1991

LAKE & WETLAND MONITORING PROGRAM

REPORT/SUMMARY

C. Edward Carney

November 1992

Science And Standards Section
Office of Science and Support
Kansas Department of Health and Environment

Summary

The Kansas Department of Health and Environment (KDHE), Lake and Wetland Monitoring Program, surveyed the water quality conditions within 27 Kansas lakes during 1991. Eight of these lakes were federal reservoirs, three were major wetlands, and the remaining 16 represented State Fishing Lakes/State Parks or city/county lakes.

Most of the surveyed lakes appeared to be constant to increasing, over time, with regard to their assigned trophic state. Nine lakes indicated reasonably constant trophic states since their last surveys, while 12 indicated an increased trophic state. In general, increases in lake trophic state indicate degrading water quality conditions. Five lakes were surveyed in 1991 that indicated an improvement, or decrease in trophic state, since their last water quality survey.

A total of 133 documented exceedences of Kansas numeric water quality criteria, or Environmental Protection Agency (EPA) water quality guidelines, occurred in the surface waters of the 27 surveyed lakes. Thirty-three of these exceedences concerned chronic and/or acute aquatic life support criteria. One hundred concerned water supply, livestock watering, and irrigation uses. Of the latter 100 exceedences, only 37 occurred in lakes that hosted water supply, livestock water, or irrigation uses. Therefore, 63 of these exceedences are reported for informational purposes only, and do not represent impairment of existing lake uses.

Atrazine was the most often detected pesticide in Kansas lakes during 1991. Six lakes had detectable concentrations of atrazine within their main bodies. These detections ranged in concentration from 1.2 to 15.0 ug/L. Dual was detected in four lakes (concentration ranging from 0.37 to 4.6 ug/L), while alachlor was detected in two (concentration ranging from 0.31 to 2.7 ug/L). Sencor was detected at 0.22 ug/L in a single lake. All six lakes with detectable atrazine levels exceeded available aquatic life support numeric criteria (EPA Criterion Continuous Concentration of 1.0 ug/L). Three of the six lakes, all of which support drinking water supply use, exceeded the Environmental Protection Agency Maximum Contaminant Level (MCL) for atrazine (3.0 ug/L). Dual, alachlor, and sencor detections did not exceed any of the published numeric criteria.

TABLE OF CONTENTS

Page

Introduction 1

Development of the Lake and Wetland Monitoring Program. .1

Overview of the 1990 Monitoring Activities 1

Methods 3

Yearly Selection of Monitored Sites 3

Sampling Procedures 3

Taste and Odor Program 4

Results and Discussion 4

Lake Trophic State 4

Trends in Trophic State 6

Surface Water Exceedences of State Water Quality Criteria 9

Pesticides in Kansas Lakes, 1990 10

Discussion of Nonpoint Pollution Sources For Selected Lakes, 1990 10

Taste and Odor Investigations/Special Investigations 1990 14

Conclusions 16

References 16

Lake Data Availability 18

TABLES

		Page
Table 1.	General Information Pertaining to Lakes in 1991	2
Table 2.	Present and Past Trophic States of Lakes in 1991	5
Table 3.	Algal Community Composition of Lakes in 1991	7
Table 4.	Trophic State Listed by Lake Type, 1991	8
Table 5.	Average Trophic State by Basin, 1991	8
Table 6.	Change in Lake Trophic State For Each Basin Over Time	9
Table 7.	Aquatic Life Support Exceedences in Surface Water	11
Table 8.	Exceedences for Human Use Categories in Surface Water	12
Table 9.	Pesticide Detections in Lakes, 1991	13

Table 1. General Information Pertaining to Lakes Surveyed in 1991.

