abatement initiatives in the state.

General Assessment Approach

KDHE administers several programs that collectively satisfy the environmental surveillance and reporting requirements of the CWA (KDHE, 2005c). These programs also provide the technical data needed to respond to existing and emerging water pollution problems. Departmental monitoring operations currently focus on the condition of the state's surface waters (rather than groundwater) and involve two different but complementary conceptual approaches. The first involves a targeted survey design that focuses on selected stream reaches, lakes, and wetlands. The second approach involves a probabilistic survey design that assesses randomly chosen stream reaches and extrapolates the monitoring results to the entire population of streams in the state. Targeted monitoring operations accommodate the development and refinement of the Kansas 303(d) list, whereas both targeted and probabilistic data are needed to meet section 305(b) and 314(a) reporting requirements.

Within KDHE, work related to section 305(b) of the CWA is performed by the Bureau of Environmental Field Services (BEFS), whereas work related to section 303(d) is performed by the Bureau of Water (BOW). The 305(b) and 314(a) assessments are the primary mechanisms for assessing the overall condition of the state's streams, lakes, and wetlands and for reporting on the presence of bioaccumulative contaminants in fish. These assessments also describe the major monitoring networks and regulatory programs involved in the tracking, management, and abatement of surface water pollution. The 303(d) analysis differs from the 305(b) and 314(a) assessments in terms of statistical approach and monitoring period of interest. Moreover, under the provisions of the CWA, the 303(d) list is subject to public review/comment and ultimately must be approved by the U.S. Environmental Protection Agency (EPA).

Organization of Report

The remainder of this report is presented in several major parts. Part B contains background information on surface water resources within the state, describes the governmental programs

primarily responsible for improving water quality, considers the overall costs and benefits of water pollution control, and summarizes several important water quality issues facing Kansas. Part C describes the various water quality monitoring programs administered by KDHE, discusses the diagnostic criteria and statistical methods employed in the 303(d) and 305(b) analyses, and presents the major findings stemming from these analyses. Part D summarizes the current status of groundwater quality monitoring efforts in Kansas. Finally, Part E describes the measures taken by KDHE to comply with the public participation provisions of the CWA, as related to the development of the 303(d) list. Technical appendices to this report provide additional information on KDHE's water quality monitoring programs and the results of the most recent 303(d), 305(b), and 314(a) assessments. Specifically, Appendix A identifies the individual water chemistry parameters considered in the 2008 305(b) assessment, Appendix B presents the most recently completed 303(d) list for Kansas, and Appendix C addresses the overall condition of the state's lakes and reservoirs, as required by section 314(a) of the CWA.

PART B: BACKGROUND

Total Waters

Table 1. Kansas atlas

Topic	Value
State population*	2,764,075
State surface area in square miles*	81,815
Number of major river basins	12
Total classified stream miles**	27,816
Number of classified lakes/reservoirs/ponds	322
Acres of classified lakes/reservoirs/ponds	190,982
Acres of classified freshwater wetlands	55,969

* Estimate for 2006, U.S. Census Bureau
** Based on Kansas Surface Water Register, April 18, 2007
National Hydrography Dataset (NHD), 1:100,000-scale

Water Pollution Control Program

Point Source Pollution Control

The Kansas point source program was initiated in 1907 (K.S.A. 65-161 *et seq*.) and continues to be modified and expanded in response to ongoing amendments to the Federal Water Pollution Control Act. The federal regulations implementing this law are found in Title 40 of the Code of Federal Regulations. Federal water pollution control programs are designed to protect the navigable waters of the United States, whereas the Kansas water pollution control program is designed to protect all surface waters and groundwater by controlling discharges from municipal, federal, commercial, and industrial wastewater treatment facilities and large confined animal feeding operations.

In addition to controlling the wastewaters generated by these entities, the Kansas and federal programs have expanded recently into the area of stormwater pollution control. Kansas has started developing and issuing general permits for the control of stormwater runoff from construction and industrial sites, larger cities, and urbanized counties. Industrial facilities with individual permits are required to develop and implement stormwater pollution prevention plans as part of their individual permit requirements.

KDHE is authorized to administer federal and state laws governing the treatment, re-use, and discharge of wastewaters in Kansas. Specifically, the department is responsible for the development and periodic review of water pollution control permits, the approval of engineering plans and specifications for wastewater treatment facilities/collection systems, the development of stormwater best management practices or BMPs, the establishment of pretreatment requirements for facilities in non-pretreatment program cities, and the performance of treatment plant compliance reviews. The department also oversees the development and management of operator training and certification programs in Kansas. Non-overflowing wastewater treatment systems are regulated through the Kansas Water Pollution Control permitting system (K.S.A. 65-165). National Pollutant Discharge Elimination System (NPDES) permits are required for all discharging wastewater treatment facilities and larger livestock operations (Table 2). Discharges from these treatment facilities/operations are subject to technological effluent limitations, effluent guideline limits, and the Kansas surface water quality standards. Individual permits normally are issued for a period of five years. All are reviewed by KDHE prior to re-issuance. The state's wastewater treatment facility (WWTF) permit compliance record for the past two years is summarized in Table 3 below.

Table 2. Number of active KWPC and NPDES permits*

Number of Permitted Facilities					
Municipal and Commercial		**Industrial/Federal**		**Agricultural**	
Total Municipal and Commercial KWPC (non-overflowing)	424	Total Industrial/federal KWPC (non-overflowing)	82	Agricultural NPDES	461
Discharging Lagoons	359	Total Industrial (discharging)	527	Agricultural State	1,292
Mechanical Treatment Facilities	146	Pretreatment	59	Agricultural Certification	1,627
Municipal Stormwater	57				
TOTAL	986		668		3,380

KWPC = Kansas Water Pollution Control * as of January 1, 2008
NPDES = National Pollutant Discharge Elimination System

Table 3. Permit compliance record (absolute compliance* for discharging WWTFs)

Year	TYPE OF FACILITY	
	Municipal and Commercial	**Industrial and Federal**
2006	89%	97%
2007	92%	98%
Total Number	505	527

WWTF = wastewater treatment facility
*Absolute compliance means that a facility reported on all parameters specified by its NPDES permit and met all permit limits for the monitoring period.

Nonpoint Source Pollution Control

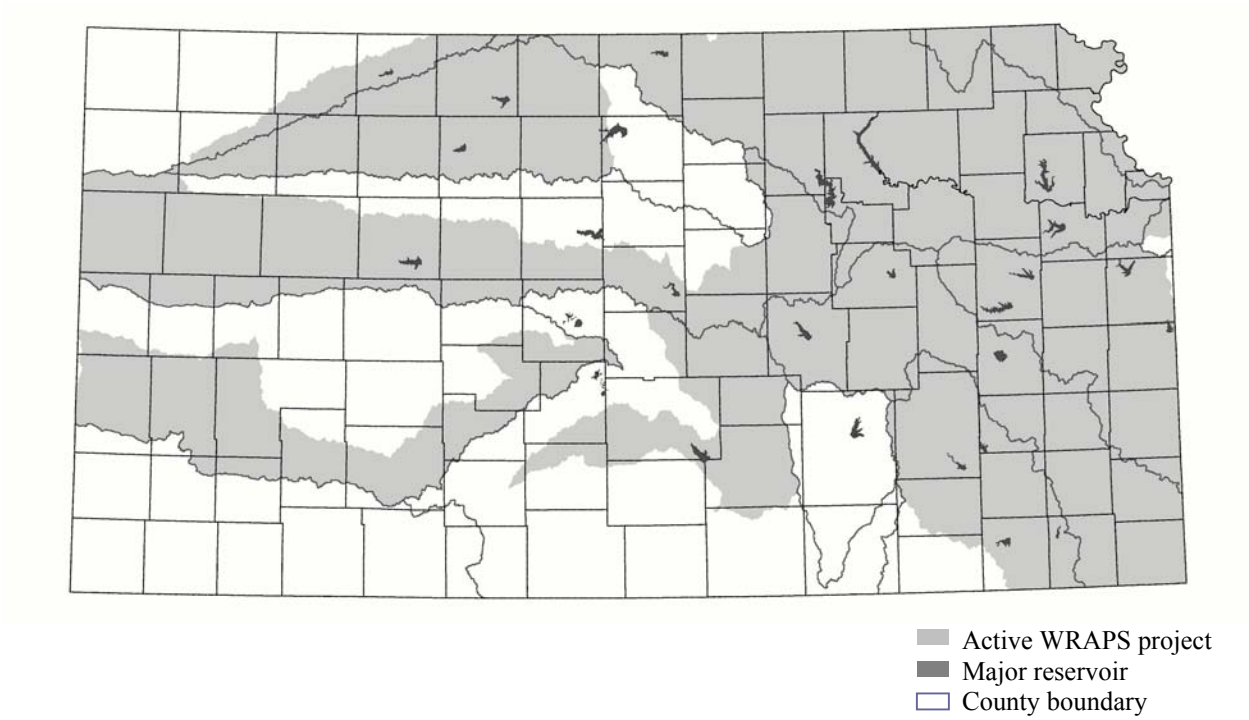
Watershed Restoration and Protection Strategy

Kansas has implemented a watershed-based program for controlling NPS pollution. Known as the Watershed Restoration and Protection Strategy (WRAPS), this program is unique because the natural resource agencies of Kansas, with support from EPA, aggressively seek citizen and stakeholder input and participation on watershed management and protection issues. This approach involves:

- Identifying watershed protection and restoration needs
- Establishing watershed protection and restoration goals
- Developing plans to achieve the established goals
- Implementing the plans

Currently, 59% of the state's watersheds are served by a WRAPS project. These include most of the watersheds draining into larger reservoirs (Figure 1). Annual investments in WRAPS total approximately $3.3 million (M). Of this amount, about $0.8 M is derived from State Water Plan funds, $1.2 M from EPA section 319 funds, and $1.3 M from local funding sources.

Figure 1. 2007 Kansas WRAPS Projects



Source Water Protection Program

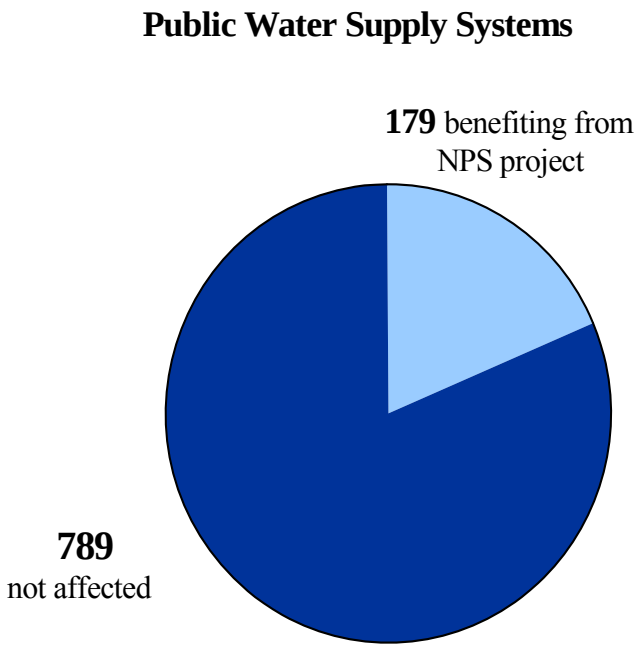
Source water protection plans for individual communities in Kansas are in various stages of implementation. Most activities are voluntary and require a long-term commitment from the participating communities and collaborating organizations. Major tracking phases for the protection plans include: development, assessment, planning, and implementation. Public water supply systems utilizing groundwater are becoming more active in the WRAPS process and in the adoption of wellhead protection plans. The following table summarizes the overall status of wellhead protection plans in Kansas.

Table 4. Wellhead protection plans and associated NPS watershed projects

Wellhead Protection Plans			Nonpoint Source Watershed Projects	
Number		Population Served	Number	Population Served
Registered	12	10,626	179	923,664
Approved	10	9,076		
Adopted	9	14,826		

Currently, four public water supply systems have approved wellhead protection plans and are participating in NPS watershed projects. Of the 968 public water supply systems in Kansas, 179 currently benefit from a NPS watershed project (Figure 2).

Figure 2. Proportion/Number of Water Supply Systems Benefiting from a NPS Watershed Project



Local Environmental Protection Program

The Local Environmental Protection Program (LEPP), administered by KDHE and funded by the Kansas Water Office (KWO) under the auspices of the State Water Plan, provides financial assistance to local governmental units developing and implementing local environmental protection plans. These plans include a sanitary code and address subdivision water and wastewater, solid waste, hazardous waste, public water supply protection, and NPS pollution abatement. Currently, 102 of the 105 counties in Kansas participate in this program (Table 5).

Table 5. Summary of local environmental code action through 2007

Status	Number
Adopted and Being Administered	102
Approved for Adoption	1
Being Developed	0
No Action	2

Cost and Benefits of Water Pollution Control

The direct and indirect costs of water pollution control can be measured, or at least estimated, with some degree of confidence. In contrast, environmental benefits stemming from pollution control are less amenable to expression in monetary terms. Section 101(a) of the CWA establishes national water quality objectives and interim goals reflecting the belief that the monetary costs of water pollution control are outweighed by the ecological and societal benefits of clean water. The following paragraphs (and accompanying tables) address some of the major costs associated with water pollution control efforts in Kansas.

Pollution control expenditures in the state are associated predominantly with administrative expenses, capital investments, and operational costs for wastewater treatment facilities. Although minimal information is available regarding the costs of privately owned industrial or agricultural facilities, capital expenditures associated with the construction and upgrading of municipal facilities have been documented carefully by KDHE. For example, the department administers the Kansas Water Pollution Control Revolving Fund (KWPCRF), which provides low interest loans to municipalities for water pollution control projects. Available monies are maximized through the sale of "leveraged revenue bonds." During the past ten years, these bonds have provided $474 M for facility improvements in Kansas. KDHE also coordinates the Community Development Block Grant (CDBG) program on behalf of the state. This program typically covers about 50% of the costs of a water pollution control project. During 2006 and 2007, KWPCRF, CDBG, and other state and federal programs have provided nearly $110 M in financial aid to communities in Kansas (Table 6). NPS pollution abatement measures have received much less funding (Table 7), relying instead on the predominantly voluntary measures discussed previously.

