

MISSOURI POLLUTION AND FISH KILL INVESTIGATIONS 2019



Report compiled by
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USE OF DATA

Data and information in this report are distributed for communicating incidents of water quality problems and injuries to fish and wildlife throughout the state of Missouri. By doing so, we hope to increase awareness of water pollution and natural causes of mortality in aquatic life. The reader may choose to use the data for other purposes, but the appropriateness of the data for those purposes must be evaluated by the user.

Cover photographs: Top-left: Austin Lake, Texas County, 7/3/19, Sample of a toxic algal bloom, photo taken by Mary Scott (Fisheries Management Biologist). Top-right: East Fork of the Little Chariton River, Macon County, 9/10/19, Fish kill due to low dissolved oxygen from dewatering of the Long Branch Dam, photo taken by Mark Switzer (Forestry/Wildlife Technician). Bottom: Ray County Lake, Ray County, 8/28/19, Paddlefish and gizzard shad from a fish kill likely related to an algal bloom, photo taken by Eric Dennis (Fisheries Management biologist).

EXECUTIVE SUMMARY

The Missouri Department of Conservation (MDC) conducts fish kill investigations under the authority of the *Wildlife Code of Missouri* (Section 252.210, RSMo) and has maintained a Fish Kill and Pollution Program since the 1940s. The overarching goals of the program are to protect aquatic resources and to maintain high-quality fishing and recreational opportunities. We work towards these goals by 1) conducting fish kill and water pollution investigations so pollution abatement and mitigation is achieved and 2) increasing awareness of water pollution and mortality in aquatic life through reporting of incidents. The program is a partnership among multiple resource agencies; however, the Missouri Department of Natural Resources (DNR) is the primary partner.

During 2019, MDC personnel investigated 78 water quality and pollution incidents. Animal mortality was associated with 43 of these incidents. Overall, at least 22,961 fish and other organisms were killed during these incidents. Incidents were placed into one of three major categories: regulated, non-regulated, and unknown cause. Regulated incidents are sub-categorized by pollution source: municipal, agricultural, industrial, transportation, and other. There were 35 regulated incidents, of which 22 involved a kill. An estimated 14,825 animals valued conservatively at \$24,081.12 were killed during regulated source pollution incidents. Municipal pollutants were the most common cause of regulated incidents. Non-regulated incidents are attributable to natural causes, such as disease, spawning stress, and low dissolved oxygen. During 2019, there were 32 non-regulated incidents, 16 of which, were fish kills. Personnel could not determine the cause of 11 incidents (unknown cause). At least 771 animals died due to unknown causes. Monetary values (damages) for non-regulated and unknown fish kills were not calculated because damages for these kills are not reimbursed.

Cause	Number Incidents	Number Fish Kills
Regulated		
Municipal	17	15
Agriculture	8	3
Industry	3	0
Transportation	4	2
Other	3	2
Subtotal	35	22
Non-Regulated	32	16
Unknown	11	5
Totals	78	43

The summer season had the greatest number of incidents (42), followed by fall (17), spring (10) and winter (9). Most incidents occurred in ponds (30), followed by streams (25) and lakes (24).

The MDC, DNR, EPA, and the Attorney General enforced the incidents described in this report. Twelve cases were resolved during 2019 through compliance and enforcement actions. Five of these cases involved civil legal agreements and consent judgements, which included reimbursements for natural resource damages and investigative costs totaling \$62,476.35 and civil penalties amounting to \$43,286. Thirty potentially enforceable incidents have not been resolved as of December 31, 2019.

An analysis of long-term trends (1988-2019) shows the number of regulated incidents peaked in the mid-1990s and declined from the mid-1990's to 2002. Since 2003, the number of regulated incidents has fluctuated between 10 and 28. Across pollution types, municipal pollutants are historically and currently the dominant cause of pollution incidents.

TABLE OF CONTENTS

USE OF DATA	iii
EXECUTIVE SUMMARY	iv
TABLE OF CONTENTS	vi
LIST OF TABLES AND FIGURES	vii
INTRODUCTION	1
METHODS	2
RESULTS AND DISCUSSION	4
INCIDENT CAUSES	4
TEMPORAL DISTRIBUTION	8
DISTRIBUTION OF INCIDENTS THROUGHOUT THE STATE	9
DISTRIBUTION BY HABITAT TYPE	11
ENFORCEMENT STATUS OF FISH KILL AND POLLUTION CASES	12
PROJECTS FUNDED BY FISH KILL GRANTS	12
LONG-TERM TRENDS.....	13
CONCLUSION	15
LITERATURE CITED	16
Appendix A. Program accomplishments.....	17
Appendix B. Table of regulated source incidents	20
Appendix C. Table of non-regulated source incidents.....	22
Appendix D. Table of unknown source incidents	24
Appendix E. Summary of Clean Water Law settlements	25
Appendix F. Case enforcement status and descriptions.....	26
Appendix G. Table of pollution investigations, fish kills, and estimated mortality (1970-2019).....	34

LIST OF TABLES AND FIGURES

Table 1. Summary of fish kill and pollution incidents.....	4
Figure 1. Number of incidents by pollution source.	5
Figure 2. Monthly and seasonal distribution of incidents.	8
Figure 3. Map of number of incidents by county.....	9
Figure 4. Map of number of incidents by source category.....	10
Figure 5. Distribution of incidents by habitat type.	11
Figure 6. Long-term trends among sources of regulated incidents.....	13
Figure 7. Long-term trends for regulated fish kill and pollution incidents	14

INTRODUCTION

The Missouri Department of Conservation (MDC) holds the authority to enforce the *Wildlife Code of Missouri* (Chapter 10, 3 CSR 10). According to the *Wildlife Code of Missouri*, it is illegal to cause or allow any deleterious substance to be placed, run, or drained into any waters of the state in quantities sufficient to injure, stupefy, or kill fish or other wildlife which may inhabit such waters. Under this mandate, MDC maintains a Fish Kill and Pollution Program. The goals of the program are to protect aquatic resources and maintain high-quality fishing and recreational opportunities. We work towards these goals by conducting fish kill and water pollution investigations, so pollution abatement and mitigation is achieved and by increasing awareness of water pollution and mortality in aquatic life through reporting of incidents. The program is a partnership among multiple resource agencies¹; however, the Missouri Department of Natural Resources (DNR) is the primary partner.

During the investigation, MDC determines the size of the affected area, estimates the number of organisms killed, calculates a monetary value for those organisms, and distributes collected information to interested personnel and agencies. Although MDC has the authority to prosecute responsible parties for killing fish under the *Wildlife Code of Missouri* (Section 252.210, RSMo), compliance and enforcement action is usually deferred to DNR who holds the authority to enforce *Missouri Clean Water Law* (Chapter 644, RSMo). Two additional roles of DNR during investigations are overseeing the clean-up of spills and acting as the incident command center (Missouri's Spill Bill, sections 260.500-260.550, RSMo).