Lake	Basin	Authority	PWS (*)	Last Surveyed
Clinton Lake	KR	FMPR	*	1988
Milford Lake	KR	FMPR	*	1988
Perry Lake	KR	FMPR	*	1988
Tuttle Creek Lake	KR	FMPR	*	1988
Cheyenne Bottoms	LA	State		1988
Barber SFL	LA	State		1989
Kiowa SFL	LA	State		1989
Quivera Big Marsh	LA	Fed.		1988
Quivera Little Marsh	LA	Fed.		1988
Bartlett City Lake	NE	Local		1989
Gridley City Lake	NE	Local	*	1989
Lake Parsons	NE	Local	*	1989
Mined Land Lake #6	NE	State		1987
Mined Land Lake #17	NE	State		1987
Olpe City Lake	NE	Local	*	1989
Santa Fe Lake, Chanute	NE	Local		1987
Antelope Lake	SO	State		1989
Sheridan SFL	SO	State		1989
Webster Lake	SO	FMPR	*	1989
Cedar Bluff Lake	SS	FMPR	*	1988
Kanopolis Lake	SS	FMPR	*	1988
Wilson Lake	SS	FMPR	*	1988
St. Francis GMA Pit	UR	State		1989
Eureka City Lake	VE	Local	*	1989
Yates Center Lake	VE	Local	*	new
Augusta City Lake	WA	Local	*	1989
Butler SFL	WA	State		1987

CI = Cimarron
KR = Kansas/Lower Republican
LA = Lower Arkansas
MC = Marais des Cygnes
MO = Missouri
NE = Neosho
SO = Solomon
SS = Smoky Hill/Saline
UA = Upper Arkansas
UR = Upper Republican
VE = Verdigris
WA = Walnut

FMPR = Federal Multipurpose Reservoir

GMA = Wildlife/Game Management Area

In addition to routine lake monitoring, one public water supply and numerous private ponds were investigated as part of a taste and odor/algae bloom identification program within KDHE. The thrust of the program is to determine if lake processes or algal ecology is the primary cause of a given taste and odor incident and to suggest possible corrective measures when applicable. Special water quality investigations were conducted at Webster Lake, Lake Dabanawa (Jefferson County), a private pond near Topeka, Rainbow Lake (Barber County), and Pratt County Lake during 1991.

METHODS

Yearly Selection of Monitored Sites

Since 1985, the 24 large federal lakes in Kansas have been arbitrarily partitioned into three groups of eight. Each group is sampled once during a three year period of rotation. Up to 22 smaller lakes are sampled each year in addition to that year's block of eight federal lakes. These smaller lakes are chosen each year for sampling based on three considerations: (1) Is there recent data available (within the last 3-4 years)?; (2) Is the lake showing indications of pollution that require enhanced monitoring?; or (3) Have there been water quality assessment requests from other administrative or regulatory agencies (state, local, or federal)?

Sampling Procedures

At each lake, a boat is anchored over the old stream channel near the dam. This point is station 1 for each lake, and should represent the area of maximum depth. Duplicate samples are taken by Kemmerer sample bottle at 0.5 meters below the surface for inorganic chemistry (basic anions and cations), algal community composition, chlorophyll-a, nutrients (ammonia, nitrate, and total phosphorus), and metals (aluminum, antimony, arsenic, barium, beryllium, cadmium, chromium, cobalt, copper, iron, lead, manganese, mercury, molybdenum, nickel, selenium, silver, thallium, vanadium, and zinc). Duplicate samples are also taken at 0.5 meters above the lake substrate for inorganic chemistry, nutrients, bacteriology, and metals. In addition, a single pesticide sample is taken at 0.5 meters and duplicate surface bacterial samples (fecal coliform and fecal streptococci) are taken at either the public swimming area or main boat ramp area.

Measurements are made in the field for temperature and dissolved oxygen profiles, pH, and Secchi disk depth for each lake at station 1. All samples are preserved and stored in the field as per KDHE Standard Operating Procedure (SOP) requirements (KDHE, 1985). Field measurements, chlorophyll analysis, and algal taxonomy are conducted by staff of the Office of Science and Support at KDHE.

All other analyses are carried out by the KDHE Health and Environmental Laboratory (KDHE, Division of Laboratories, 1984).

Taste and Odor/Algae Bloom Program

In 1989, KDHE initiated a formal Taste and Odor/Algae Bloom Technical Assistance Program. Technical assistance concerning taste and odor incidences in water supply lakes, or algae blooms in lakes and ponds, may take on varied form. Investigations may simply involve identification of algal species present within a lake, or they may entail the measurement of numerous physical, chemical, or biological parameters including watershed land use analysis to identify nonpoint pollution sources. Investigations are generally initiated at the request of treatment plant personnel, local authorities, or personnel at any KDHE District Office. While lakes used as public water supplies are the primary focus, a wide variety of samples related to algal odors and fishkills, from both streams and lakes, are accepted for analysis.