Table 6. KDHE cooperative funding for construction of municipal wastewater treatment facility upgrades and expansion (monetary values in millions of dollars)

Funding Year (FY)	KWPRCRF*		CDBG**		RD***	TOTAL
	Basic	Leveraged	Federal	Match	Federal	
2006	18.027	26.007	3.318	0.171	7.906	55.429
2007	12.088	28.419	2.592	0.487	10.449	54.035
TOTAL	30.115	54.426	5.910	0.658	18.355	109.464

* KWPCRF = Kansas Water Pollution Control Revolving Fund
** CDBG = Community Development Block Grant
*** RD = Rural Development Grants and Loans

Table 7. Nonpoint source pollution program awards (in dollars)

NPS Program Award	2006	2007
NPS Program Implementation	937,673	1,127,233
NPS Abatement Projects	755,427	705,000
WRAPS Projects	1,959,000	1,725,567
Program Total	3,652,100	3,557,800

Major Environmental Concerns and Recommendations

Agricultural concerns. Agriculture exerts a strong influence on surface water quality conditions in Kansas. Erosion of cropland soils produces elevated concentrations of silt in many streams and lakes, often to the detriment of native aquatic and semiaquatic life. The presence of nitrogen- and phosphorus-containing fertilizers in stormwater runoff promotes nuisance growths of algae and often detracts from the recreational and drinking water uses of surface water. Stormwater runoff from feedlots, livestock wintering areas, and heavily grazed pastures introduces fecal pathogens and oxygen consuming organic wastes into nearby lakes and streams, sometimes compromising the sanitary condition of these waters. Pesticide residues in some drinking water supply lakes pose potential long-term risks to human health.

Efforts to alleviate the impacts of agriculture on the aquatic environment have focused primarily on the abatement of soil erosion and proper management of chemical fertilizers, biocides, and livestock wastes. Although the wider adoption of agricultural BMPs should lead to measurable reductions in stream contaminant levels, runoff water quality is not the only agricultural factor limiting the use attainment of surface waters. Throughout much of western Kansas, for example, decades of irrigated crop production have exacted a heavy toll on stream life by lowering groundwater tables, reducing base stream flows, and transforming formerly perennial water bodies into intermittent or ephemeral systems. In some areas of northeastern Kansas, stream channelization has radically simplified the original aquatic habitats and decimated a formerly diverse fish and shellfish fauna. Impoundments (large and small) throughout the state have encouraged the establishment of predominantly nonnative fish assemblages, fragmented the remaining stream habitats, and diminished the seasonal peak flows needed by certain native fishes for spawning and egg development.

The complete restoration of these degraded aquatic ecosystems would require major habitat rehabilitation efforts and fundamental changes in the laws, policies, and attitudes currently controlling the use and allocation of water in this region. Less effective, but more readily implemented, options for partially offsetting the historical effects of agriculture would include: the enhancement of minimum stream flows through the State-mediated purchase and retirement of senior water rights; the expansion of hatchery restocking programs for native fish and shellfish; the selective removal of lowhead dams and other barriers to fish migration; the installation of fish ladders and elevators on larger dams; and other related management

initiatives – all in addition to concurrent improvements in agricultural practices. Most of these concepts are not new. For example, the importance of maintaining migrational corridors for fish was emphasized repeatedly by Kansas officials during the late nineteenth century but never seriously considered in the course of water resource development.

Municipal and industrial concerns. Discharging WWTFs and other point sources also influence surface water quality throughout much of Kansas. Releases of inorganic nitrogen and phosphorus from some facilities promote blooms of filamentous or scum-forming algae in downstream waters and detract from their capacity to support primary and secondary contact recreation. Bypasses of raw or partially treated sewage occur each year owing to treatment plant malfunctions, operator error, or natural catastrophes. Such bypasses often result in fishkills or other conspicuous water quality problems.

Stormwater runoff from lawns, golf courses, roadways, and parking lots often contains a complex mixture of chemical pollutants (*e.g.*, biocides, fertilizers, oil, grease, antifreeze, deicing salts, solvents, detergents, asbestos), and these can prevent the development and maintenance of representative aquatic communities in receiving surface waters. Similarly, concentrations of mercury, PCBs, and other bioaccumulative contaminants in fish collected from some urban streams may pose unacceptable risks to human consumers. Many urban streams in the state have suffered from the illegal dumping of trash and other unwanted materials. The commonplace practice of discarding grass clippings and brush in streams (and the subsequent decay of these materials) reduces dissolved oxygen levels and jeopardizes native populations of fish and other aquatic life. Discarded paint cans, pesticide containers, and batteries may leach appreciable quantities of toxic materials, thereby posing a serious threat to resident aquatic biota.

Urban sprawl also negatively influences the physical habitats supporting aquatic life. The elimination of wetlands and riparian buffers diminishes the capacity of streams to remove pollutants and mitigate the effects of flooding. The eventual channelization of most urban streams results in highly simplified aquatic habitats incapable of supporting the full range of fish and wildlife indigenous to this region. Stormwater runoff from impervious surfaces such as paved areas and rooftops can lead to powerful flooding events, scouring stream bottoms and effectively eliminating the habitat required by some native aquatic species. In many instances, the negative effects of urban development on the state's streams, lakes, and wetlands could be reduced through careful planning and adherence to recognized BMPs and established surface water quality standards. For example, the retention of natural corridors or "greenways" along rivers and creeks, and strict adherence to the antidegradation provisions of the surface water quality standards (KDHE, 2004), would do much to preserve the natural physical and chemical attributes of the state's urban streams. Local, state, and federal authorities also could support litter cleanup initiatives more enthusiastically. Improvements in the visual and aesthetic properties of the state's surface waters would increase the recreational value of these resources and encourage their protection and sustainable use.

Nuisance aquatic species. A number of exotic plant and animal species have established populations within the state, and some pose a serious risk to native aquatic life and the beneficial uses traditionally associated with surface waters. For example, Asian clams (*Corbicula fluminea*) have established large populations in streams and lakes throughout the state, and the zebra

mussel (*Dreissena poymorpha*) has gained footholds in recent years in the Walnut, Ninnescah, and Delaware river basins. Both of these exotic bivalves have the capacity to injure native populations of shellfish and reduce the fitness of surface waters for recreational activities and raw drinking water uses. At least four species of Asian carp have established populations in the state, and additional exotic fishes are expected to appear in Kansas in the near future. These animals compete with native fish and wildlife for food and shelter, and some dramatically reduce water clarity by disturbing bottom sediments during feeding.

A number of introduced plant species also have proven problematic. Salt cedar (*Tamarix* spp.) thickets have become established along many streams in western and central Kansas, crowding out the native riparian vegetation and removing (via evapotranspiration) vast amounts of water from the adjoining streams and underlying alluvial aquifers. Purple loosestrife (*Lythrum salicaria*) has become the dominant herbaceous species in many wetlands, overwhelming many of the state's native plants and jeopardizing the animals depending on these plants for food and shelter. Eurasian watermilfoil (*Myriophyllum spicatum*), an exotic plant sold in the aquarium trade, has been discovered in several streams in western Kansas and a growing number of lakes in eastern Kansas. This plant propagates via seeds and vegetative fragments and can spread rapidly between water bodies by attaching to boat propellers, boat trailers, and fishing gear. Once introduced into a lake or stream, it tends to form dense mats of vegetation that can interfere with recreational activities, crowd out native aquatic vegetation, disrupt the feeding behavior of native fish, and choke water intakes used for municipal water supply, power generation, and irrigation.

In 2008, Senate Bill 606 was introduced into the Kansas Legislature. This bill endeavors to control the spread of invasive plant and animal species in Kansas. If adopted, it would create an aquaculture advisory council and require boaters, anglers, hunters, and other outdoor enthusiasts to ensure they are not transporting invasive species between bodies of water. Noncompliance would subject responsible parties to civil penalties. The Kansas Department of Wildlife and Parks (KDWP) would be tasked with the implementation, management, and enforcement of this legislation.

PART C: SURFACE WATER MONITORING AND ASSESSMENT

Monitoring Programs

Targeted monitoring operations

Stream chemistry monitoring program. The stream chemistry monitoring program is the largest and longest running environmental monitoring operation administered by the BEFS Technical Services Section. Water samples are obtained routinely from streams throughout Kansas and analyzed for a large suite of physical, organic, inorganic, radionuclide, and bacteriological parameters (Appendix A). The program database currently comprises over two million records representing nearly 400 active and inactive monitoring locations and approximately 100 different analytical parameters. Some records in the database date to the late 1960s, and several monitoring sites have a continuous period-of-record extending from that time to the present (KDHE, 2007d).

Currently, the stream chemistry sampling network comprises 320 monitoring sites spanning all the major river basins and physiographic regions of Kansas. Monitoring personnel visit about 165 core sites on a bimonthly basis every year, whereas the remaining 155 sites are monitored using a four-year rotational approach; *i.e.*, samples are collected bimonthly from approximately 25 percent of these sites each year. Sampling sites have been chosen to represent water quality conditions in specifically targeted watersheds or stream reaches. For example, some sites reflect water quality conditions in streams as they enter or exit Kansas; others represent conditions above or below major discharging facilities, urban areas, or reservoirs, and still others reflect water quality conditions in predominantly rural watersheds. A few "minimally altered" and several "least impacted" reference streams have been included in the network to gain a better understanding of baseline water quality conditions in the various ecoregions of Kansas (*cf.*, Chapman *et al.*, 2001). Stream reaches hosting monitoring sites range in size from first to eighth order on the Strahler (1957) scale (based on the NHD 1:100,000 stream coverage). As currently configured, the network provides water quality information useful in the characterization of pollutant loadings from more than 97 percent of the state's contributing drainage area. Many monitoring sites are located near the lower terminus of eight-digit hydrological unit code (HUC) watersheds and play an important role in the development and refinement of TMDLs for 303(d)-listed streams.

Stream biological monitoring program. This program examines the structural attributes of aquatic macroinvertebrate assemblages and utilizes this information to provide a more refined picture of the ecological status of streams in Kansas. Unlike water chemistry measurements alone, which reflect conditions occurring at the moment of sample collection, biological monitoring provides an integrated measure of environmental condition over time frames ranging from weeks to years, depending on the biological assemblage of interest. The KDHE aquatic macroinvertebrate database currently contains some 52,000 high resolution (predominantly genus/species level) records, and a separate freshwater mussel database contains more than 10,000 high resolution records.

The macroinvertebrate sampling network includes 180 monitoring sites distributed throughout the state. Samples normally are obtained from 60-65 sites each year, including 45 core stations and 15-20 rotational stations sampled three consecutive years per rotation. The remaining sites in the sampling network represent short-term monitoring stations that are visited by staff on a sporadic basis as dictated by TMDL development needs or other regulatory considerations. As weather conditions allow, monitoring activities at all sites adhere to a seasonal rotation to reduce statistical bias and provide a more comprehensive picture of the resident macroinvertebrate communities; *i.e.*, samples are collected during the spring of one year, the summer of the next, and the fall of the next, a cycle that is repeated every three years (core sites) or every rotational sequence. Streams hosting core or rotational monitoring sites range in size from second to eighth order on the Strahler scale; approximately 50 percent of these sites are located on fifth or sixth order streams and 80 percent are located on fourth to seventh order streams. The sampling network incorporates a targeted monitoring strategy comparable to that employed in the stream chemistry monitoring program. However, a greater proportion of core sites in the biological monitoring program are located on minimally impacted or least impacted reference streams (KDHE, 2007c).

Lake and wetland monitoring program. This program surveys water quality conditions in publicly owned and/or publicly accessible lakes and wetlands throughout Kansas. Program personnel visit individual water bodies on a three- to five-year rotational schedule, and field measurements and subsequent laboratory analyses provide data on a large suite of physical, organic, inorganic, and biological (*i.e.*, phytoplankton and macrophyte) parameters (Appendix A). The program's primary database now contains more than 250,000 analytical records representing more than 300 water bodies. Watersheds associated with many of these monitored lakes and wetlands are surveyed periodically with respect to prevailing land use/land cover and the location and size of any discrete pollutant sources (wastewater treatment plants, feedlots, etc.). Macrophyte community composition and aerial macrophyte coverage also are evaluated in selected water bodies smaller than 300 acres (KDHE, 2005a).

Water quality information currently is obtained from 121 lakes and wetlands distributed throughout the state. These include all 24 federal reservoirs, most state-administered fishing lakes (those retaining open water in most years), various other state, county or locally owned lakes, several privately owned but publicly accessible lakes, and seven state or federally owned marshes. Because only a few of these water bodies are naturally occurring, an effort has been made to identify artificial lakes in minimally disturbed or least disturbed watersheds to serve the function of reference systems. This program routinely shares a large amount of data and expertise with other agencies and organizations involved in lake and wetland management, environmental restoration, water quality monitoring, and environmental education. Additional collaborative efforts have addressed the abatement of toxic algal blooms and taste/odor problems in public drinking water supply reservoirs.

Fish tissue contaminant monitoring program. This program obtains information on chemical contaminant levels in fish collected from streams and lakes in Kansas. Whole-fish samples (composite samples of three to six individuals) are obtained from selected monitoring sites, transferred to the EPA laboratory in Kansas City, and analyzed for organochlorine pesticides, polychlorinated biphenyls, toxic metals, and other bioaccumulative contaminants. Resulting data

are used to track the occurrence of these contaminants within the ecological food web and ascertain temporal and spatial trends in environmental condition. Composite fillet samples also are obtained from both targeted and probabilistic monitoring sites and analyzed by KDHE and EPA laboratories for contaminants of potential human health concern. In consultation with KDWP, KDHE evaluates the contaminant data to determine the need for issuing, rescinding, or modifying local fish consumption advisories. The fish tissue database currently comprises approximately 13,400 records, representing 80 sites and more than 200 (79 detected) contaminant parameters (Appendix A).

Fish tissue samples normally are obtained each year from 30-40 water bodies across the state. Sampling efforts focus primarily on streams and lakes with known water quality problems and existing fish consumption advisories. Although chlordane traditionally has been viewed as the contaminant of greatest concern (Arruda *et al.* 1987a-b; KDHE 1988a-b), chlordane concentrations in fish have declined dramatically in recent years, and attention has shifted gradually to mercury, polychlorinated biphenyls, and a few other persistent contaminants. The agency recently has devoted a greater proportion of its monitoring resources and laboratory sample allocation to the collection and analysis of predatory fish from recreational reservoirs. This initiative acknowledges national trends in mercury levels in freshwater fish and the potential for mercury-related health problems, especially in more vulnerable segments of the human population (*e.g.*, children and women of child bearing age) (EPA 2000a-b; http://www.epa.gov/waterscience/fishadvice/factsheet.html). On January 7, 2007, advisories were issued for nine water bodies in eastern and central Kansas owing to elevated levels of mercury, polychlorinated biphenyls, and/or other contaminants in fish and shellfish. As an additional precaution, a statewide consumption advisory was issued for certain predatory fish species based on nationally reported trends in the mercury content of these animals (KDHE, 2007b)

Probabilistic monitoring operations

Stream probabilistic monitoring program. Probabilistic sampling is a method of environmental monitoring that yields statistically representative information on the physical, chemical, and/or biological condition of natural resources. It differs from conventional sampling in that probabilistic monitoring stations are a randomly selected subset of the resource as a whole. In Kansas, stream chemistry and stream biological monitoring programs traditionally have employed a targeted monitoring design that positions stations in a deliberate and strategic manner (e.g., near the terminus of a specific watershed or above and below a discrete pollution source). Although these programs are of critical importance in determining site- and watershed-specific water quality conditions, funding and logistical constraints limit the number of targeted sites that can be sampled on an ongoing basis. In contrast, probabilistic monitoring focuses on the total resource rather than the individual monitoring locations. Results generated from this approach can be extrapolated with known confidence to the state's entire population of streams, including hundreds of smaller water bodies (e.g., headwater streams) largely outside the historical and current purview of the targeted monitoring programs.