This report is a summary of all fish kills and pollution investigations conducted by MDC during 2019.

¹ Other agencies involved during investigations include: Missouri Department of Natural Resources, Missouri Department of Health and Senior Services, Missouri Department of Agriculture, U.S. Environmental Protection Agency, U.S. Coast Guard, U.S. Fish and Wildlife Service, and U.S. Army Corps of Engineers.

METHODS

MDC conducts fish kill investigations under the authority of the *Wildlife Code of Missouri* (Section 252.210, RSMo). This is communicated to all MDC staff through a memo distributed by the Fisheries, Protection, and Resource Science division chiefs. The memo states that all MDC employees are responsible for reporting water quality problems, water pollution, and fish kills that are noted during the performance of their normal job duties and for assisting with the investigation, if needed.

MDC and DNR have a cooperative agreement which streamlines investigations. Under the cooperative agreement, the DNR-Environmental Emergency Response (EER), which operates a 24 hour a day environmental emergency spill line, notifies DNR and MDC staff statewide during fish kills and water pollution events which have potential to injure fish and wildlife. As part of the cooperative agreement, MDC Environmental Health Unit supplies EER with contact lists of MDC regional staff for use during normal business hours and a contact list of Protection District Supervisors for use after normal business hours. All DNR and MDC staff learning of or discovering a fish kill are to notify the EER spill line as soon as possible as a precautionary measure. On-scene, DNR collects environmental samples and data for evidence and ensures the pollution is remediated, if possible.

MDC's Conservation Agents and Fisheries Division staff are trained to respond to fish kill and pollution incidents where there is potential for fish and wildlife injury. The presence of Conservation Agents in each county of the state allows for an immediate assessment of the incident and action which may prevent greater injury to the resource. During an investigation when time is crucial and/or DNR personnel cannot respond, these procedures minimize environmental damage and ensure useable evidence that may otherwise be lost.

The objectives of the MDC investigator are to determine the likely cause of the fish kill or water pollution incident, prevent additional damage by containing the pollution (if possible), and to determine the extent of the damage to the resource. The MDC investigator conducts water chemistry screening at the source of the pollution, upstream, and downstream of the pollution source. This procedure aids in determining the cause of the fish kill or water quality problem. Water chemistry measurements include temperature, pH, dissolved oxygen, and unionized ammonia. Water samples are also collected in these three locations if DNR has not arrived on-scene.

During 2019, fish counting procedures outlined in *Investigation and Monetary Values of Fish and Freshwater Mollusk Kills* (Southwick and Loftus 2017) were followed. The species and size of dead fish are recorded within the affected area. If the affected area is subsampled, the Environmental Health Unit (EHU) extrapolates the total number of dead fish and wildlife. These methods are labor intensive and therefore are not usually used for natural fish kills (*non-regulated*) where investigative costs are not reimbursed. Once the total number of dead fish and wildlife is determined, the EHU calculates a monetary value (damage). Damages are not usually calculated for cases with an unidentified responsible party, those with *unknown* causes, or those occurring in private waters. A report of investigative activities, findings, and damages is compiled for each *regulated* incident (incidents with identified pollution sources). Copies of these reports are distributed to DNR and other interested agencies.

Fish kill and pollution cases with a responsible party are typically enforced by DNR under the *Missouri Clean Water Law* (Chapter 644, RSMo) or the *Clean Water Act*. By holding the offender responsible, restitution is achieved. Restitution consists of reimbursements for fish damages and investigative costs, completion of supplemental environmental projects, and payment of penalties, which DNR assesses.

Damages are directed to two separate funds: ninety percent of damage reimbursements are directed to projects benefiting aquatic resources through the Fish Kill Grant fund and ten percent of damage reimbursements are directed to the Chemical Emergency Preparedness Fund (Section 640.235, RSMo). Penalty monies are transferred to the county school system in which the pollution event occurs. This report contains information on case status and reimbursements received as of December 31, 2018.

MDC tracks information on fish kills and pollution incidents in a central database, including incidents that have not been directly reported to MDC. However, the focus of this report is incidents where MDC personnel were directly involved in the investigation. Reports of false kills (e.g. angling mortalities) are not included in this report. Additionally, the main body of this report does not summarize other activities of the Fish Kill and Pollution Program. Highlights of these activities can be found in Appendix A.

RESULTS AND DISCUSSION

MDC personnel investigated 78 water quality problems during 2019 (Table 1). Fish kills occurred in 43 of the incidents. An estimated 22,961 fish and other organisms were killed. The remainder of the results and discussion is broken down by incident causes, temporal trends, spatial trends, enforcement status, projects funded by fish kill grants, and long-term trends.

Table 1. Summary of fish kill and pollution investigations conducted by MDC staff during 2019. Animals killed include all fish and wildlife species killed during an event.

Cause	Number Incidents	Number Kills	Number Animals Killed	Value of Animals Killed
Regulated				
Municipal	17	15	10,246	\$19,865.53
Agriculture	8	3	3,347	\$1,326.09
Industry	3	0	0	\$0.00
Transportation	4	2	810	\$89.92
Other	3	2	422	\$2,799.58
<i>Subtotal</i>	35	22	14,825	\$24,081.12
Non-regulated	32	16	6,365	Undetermined
Unknown	11	5	771	Undetermined
Totals	78	43	22,961	\$24,081.12

INCIDENT CAUSES

Incidents are placed into one of three major categories: regulated cause, non-regulated cause, and unknown cause. For purposes of this report, incidents with *regulated* causes are those which have a known source of pollution, incidents with *non-regulated* causes are attributable to natural processes, and incidents with *unknown* causes are those which investigators could not determine the source or cause of the problem. A list of regulated incidents, non-regulated incidents, and incidents with unknown causes can be found in appendices B, C, and D.

Regulated Cause

Incidents falling in the *regulated* category are broken down by the source of pollution: municipal, agricultural, industrial, transportation, and other sources. There were 35 regulated incidents, which accounted for over 44% of all incidents in 2019 (Figure 1). Of the 35 regulated incidents, 22 resulted in fish and wildlife mortality. An estimated 14,825 dead fish and wildlife were recorded for all 22 fish kills. Monetary damages totaled \$24,081.12 (Table 1). Municipal source pollutants (e.g. municipal wastewater, drinking water, and hydro-electric facilities) were the leading cause of regulated incidents in 2019, accounting for 48% of all regulated investigations (Figure 1).