RESULTS AND DISCUSSION

Lake Trophic State

Calculation of the Carlson Chlorophyll-a Trophic State Index (TSI) (Carlson, 1977) remains a useful tool for comparison of lakes in regard to general ecological functioning and level of productivity. Table 2 presents TSI scores for the 1991 lakes, previous TSI scores for those lakes with past data available, and an indication of the extent that individual lakes were dominated by submersed vascular plant communities (macrophytes). Since chlorophyll TSI scores are based on the planktonic algal community, a dominance by macrophytes "bumped" the trophic state classification to the next highest level than that assigned by TSI score alone. The system used to assign trophic state, based on the TSI score, is given below. It represents an in-house modification of the Carlson TSI system to account for macrophytic productivity. Trophic state classification is adjusted for macrophytes where percent areal cover is at 30% or greater.

TSI score of 0-39 = Oligotrophic/Mesotrophic = O/M or,

O/M = A lake with a low level of planktonic algae and no large macrophyte community.

TSI score of 40-49 = Mesotrophic = M or,

M = A lake with only a moderate planktonic algal community, or a small algal community combined with a large macrophyte community.

Table 2. Current and past TSI scores, and trophic state classifications for the 1991 lakes. The abbreviations used previously for trophic state levels (O/M, M, E, H) apply here. An asterisk appearing after the name of a lake denotes that the lake was macrophyte dominated. In such a case, the trophic state based solely on TSI score is given in parentheses, followed by the macrophyte adjusted classification.

Lake	1991 TSI & Status		Previous Status
Antelope Lake *	45.5	M(E)	E
Augusta City Lake	64.5	H	H
Barber SFL	54	SE	M
Bartlett City Lake	70	H	H
Butler SFL	73.5	H	E
Cedar Bluff Lake	70.5	H	M
Cheyenne Bottoms	69	H	H
Clinton Lake	61	VE	M
Eureka City Lake	55.5	E	E
Gridley City Lake	61	VE	E
Kanopolis Lake	52.5	SE	E
Kiowa SFL	63.5	VE	H
Lake Parsons	46.5	M	M
Milford Lake	55	E	E
Mined Land Lake #6	54.5	E	M
Mined Land Lake #17	37	O/M	M
Olpe City Lake	63.5	VE	E
Perry Lake	51	SE	E
Quivera Big Marsh	64.5	H	E
Quivera Little Marsh	72.5	H	H
St. Francis GMA Pit *	57	E(H)	E
Santa Fe Lake, Chanute	65.5	H	H
Sheridan SFL *	60.5	VE(H)	M
Tuttle Creek Lake	39.5	O/M	M
Webster Lake	70	H	M
Wilson Lake	52	SE	M
Yates Center Lake	47	M	-

TSI score of 50-63 = Eutrophic = E or,

E = A lake with a large planktonic algal community or a moderate algal community combined with a large macrophyte community. This category is further divided as follows:

TSI = 50-54 = slightly eutrophic
TSI = 55-59 = eutrophic
TSI = 60-63 = very eutrophic.

TSI score of 64 or greater = Hypereutrophic = H or,

H = A lake with a very large planktonic algal community or a large algal community combined with a large macrophyte community.

All Carlson chlorophyll TSI scores are calculated by the following formula, where C is the phaeophytin corrected chlorophyll-a level in ug/L (Carlson, 1977):

$$TSI = 10(6-(2.04-0.68\ln(C))/\ln 2).$$

The composition of the algal community often gives a better ecological picture of a lake than relying solely on a trophic state classification. Table 3 presents both total algal cell count and percent composition of several major algal groups for the 1991 lakes. Lakes in Kansas that are nutrient enriched may tend to be dominated by green or blue-green species, while those dominated by diatom communities may not be so enriched. Certain species of blue-green, diatom, or dinoflagellate algae may contribute to taste and odor problems, when present in large numbers, in lakes or streams that serve as public drinking water sources.

Trends in Trophic State

Surveyed lakes in 1991 are presented in four major categories in Table 4: all lakes, large federal lakes, water supply lakes, and wetlands. Overall, many of the lakes surveyed were very productive; 44% were eutrophic and about 41% were classed as hypereutrophic. For the larger federal lakes, 62% were eutrophic and only one was characterized as mesotrophic.