In 2004, KDHE participated in EPA's National Wadeable Streams Assessment and gained experience in the application of probabilistic sampling designs and associated field methodologies (EPA, 2004; http://www.epa.gov/owow/streamsurvey/WSA_Assessment_Dec 2006.pdf). In 2005, availability of supplemental monitoring funds under section 106(b) of the CWA provided an opportunity for BEFS to: (1) develop a quality assurance management plan and accompanying set of standard operating procedures for a similar statewide probabilistic program (2) hire and train two environmental scientists to assist with the implementation of field and taxonomic duties; (3) develop a list of randomly selected (candidate) stream reaches; (4) obtain landowner permission to perform evaluations on these stream reaches; (5) initiate probabilistic monitoring operations; and (6) develop a methodology for applying probabilistic data to CWA section 305(b) water quality assessments. Probabilistic monitoring was formally implemented by BEFS in December 2005 under the auspices of the newly created Kansas stream probabilistic monitoring program or SPMP.

From its inception, the SPMP was designed to complement, rather than supplant, the department's traditional monitoring programs. Targeted monitoring continues to serve as the primary basis for CWA section 303(d) list development, TMDL formulation, and NPDES permit review and certification. Although site selection procedures for the probabilistic and targeted monitoring programs differ substantially, field methodologies developed for the targeted programs have been integrated with little alteration into the probabilistic program. This decision has maintained methodological continuity across programs and should facilitate inter-program data comparability in future assessments. Staff of the targeted monitoring programs have contributed to the development of the SPMP and continue to play an important role in the implementation of this program, primarily through the training of staff and participation in field and laboratory operations and quality control functions.

The SPMP sampling network is predicated on a random, but spatially balanced, site selection process (*cf.*, Kaufmann *et al.*, 1991; Messer *et al.*, 1991; Larsen *et al.*, 1994; Urquhart *et al.,* 1998; Herlihy *et al.*, 1998, 2000). Site coordinates are based on the random selection of points from the universe of classified stream segments identified in the most recently approved version of the Kansas surface water register (KSWR) (KDHE, 2007f). This register represents all potential sampling locations or "the sampling frame." It is subject to incremental change over time owing to the deletion or addition of classified stream segments by the BEFS Use Assessment Section (KDHE, 2005b). In effect, an infinite number of potential sampling sites can be selected from the KSWR, allowing a manageable subset of about 50 newly selected sites to be sampled each year. Additional details are given in the SPMP quality assurance management plan (KDHE, 2007e).

SPMP personnel and other participating BEFS employees evaluate surface water chemistry, macroinvertebrate community composition, and phytoplankton community composition at each of the scheduled sampling locations. Physical habitat data also are collected to help discriminate between chemistry- and habitat-mediated limitations to the biotic community. As mentioned previously, SPMP personnel employ field protocols developed originally for the BEFS targeted stream monitoring programs. These established methods are robust, and their utility has been demonstrated over the course of several decades. Moreover, data comparability and consistency among monitoring programs may prove important to future statewide water quality assessments.

Assessment Methodology

305(b) Assessment Methodology

As discussed previously, two statewide monitoring programs, the SPMP and the lake and wetland monitoring program, produced information amenable to inclusion in the 305(b) assessment. The statistical methods and assumptions employed in the 305(b) assessment are presented separately for these two programs in the following paragraphs.

Stream Probabilistic Monitoring Program

The target population for the 2008 probabilistic stream assessment comprised that portion of the KSWR stream extent that contained water during the summer low-flow periods of 2006–2007. The sampling frame used to represent the target population was the December 2005 version of the KSWR. Reporting was based on the segment geometries and uses published in the April 18, 2007 version of the KSWR. The sampling frame for reporting represented approximately 27,816 stream miles.

Site selection was performed by the EPA design team in Corvallis, Oregon (Olsen, 2006) using the methods and assumptions of Stevens and Olsen (2004). Desk and field reconnaissances were performed in 2006. The target population was determined to comprise 18,679 miles or about 67% of the sampling frame (a difference attributable largely to severe drought conditions and an accompanying loss of stream mileage during 2006). Data collected in 2006–2007 were used to assess the prevailing level of support for CWA section 101(a) uses (Table 8).

Table 8. Types of data used in assessing designated use support (2006–2007)

Designated Use	Macroinvertebrate Community Structure	Water Chemistry	*E. coli* Concentrations	Fish Tissue Chemistry
Aquatic Life	X	X		
Contact Recreation			X	
Food Procurement				X

The capacity of a given stream reach to provide for recreation, food procurement, and aquatic life support was determined by considering the local water chemistry, fish tissue chemistry, suspended bacterial concentrations, and condition of the benthic macroinvertebrate community. Monitoring sites meeting the applicable water quality criteria or diagnostic thresholds for a given use were deemed “fully supportive” of that use. Any site failing to meet these criteria or thresholds was deemed “non-supportive” of the use. Assigned causes and sources of non-support were based on several considerations, including the prevalence and proximity of upstream point sources and nonpoint sources, point source performance during the reporting period, dominant land uses within the watershed (and near the sampling location), and any instream manifestations reflecting degraded water quality (silt blanketing of sediments, large growths of filamentous or mat forming algae, effluent odors, etc.).

Aquatic Life Use. Stream macroinvertebrate data from 92 randomly chosen sites were considered during the assessment of the aquatic life use (Figure 3). Use support was determined using the site scores for four biological metrics: macroinvertebrate biotic index (MBI), nutrient-oriented Kansas biotic index (KBI-NO), Ephemeroptera-Plecoptera-Trichoptera index (EPT), and percent EPT with respect to total macroinvertebrate abundance (%EPTCNT). Support thresholds for these metrics were derived from an analysis of 24 reference streams, all sampled during the 2006–2007 assessment period (Figure 3).

Reference and probabilistic sites were partitioned into three stream flow categories (<10 cfs; 10-99.99 cfs; ≥100 cfs) using 10-year median discharge estimates for the surrounding stream reaches (Perry *et al.,* 2004). Within each flow category, support thresholds for the biological metrics were set at the 75th percentile (MBI and KBI-NO) or 25th percentile (EPT and %EPTCNT) reference site score (www.epa.gov/bioindicators/html/biological_endpoints.html). This procedure effectively adjusted the expected performance of each monitored stream reach on the basis of stream size (*e.g.*, a second order stream would not be expected to support the same number of EPT taxa as a sixth order stream, but would be expected to perform as well as a similarly sized stream in the absence of environmental stressors). Support thresholds derived from this process are presented in Table 9.

Table 9. Aquatic life use non-support thresholds for biological metrics across three flow groups

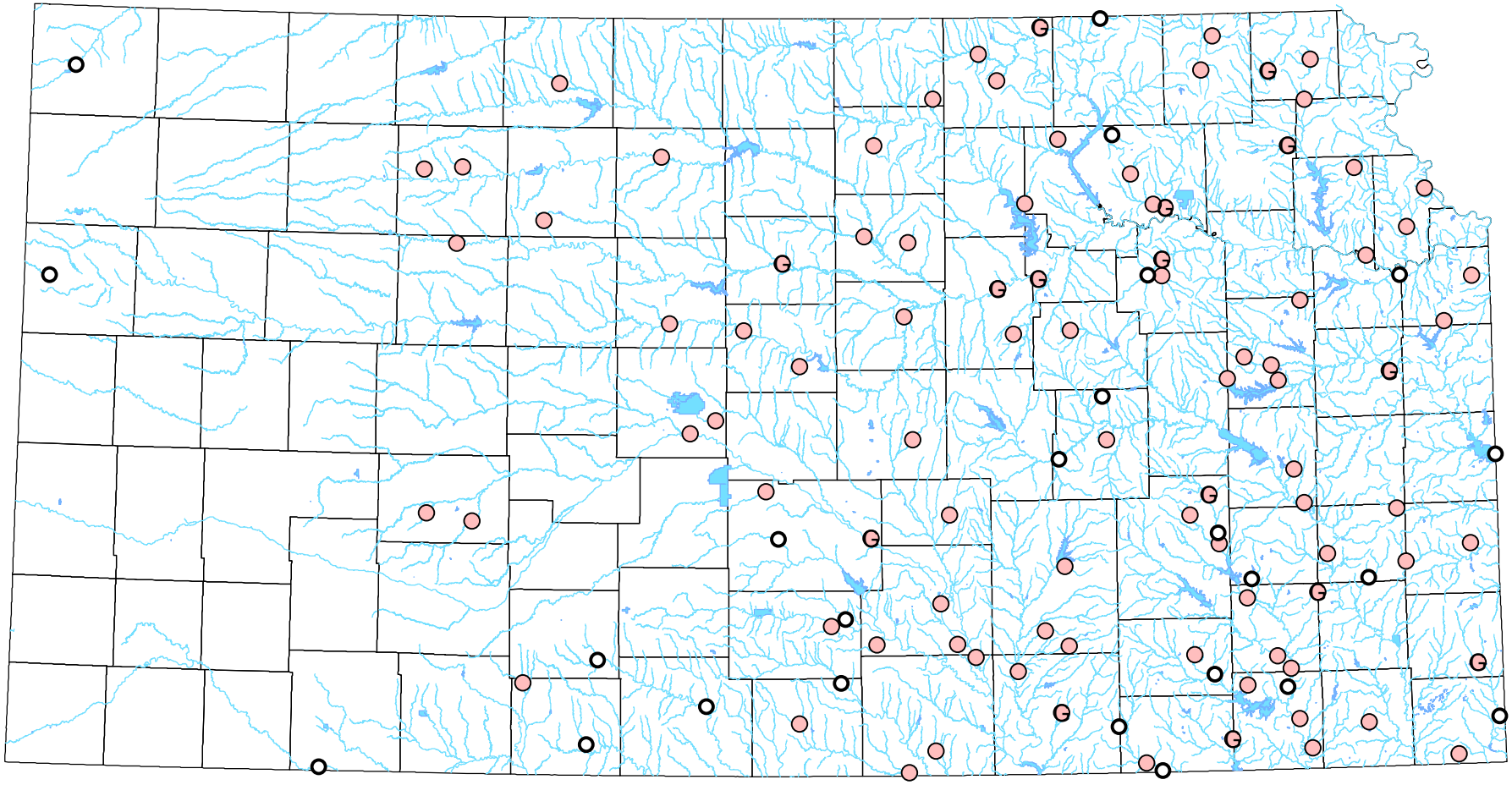
Flow Group	MBI	KBI-NO	EPT	%EPTCNT
<10 cfs	>5.13	>3.10	<5	<8%
10-99 cfs	>4.82	>2.84	<7	<34%
≥100 cfs	>4.28	>2.52	<13	<28%

Scores from probabilistic sites were compared to the flow-adjusted thresholds and assigned a value of 1 (non-support) or 2 (full support). These values were averaged across the four metrics to obtain a final average value for each site. If an average support value exceeded 1.5, the site in question was deemed fully supportive of the aquatic life use. If an average value was less than 1.5, the site was considered non-supportive of the aquatic life use.

In some instances, the average support values equaled the full support/non-support threshold (*i.e.*, 1.5). Chemistry data were used in these instances to assign sites to the most appropriate use attainment category. If pollutant concentrations were found to exceed a given (acute or chronic) aquatic life criterion concentration in at least 25% of samples, the site in question was deemed non-supportive of the aquatic life use. However, chronic (48- to 96-hour) criteria were not applied during transient stream runoff events, and the dissolved oxygen criterion was not applied during periods of drought-induced pooling.

Figure 3. Kansas Stream Probabilistic Monitoring Network

(2006 -2007)



Probabilistic site

G Fish tissue collected at site

Reference site

County boundary

Kansas Surface Water Register, 2007

streams

lakes

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Contact Recreational Use. All probabilistic sites were assessed for recreational use support based on measured suspended concentrations of *Escherichia coli*. This bacterium is part of the normal intestinal fauna of humans and many other warm blooded animals. It is utilized in many water quality studies as a general indicator of fecal contamination. For formal regulatory purposes (e.g., 303(d) listing), bacteriological criteria generally are applied as geometric mean concentrations, calculated using data from at least five different samples collected in separate 24-hour periods during a 30-day assessment window (KDHE, 2004). The frequency and timing of the SPMP sample collections did not meet these rigid requirements. Therefore, the results reported below for the state as a whole (i.e., pursuant to section 305(b) of the CWA) were based on seasonal samples collected from each probabilistic site over the course of a single year.

Based on studies undertaken previously by the BEFS Use Assessment Section, each stream segment listed in the KSWR was assigned to one of four recreational use categories (two primary and two secondary) depending on stream size, extent of public access, and other use attainability considerations (KDHE, 2005). *E. coli* data from each probabilistic site were compared to the applicable criterion concentration. Many of these sites were designated for secondary contact recreation only, in which case all available data were combined, and the geometric mean was compared directly to the appropriate criterion concentration. Sites designated for primary contact recreation were evaluated with respect to recreational season (primary contact, April 1 – October 31; secondary contact, November 1 – March 31), and the geometric mean for each season was compared to the appropriate criterion concentration (Table 10). If the geometric mean exceeded the applicable criterion concentration, the monitoring site in question was deemed non-supportive of the recreational use.

Table 10. *Escherichia coli* criteria used in recreational use assessments

Use	**Colony Forming Units (CFUs)/100mL**	
Primary Contact Recreation	**Geometric Mean April 1 – Oct. 31**	**Geometric Mean Nov. 1 – March 31**
Class B	262	2358
Class C	427	3843
Secondary Contact Recreation	**Geometric Mean Jan. 1 – Dec. 31**	
Class a	2358	
Class b	3843	

Food Procurement Use. Fish tissue contaminant data were obtained from 15 probabilistic sites in 2006 (Figure 3). Eleven additional sites were sampled in 2007, but a delay in the reporting of the analytical results precluded inclusion of the data in this report. Because smaller streams were less likely to contain fish of edible size, only probabilistic sites with an estimated median discharge of 3.0 cfs or more (*cf.*, Perry *et al.*, 2004) were regarded as viable candidates for fish

tissue contaminant sampling. All sampling sites had been designated previously for food procurement use.