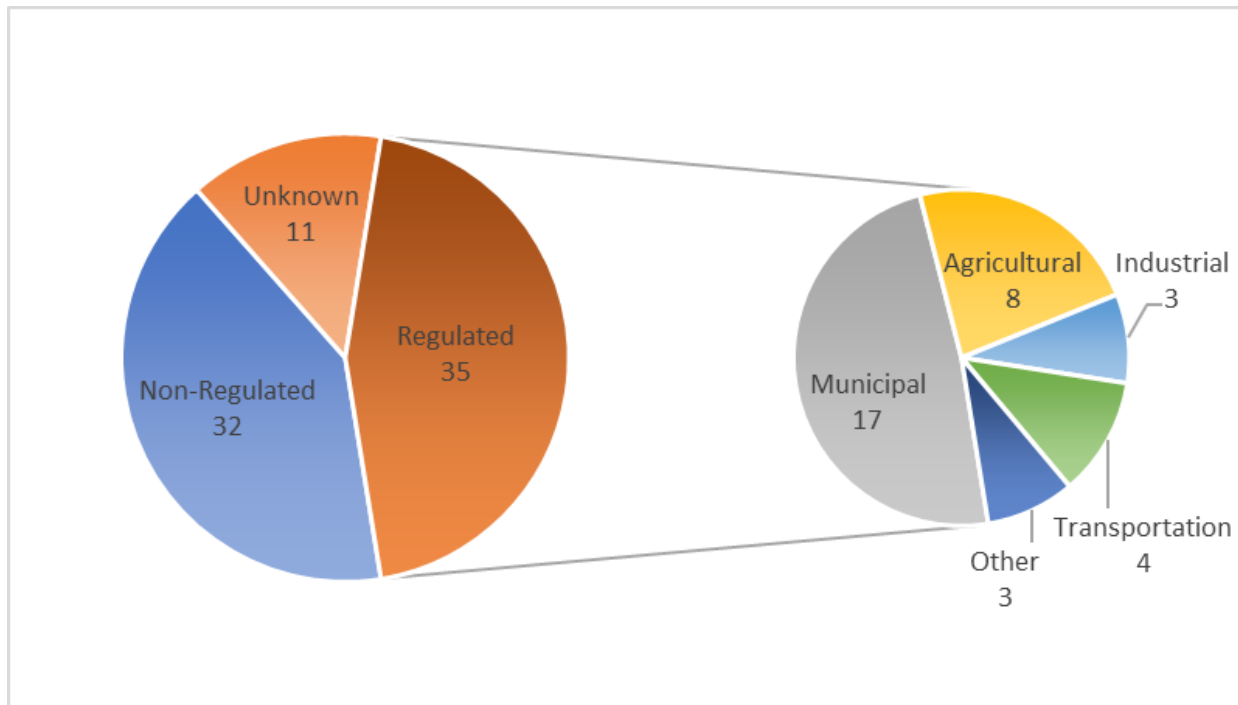


Figure 1. Number of incidents by pollution source in 2019.

Municipal Source

Incidents falling in the municipal source category include, but are not limited to municipal waste, drinking water, and hydropower dams. Municipal pollutants were involved in 17 incidents. 15 of these resulted in the death of at least 10,246 fish and aquatic life valued at \$19,865.53 (Table 1). Municipal pollutants were the leading cause of regulated incidents in 2019, accounting for over 48% of all regulated investigations (Figure 1). Chlorinated water spills were the leading cause of 2019 municipal incidents, amounting to 44% of these incidents.

The most significant incident in this category occurred in St. Francois County on September 11, 2019. Permitted discharges from the Farmington West Waste Water Treatment Plant into the St. Francis River resulted in hypoxic conditions and a fish kill. An estimated 6,549 dead fish and organisms were observed in 1.5 miles of stream, over 2 days. These organisms are valued at \$7,245.37. This specific waste water treatment plant has been involved in eight fish kill and pollution cases since 1987.

Agricultural Source

Agricultural source pollutants include, but are not limited to animal waste, fertilizer, and pesticides. During 2019, agricultural source pollution represented 8 incidents, 3 resulted in fish and wildlife mortality. The only mortality incident where fish were counted happened on July 27, 2019 in Audrain County. A pump malfunction at a concentrated animal feeding operation (CAFO), caused the release of swine waste effluent into a tributary of the West Fork Cuivre River. The effluent had been discharging for possibly 2-4 days prior to the discovery of the malfunction. Black coloration of the water made an accurate fish count impossible. An estimated 3,347 fish and aquatic organisms were killed at a value of \$1,326.19 (Table 1). Follow-up monitoring in the week following the event indicated the fish community was nearly or entirely killed in the 1.5 mile zone of impact.

Industrial Source

Industrial source pollutants include but are not limited to organic and chemical wastes generated by industrial operations and habitat destruction related to gravel mining operations. During 2019, three incidents were attributed to industrial pollution. For two incidents, the pollutant did not enter a waterbody. The third incident was a complaint of restaurants dumping used cooking oil into streams; however, investigators were unable to verify if the pollution event occurred.

Transportation Source

Incidents falling within this category involve pollutants originating from pipelines, aviation, rail, boat, and road vehicle sources. During 2019, MDC was involved in four transportation-related fish kill or pollution incidents, 2 involved fish kills. The two incidents that did not involve fish kills involved pipeline breaks. One by the TransCanada Keystone Pipeline in St. Charles County, and the other a natural gas pipeline on Davisdale Conservation Area in Howard County.

The incident with the most mortalities was on April 4, 2019, in Cape Girardeau County. A truck hauling liquid nitrogen tipped over, releasing 1,000 gallons of 32% liquid nitrogen and 50 gallons of diesel fuel into Cane Creek. Early in the response, the local fire department constructed a dike around the drain in the median of the highway to stop further impact. The spill killed 794 fish and other aquatic organisms in the 300-yard zone of impact. The value of the kill was \$55.42.

Other Source

Other regulated sources of pollution include, but are not limited to dewatering, fire suppression run-off water, and pesticide application in residential areas. "Other" source pollution was associated with three incidents, two of which resulted in a fish kill (Table 1).

On September 10, 2019, the Army Corps of Engineers were repairing/removing bulk head gates to the Dam on Long Branch Lake in Macon County. For the safety of the divers doing the repairs, the spillway gates were shut, allowing no water to spill into the Little Chariton River and causing dissolved oxygen to plummet to 0.65 ppm as documented by MDC personnel. MDC observed 381 dead fish, valued at \$4,695.26 at the spillway, many being memorable-sized hybrid striped bass. To remedy the situation, the gates were opened to allow 50 cfs into the river while the divers continued with repairs. The USACE has agreed they would notify MDC of any dewatering for potential rescue/salvage of stranded fish at this site in the future.