Of the lakes with drinking water supply use, 21% were mesotrophic and 57% were eutrophic. Another 21% of water supply lakes were classed as hypereutrophic. Only three lakes had macrophyte communities large enough to require adjustment of trophic state classifications. These three lakes (Sheridan SFL, Antelope Lake and St. Francis GMA Pit) were all public recreational lakes with no existing water supply use. All three are in the western third of the state where macrophyte problems are more common.

Table 3. Algal communities present in the 1991 lakes at the time of sampling. The value in the count column is in cells/uL. "Other", in the far right column, refers to euglenoids, cryptophytes, dinoflagellates, and other single celled flagellates.

Lake	Total Count (cells/uL)	Percent Composition			
		green	blue-green	diatoms	other
Antelope Lake	8.3	98	0	<1	<2
Augusta City Lake	81.6	8	88	4	0
Barber SFL	6.7	40	34	18	8
Bartlett City Lake	35.0	88	3	<4	<6
Butler SFL	145.1	1	98	<1	<1
Cedar Bluff Lake	232.2	3	96	<1	<1
Cheyenne Bottoms	28.7	57	0	32	11
Clinton Lake	29.5	15	75	4	6
Eureka City Lake	6.7	36	33	25	6
Gridley City Lake	68.7	20	80	<1	0
Kanopolis Lake	10.1	50	20	27	3
Kiowa SFL	45.9	5	94	<1	<1
Lake Parsons	9.1	4	83	13	0
Milford Lake	12.4	18	74	8	<1
Mined Land Lake #6	30.2	16	82	<1	<2
Mined Land Lake #17	5.7	13	55	32	0
Olpe City Lake	46.6	1	98	<1	0
Perry Lake	9.0	69	0	22	9
Quivera Big Marsh	63.9	38	59	1	2
Quivera Little Mar.	73.8	17	78	4	<1
St. Francis GMA Pit	6.0	27	51	4	18
Santa Fe Lake	202.9	<4	96	0	<1
Sheridan SFL	31.9	22	71	7	<1
Tuttle Creek Lake	1.3	43	29	19	10
Webster Lake	101.1	24	73	<3	<1
Wilson Lake	15.8	14	78	6	<2
Yates Center Lake	3.9	73	24	0	3

Table 4. Lake trophic state trends by general lake type.

Category	Number of Lakes		Category	Number of Lakes	
1991 Overall	O/M	2	Public Water Supply Lakes	O/M	1
	M	2		M	2
	SE	4		SE	3
	E	4		E	2
	VE	4		VE	3
	H	11		H	3
Federal Lakes	O/M	1	Wetlands	O/M	0
	M	0		M	0
	SE	3		SE	0
	E	1		E	0
	VE	1		VE	0
	H	2		H	3

Table 5. Mean trophic state for the 1991 lakes in each major river basin in Kansas. Mean trophic states given in parentheses indicate that some lakes contained large macrophyte communities.

Basin (No. of Lakes)	Mean TSI	Mean Trophic State
Kansas/Lower Republican (4)	51.6	SE
Lower Arkansas (5)	64.7	H
Neosho (7)	56.9	VE
Solomon (3)	58.7	VE(H)
Smoky Hill/Saline (3)	58.3	VE
Upper Republican (1)	57.0	VE(H)
Verdigris (2)	51.3	SE
Walnut (2)	69.0	H

Table 5 represents the average trophic state of the lakes sampled within each major river drainage basin in Kansas. Several of the basins are represented by only one or two lakes during 1991 due to the smaller number of lakes occurring in those basins. Table 6 presents changes within each basin over time for the 26 lakes with previously calculated TSI scores. In general, the basins appear constant (35%) to degrading (46%) with regard to lake trophic state. Only 19% of 1991 lakes appeared to have improved since their last survey date.

Table 6. Trends over time for lake trophic state classification within each major river basin in Kansas. This table deals only with those 26 lakes that have past data.

Basin	Number of Lakes Constant	Improving	Degrading
Kansas/Lower Republican	1	2	1
Lower Arkansas	2	1	2
Neosho	3	1	3
Solomon	1	-	2
Smoky Hill/Saline	-	1	2
Upper Republican	-	-	1
Verdigris	1	-	-
Walnut	1	-	1
Totals	9	5	12

Surface Water Exceedences of State Water Quality Criteria

All numeric water quality criteria referred to in this section are taken from Chapter 28 of the Kansas Administrative Regulations (K.A.R. 28-16-28b through K.A.R. 28-16-28f), effective May 1, 1987, or from EPA water quality criteria guidance documents (EPA 1972, 1976; KDHE, 1987). Copies of the Standards may be obtained from the Office of Science and Support, KDHE, Building 740, Forbes Field, Topeka, Kansas 66620.