At each of the 15 sites sampled during 2006, SPMP personnel endeavored to collect one composite (three- to five-fish) sample of a representative bottom-feeding fish species (*e.g.*, channel catfish, common carp) and another composite sample of an open-water predatory species (*e.g.*, largemouth bass). Food procurement use support was assessed on the basis of measured contaminant concentrations and contaminant-specific hazard threshold values for a consumption rate of greater than one meal per month (EPA, 2000a-b). For contaminants with both carcinogenic and non-carcinogenic endpoints, the more conservative of the two values was applied in the 305(b) assessment (*cf.*, EPA, 2000a-b). Fish contaminants rated as carcinogens were assessed on the basis of EPA's cancer potency factors and an allowable population cancer risk of 1:100,000 (KDHE, 2004). Non-carcinogens were evaluated using EPA's health endpoints for chronic systemic effects. Further assumptions included consumption of fish tissue over the duration of an average human lifetime, average adult body weight, and eight-ounce meal portions. If the level of a contaminant in fish tissue was found to surpass the applicable threshold concentration, the site in question was deemed non-supportive of the food procurement use.

*Population Extent Estimation***.** Data from the 92 sites assessed for aquatic life and contact recreation and from the 15 sites assessed for food procurement were used to derive estimates for the target population as a whole. If a site failed to support any single designated use, it was considered non-supportive overall. The design team at the EPA Western Ecology Division provided the population extent and variance estimates applied in this report (personal communication, Tony Olsen and Tom Kincaid). Calculations were performed using the "R" programming environment (www.r-project.org), the most current "sp" and "spsurvey" custom software modules (www.epa.gov/nheerl/arm/analysis pages/software.htm), and the methods and assumptions of Diaz-Ramos *et al*. (1996) and Stevens and Olsen (2003).

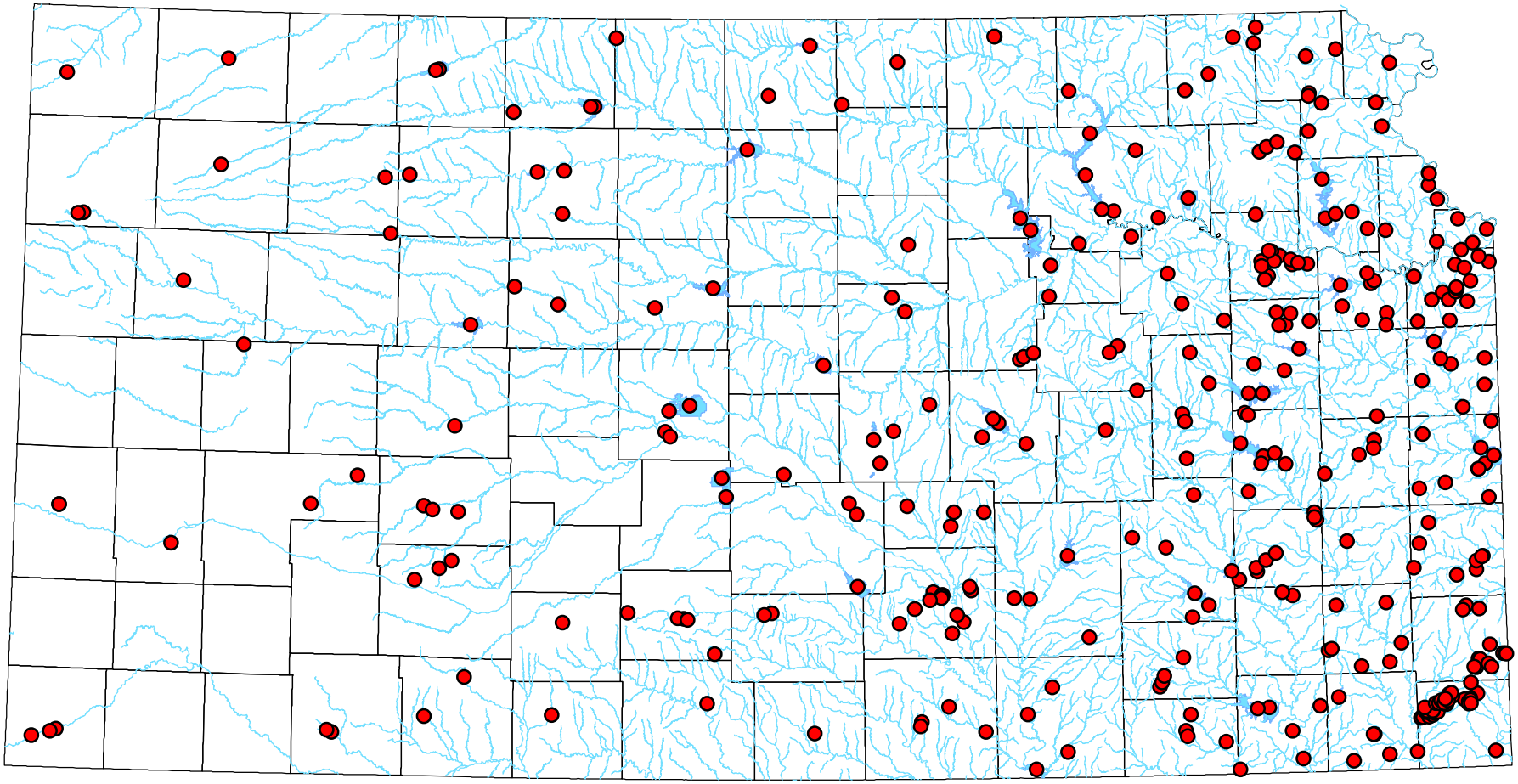
Lake and Wetland Monitoring Program

This targeted monitoring program assessed 322 publicly owned lakes and wetlands during the six-year reporting period, 2002–2007 (Figure 4). Physicochemical data obtained from the surveys were compared to established water quality standards to characterize the prevailing level of use support. A water body was deemed non-supportive of a designated use if more than 25% of the samples exceeded a given criterion applicable to that use, partially supportive if more than 10% (but fewer than 25%) of the samples exceeded the criterion, and fully supportive if a smaller percentage of samples exceeded the criterion. This assessment focused primarily on epiliminetic water quality conditions, but temperature data were evaluated to a maximum depth of 3.0 m irrespective of the thermal stratification status of the monitored water body.

The 305(b) assessment also considered long-term trends in the trophic condition of monitored lakes and wetlands. Mean concentrations of chlorophyll-a were computed for each water body based on the entire period-of-record for that water body. These concentrations were compared to an existing set of thresholds used to interpret narrative standards for lake trophic state, nutrient enrichment,

Figure 4. Kansas Lake and Wetland Monitoring Network

(2002 - 2007)



Lake/Wetland site

County boundary

Kansas Surface Water Register, 2007

streams

lakes

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and turbidity (KDHE, 2004). Mean chlorophyll-a thresholds for the contact recreational and domestic water supply uses were: <10 ug/L (fully supportive); 10-12 µg/L (fully supportive but threatened); 12-20 ug/L (partially supportive); and >20 ug/L (non-supportive). Mean chlorophyll-a thresholds for irrigation, livestock watering, secondary contact recreation, and aquatic life support were: <18 ug/L (fully supportive); 18-20 ug/L (fully supportive but threatened); 20-30 ug/L (partially supportive); and >30 ug/L with blue-green algal dominance or >56 ug/L regardless of algal composition (non-supportive).

303(d) Assessment Methodology

The 2008 list of impaired (Category 5) waters builds upon listings developed in 2004 and 2006. A complete description of the procedures and assumptions applied during the preparation of this list is provided in the report, *Methodology for the Evaluation and Development of the 2008 Section 303(d) List of Impaired Water Bodies for Kansas* (http://www.kdheks.gov/tmdl/download/2008_303_d_ Methodology.pdf).

Development of the 2008 list depended primarily on data from targeted water quality monitoring programs administered by BEFS and described elsewhere in this report. The statewide water quality assessment prepared by BEFS pursuant to section 305(b) of the CWA also provided the initial candidate waters for listing. BOW performed more extensive follow-up analyses, and these provided the ultimate basis for identifying and listing impaired waters in Kansas.

Stream chemistry data were obtained from the statewide network of permanent monitoring stations (assessment period, 1998–2007) and rotational stations (assessment period, 1990–2007) and analyzed using binomial techniques with adjustments to combat Type II error. Streams impaired by excessive concentrations of total suspended solids and total phosphorus were identified using screening values developed by BOW. Formal numeric criteria for these two pollutants likely will be promulgated by KDHE in the near future as part of the triennial water quality standards review process.

Watersheds monitored by individual stream chemistry stations comprised stream assessment units for the section 303(d) list. Streams draining into some large reservoirs were not surveyed as part of the stream chemistry monitoring network, and their watersheds were assessed using data obtained from the reservoirs.

The public notice for the draft section 303(d) list provided a mechanism for soliciting all readily available water quality data from other parties (see Part E, this report). The U.S. Geological Survey provided some additional information, but this pertained to streams already included on the 303(d) list or to watersheds with completed and approved TMDLs for the pollutants of interest.

Priorities and Schedules

Since 1999, TMDL development efforts in each of the state's twelve major river basins have adhered to a five-year rotational schedule. The 2008 section 303(d) list identifies all water bodies in Kansas scheduled for TMDL development through the end of 2010 (Appendix B). Work in the Smoky Hill/Saline, Solomon, and Upper Republican river basins will be performed in 2008-2009. Work in the Kansas/Lower Republican River Basin will occur in 2009–2010. Additional TMDLs currently are being developed for several lakes in the Verdigris and Walnut river basins.

Specifically, TMDL development efforts during 2008–2009 will address 19 identified impairments in the Smoky Hill/Saline River Basin, seven impairments in the Solomon River Basin, and three impairments in the Upper Republican River Basin. Most of the indicated impairments relate to low dissolved oxygen levels or to elevated nitrate, phosphorus, total suspended solids, or *E. coli* concentrations. By the summer of 2008, five TMDL packages will be completed for the Verdigris and Walnut river basins. Each will address lake eutrophication- and siltation-related impairments. During 2009–2010, 33 additional TMDLs will be completed for waters in the Kansas/Lower Republican River Basin. These will address impairments related to accelerated eutrophication rates, low dissolved oxygen levels, excessive siltation, and elevated total phosphorus and total suspended solids concentrations. Moreover, they will address impairments related to stream biology as indicated by macroinvertebrate sampling.

Tracking Previously Listed Waters

The 2008 section 303(d) list also identifies waters from previous lists that were once impaired by a pollutant (Category 5) but now are placed in other listing categories established by EPA. TMDLs have been established for most of the Category 5 waters identified on the 1998, 2002, and 2004 lists, and these waters have been placed in Category 4a (http://www.kdheks.gov/tmdl/).

A number of water bodies in Kansas have been placed in Category 4b, meaning their particular impairments have been addressed by some means other than the development of a TMDL. For most of these waters, the indicated impairments have been addressed through the NPDES permitting process (*i.e.*, through effluent limits and schedules of compliance leading to WWTF upgrades). Discharge monitoring records indicate that (1) most of these facilities now comply with their NPDES permits and (2) streams receiving the treated effluent now comply with applicable surface water quality criteria. KDHE plans to maintain the Category 4b status of these streams for several more years to obtain additional monitoring data and ensure the successful resolution of the indicated water quality impairments. If the facilities continue to have compliance issues, the affected stream reaches will revert back to Category 5. If the facilities remain in compliance, these stream reaches will be placed in Category 2, indicating their use impairments have been resolved.

Some water quality impairments related to atrazine have been addressed through watershed protection plans and biocide management initiatives. For example, in two separate instances, WRAPS has facilitated the local implementation of BMPs and reduced atrazine loadings to affected stream reaches. In another instance, the establishment of a Pesticide Management Area (PMA) by the Kansas Department of Agriculture has led to changes in atrazine label

requirements and promoted BMPs within a large watershed experiencing heavy levels of atrazine contamination. KDHE plans to maintain the Category 4b status of the affected stream reaches for several more years. If these reaches continue to exhibit atrazine related impairments, they will revert back to Category 5. If problems related to atrazine contamination are resolved, the streams will be placed in Category 2.

Currently, only one water body in Kansas is assigned to Category 4c, which means the documented water quality impairment is not caused by a pollutant. In this case, biological impairment defined by macroinvertebrate monitoring appears to be linked to deficient hydrology, brought about by drought and diversions. This impairment may be managed best through water allocation management and water rights administration. This stream will be reevaluated in 2012.

Several water bodies in Kansas are assigned to Category 3, which means their quality may be impaired but a definitive determination is not possible owing to insufficient supporting data. In some such cases, high bacterial levels appear to be impacting the designated recreational use, but more intensive sampling is needed to appropriately assess compliance with the applicable standards. All waters placed in Category 3 are scheduled for additional monitoring and evaluation.

Some waters in the state are assigned to Category 2, meaning they were previously listed as impaired but now comply with applicable water quality criteria. In effect, each Category 2 water re-attained compliance before a corresponding TMDL could be developed and approved. This outcome resulted from the evaluation of more recent monitoring data, changes in water quality criteria, or removal of the applicable designated uses through the use attainability analysis (UAA) process.

Finally, surface waters in Kansas that never have been listed for a water quality impairment normally are assigned to Category 1. All categorical assignments (Category 1-5) are recorded by KDHE in an electronic database. This extensive database has been submitted to EPA as part of the 2008 integrated report.

Assessment Results

305(b) Assessment Results

Probabilistic Stream Assessment

The KSWR identifies all currently classified stream segments in Kansas. Collectively, these represent about 27,816 stream miles and include both perennial and intermittent waters. During prolonged droughts, some of this mileage is expected to be nonviable for sampling purposes. Thus, the target sampling population is restricted to those classified stream segments containing substantive aquatic habitats during the assessment period of interest. These habitats may include isolated pools, continuously wetted (but non-flowing) reaches, or continuously flowing reaches.

Based on a combined desk and field reconnaissance, the target sampling population during the summers of 2006 and 2007 was estimated at 18,679 stream miles or approximately 67% of the total classified stream mileage. This extent was assessed for recreational and aquatic life uses using chemical and biological data from 92 monitoring sites. As discussed previously, the food procurement use was assessed using fish tissue contaminant data from only 15 sites, which effectively reduced the level of confidence in the reported results. Table 11summarizes the overall use support findings for streams in Kansas. Table 12 outlines the probabilistic sampling design.

Table 11. Overall use support for streams (in miles)

Water Body Type	Extent Supporting All Designated (§101(a)) Uses	Extent Failing to Support One or More Designated (§101(a)) Uses	Total Targeted Extent	Total Assessed Extent
Streams (targeted population only)	6,903 ± 1,498*	11,776 ± 1,498*	18,679	18,679

*95% confidence intervals derived using local variance estimator (Stevens and Olsen, 2003)

Table 12. Probabilistic stream assessment fact sheet

EPA Project ID	KSR-06950
Project Name	Kansas stream probabilistic monitoring program
Type of Water Body	Stream or river
Units of Measurement	Miles
Size of Target Population	18,679 miles
Designated Uses	Aquatic life, contact recreation, and food procurement*
Percent attaining	37% (29-45%)
Percent not attaining	63% (55-71%)
Percent nonresponse	0%
Indicators	Macroinvertebrate community assessments, water chemistry analyses, fish tissue contaminant analyses, *E. coli* measurements
Assessment Date	20080318
Precision	95%

*Food procurement was designated for only 74% of the target population, so the assessment mileage for this use was 13,807 miles

Stream Use Support in Relation to Individual Designated Uses

Those uses of surface water recognized in section 101(a) of the CWA correspond to the following three uses in Kansas: aquatic life support, contact recreation, and (human) food procurement (KDHE, 2004). The first two uses apply in some form to virtually all streams listed in the KSWR. Contrastingly, the food procurement use is assigned only to a portion (61%) of the state's classified stream mileage. The Kansas surface water quality standards recognize

additional uses of surface water, but these uses are associated with a smaller percentage of the state's classified streams and are not considered in this probabilistic assessment (Table 13).