Non-Regulated Cause

Incidents within this category include those occurring due to natural causes such as lake inversion, summer and winter kill, disease, and spawning stress. Kills caused by non-point source nutrient pollution often cannot be differentiated from natural dissolved oxygen kills. Therefore, eutrophication from non-point sources is included in this category. Non-regulated incidents commonly present multiple related causes of death. For example, non-point source nutrient enrichment causes algal blooms, which deplete dissolved oxygen at night resulting in fish kills.

Thirty-two non-regulated incidents occurred, which comprised 41% of all incidents during 2019 (Figure 1). Sixteen of these incidents were fish kills. An estimated 6,365 dead fish and aquatic organisms were observed during non-regulated incidents. However, this is an underestimate as thorough fish counts and damage assessments are not conducted for most non-regulated incidents because investigative time and damages are not reimbursed.

During 2019, there was an increase in incidents involving algal blooms, representing 62% of non-regulated incidents compared to 28% of non-regulated incidents in 2018 (O’Hearn and Abel, 2018). Staff observed a sudden increase in the number of algae incidents reported following a few social media posts describing dog deaths in early August. The most notable incident was in Texas County on July 3, 2019. Austin Community Lake had large clumps of green algae throughout the lake and a strong odor. The lake has experienced an explosion in a macrophytes in the last 6 years, and personnel are unaware of any changes in the watershed that would cause a drastic change in nutrient and chlorophyll levels. During a phytoplankton workshop in October 2019, a water sample from Austin Community Lake tested positive for algal toxins.

Unknown Cause

Personnel were unable to identify the source or cause of the water quality problem for 11 incidents, five of which involved the death of fish (Table 1, Figure 1). At least 771 fish were killed due to unknown causes. The most notable incident due to unknown causes was in Jasper County on September 28, 2019. A Landowner was mowing grass when he found dead bass and bluegill in a 300-yard-long pool of Opossum Creek. Decomposition of the fish and the lack of dead fish upstream suggested the kill occurred several days prior to notification. Permitted discharges in the area included an MFA plant discharging storm water 0.5-miles upstream and two concentrated animal feeding operations (CAFO) around 3.5 miles upstream, one of which holds a permit for land application of manure.

TEMPORAL DISTRIBUTION

Seasonally, the distribution of kills throughout the year presented a bell-shaped pattern similar to previous years (Figure 2, O’Hearn and Baker 2017, O’Hearn and Abel 2018). Across seasons, the most regulated, non-regulated, and total incidents occurred during summer. Across months, the most regulated incidents occurred in July (9 incidents) and the most non-regulated incidents occurred in August (12 incidents).

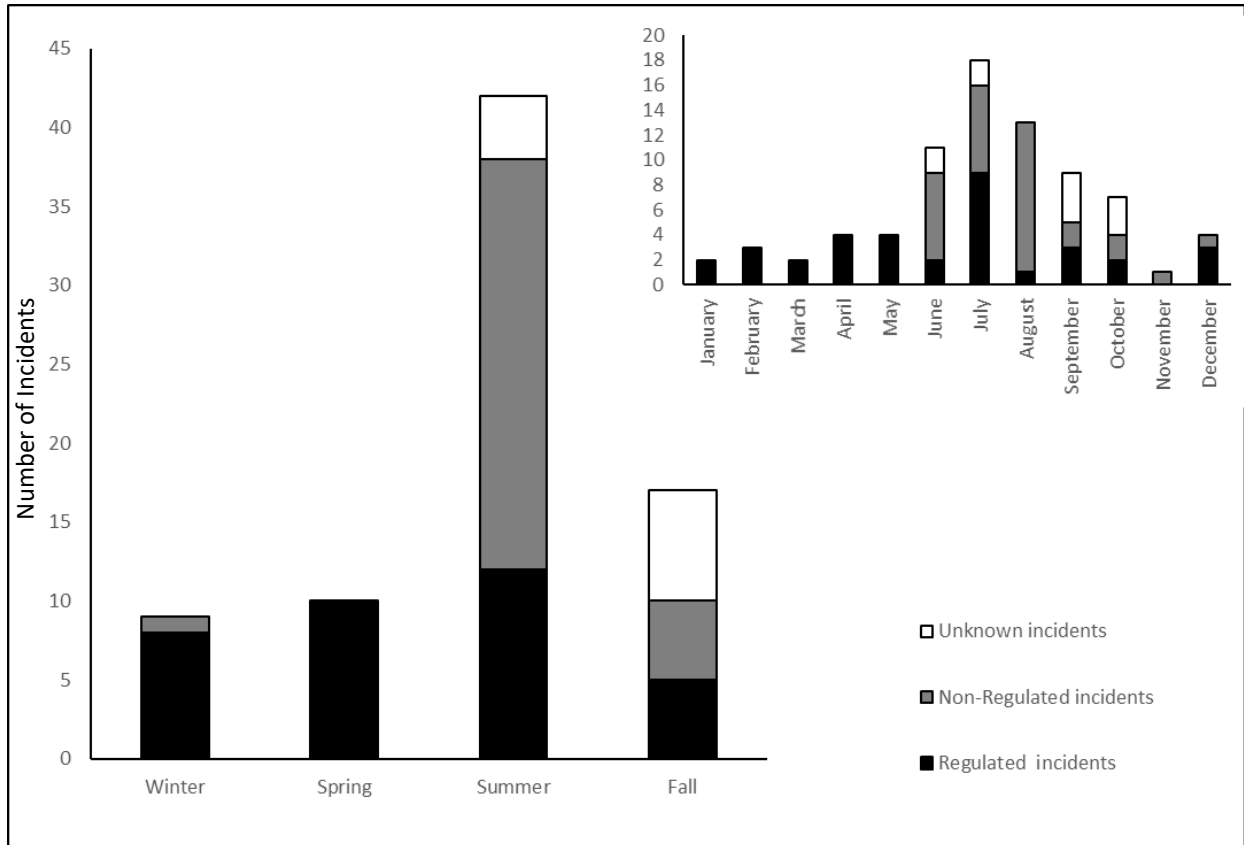


Figure 2. Monthly and seasonal distribution of regulated, non-regulated, and unknown source incidents during 2019.

DISTRIBUTION OF INCIDENTS THROUGHOUT THE STATE

Investigations took place in 42 of 115 counties. The Department’s Central Region experienced the most incidents (29 incidents), while the Ozark and Northwest Regions experienced only four incidents each (Figure 3). Among counties, Boone County had the highest number of incidents (10 incidents). Among major source categories, the most regulated incidents (five) occurred in Boone County (Figure 4). The most non-regulated incidents also occurred in Boone County (4 incidents).