Under the category of chronic aquatic life support, a total of 27 exceedences of existing numeric criteria were documented during 1991. These occurred for seven different metals, with copper being the parameter exceeded most often (44%). There were a total of six exceedences of existing numeric criteria under the category of acute aquatic life support during 1991. The majority of these (67%) were for high pH values, due to highly productive algae or macrophyte communities (Table 7).

Under the categories of water supply, irrigation, and livestock water; a total of 100 exceedences of existing water quality numeric criteria were documented during 1991 (Table 8). Out of these 100, 37 occurred in lakes that currently are serving those specific uses. Therefore, 63 of the reported exceedences are for informational purposes only and do not represent any impairment of existing uses. Of those 37, 32 were within the category of water supply and five were within the irrigation category. The majority of exceedences under water supply were split evenly between iron and manganese (56% total), while 80% of irrigation exceedences were for total dissolved solids.

Pesticides in Kansas Lakes, 1991

Six lakes had detectable pesticides within the main body of the lake during 1991. Table 9 lists these lakes and what pesticides were detected, along with the level detected and analytical quantification limit. Four pesticides were detected in total.

Atrazine continues to be the most often detected pesticide in lakes in Kansas (KDHE, 1991). All six lakes with measurable levels of pesticides had atrazine present in detectable quantity (Table 9). Dual (metolachlor), alachlor and sencor (metribuzin) were detected in four, two and one lake, respectively.

In all cases, the detection of these pesticides indicates impacts from agricultural nonpoint pollution. The lake of most concern in 1991, with regard to pesticides, is Tuttle Creek Lake. Tuttle Creek Lake not only had the highest level of detected atrazine during 1991, but also the highest detected levels of dual and alachlor. Perry Lake was the second most impaired site in 1991, based on pesticide levels. Both lakes have watersheds rich in cultivated land and have been recognized for several years as having pesticide loading problems from nonpoint source pollution.

Discussion of Nonpoint Pollution Sources for Selected Lakes

Ten lakes were selected, out of the 27, for individual discussion of nonpoint pollution sources. It was felt that these lakes merited individual attention based on the number and type of observed Water Quality Standard exceedences. From Table 7, a lake was selected if more than three parameters exceeded an aquatic life support criterion, or more than one acute aquatic life support criterion was exceeded. From Table 8, a lake was selected if more than one parameter exceeded a "human use" water quality criterion, or if more than one use category had an exceedence. For the purpose of this discussion, only use exceedences in lakes that hosted those particular uses were considered.

The ten lakes meriting additional discussion included Antelope Lake, Augusta City Lake, Bartlett City Lake, Cedar Bluff Lake, Gridley City Lake, Kanopolis Lake, Lake Parsons, Olpe City Lake, Webster Lake, and Wilson Lake.

Table 7. Chemical parameters exceeding chronic and acute aquatic life support criteria in the surface waters of the 1991 lakes. Chemical symbols are from the Periodic Table of the Elements, except for pH. Aquatic life support is abbreviated as ALS. Yates Center Lake is not included as no inorganic chemical samples were taken for 1991.

Lake	Chronic ALS							Acute ALS		
	Hg	Cu	Se	Fe	Cr	Cd	Pb	Hg	Cu	pH
Antelope Lake	x							x		x
Augusta City Lake	x	x								
Barber SFL										
Bartlett City Lake				x		x				x
Butler SFL		x								x
Cedar Bluff Lake					x					
Cheyenne Bottoms				x						
Clinton Lake	x	x								
Eureka City Lake	x									
Gridley City Lake		x								
Kanopolis Lake										
Kiowa SFL		x								
Lake Parsons		x		x		x	x			
Milford Lake		x								
Mined Land lake #6										
Mined Land Lake #17										
Olpe City Lake		x								
Perry Lake										
Quivera Big Salt Marsh			x							x
Quivera Ltl.Salt Marsh				x						
St. Francis GMA Pit		x							x	
Santa Fe Lake, Chanute		x								
Sheridan SFL	x	x								
Tuttle Creek Lake		x		x						
Webster Lake										
Wilson Lake										

Table 8. Exceedences of human use criteria within the surface waters of the 1991 lakes. Symbols are taken from the Periodic Table of the Elements, with the exception of TDS which stands for Total Dissolved Solids, TH which stands for Total Hardness, SO4 which stands for sulphate, pH which stands for pH, and R which stands for Na Ratio. Use category abbreviations are as follows: IR = irrigation, LW = livestock watering, and WS = water supply. Use of an "*" means that while a certain parameter exceeded the water quality criterion for that use, the use was not hosted at that particular lake. Exceedences are otherwise noted by an "x." Lakes are included within this table only if they had documented exceedences.