Table 13. Allocation of designated uses among classified streams in Kansas

Designated Use	Proportion of Total Stream Mileage Designated for Specified Use*
Aquatic life support (any category)	100%
Contact recreation (any category)	100%
Food procurement	61%
Groundwater recharge	40%
Drinking water	40%
Livestock watering	39%
Industrial water supply	38%
Irrigation	35%

* relative to the entire KSWR extent of 27,816 miles

Table 14 presents use support findings for individual section 101(a) uses (aquatic life support, contact recreation, and food procurement). The indicated 95% confidence intervals were derived using a local variance estimator approach (Stevens and Olsen, 2003). The relatively large confidence intervals associated with food procurement reflect the small number of probabilistic sites with reported data for fish tissue chemistry (attributable to delays in laboratory analysis and a lack of reported results for 2007). Future 305(b) assessments will include at least three years of fish tissue chemistry data and should yield much smaller confidence intervals for the food procurement use.

Table 14. Support of individual designated uses in Kansas streams (in miles**)**

Designated §101(a) Use	Total Targeted Extent	Total Assessed Extent	Extent Supporting Indicated Use*	Extent Failing to Support Indicated Use*	Extent with Insufficient Data
Aquatic Life	18,679	18,679	8,121 ± 1,418	10,558 ± 1,418	0
Contact Recreation	18,679	18,679	16,582 ± 971	1,827 ± 971	0
Food Procurement	13,806	13,806	11, 045 ± 2,320	2,761 ± 2,320	0

* 95% confidence intervals derived using local variance estimator approach (Stevens and Olsen, 2003)

Causes and Sources of Stream Impairment

Causes and sources of non-support were identified for each probabilistic monitoring site exhibiting water quality impairments. Published and unpublished water quality studies, and geographical coverages identifying point and nonpoint sources of pollution, were considered during this phase of the probabilistic assessment. Findings were extrapolated to the overall population of streams targeted during the 2006–2007 assessment period. Because multiple causes and sources of impairment were associated with some individual monitoring sites, the

stream mileage affected by all causes and sources was not amenable to meaningful summation (Tables 15 and 16).

Table 15. Major causes of water quality impairments in Kansas streams

Cause/Impairment Category	Impaired Mileage
Nutrient enrichment	14,492
Natural climatic conditions	
Low flow regime	11,272
High flow regime	1,932
Sedimentation/siltation	9,017
Escherichia coli	2,898
Hydrological modification	
Direct habitat alterations	966
Altered depth and velocity patterns	1,288
Mercury in fish tissue	966

Table 16. Major sources of water quality impairments in Kansas streams

Source Category	Impaired Mileage
Agriculture	
General agriculture	10,950
Crop production	2,898
Unrestricted cattle access	1,288
Livestock grazing or feeding	966
Weather related natural phenomena	
Drought-related impacts	11,272
Major flooding	1,932
Urbanization	
High density urban area	1,288
Municipal point source	966
Rural residential area	644
Hydrological modification	
Impacts from hydrologic flow regulation	1,288
Channelization	966
Low water crossing	322
Atmospheric deposition – toxins	966
Impacts from abandoned mine lands	322

Major causes of non-support for streams, in order of prevalence, were nutrient enrichment, natural climatic impacts, sedimentation, elevated *E. coli* concentrations, and hydrological modifications. Sources primarily responsible for pollutant loadings and/or use impairments included agriculture (irrigated and nonirrigated crop production, livestock grazing and feeding operations, unrestricted cattle access), natural phenomena (e.g., weather related impacts), and physical habitat degradation.

Sampling activities during 2006 coincided with one of the worst droughts on record for Kansas. From 2000 to 2006, annual average flows in the Republican River, Smoky Hill River, Solomon River, upper Kansas River, and upper Arkansas River, as well as in many tributaries, were lower than the flows reported during all previously recorded droughts (e.g., 1929–1941; 1952–1957) (http://ks.water.usgs.gov/Kansas/waterwatch/drought/drought-comparison.rev.htm). The recent drought ended in southeastern Kansas during the summer of 2007, when counties in that portion of the state received nearly 20 inches of rain between June 26 and June 30. These rains resulted in major floods that effectively scoured many larger water bodies. That also let to sustained high stream flows during much of the summer. The combined effects of these dramatic weather-related events clearly contributed to many of the stream impairments documented during 2006 and 2007.

Targeted Lake Assessment

Table 17 summarizes the overall use support ratings for lakes assessed during this 305(b) reporting cycle. Approximately 93% of the assessed lake acres were monitored for "toxics" such as heavy metals and pesticides as well as other inorganic and biological parameters common to KDHE lake surveys (Appendix A). About 14% of the monitored lake acres exhibited some level of impairment from heavy metals and/or pesticides.

Table 17. Summary of fully supporting, threatened, and impaired lakes (in acres)

Degree of Use Support	Assessment Category		Total Assessed
	Evaluated	Monitored	
Insufficient Data	1,834	0	1,834
Fully Supporting of All Uses	1,547	30,760	32,307
Threatened for One or More Uses (But Not Impaired for Any Uses)	83	1,418	1,501
Impaired for One or More Uses	10,792	144,548	155,340
Total Size Assessed	14,256	176,726	190,982

Table 18 partitions the above findings by individual use category. Table 19 presents information on the direct and indirect causes of water quality impairment documented during this reporting cycle. Table 20 presents similar information with respect to sources of impairments.

For the most part, the reported results were very similar to those presented in past 305(b) reports. Nutrient- and eutrophication-related impacts dominated the list of water quality problems, with agriculture, urban runoff, natural sources, and point source nutrient loads being the most dominant sources. Natural sources included climate and weather driven impacts (e.g., water depletion and shallow thermal stratification), and high salinity and fluoride concentrations in some water bodies. Natural sources accounted for virtually none of the observed nutrient- and eutrophication-related impacts or heavy metal-related impacts.

Table 18. Individual use summary for lakes (in acres**)**

	Goals Use	Size Assessed	Fully Supporting	Full Support but Threatened	Partially Supporting	Non Supporting	Insufficient Data
Protect and Enhance Ecosystems	Aquatic Life (acute criteria)	190,982	108,824	4,270	71,592	4,462	1,834
Protect and Enhance Public Health	Fish Consumption +	190,982	187,639	0	948	641	1,754
	Shellfishing	*	*	*	*	*	*
	Primary Contact	190,853	47,666	8,413	128,877	4,087	1,810
	Secondary Contact	190,982	138,286	4,484	42,769	3,609	1,834
	Domestic Water Supply	185,866	36,562	4,233	94,864	49,183	1,024
Social and Economic Enhancement	Irrigation	183,878	146,739	13,869	14,455	7,835	980
	Livestock Water Supply	184,133	151,327	13,876	14,425	3,525	980
	Cultural	*	*	*	*	*	*

* = Category not applicable.

+ = Based on food procurement criteria for water as well as fish tissue analysis. During 2004–2006, 20 lakes, comprising 80,459 acres, were assessed for fish tissue contaminants (heavy metals, PCBs, and pesticides).

Table 19. Lake acreage impacted by various cause categories

Cause Category	Acres by Contribution to Impairment	
	Major	Moderate/Minor
Pesticides (atrazine)	112	4,623
Heavy Metals (arsenic)	0	9,365
Heavy Metals (copper)	0	396
Heavy Metals (lead)	0	1,469
Heavy Metals (selenium)	0	8,611
Heavy Metals (mercury)	0	781
Fluoride	41	5,440
Boron	30	0
Nutrients and Eutrophication	26,054	142,306
pH (high)	205	1,067
pH (low)	0	10
Siltation and Turbidity	42,739	16,687
Low Dissolved Oxygen	0	15,117
Chloride	0	15,985
Sulfate	649	37,337
Flow Alterations	633	3,666
Pathogen Indicators	0	0
Taste and Odor	29,244	0
Aquatic Plants	259	138
Zebra Mussels	30,870	0
Perchlorate	128	0

Table 20. Lake acreage impacted by various source categories

Source Category	Contribution to Impairment	
	Major	Moderate/Minor
Municipal Point Sources	25,600	122,141
Agriculture	33,991	105,642
Urban	426	12,237
Resource Extraction	0	1,037
Hydromodification	3,533	7,213
Atmospheric Deposition	0	781
Natural Sources	554	36,856
In-Lake Management	254	45
Resuspension	9665	0
Introductions of Non-Native Organisms	30,870	0

However, this reporting cycle did document a new and potentially significant environmental concern related to the establishment of zebra mussel (*Dreissena polymorpha*) populations in at least four major lakes in Kansas. As stated previously, these exotic bivalves have the capacity to

injure native fish and shellfish populations and reduce the fitness of surface waters for recreational and water supply uses (KDWP, 2005)

Acid Effects on Lakes

Approximately 189,000 acres of lakes in Kansas were monitored or evaluated for pH. This accounted for 99% of the lake acreage considered in this integrated report. Recorded water quality impacts were related almost entirely to high pH values, occurring when lakes were over-enriched with nutrients and suffered from accelerated eutrophication rates and advanced trophic conditions.

During this reporting cycle, only one lake exhibited an epilimnetic pH below 6.5 units. This lake was located in the Mined Land Lakes Recreational Area of southeastern Kansas and was formed in a basin created by a former strip mine. Many decades have passed since this area was actively mined for coal. Although some lakes in the region have been treated sporadically with lime to prevent low pH problems, anecdotal accounts suggest that a few privately owned strip pit lakes continue to exhibit low pH.

In Kansas, the lack of widespread acidification problems is attributable largely to the region's modest level of industrialization, relatively good air quality, and prevailing limestone geology. With respect to the latter factor, much of this region is underlain with calcareous bedrock and contains soils derived from the weathering of this bedrock. Therefore, the state has some natural defense against the atmospheric deposition of acids and acid precursors.

Trends in Lake Water Quality

Trends in water quality are difficult to determine for individual lakes in Kansas, owing primarily to a traditional emphasis on the performance of statewide assessments rather than intensive, site-specific studies. Lake trophic status appears to provide the best long-term indicator of water quality and has been used by KDHE for 305(b) assessment purposes for many years. For the purposes of this report, trend analyses for individual lakes were performed only if the water bodies had undergone three or more trophic state assessments since the inception of the lake and wetland monitoring program. These analyses involved the following considerations:

(1) If there was an evident increase in trophic state over time, the lake was assigned to the "improving" category.

(2) If there was an evident decrease in trophic state over time, the lake was assigned to the "degrading" category.

(3) Lakes were assigned to the "stable" category if assessments changed little over time, or if they fluctuated widely, preventing the detection or confirmation of any trend.

(4) Lakes were assigned to the "unknown" category if they had little or no historical data or if fewer than three trophic state assessments had been performed during the monitoring period-of-record.

Table 21 summarizes the trophic condition of lakes assessed during the most recent 305(b) reporting cycle. Table 22 summarizes the results of the trend analyses performed for lakes with sufficient monitoring data.

Table 21. Trophic status of lakes assessed during this reporting cycle

Trophic Status	Number of Lakes		Acreage of Lakes	
	Count	% Total	Acres	% Total
Argillotrophic	13	4.0	41,814	21.9
Oligomesotrophic	13	4.0	450	0.2
Mesotrophic	36	11.2	12,071	6.3
Slightly Eutrophic	47	14.6	43,793	22.9
Eutrophic	65	20.2	73,560	38.5
Very Eutrophic	39	12.1	13,568	7.1
Low Hypereutrophic	17	5.3	283	0.1
High Hypereutrophic	66	20.5	3,096	1.6
Dystrophic	0	0	0	0
Unknown	26	8.1	2,347	1.2
Totals	322	100.0	190,982	100.0

Table 22. Trophic state trends in lakes

Category	Number of Lakes		Acreage of Lakes	
	Count	% Total	Acres	% Total
Assessed for Trends	322	100.0	190,982	100.0
Improving	17	5.3	7,423	3.9
Stable	148	46.0	128,005	67.0
Degrading	38	11.8	49,903	26.1
Unknown	119	37.0	5,651	3.0

Targeted Wetlands Assessment

Extent of Wetland Resources

Dahl (1990) estimated that Kansas historically contained 841,000 acres of wetlands but had lost about half this acreage by 1980. Similarly, a study conducted by the U.S. Fish and Wildlife Service concluded that Kansas retained only 435,400 acres of wetlands as of 1980 (WRAP, 1992). The state's remaining wetlands generally fall into one of the following descriptive categories: palustrine freshwater marshes, palustrine saltwater marshes, riparian wetlands, playas, or wet meadows.

Approximately 56,000 acres of wetlands were assessed by KDHE during the most recent 305(b) reporting cycle. This total included all state and federally administered public wetland areas, plus several wetlands owned or managed at the local level. It did not include any privately owned water bodies, which account for a large share of the state's remaining wetland resources.

Integrity of Wetland Resources

Of the 55,969 acres (36 wetlands) assessed during the most recent reporting cycle, 45,066 acres (81%; 8 wetlands) were monitored by KDHE and the condition of an additional 10,903 acres (19%; 28 wetlands) was evaluated by the department using available information. Aquatic life support and secondary contact recreation traditionally have comprised the major designated uses of wetlands in Kansas. These uses were applicable to all wetlands monitored or evaluated by KDHE during the 2002–2006 reporting period.

Only about 103 acres of wetlands were deemed fully supportive of the aquatic life support use. In contrast, 6,035 acres were judged partially supportive and 40,749 acres were judged non-supportive of this use. The condition of an additional 9,082 acres was considered "unknown" owing to insufficient data. In most cases, this categorical assignment was associated with a lack of standing water when the field surveys were conducted by KDHE.

Water quality conditions were deemed fully supportive of secondary contact recreation in 104 wetland acres, partially supportive in 6,034 acres, and non-supportive in 40,749 acres. Conditions were fully supportive of food procurement in 43,592 acres and partially supportive in 3,295 acres. No assessed acreage was considered non-supportive of the food procurement use.

The primary causes of wetland impairment were nutrient enrichment and extreme trophic state, high turbidity levels, high pH levels, hydrological modifications, drought, and elevated selenium levels. The major sources of these impairments were agricultural runoff, hydrologic modifications, and natural processes related to drought.