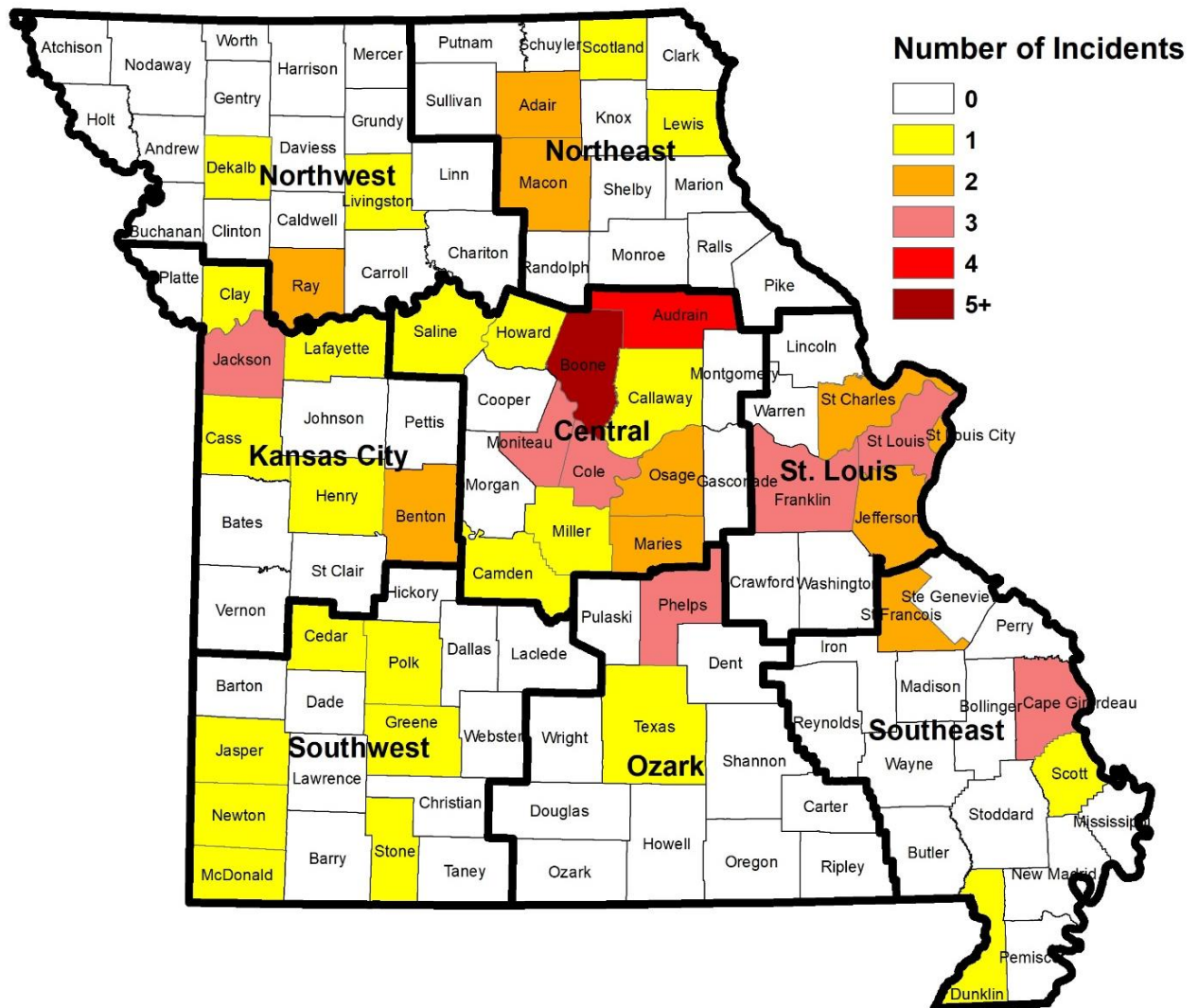


Figure 3. Map of number of incidents per county during 2019. The eight regions for the Missouri Department of Conservation are outlined in bold.