Lake	WS									IR						LW				
	Fe	Mn	SO4	TH	TDS	Na	Cl	F	Ca	TDS	F	pH	R	Mn	Al	Cl	TDS	F	SO4	Al
Antelope Lake		*																		
Augusta City Lake	x	x																		
Barber SFL			*	*	*					*										
Bartlett City Lake	x	x												*						
Butler SFL	*	*										*		*						
Cedar Bluff Lake	x	x	x	x	x	x			x	x										
Cheyenne Bottoms	*	*	*	*	*	*	*			*			*							
Clinton Lake		x																		
Eureka City Lake		x																		
Gridley City Lake	x	x																		
Kanopolis Lake	x				x	x				x										
Kiowa SFL	*	*																		
Lake Parsons	x	x													*					*
Mined Land Lake #6		*	*	*	*				*	*				*						
Mined Land Lake #17		*	*	*	*	*			*	*									*	
Olpe City Lake	x	x												*						
Quivera Salt Marshes	*	*	*	*	*	*	*			*	*	*	*			*	*			
St. Francis GMA Pit					*	*		*		*	*							*		
Santa Fe Lake		*												*						
Sheridan SFL		*																		
Tuttle Creek Lake	x																			
Webster Lake	x	x	x		x					x										
Wilson Lake			x	x	x	x	x			x			x							

Table 9. Pesticides detected during 1991 in Kansas lakes. All values are in ug/L. Analytical quantification limits (in ug/L), and abbreviations, are as follows for the four detected pesticides: atrazine (atz) = 1.2, dual (dual) = 0.25, alachlor (ala) = 0.25, sencor (sen) = 0.10. The "exceeded" column refers to whether the detection of atrazine exceeded current EPA aquatic life support (ALS) levels (1.0 ug/L), or whether the detection exceeded the current MCL of 3.0 ug/L for water supply (WS).

Lake	Pesticide				Exceeded	
	Atz	Dual	Ala	Sen	ALS	WS
Clinton Lake	2.6	0.37	-	-	x	
Milford Lake	4.8	0.47	-	-	x	x
Perry Lake	6.0	0.87	0.31	-	x	x
Santa Fe Lake	1.5	-	-	-	x	
Sheridan SFL	1.2	-	-	-	x	
Tuttle Cr. Lake	15.0	4.60	2.70	0.22	x	x

Out of the ten, Cedar Bluff, Kanopolis, Webster, and Wilson Lakes constituted a distinct group. These four larger, western Kansas lakes had numerous metal and dissolved solids exceedences for water supply and irrigation. The cause of these conditions is a combination of their large catchment areas, regional geology, and regional hydrological conditions.

Augusta, Gridley, and Olpe City Lakes constituted a second distinct group out of the ten selected lakes. These lakes were selected because they had iron and manganese problems within the water supply use category. All three lakes are within the southeastern quarter of the state where iron and manganese levels frequently exceed available numeric criteria. Therefore, their problems are primarily due to regional geology combined with the higher runoff of southeastern Kansas, relative to the remainder of the state.

Of the remaining three lakes, Bartlett City Lake and Lake Parsons were similar to the group discussed in the preceding paragraph. They both had iron and manganese problems under the category of water supply use. However, they also had exceedences of certain aquatic life support criteria that set them apart. Bartlett City Lake exhibited exceedences of iron, cadmium, and pH for aquatic life support, while Lake Parsons exhibited exceedences of iron cadmium and lead. For both lakes, the metal problems likely derive from their location in extreme southeastern Kansas. This region of Kansas has the highest runoff levels within the state, combined with a regional geology conducive to metal pollution. In this region of the state, there has been past mining for lead and zinc,

and cadmium is often found associated with lead ore. For Bartlett City Lake, problems were exacerbated by extremely shallow, wind-mixed conditions combined with a dense algal community (high pH).