Approximately 74.8% of the assessed wetland acreage was categorized as hypereutrophic, 0.8% as slightly-to-very eutrophic, 0.1% as mesotrophic, and 8.2% as argillotrophic. The remaining acreage (16.2%) was not assigned to a trophic category owing to insufficient data. With respect to trends in trophic condition, approximately 52% of the assessed acreage was characterized as stable over time, 27% as degrading over time, and 4% as improving over time. Trends for the remaining acreage (17%) could not be determined owing to insufficient data.

Development of Wetland Water Quality Standards

Wetlands are classified as "waters of the state" in the Kansas surface water quality standards. UAAs have been completed for all classified (publicly owned and/or publicly accessible) wetlands, and the results have been (or will be) incorporated into the KSWR. Classified wetlands and classified lakes receive identical protection under the standards' narrative and numeric water quality criteria, antidegradation provisions, and related implementation procedures. Although EPA has proposed wetland-specific biocriteria, the development of definitive biocriteria is not feasible at this time.

Additional Wetland Protection Activities

Wetland protection responsibilities are distributed among several agencies in Kansas. KDHE, KDWP, the Kansas Department of Agriculture, and the U.S. Army Corps of Engineers (ACOE) all have involvement in wetland protection and regulation. Kansas statutes direct KDHE and seven other state agencies to review proposed wetland development projects for possible environmental effects (K.S.A. 82a-325 *et seq.*).

In general, any agency, company, or person planning to physically alter a regulatory wetland must first file a section 404 (dredge and fill) permit application with ACOE. These applications are routed to KDHE for section 401 water quality certification purposes. The department determines the likely impact of the proposed action on water quality, then approves the action, approves it with modifications, or denies the action based on the projected impacts.

Another recent and noteworthy activity in Kansas has been the description of reference conditions for lakes and wetlands. Data from "minimally impacted" or "least impacted" waters have been used to define conditions that likely would occur in similar water bodies in the absence of substantive human perturbations. Reference determinations provide a valuable tool for establishing water quality restoration goals.

Using water quality data collected since the 1970s, the following general conclusions have been reached with respect to reference conditions in Kansas. Lakes with minimal pollutant loads can be expected to exhibit mesotrophic to slightly eutrophic conditions, low total nutrient concentrations, and high water clarity (Dodds *et al*., 2006). Wetlands can be expected to exhibit a trophic state in the low-to-mid eutrophic range, with low-to-moderate nutrient concentrations (KDHE, 2002).

303(d) Assessment Results

The Kansas 2008 303(d) list identifies 492 water quality impairments requiring the development of TMDLs. The complete list is included in Appendix B. This list can also be accessed by the public via the web at (http://www.kdheks.gov/tmdl/methodology.htm).

PART D. GROUNDWATER

Kansas no longer maintains a statewide groundwater quality monitoring program, and funding for the renewal of such an enterprise appears unlikely in the near future. However, an earlier monitoring program (suspended in 2002 owing to budgetary constraints) evaluated groundwater quality at more than 200 sites in Kansas. Individual wells in the monitoring network were sampled on a two-year rotational basis, with approximately half the wells being sampled in any given year. All wells in the network adhered to specific siting, depth, and construction criteria, and the network as a whole was deemed representative of the state's major aquifer systems. The program's surviving electronic database contains roughly 150,000 records spanning 120 different physical, chemical, and radiological parameters and 327 groundwater quality monitoring locations. Additional background information is presented in the program's QAPP and accompanying set of SOPs, last revised in December 2000 (KDHE, 2000).

Some groundwater quality data continues to be gathered by KDHE through the efforts of its major regulatory bureaus. For example, the Bureau of Environmental Remediation staff routinely samples groundwater from the vicinity of nearly 200 abandoned landfills and groundwater remedial sites, 1,500 storage tank cleanup sites, and a few active surface mining operations. The Bureau of Waste Management obtains groundwater quality information from a few dozen active landfills and hazardous waste sites across the state. BOW requires a number of major NPDES permit holders to periodically submit data on groundwater quality; examples include larger confined animal feeding operations, certain industrial operations (*e.g.*, meat processing facilities, power plants, injection wells), and a few municipal WWTFs. All of these monitoring activities focus on surficial groundwater and/or a very limited set of analytical parameters. Although public drinking water supplies are monitored for a wide range of parameters pursuant to the federal Safe Drinking Water Act, samples are collected after treatment and do not reliably reflect the condition of the raw water source. These assorted monitoring operations are not intended to provide representative information on the state's major aquifer systems or to serve as a coordinated and comprehensive ambient groundwater quality monitoring program.

Summary tables have been provided as follows:

Table 23. Summary of state groundwater protection programs
Table 24. Major sources of groundwater contamination
Table 25. Groundwater contamination: statewide cumulative summary

Table 23. Summary of state groundwater protection programs

Programs or Activities	Check (X)	Implementation Status	Responsible State Agency
Active SARA Title III program	X	fully established	KDHE*
Ambient groundwater monitoring		(suspended)	(KDHE)
Aquifer vulnerability assessment	X	on going	KDHE*
Aquifer mapping	X	fully established	KGS
Aquifer characterization	X	on going	KGS
Comprehensive data management	X	on going	KDHE
EPA-endorsed Core Comprehensive State Groundwater Protection Program	X	under review	KDHE
Groundwater discharge permits	X	fully established	KDHE
Groundwater Best Management Practices	X	fully established	KDHE
Interagency coordination for groundwater protection initiatives	X	on going	KWO
NPS controls	X	fully established	KDHE*
Pesticide State Management Plan	X	EPA approved plan implementation proceeding	KDA
Pollution Prevention Program	X	fully established	KDHE
RCRA Primacy	X	fully established	KDHE
Source Water Assessment Program (SWAP)	X	fully established	KDHE
State Water Plan Orphan Sites (State Superfund)	X	fully established	KDHE
State RCRA with more stringent requirements than RCRA Primacy	X	fully established	KDHE
State septic system regulations	X	fully established	KDHE
Underground Storage Tank (UST) installation requirements	X	fully established	KDHE
UST Remediation Fund	X	fully established	KDHE
UST Permit Program	X	fully established	KDHE
Underground Hydrocarbon Storage Well Program	X	fully established	KDHE
Underground Injection Control Program	X	fully established	KCC & KDHE
Vulnerability assessment for drinking water/wellhead protection	X	EPA approved plan implementation proceeding	KDHE
Well abandonment regulations	X	fully established	KDHE
Wellhead Protection Program	X	approved plan implementation proceeding	KDHE
Well installation regulations	X	fully established	KDHE

*principal administrative agency
KCC = Kansas Corporation Commission
KDAK – Kansas Department of Agriculture
KGS – Kansas Geological Survey
KWO – Kansas Water Office

Table 24. Major sources of groundwater contamination

Ten Highest Priority Contaminant Sources	Factors Considered in Selecting a Contaminant Source	Types of Contaminants
Agricultural Activities: Ag. chemical facilities/applications	A,C,D	B,C,E
Animal feedlots	A,C,D,E	E,J
Storage and Treatment: Storage tanks (AST/LUST)	A,B,C,D	D
Surface impoundments	A,E	E,J
Disposal Activities: Landfills/illegal dumping	A,C,E	H
Other: Active/abandoned industrial facilities	A,B,C	C,D,H
Oil and gas activities	A,B,C,D	D,G
Pipelines and sewer lines	A,E	D,E
Salt water intrusion	B,C,E	G
Spills	A,D	C,D

Factors Considered in Selecting a Contaminant Source:
(A) Human health and/or environmental risk (toxicity)
(B) Size of population at risk
(C) Location of sources relative to drinking water sources
(D) Number and/or size of contaminant sources
(E) Hydrogeologic sensitivity

Types of Contaminants:

(A) Inorganic pesticides	(G) Salinity/brine
(B) Organic pesticides	(H) Metals
(C) Halogenated solvents	(I) Radionuclides
(D) Petroleum compounds	(J) Bacteria
(E) Nitrate	(K) Protozoa
(F) Fluoride	(L) Viruses

Table 25. Groundwater contamination: statewide cumulative summary through December 31, 2007

Source Type	# of Kansas Sites	# of Sites with Confirmed Releases	# with Confirmed Groundwater Contamination	Primary Contaminants	# of Site Assess-ments	# of Sites with Source Removed	# of Sites with CAPs	# of Sites with Active Remediation	# of Sites with Cleanup Resolved
NPL	13	13	13	VOCs, metals	13	unavailable	0	8	4
CERCLIS (non-NPL)	86	86	11	VOCs, metals & PCBs	86	unavailable	1	66	56
DOD/FUDS	375	375	108	VOCs, metals, refined petroleum	375	unavailable	0	78	63
LUST	10,349	4,839	4,113	gasoline and diesel fuels	10,349	unavailable	not applicable	376	8,350
RCRA Corrective Action	34	34	34	VOCs, metals & semi-volatiles					
Solid Waste Landfills	167	26	26	VOCs	165	not applicable	5	5	0
Underground Injection *	32	0	0	-	0	0	0	0	0
Underground Hydrocarbon Storage Wells	10	0	0	-	0	0	0	0	465
State Sites **	1,697	1,697	909	VOCs, metals, refined petroleum	1,697	unavailable	36	515	531
NPS	unknown								

CAPs - Corrective Action Plans
CERCLIS - Comprehensive Environmental Response, Compensation, and Liability Information System (Includes non-NPL Management Assistance (CERCLA Lead and Supefund sites)
DOD/FUDS - Department of Defense/Formerly Used Defense Sites
LUST - Leaking Underground Storage Tanks
NPL - National Priority List NPS - Nonpoint Source RCRA - Resource Conservation and Recovery Act*
* Represents Class I and III injection wells and hydrocarbon storage sites, but does not include Class II brine injection wells.
** Numbers do not include sites under KCC jurisdiction or LUST sites.

PART E. PUBLIC PARTICIPATION

As required by federal regulation and the Kansas Continuing Planning Process, the Kansas 2008 303(d) list and its associated methodology were subjected to public review and comment through a variety of venues. Formal public notice was provided in the Kansas Register on February 7, 14, and 21, 2008. This notice included a link to the complete 303(d) list and a full description of the accompanying methodology on KDHE's TMDL website. Public hearings were held on February 20, 2008, in Hays and February 26, 2008, in Topeka. The public comment period extended through March 7, 2008. Ten individuals attended the Hays hearing, and seven attended the Topeka hearing.

The public provided no formal comments with respect to the proposed 303(d) list. However, one comment letter was received from EPA Region VII. This letter noted the use of screening values for assessing and listing total phosphorus and total suspended solids in streams, but warned that such screening values could not be construed as applicable or appropriate water quality criteria for either pollutant. The letter also outlined the elements comprising a complete submittal of the 2008 integrated report to EPA. The stated elements included a description of the required data, documentation, methodologies, priorities, and schedules, as well as an accompanying certification from the Kansas Attorney General.

In response, KDHE concurred with the use of the screening values for listing purposes only and clarified it did not purport them to be water quality criteria. KDHE generally agreed with EPA's interpretation of the elements comprising an integrated report submittal package. However, the department disagreed with the need for a certification from the Kansas Attorney General. Such a requirement is not set forth in any federal or Kansas statute, rule, or regulation, and KDHE elected not to seek a certification from the Kansas Attorney General. Although a certification requirement does exist for revisions to surface water quality standards, the integrated report and accompanying 303(d) list do not rise to the same level of regulation and are not subject to review by other Kansas authorities.

KDHE also briefed basin advisory committees (BACs) in the Smoky Hill/Saline, Solomon, Upper Republican, and Kansas/Lower Republican river basins. BACs are composed of individuals within the basins that have an interest in water resources and represent various uses of water, such as public water supply, irrigation, or recreation. BACs are the primary local forum for water planning and policy in Kansas, pursuant to the Kansas Water Planning Process. Traditionally, KDHE has called upon the BACs to help establish priorities in the 303(d) listing/TMDL implementation process. Recent discussions with the BACs led to the assignment of a "high" priority to TMDLs addressing total phosphorus impairments in Prairie Dog and Sappa creeks in the Upper Republican River Basin. Otherwise, the BACs agreed with the identified Category 5 waters and their designated priorities.

KDHE also briefed several WRAPS groups representing the river basins coming into rotation during 2008-2010. As described previously, these groups work with the State to plan and implement watershed management projects to improve surface water quality. The WRAPS groups briefed by KDHE included the Upper/Middle Kansas, Lower Kansas, Solomon, Big Creek/Middle Smoky Hill, and Prairie Dog Creek groups. Only one change stemmed from these

discussions: biological impairments documented in Vermillion Creek (within the Middle Kansas WRAPS jurisdictional area) were assigned an upgraded (high) priority for TMDL development.

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APPENDIX A.

List of Parameters.

Stream Chemistry Monitoring Program

Core Composite and Inorganic Parameters

Alkalinity, total (as $CaCO_3$)	Dissolved oxygen	Potassium, total recoverable
Aluminum, total recoverable	Fluoride	Selenium, total recoverable
Ammonia, total (as N)	Hardness, total (as $CaCO_3$)	Silica, total recoverable
Antimony, total recoverable	Iron, total recoverable	Silver, total recoverable
Arsenic, total recoverable	Kjeldahl nitrogen	Sodium, total recoverable
Barium, total recoverable	Lead, total recoverable	Specific conductance
Beryllium, total recoverable	Magnesium, total recoverable	Strontium, total recoverable
Boron, total recoverable	Manganese, total recoverable	Sulfate
Bromide	Mercury, total	Thallium, total recoverable
Cadmium, total recoverable	Molybdenum, total recoverable	Total dissolved solids (calculated)
Calcium, total recoverable	Nickel, total recoverable	Total suspended solids
Carbon, total organic	Nitrate (as N)	Turbidity
Chloride	Nitrite (as N)	Vanadium, total recoverable
Chromium, total recoverable	pH (field)	Zinc, total recoverable
Cobalt, total recoverable	Phosphate, ortho- (as P)	Temperature (field)
Copper, total recoverable	Phosphorus, total (as P)	

Core Organic Parameters

Acetochlor	p,p'-DDD	Metribuzin (Sencor)
Alachlor	p,p'-DDE	PCB-1016
Aldrin	p,p'-DDT	PCB-1221
Atrazine (Aatrex)	Dieldrin	PCB-1232
alpha-BCH	Endosulfan I	PCB-1242
beta-BCH	Endosulfan II	PCB-1248
delta-BCH	Endosulfan sulfate	PCB-1254
gamma-BCH (Lindane)	Endrin	Picloram (Tordon)
Butachlor	Heptachlor	Propachlor (Ramrod)
Carbofuran (Furadan)	Heptachlor epoxide	Propazine (Milogard)
Chlordane	Hexachlorobenze	Simazine
Cyanazine (Bladex)	Hexachlorocyclopentadiene	2,4,5-T as acid
2-4-D as acid	Methoxychlor	2,4,5-TP as acid (Silvex)
DCPA (Dacthal)	Metolachlor (Dual)	Toxaphene