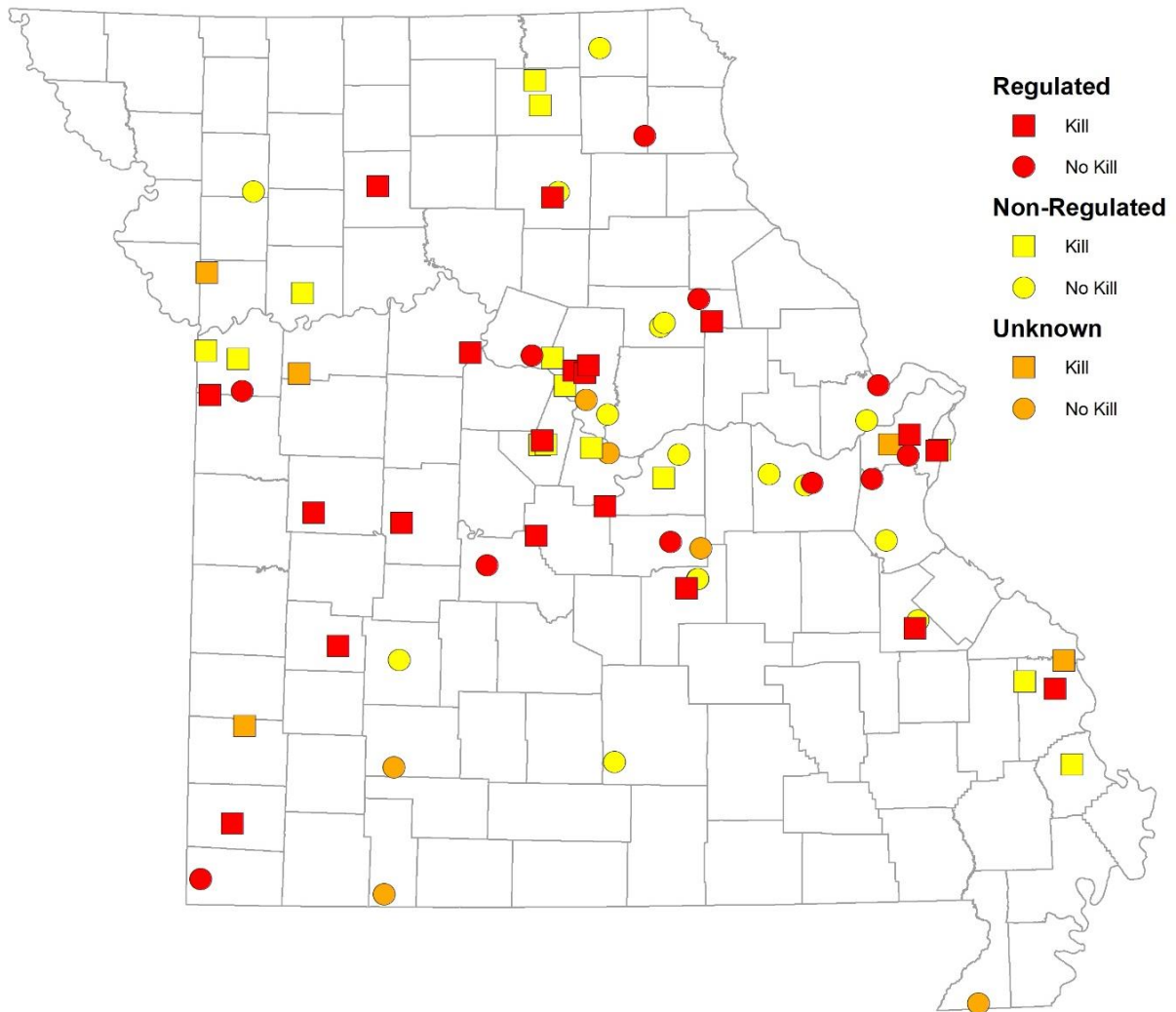


Figure 4. Map of regulated, non-regulated, and unknown source investigations conducted by Missouri Department of Conservation personnel during 2019. Squares indicate fish kills and circles indicate investigations without fish kills.

DISTRIBUTION BY HABITAT TYPE

Among habitat types, incidents occurred more often in ponds than in streams and lakes (Figure 5). There were two incidents in 2019 not involving waters (“None Impacted”, Figure 5). These events occurred in areas where the spill was contained before any effluent could spill into a waterbody. Non-regulated source pollutants were the leading cause of lake and pond incidents, representing 86% and 79% of the incidents in these habitat types, respectively. Regulated causes were the most common type of incident in streams comprising 74% of stream incidents.

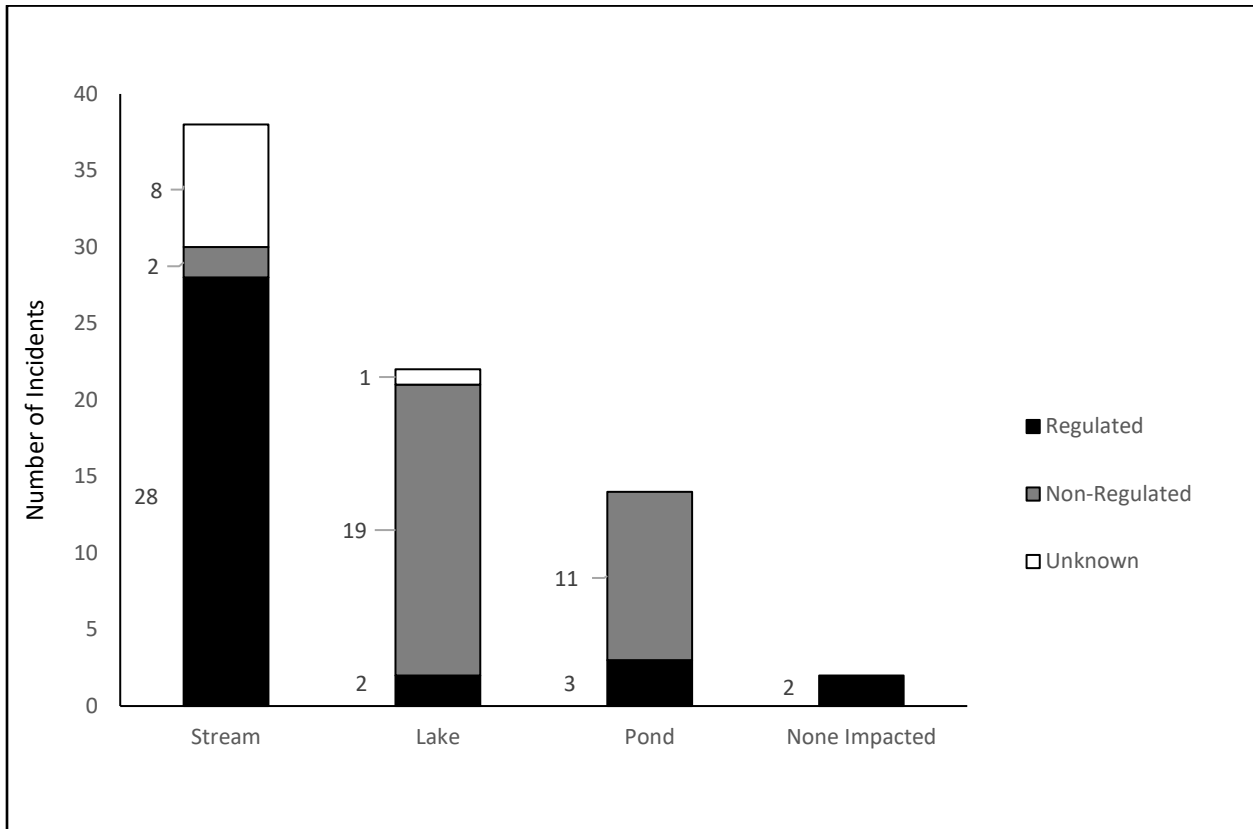


Figure 5. Distribution of incidents during 2019 by habitat type. None impacted indicates an event for which no waters were impacted.

ENFORCEMENT STATUS OF FISH KILL AND POLLUTION CASES

Twelve incidents were resolved through compliance and enforcement actions during 2019. These incidents occurred from 2010 to 2019. DNR, MDC, EPA, and the Missouri Attorney General enforced the cases described in this section. Five of these cases were resolved through civil legal agreements and consent judgement, which included reimbursements of natural resource damages, reimbursements of investigative costs, and payments of civil penalties. Of these cases, four were resolved by DNR and are summarized in Appendix E.

Payments made during resolution of these infractions totaled \$105,762.35 in damages, investigative costs, and penalties. Reimbursements for damages and investigative costs totaled \$62,476.35. Damages included fish damages calculated by MDC (\$117.10) and water quality damages calculated by DNR (\$39,292.17). Of the reimbursed damage funds, \$105.39 was transferred to the MDC Fish Kill Grant Fund, which will be spent on projects benefiting aquatic resources in Missouri. The remaining damage funds (\$39,303.88) were transferred to the DNR Chemical Emergency Preparedness Fund and Natural Resources Damages Fund. MDC received \$2,244.54 in reimbursements for investigative costs, which was also transferred to the MDC Fish Kill Grant Fund. Penalty monies assessed by the DNR amounted to \$43,286. Penalty monies were transferred to the school district of the county in which the pollution occurred.