The remaining lake, Antelope Lake, had both mercury and pH exceedences for the acute aquatic life support category. The high pH problem can be explained due to the extensive macrophyte community (100% cover). The levels of mercury may be reflective of local geology or atmospheric deposition. Sheridan SFL, which lies very near to Antelope Lake, also had chronic aquatic life support exceedences for mercury, suggesting a common connection. The extensive rooted macrophyte community of Antelope Lake may act to increase cycling of the metal back to the water column (Wetzel, 1983).

Taste and Odor/Algae Bloom Investigations/Special Investigations in 1991

During October 1, 1990 to October 1, 1991, there was one taste and odor investigation conducted by KDHE's Taste and Odor/Algae Bloom Program. In addition, algae samples were investigated for numerous algae bloom problems in Kansas during the summer of 1990. Given the low rainfall conditions of the summer of 1991, the large number of bloom complaints were not surprising. These bloom complaints ranged from the more common blue-green algae, to Euglena spp. blooms on sluggish streams, to a Prymnesiophyte bloom in a small urban lake in Wichita, to monitoring of dinoflagellate communities within the Marais Des Cygnes River above Melvern Lake.

The single taste and odor investigation during the 1990 water year was at Wellington City Lake during late August. On August 27, 1991, KDHE South Central District Office Staff submitted water samples related to an extreme taste and odor problem throughout the water system at Wellington. Microscopic examination of the sample revealed the presence of a moderately large population of the blue-green algae Anabaena sp. This algae is a common producer of off-flavors in water, as well as an occasional toxin producer. Activated carbon was suggested as the best potential treatment.

In addition to work with algae blooms, five lakes received more intensive water quality investigations for a variety of reasons. These five lakes, and their investigations, are discussed in detail below.

Webster Lake, Rooks County, was investigated on August 13, 1991, at the request of the Kansas Department of Wildlife and Parks. During the summer of 1991, this lake experienced excessive irrigation withdrawals combined with no inflow and high evaporation rates. The investigation was designed to provide documentation of water quality impacts related to the drawdown. Impacts documented by the investigation included a large increase in both algal

biomass and lake nutrient levels, combined with greatly increased turbidity. The investigation concluded that the reduced lake surface area and volume, combined with increased wind mixing of sediments resulted in the rapid artificial eutrophication of the lake.

Lake Dabanawa, Jefferson County, was investigated following complaints of human fecal matter observed floating on the lake surface, and fears of failed or by-passed septic systems. Computer trophic state modeling using Eutromod 2.40 (Henning & Reckhow, 1990) indicated that under normal conditions, septic systems could be expected to promote only 3-4% of observed trophic state conditions. With this data in hand, water quality sampling was conducted to locate areas where septic systems might be by-passed or failing. The investigation indicated no evidence of by-passed septic systems, or septic conditions anywhere along the shoreline. Only slight indications of septic system leaching were seen in two separate cove areas. It was suggested that the Lake Dabanawa Association, based on the investigation, might wish to locate a firm with experience in septic systems to conduct further tests in those two cove areas.

Rainbow Lake, Barber County, was investigated on August 21, 1991, as a result of complaints about an upstream feedlot lagoon that was improperly disposing of its waste. Field reconnaissance revealed that both the feedlot lagoon and the discharge path to North Fork Elm Creek were not in line with the lake or watershed. Rainbow Lake was essentially an impoundment fed by a spring and a very small watershed, with no observable impairments. It was concluded that, unless the lagoon was causing groundwater contamination that would affect the spring, the lagoon would not impact Rainbow Lake. It was pointed out, however, that the lagoon discharges would have impaired the access to Rainbow Lake, if only aesthetically. The investigation also revealed that cabins on septic systems around Rainbow Lake were the third largest source of nutrients to the system and merited corrective action.

Myer's Pond, Shawnee County, is a private pond that receives the effluent from a discharging lagoon treatment system. The pond owner had filed complaints of the discharge's impact on his lake with KDHE. Department staff investigated the lake to determine the point source contribution to the lake's condition and what the effects of effluent elimination would be. While computer modeling indicated that 45% of the phosphorus load and 9% of the nitrogen load to Myer's Pond was due to effluent, removal of the effluent would only reduce in-lake phosphorus by 12%. The lake conditions would be essentially the same (hypereutrophic) whether the lagoons discharged to the lake or not, due to the small, but cultivation rich, watershed above the lake. It was also pointed out that the effluent provided a constant water supply to the lake. If stopped, the lake would likely experience periods of extreme drawdown, which would also impair recreational use. However, it was recommended

that contact recreation would not be appropriate in Myer's Pond due to extensive macrophytic growth combined with the close proximity of the discharge.