Stream Chemistry Monitoring Program - continued

Supplemental Organic Parameters

Bromacil
Chlorophyll-a
Chlorpyrifos (Dursban)
Deethylatrazine
Deisoproplyatrazine
Diazinon
Pentachlorophenol
Pheophytin-a
Prometon (Pramitol)

Core Microbiological Parameters

Escherichia coli (*E. coli*)

Supplemental Radiological Parameters

Actinium-228
Antiomony-125
Barium-140
Beryllium-7
Cerium-141
Cerium-144
Cesium-134
Cesium-136
Chromium-51
Cobalt-57
Cobalt-58
Gallium-67
Gross alpha
Gross beta
Gross uranium
Indium-111
Iodine-123
Iodine-131
Iodine-132
Iodine-133
Iron-59
Lanthanum-140
Manganese-54
Molybdenum-99
Neodymium-147
Neptunium-239
Niobium-95
Potassium-40
Radium-226
Ruthenium-103
Ruthenium-106
Silver-110m
Strontium-89
Strontium-90
Technetium-99m
Thorium-228
Total Solid
Tritium
Ytterbium-169
Zinc-65
Zirconium-95

Field Measurements

pH
Temperature

Lake Monitoring Program

Core Composite and Routine Inorganic Parameters

Alkalinity, total (as $CaCO_3$)
Aluminum, total recoverable
Ammonia, total (as N)
Antimony, total recoverable
Arsenic, total recoverable
Barium, total recoverable
Beryllium, total recoverable
Boron, total recoverable
Bromide
Cadmium, total recoverable
Calcium, total recoverable
Carbon, total organic
Chloride
Chromium, total recoverable
Cobalt, total recoverable
Copper, total recoverable
Dissolved oxygen
Fluoride
Hardness, total (as $CaCO_3$)
Iron, total recoverable
Kjeldahl nitrogen
Lead, total recoverable
Magnesium, total recoverable
Manganese, total recoverable
Mercury, total
Molybdenum, total recoverable
Nickel, total recoverable
Nitrate (as N)
Nitrite (as N)
pH (field)
Phosphate, ortho- (as P)
Phosphorus, total (as P)
Potassium, total recoverable
Selenium, total recoverable
Silica, total recoverable
Silver, total recoverable
Sodium, total recoverable
Specific conductance
Strontium, total recoverable
Sulfate
Thallium, total recoverable
Total dissolved solids (calculated)
Total suspended solids
Turbidity
Vanadium, total recoverable
Zinc, total recoverable
Temperature (field)

Core Organic Parameters

2,4-D
2,4,5-T
Acetochlor
Alachlor
Aldrin
Atrazine
Butachlor
Carbofuran (Furadan)
Chlordane
Cyanazine (Bladex)
DCPA (Dacthal)
p,p'-DDD
p,p'-DDE
p,p'-DDT
Deethylatrazine
(breakdown product)
Deisopropylatrazine
(breakdown product)
Dieldrin
Endosulfan I & II
Endosulfan sulfate
Endrin
Alpha BHC
Beta BHC
Gamma BHC (Lindane)
Delta BHC
Heptachlor
Heptachlor epoxide
Hexachlorobenzene
Hexachlorocyclopentadiene
Methoxychlor
Metolachlor (Dual)
Metribuzin (Sencor)
PCB-1016
PCB-1221
PCB-1232
PCB-1242
PCB-1248
PCB-1254
PCB-1260
Picloram (Tordon)
Propachlor (Ramrod)
Propazine (Milogard)
Silvex (2,4,5-TP)
Simazine
Toxaphene

Lake Monitoring Program - continued

Core Microbiological Parameters

Escherichia coli (E. coli) bacteria

Miscellaneous Core Parameters

Algal taxonomy*
Chlorophyll-a
Dissolved oxygen
Macrophyte abundance*
Phaeophytin-a
Photosynthetically active radiation (PAR)*
Secchi depth*
Temperature
Total inorganic carbon (by calculation)

Miscellaneous Supplemental Parameters

Biological oxygen demand
Chemical oxygen demand
Zooplankton taxonomy*

*not a chemical analyses

Fish Tissue Monitoring Program

Fillet Analysis

Core Inorganic Parameters
Cadmium
Lead
Mercury
Selenium

Core Organic Parameters
p,p'-DDD
p,p'-DDE
p,p'-DDT
Dieldrin
Heptachlor
Heptachlor epoxide
Hexachlorobenzene
gamma-Hexachlorocyclohexane (BHC)
PCB-1248
PCB-1254
PCB-1260
Pentachloroanisole
Technical Chlordane
- Oxychlordane
- cis-Chlordane
- trans-chlordane
- cis-Nonachlor
- trans-Nonachlor

Trifluralin (Treflan)

Wholefish Analysis

Core Inorganic Parameters
Cadmium
Lead
Mercury
Selenium

Core Organic Parameters
1,2,4,5 -Tetrachlorobenzene
p,p'-DDD
p,p'-DDE
p,p'-DDT
Dieldrin
Heptachlor
Heptachlor epoxide
Hexachlorobenzene
gamma-Hexachlorocyclohexane (BHC)
Mirex
PCB-1248
PCB-1254
PCB-1260
Pentachloroanisole
Pentachlorobenzene
Technical Chlordane
Trifluralin (Treflan)

APPENDIX B.

2008 303(d) List of Impaired Waters

The list can be accessed by the public via the web at (http://www.kdheks.gov/tmdl/methodology.htm).

APPENDIX C.

Kansas 2008 CWA Section 314(a) Report

Summary

This document satisfies various water quality reporting requirements placed on the State of Kansas by section 314(a) of the federal Clean Water Act (CWA). Specifically, it addresses the contemporary status of publicly owned lakes within the state, evaluates historical trends in water quality, and identifies water pollution control measures and lake restoration programs currently being implemented in Kansas. Section 314(a) also requires the development of a list of lakes known to suffer from water quality impairments. This list is provided in the preceding appendix (Appendix B).

Table C.1 summarizes the results of aquatic life use support (ALUS) assessments performed on lakes by the Kansas Department of Health and Environment (KDHE). Contemporary water quality conditions were assessed using water chemistry and biological data obtained during the summers of 2002-2007. Historical trends in water quality were assessed using biological data extending further back in time, in many instances to the mid 1980s.

Table C.1. ALUS assessment results for lakes in Kansas

Degree of Support	Acres Assessed Using Biological Habitat Data Only	Acres Assessed Using Physico-Chemical Data Only	Acres Accessed Using Biological and Physico-Chemical Data	Total Acres Assessed for ALUS
Insufficient Data	0	0	0	1,834
Fully Supportive	0	0	108,824	108,824
Fully Supportive but Threatened	0	0	4,270	4,270
Partially Supportive	0	0	71,592	71,592
Nonsupportive	0	0	4,462	4,462

Table C.2 presents information on the total number and acreage of lakes impacted by identifiable sources of pollution, and on the total number and acreage of lakes lacking identified use impairments. Most of the state's smaller lakes exhibit impairments related to nonpoint sources, whereas many larger lakes are impacted by a combination of point and nonpoint sources. The values given in Table C.2 represent any level of point source-related impairment and any magnitude and combination of nonpoint source-related impairment. Some lakes have both source types within their watersheds, preventing meaningful summation of the two numerical columns in the table.

Table C.2. Lakes impairments related to point sources and/or nonpoint sources

Pollution Source	Lake Number	Lake Acreage
Point Sources	25	147,741
Nonpoint Sources	262	157,174
None Identified	60	33,808

Background

A total of 322 classified (publicly owned or publicly accessible) lakes were assessed by KDHE during this most recent 314(a) reporting cycle. This represented all lakes known to KDHE through previous monitoring activities or through the publications of other natural resource agencies, most notably the Kansas Department of Wildlife and Parks (KDWP) and the U.S. Army Corps of Engineers (ACOE). The assessed lakes comprised a total surface area of 190,982 acres at normal conservation pool levels. In Kansas, lakes with shorelines under common private ownership generally are considered private water bodies. Pursuant to the Kansas surface water quality standards, however, some may be listed as classified water bodies if they represent public drinking water supplies or are open to the general public for recreational use (KDHE, 2004).

In this report, all classified lakes, reservoirs, and ponds are regarded as significant public water bodies. This acknowledges that any standing (or "lentic") water body that is owned by, or accessible to, the general public will provide benefits to the general population (e.g., recreational and water supply benefits). Such water bodies also provide habitat for indigenous aquatic and semi-aquatic organisms, such as fish and migratory waterfowl. Except for wetlands, this report labels all lentic water bodies as "lakes" to avoid the semantics involved in distinguishing among naturally occurring lakes and artificially constructed reservoirs and ponds.

Trophic Status

Trophic state classifications for lakes in Kansas are based primarily on planktonic chlorophyll-a concentrations, corrected for phaeophytin-a and averaged over the entire monitoring period-of-record. This approach acknowledges that planktonic algal biomass forms the base of the typical lacustrine food web. Aquatic macrophytes and epiphytic algae also contribute to biological production but rarely comprise a large portion of the lacustrine food web base. Therefore, lake trophic state assignments in Kansas seldom require adjustment for macrophytic production and/or epiphytic algal production.

Mean chlorophyll-a concentration provides an excellent indicator of lake primary productivity and production. In addition, high algal biomass often can diminish a lake's aesthetic appeal, reduce its recreational value, increase the costs of producing potable water, and interfere with other water supply uses (e.g., irrigation and livestock watering). Accordingly, trophic state provides a useful indicator for assessing a lake's use support status.

In many Midwestern lakes, accelerating rates of sedimentation often accompany the eutrophication process. Available monitoring data allow for only a rough assessment of sedimentation impacts in Kansas. In most instances, water quality impacts related to sedimentation are inferred from shoreline weathering, influent stream observations, watershed land use configuration, and the general turbidity of the lake in question. If high turbidity seems to pose a chronic problem, trophic state may be assigned on the basis of nutrient concentrations and turbidity levels rather than chlorophyll-a concentrations.

For the purposes of this 314(a) assessment, mean chlorophyll-a values for a given lake have been converted to a corresponding trophic state class using the approach of Carlson (1977). This approach employs the following scale, where TSI refers to trophic state index (as determined by mean chlorophyll-a concentration):

Oligomesotrophic	TSI < 40
Mesotrophic	TSI 40 to 49.99
Eutrophic	TSI 50 to 63.99
Slightly Eutrophic	TSI 50 to 54.99
Fully Eutrophic (Eutrophic)	TSI 55 to 59.99
Very Eutrophic	TSI 60 to 63.99
Hypereutrophic	TSI >63.99
Lower Hypereutrophic	TSI 63.99 to 69.99
Upper Hypereutrophic	TSI >69.99

In addition, KDHE has applied two additional trophic state classes in this 314(a) assessment.

Argillotrophic	Water body is chronically light-limited and nutrient rich, resulting in artificially low algal biomass and chlorophyll-a concentrations.
Dystrophic	Water body is highly colored by humic/organic dissolved matter, potentially resulting in lower than expected chlorophyll-a concentrations. Dystrophic lakes are rare in Kansas.

The eutrophic class is divided into three sub-classes to better describe the expected levels of use impairment. The hypereutrophic class is divided into two sub-classes for the same reason. In distinguishing among the hypereutrophic sub-classes, blue-green algal (cyanophycean) dominance is considered by KDHE and ultimately factored into the use support assessments. Table C.3 summarizes the lake trophic state assignments made during this 314(a) reporting cycle.

Table C.3. Trophic status summary for lakes in Kansas

Trophic Status	Lake Number and Percentage		Lake Acreage and Percentage	
Argillotrophic	13	4.0%	41,814	21.9%
Oligomesotrophic	13	4.0%	450	0.2%
Mesotrophic	36	11.2%	12,071	6.3%
Slightly Eutrophic	47	14.6%	43,793	22.9%
Eutrophic	65	20.2%	73,560	38.5%
Very Eutrophic	39	12.1%	13,568	7.1%
Low Hypereutrophic	17	5.3%	283	0.1%
High Hypereutrophic	66	20.5%	3,096	1.6%
Dystrophic	0	0%	0	0%
Unknown	26	8.1%	2,347	1.2%
Totals	322	100.0%	190,982	100.0%

A majority of the assessed lakes fell into the slightly-to-fully eutrophic and upper hypereutrophic classes, whereas most lake acreage was assigned to the slightly-to-fully eutrophic and argillotrophic classes. These findings reflect the fact that most lakes in Kansas are relatively small and shallow and are impacted rather strongly by pollution sources (on a watershed acreage-to-lake acreage basis). Also, several large lakes in the state are located on rivers that import a great deal of eroded sediment. These lakes are chronically turbid and generally assigned to the argillotrophic class.

Owing to insufficient data, roughly 8% of the lakes assessed during the reporting cycle could not be assigned confidently to a particular trophic state class. These lakes comprised about 1% of the assessed lake acreage.

Pollution Control Methods

To prevent and reverse water pollution problems in lakes throughout Kansas, KDHE offers technical advice and limited technical support. The department also provides limited financial support in the form of section 319 grants. Most grants are awarded to promote public awareness and to implement watershed best management practices (BMPs).

The KDHE Bureau of Environmental Field Services (BEFS) has operated a technical assistance program for water supply lakes since 1989. To date, about 150 investigations have been undertaken by the bureau. Most have dealt with drinking water supply taste and odor problems, algal blooms, fish kills, or related public health concerns. Many of these investigations have involved the provision of taxonomic (algal identification) assistance to drinking water purveyors and lake managers.

BEFS also maintains a lake and wetland water quality monitoring program to help the State of Kansas meet various environmental surveillance and reporting requirements set forth in the CWA (e.g., sections 303(d), 305(b), 314(a)). This program has been in place since 1975 and provides a near-census of the state's classified lake acreage. Water quality data obtained through this program has supported the development of numerous water quality models of interest to lake managers. Moreover, these data have facilitated the tracking of long-term trends in water quality on a statewide basis.

Past lake restoration projects in Kansas depended primarily on Clean Lakes Program (CLP) awards from the U.S. Environmental Protection Agency (EPA). Responsibilities related to funding have been transferred effectively to the KDHE Bureau of Water (BOW), which maintains a nonpoint source pollution control program supported largely by section 319 grants from EPA. However, even with the availability of section 319 pass-through monies, lake restoration projects in the state have been reduced markedly in overall scope. In the past, cost-match requirements were imposed on communities, and this often reduced the level of interest in CLP projects. This problem is perhaps even more pronounced under the current, section 319-based funding approach.

BOW also provides guidelines for the construction of new water supply lakes in Kansas. Recommendations include: the use of fences to keep cattle at least 15 feet from the high water mark; a prohibition on the direct discharge of treated or untreated wastewater to any water supply lake; a prohibition on the placement of wastewater facilities, septic tanks, or sanitary sewers within 200 feet of the high water mark; and the assessment of the pollution potential of any watershed draining into a planned water supply lake. When reviewing NPDES discharge permits and setting effluent limits, a discharging facility's proximity to a water supply lake is considered carefully by BOW.