Thirty potentially enforceable cases remain open. Incidents involved in these cases occurred during 2012 to 2019. Among these forty open cases, three entities caused fish kills or pollution events on multiple occasions: US Army Corps of Engineers (13 incidents); City of Columbia (6 incidents); City of Kansas (3 incidents). US Army Corps of Engineers incidents involved fish mortality related to dam operations. City of Columbia incidents all involved fish mortality from failing drinking water infrastructure. City of Kansas incidents involved fish mortality from waste water overflows and bypasses.

A breakdown of settlement funds and brief descriptions of open and closed cases are located in appendices E and F.

PROJECTS FUNDED BY FISH KILL GRANTS

Reimbursements for MDC investigative costs and 90% of fish and wildlife damages are directed to a Fish Kill Grant Fund that is administered by Fisheries Division. Project proposals are solicited in July on an annual basis from Fisheries, Protection, and Resource Science divisions. Eligible projects benefit aquatic resources.

Ashland City Lake Aeration System

MDC purchased a replacement aeration system for Ashland City Lake to prevent future fish kills related to hypoxia caused by eutrophication and to manage for algae and macrophytes creating nuisance surface scums.

LONG-TERM TRENDS

Data are presented in this section to examine long-term trends dating back to 1988. The Fish Kill and Pollution Program stores information for incidents occurring prior to 1988; however, data for events prior to 1988 are not completely digitized. Two major categories of incidents are not included in this section. The “unknown” and regulated-other categories are not included because they contain incidents with wide ranging pollution sources and causes. Non-regulated incidents are not included because temporal variability for these incidents has been due to changes in reporting procedures (O’Hearn and Martin 2013).

The number of regulated incidents peaked in the mid-1990s and declined from the mid-1990’s to 2002 (Figure 6). Since 2003, the number of regulated incidents has fluctuated between 10 and 28, with 2018 setting a record low of 10 incidents since MDC began electronically recording data in 1988 (O’Hearn and Abel 2018). Municipal source incidents were and continue to be the dominant cause of regulated incidents over time, for 24 out of 32 years. Municipal source incidents in 2019 were at a 17-year high (Figure 7A).

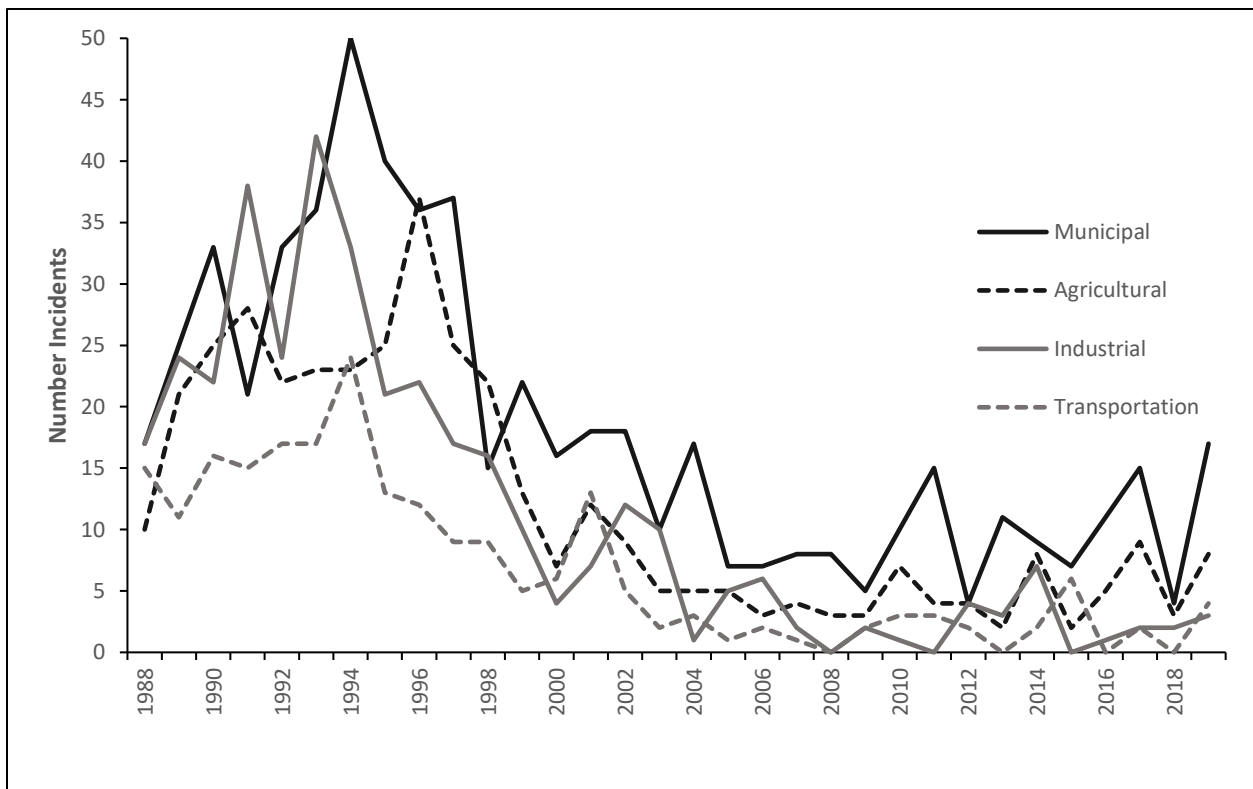


Figure 6. Long-term (1988-2019) trends in regulated incidents. The “other” source category involves miscellaneous pollution sources and is not included in the figure.