Pratt County Lake was investigated on October 28, 1991, as part of the recertification of the Pratt Municipal Wastewater Treatment Plant's (WTP) National Pollutant Discharge Elimination System (NPDES) permit. The main goal of the investigation was to estimate the percent contribution the Pratt discharge has on the hypereutrophic Pratt County Lake, which lies roughly two miles downstream. Trophic state modeling suggested that the Pratt WTP effluent contributes about 32% of the total phosphorus load to the lake and about 24% of the total nitrogen load. These loading rates translated to roughly 28% contribution to in-lake phosphorus levels and 19% contribution to in-lake nitrogen levels. While this discharge would appear to be a major contributor to the overall trophic state of Pratt Co. Lake, it was not deemed sufficient, in the absence of nonpoint source pollution controls, to recommend nutrient limitations for the Pratt WTP NPDES permit.

Conclusions

The following conclusions are offered, based upon the lake monitoring data obtained during 1991.

1. Trophic state conditions suggested that most lakes surveyed in 1991 were either maintaining past levels of water quality or experiencing degradation of water quality. Only a small percentage had trophic state conditions that indicated an improvement over past levels.

2. Ten lakes had sufficient numbers of surface water quality criteria exceedences to be discussed in more detail within the report. Of these ten, all were viewed as being impaired primarily by regional geology and/or hydrological conditions, rather than by pollution impacts directly related to human activity.

3. Six of the 27 surveyed lakes had detectable concentrations of agricultural pesticides during the summer of 1991. Atrazine was the most commonly encountered pesticide. Most of these six lakes were major impoundments within the Kansas River drainage.

References

Carlson, R. E., A Trophic State Index for Lakes, Limnology and Oceanography, 22(2), 1977, p. 361.

Carmichael, W. W., et. al., Algal Toxins And Water-Based Diseases, in "CRC Critical Reviews in Environmental Control", Vol. 15, Issue 3, 1985, pp. 275-313.

EPA, Ecological Research Series, Water Quality Criteria 1972, National Academy of Sciences/National Academy of Engineering, 1972.

EPA, Quality Criteria for Water, United States Environmental Protection Agency, Washington, D.C., 1976.

Fields, S. D. and R. G. Rhodes, Repeated Myzocytosis of Blue-Green Cryptophytes by Gymnodinium acidotum (Dinophyceae), Submitted: Journal of Phycology, September, 1990.

Haynes, R. C., An Introduction to the Blue-Green Algae with an Emphasis on Nuisance Species, North American Lake Management Society, Washington DC, 1988.

Henning, M. H. and K. H. Reckhow, Using Eutromod, Duke University School of Forestry and Environmental Studies, 1990.

Kansas Department of Health and Environment, Atrazine in Kansas, Second Edition, 1991.

KDHE, Draft Standard Operating Procedures W001 through W033, 1985.

KDHE, Division of Laboratories, Policy Statement and Procedures Manual, 1984.

KDHE, Kansas Surface Water Quality Standards, 1987.

Palmer, C. M., Algae In Water Supplies: An Illustrated Manual on the Identification, Significance, and Control of Algae in Water Supplies, U.S. Department of Health, Education and Welfare, Public Health Service Publication No. 657, 1959.

Reckhow, K. H., M. N. Beauliac, and J. T. Simpson, Modeling Phosphorus Loading and Lake Response Under Uncertainty: A Manual and Compilation of Export Coefficients, US EPA Office of Water Regulations and Standards, 440/5-80-011, 1980.

Reckhow, K. H., S. W. Coffey, and C. Stow, Technical Release: Managing the Trophic State of Water Bodies, United States Soil Conservation Service, 1990.

Wetzel, R. G., Limnology, Second Edition, Saunders College Publishing, New York, New York, 1983.

LAKE DATA AVAILABILITY

Lake data are available for all lakes included within the Kansas Lake and Wetland Monitoring Program. Water quality data may be requested by writing to the Office of Science and Support, KDHE, Building 740, Forbes Field, Topeka, Kansas 66620-0001. All data referenced within this report are accessible on STORET.