The Kansas Department of Wildlife and Parks (KDWP) also provides lake technical assistance to resource managers and interested citizens. Most of this agency's efforts are geared toward fisheries management rather than improvements in surface water quality. Some common fisheries practices (e.g., use of grass carp, *Ctenopharyngodon idella*, for plant control; use of mechanical devices to aerate or destratify lakes) can exacerbate existing water quality problems.

Lake Restoration and Rehabilitation Efforts

Several lake restoration techniques have been applied in Kansas, but the efficacy of most has not been documented carefully in the peer-reviewed scientific literature. Two common practices involve the use of copper sulphate for algal control and grass carp for macrophyte control. KDHE has tended to discourage both practices, as applied copper often accumulates in the bottom sediments posing long-term water quality concerns, and the feeding action of grass carp can reduce water clarity (through exposure of shallow sediment to wind and wave action) and increase algal abundance (through recycling of nutrients).

Established macrophyte beds are important for maintaining the health of lakes in Kansas. Fortunately, at least two aquatic herbicides registered for use in Kansas have selective control

capabilities for the nuisance exotic plant, Eurasian watermilfoil (*Myriophyllum spicatum*). As Eurasian watermilfoil continues to expand into lakes throughout Kansas, the use of these new herbicides (fluridone and triclopyr) may supplant grass carp as the preferred control technique.

KDWP also engages in lake restoration and rehabilitation, primarily for fisheries management purposes. For example, discarded Christmas trees are used to augment fish shelter in many lakes throughout the state, and water levels are manipulated to maximize fish spawning habitat and encourage waterfowl production. KDWP annually submits water level adjustment plans for the state's larger federal lakes to the Kansas Water Office. These plans are subject to public review and ultimately must be reviewed and approved by the ACOE.

Mechanical aeration is another widely applied lake restoration technique. Unfortunately, this technique usually is implemented without adequate study to determine whether water column aeration/mixing will positively impact water quality. KDHE strongly discourages the use of aerators unless (1) a properly conducted study has concluded that the action will improve water quality and (2) the condition being addressed cannot be resolved using other, less damaging restoration techniques.

Adherence to best management practices (BMPs) constitutes the most effective and efficient means of protecting and restoring lake water quality in Kansas. BMPs address a wide range of human activities, and many BMPs are applicable to both agricultural and urban settings. Some of the more important structural practices relate to the installation and maintenance of vegetated buffer strips along streams and shorelines, storm water runoff diversion and holding structures in some urban and concentrated livestock settings, sediment retention ponds above larger lakes, and treatment wetlands below urban areas and some agricultural operations. Non-structural BMPs often relate to improved grazing, cropping, and fertilizer and biocide application practices. Most structural BMPs are installed under the auspices of the Natural Resource Conservation Service (NRCS) and local conservation districts, often in cooperation with KDHE and/or KDWP.

NPDES permits for wastewater treatment facilities and confined animal feeding operations sometimes are modified by KDHE to protect and restore lake water quality. The existing and potential impact of these facilities/operations on downstream waters is considered during permit review and the accompanying public participation process.

Dredging is another option for restoring smaller lakes. Owing to funding constraints, however, comparatively few dredging projects have been attempted in the state. Such projects have become even less common since the mid 1990s, when Congress ceased funding the CLP. KDHE is aware of only two recent dredging projects in Kansas, one in Plainville Lake (Rooks County) and the other in Mission Lake (Brown County).

From approximately 1980–1997, when CLP funds were available for lake diagnostic studies and restoration projects, watershed restoration measures were implemented at the following Kansas lakes (total surface area = 1,367 acres):

Ford County Lake (Ford County)
Sabetha City Lake (Nemaha County)
Lake Afton (Sedgwick County)
Olathe Lake (Johnson County)
Chanute Santa Fe Lake (Neosho County)
Nemaha County State Fishing Lake (Nemaha County)
Herington Reservoir (Dickinson County)
Rimrock Lake (Riley County)
Mary's Lake (Douglas County)

Only Ford County Lake and Lone Star Lake were eventually dredged under the auspices of the CLP. These two lakes comprised 243 surface acres.

As mentioned previously, the BOW nonpoint source program provides pass-through funds to communities and other entities pursuant to section 319 of the CWA. Under this program, lake restoration initiatives in the state have focused primarily on watershed improvements (e.g., BMP implementation) rather than on dredging and other in-lake treatments.

Impaired and Threatened Lakes

Table C.4 summarizes the overall use support ratings for lakes assessed during this 314(a) reporting cycle. Table C.5 partitions these support ratings according to the individual designated uses. Fully 92.5% of reported lake acres were monitored for "toxics" such as heavy metals and pesticides as well as the other inorganic and biological parameters common to KDHE lake surveys. Of the 176,726 monitored lake acres, 25,357 acres (14.3%) showed some level of impairment from heavy metals and/or pesticides.

Table C.4. Summary of use support ratings for lakes in Kansas

Degree of Use Support	Assessment Category		Total Assessed Acreage
	Evaluated	Monitored	
Insufficient Data	1,834	0	1,834
Fully Supporting of All Uses	1,547	30,760	32,307
Threatened for One or More Uses (But Not Impaired for Any Uses)	83	1,418	1,501
Impaired for One or More Uses	10,792	144,548	155,340
Total Size Assessed	14,256	176,726	190,982

Table C.5. Support summary for individual uses in Kansas lakes (in acres)

Goals	Use	Size Assessed	Fully Supporting	Full Support but Threatened	Partially Supporting	Non Supporting	Insufficient Data
Protect and Enhance Ecosystems	Aquatic Life (acute criteria)	190,982	108,824	4,270	71,592	4,462	1,834
Protect and Enhance Public Health	Fish Consumption +	190,982	187,639	0	948	641	1,754
	Shellfishing	*	*	*	*	*	*
	Primary Contact	190,853	47,666	8,413	128,877	4,087	1,810
	Secondary Contact	190,982	138,286	4,484	42,769	3,609	1,834
	Domestic Water Supply	185,866	36,562	4,233	94,864	49,183	1,024
Social and Economic Enhancement	Irrigation	183,878	146,739	13,869	14,455	7,835	980
	Livestock Water Supply	184,133	151,327	13,876	14,425	3,525	980
	Cultural	*	*	*	*	*	*

* = Category not applicable.

+ = Based on food procurement criteria for water as well as fish tissue analysis. During the 2004-2006 time period, 20 lakes, comprising 80,459 acres, also were assessed for fish tissue burdens of heavy metals, PCBs, and pesticides.

Table C.6 summarizes the direct and indirect causes of water quality impairment documented during this reporting cycle. Table C.7 presents similar information regarding sources. Code numbers associated with causes and sources reflect the most applicable EPA Assessment Database (ADB) codes. In some cases, use of single code number was deemed inappropriate and several code numbers were entered as applicable causes or sources.

An attempt has been made during this reporting cycle to link causes and sources. Given the complex array of interactions within a watershed, and between the watershed and internal lake processes, these linkages should be viewed as very general. Linkages can reflect direct or indirect associations. For example, an indirect linkage may occur between high pH and agricultural land uses (high pH may result from high trophic state, which is driven by accelerated eutrophication, itself a manifestation of agricultural nutrient loads). A linked cause and source in Table C8 does not necessarily imply a single direct link in an ecological chain of events.

For the most part, the results of this assessment were very similar to the results presented in past 314(a) reports. Nutrient- and eutrophication-related impacts dominated the list of water quality problems, with agriculture, urban runoff, natural sources, and point source nutrient loads being the most dominant sources. Natural sources included climate and weather-related impacts (e.g., water depletion and shallow thermal stratification), naturally high salinity levels, and naturally elevated fluoride concentrations. Essentially none of the observed impacts resulting from nutrient enrichment/eutrophication or elevated heavy metal concentrations were attributable to natural sources.

However, this reporting cycle did document a new and potentially significant environmental concern related to the establishment of zebra mussel (*Dreissena polymorpha*) populations in at least four major lakes in Kansas. These exotic bivalves have the capacity to injure native fish and shellfish populations and to reduce the fitness of surface waters for recreational and drinking water uses (KDWP, 2005).

Table C.6. Lake acreage impacted by various cause categories

Cause Category (and Corresponding ADB Codes)	Impaired Lake Acreage	
	Major Impairment	Minor Impairment
Cause Unknown	0	0
Pesticides 99 (atrazine)	112	4,623
Heavy Metals 96 (arsenic)	0	9,365
Heavy Metals 163 (copper)	0	396
Heavy Metals 267 (lead)	0	1,469
Heavy Metals 372 (selenium)	0	8,611
Heavy Metals 468 (mercury)	0	781
Fluoride 234	41	5,440
Boron 123	30	0
Nutrients and Eutrophication 150, 227, 412, 448, 458, 462	26,054	142,306
pH (high) 441	205	1,067
pH (low) 441	0	10
Siltation and Turbidity 368, 371, 403, 413	42,739	16,687
Low Dissolved Oxygen 322	0	15,117
Chloride 138	0	15,985
Sulfate 385	649	37,337
Flow Alterations 319	633	3,666
Pathogen Indicators 217	0	0
Taste and Odor 459	29,244	0
Aquatic Plants 226, 478	259	138
Zebra Mussels 422	30,870	0
Perchlorate 335	128	0

Table C.7. Lake acreage impacted by various source categories

Source Category (and Corresponding ADB Codes)	Impaired Lake Acreage	
	Major Impairment	Minor Impairment
Municipal Point Sources 62, 85, 99	25,600	122,141
Agriculture 143, 144, 156	33,991	105,642
Urban 169, 177	426	12,237
Resource Extraction 165	0	1,037
Hydromodification 13, 20, 36, 42	3,533	7,213
Atmospheric Deposition 10	0	781
Natural Sources 155	554	36,856
In-Lake Management 17	254	45
Resuspension 148	9665	0
Introductions of Non-Native Organisms 180	30,870	0

Table C.8. Lake acreage cause-to-source linkage estimates

Cause-to-Source Linkage	Associated Acreage
H Heavy Metals - Agriculture	10,955
Heavy Metals – Urban	5,883
ces Heavy Metals – Natural Sources	125
Heavy Metals – Atmospheric Deposition	781
Heavy Metals – In-Lake Management	45
Eutrophication – Agriculture	139,484
Eutrophication – Resource Extraction	543
Eutrophication – Hydromodifications	10,659
Eutrophication – Urban	7,398
Eutrophication – Point Sources	122,141
Eutrophication – In-Lake Management	254
Turbidity/Sedimentation – Agriculture	49,713
Turbidity/Sedimentation – Urban	660
Turbidity/Sedimentation – Natural Sources	125
Turbidity/Sedimentation – In-Lake Processes	9,705
Salinity – Agriculture	5,007
Salinity – Resource Extraction	909
Salinity – Hydromodifications	8,382
Salinity – Natural Sources	35,570
Flow Modifications – Agriculture	203
Flow Modifications – Hydromodifications	3,618
Flow Modifications – Natural Sources	4,168
Pesticides – Agriculture	4,735
Perchlorate – Industrial Site	128
Aquatic Plants – Natural Sources	397
pH – Agriculture	1,364
pH – Resource Extraction (low pH)	10
pH – Urban	116
pH – Natural Sources	11
pH – Aquatic Plants	104
Boron – Agriculture	30
Fluoride – Urban/Industrial	5090
Fluoride – Natural Sources	361
Low Dissolved Oxygen – Agriculture	4,990
Low Dissolved Oxygen – Urban	313
Low Dissolved Oxygen – Natural Sources	537
Zebra Mussels - Introductions	30,870

Acid Effects on Lakes

Approximately 189,000 acres of lakes in Kansas were monitored or evaluated for pH. This accounted for 99.0% of the lake acreage considered in this 314(a) report. Recorded water quality impacts were related almost entirely to high pH values, occurring when lakes were over-enriched with nutrients and suffered from accelerated eutrophication rates and advanced trophic conditions.

During this reporting cycle, only one lake exhibited an epilimnetic pH below 6.5 units. This lake was located in the Mined Land Lakes Recreational Area of southeastern Kansas and was formed in a basin created by a former strip mine. Many decades have passed since this area was actively mined for coal. Although some lakes in the region have been treated sporadically with lime to prevent low pH problems, anecdotal accounts suggest that a few privately owned strip pit lakes continue to exhibit low pH.

In Kansas, the lack of widespread acidification problems is attributable largely to the region's modest level of industrialization, relatively good air quality, and prevailing limestone geology. With respect to the latter factor, much of this region is underlain with calcareous bedrock and contains soils derived from the weathering of this bedrock. Therefore, the state has some natural defense against the atmospheric deposition of acids and acid precursors.

Trends in Water Quality

Trends in water quality are difficult to determine for individual lakes in Kansas, owing primarily to a traditional emphasis on the performance of regional or statewide assessments rather than intensive, site-specific studies. However, lake trophic status appears to provide the best long-term indicator of water quality and has been used by KDHE for 314(a) assessment purposes for many years. In this report, trend analyses for individual lakes have been performed only if the water bodies have undergone three or more trophic state assessments since the inception of lake monitoring activities. These analyses have involved the following considerations:

(1) If there was an evident increase in trophic state over time, the lake was assigned to the "improving" category.

(2) If there was an evident decrease in trophic state over time, the lake was assigned to the "degrading" category.

(3) Lakes were assigned to the "stable" category if assessments changed little over time, or if they fluctuated widely, preventing the detection or confirmation of any trend.

(4) Lakes were assigned to the "unknown" category if they had little or no historical data or if fewer than three trophic state assessments had been performed during the monitoring period-of-record.

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Table C.9 summarizes the trophic status of lakes assessed during the most recent 314(a) reporting cycle. Table C.10 summarizes the results of the trend analyses performed for lakes with sufficient monitoring data.

Table C.9. Trophic status of lakes in Kansas

Trophic Status	Lake Number (and Percentage)		Lake Acreage (and Percentage)	
Argillotrophic	13	4.0%	41,814	21.9%
Oligomesotrophic	13	4.0%	450	0.2%
Mesotrophic	36	11.2%	12,071	6.3%
Slightly Eutrophic	47	14.6%	43,793	22.9%
Eutrophic	65	20.2%	73,560	38.5%
Very Eutrophic	39	12.1%	13,568	7.1%
Low Hypereutrophic	17	5.3%	283	0.1%
High Hypereutrophic	66	20.5%	3,096	1.6%
Dystrophic	0	0%	0	0%
Unknown	26	8.1%	2,347	1.2%
Totals	322	100.0%	190,982	100.0%

Table C.10. Trends in the trophic status of lakes in Kansas

Category	Lake Number (and Percentage		Lake Acreage (and Percentage	
Assessed for Trends	322	100.0%	190,982	100.0%
Improving	17	5.3%	7,423	3.9%
Stable	148	46.0%	128,005	67.0%
Degrading	38	11.8%	49,903	26.1%
Unknown	119	37.0%	5,651	3.0%

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