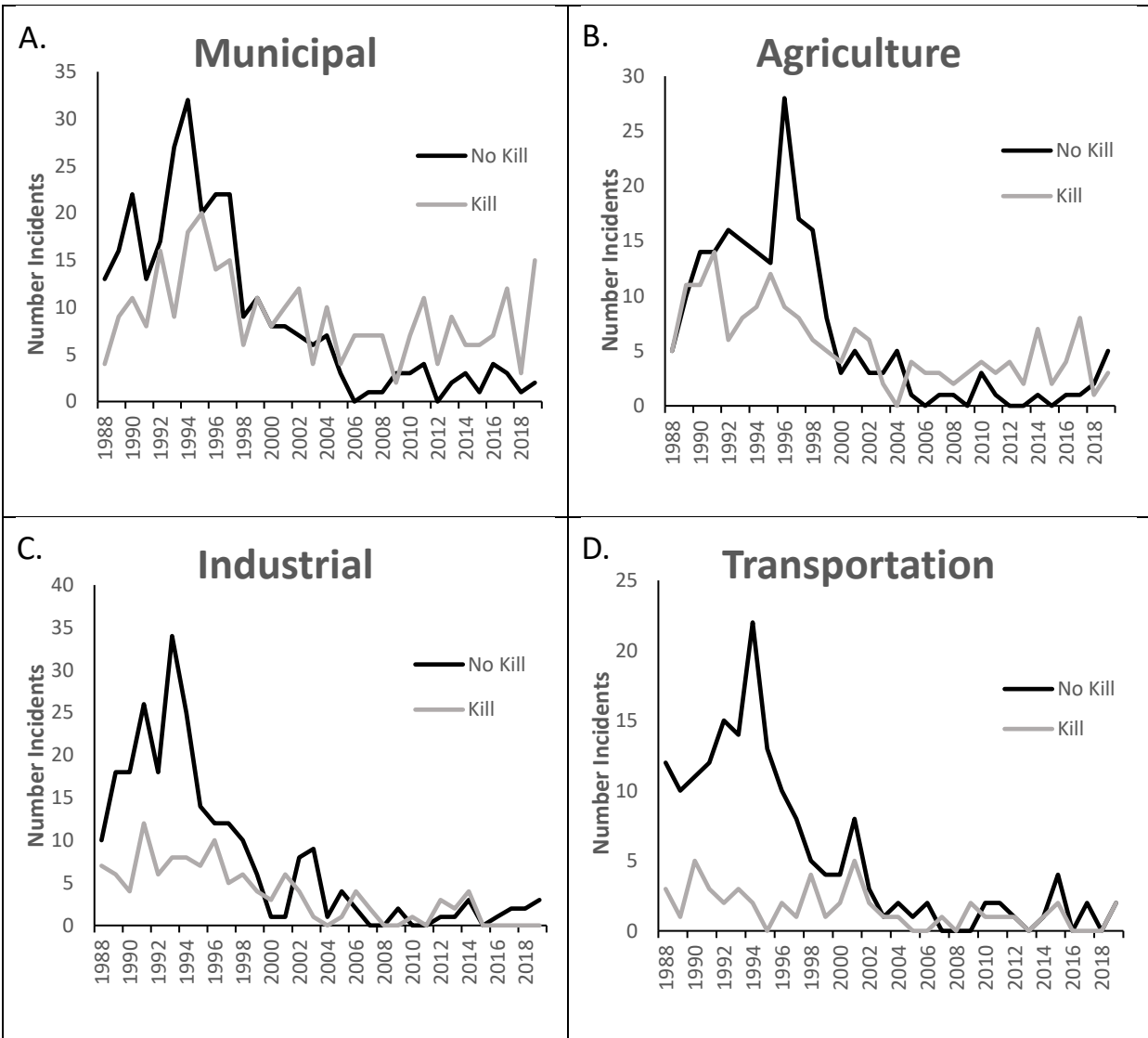


Figure 7. Long-term (1988-2019) trends for regulated fish kill and pollution incidents caused by municipal (A), agricultural (B), industrial (C), and transportation (D) sources. The “unknown” and “other” categories are not included in this figure because they contain incidents with wide ranging pollution sources and causes. Non-regulated incidents are not included because trends reflect changes in reporting procedures (O’Hearn and Martin 2013).

CONCLUSION

The success of the Fish Kill and Pollution Program relies on partnerships with state and federal resource agencies, especially the DNR (the clean water authority in Missouri). MDC's strong partnership with DNR plays a crucial role during all stages of the investigative process. Without this partnership, many polluters would not be held responsible for damaging Missouri's aquatic resources.

Although the program has documented decreases in the number of incidents over time, there remain areas of concern. Municipal pollution (i.e. waste water, chlorinated drinking water, and hydro-electric power generation) continues to be the leading cause of fish pollution-related mortality in Missouri, followed by agricultural pollution (i.e. fertilizers, animal wastes, and pesticides).

Hydropower dams release anoxic hypolimnetic water into receiving waters causing fish kills, trap fish on external structures and internal chambers, and entrain fish through turbines. MDC has been working for decades on mitigation of fish kills caused by US Army Corps of Engineer dams. Within the last several years, DNR has joined MDC in this effort, and US Army Corps of Engineers has made efforts to mitigate some of the causes of these fish kills. Success of these efforts relies on quality partnerships between agencies, which includes trust, transparency, and adaptive management to changing natural resource needs and government funding.

Similar to previous years, during 2019 both municipal and agricultural sources caused extensive damage to Missouri aquatic resources, most notably multiple chlorinated water kills (appendices B and F; pages 5, 28, 29, and 31) and multiple kills caused by livestock waste effluent. The number of chlorinated water kills in the City of Columbia over the last four years is significant when evaluated from a state-wide perspective. The addition of 4 new chlorinated water incidents in Columbia in 2019 brings the total of open chlorinated water cases in Columbia to 10 over the last four years and contributing to the highest number of municipal fish kills within the last 17 years of the program (page 14, Figure 7A). Chlorine is extremely toxic to gilled-aquatic life at low concentrations and persists in the environment when combined with ammonia to form chloramines. MDC has observed complete kills in streams where large chlorinated water releases occur, including streams in the City of Columbia (Flat Branch Creek recolonization study, unpublished data). In some chlorinated water kills, the solution is repairing and replacing aging infrastructure to reduce the number of water main breaks. Other cases can be largely prevented through proper training of contractors and city employees working on construction sites.

Releases of livestock waste effluent and runoff from fields where manure is applied also result in complete kills in streams as documented in the West Fork Cuivre River incident (page 30). Livestock waste contains high levels of ammonia which is toxic to gilled-organisms in low concentrations. Decomposition of livestock waste also decreases dissolved oxygen levels in streams creating hypoxic zones where gilled-organisms asphyxiate. The program documented 5 fish kills in 2019 resulting from discharges of livestock waste into streams (pages 5, 20, 21, and 30). MDC suspects fish kills resulting from livestock waste effluent are more prevalent than what is presented in this report. This suspicion is grounded in conversations with residents who often alert MDC to recurring past discharges and fish kills that they had not previously reported. The first step to mitigating pollution in remote or rural areas is to increase vigilance of residents and reporting of incidents to government representatives. MDC may be able to increase awareness of water pollution, fish kills, and reporting mechanisms by incorporating these themes into social media and traditional media content and by working with local media outlets to notify residents of pollution in their local area.

LITERATURE CITED

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* For readers outside MDC that desire a copy, please contact the Fish Kill Program Manager at 3500 East Gans Road, Columbia, Missouri 65201.

Appendix A. Program accomplishments during 2019.

As part of a continuous effort to achieve complete and thorough investigations, more efficient and rapid response to pollution incidents by MDC personnel, and enhanced protection of the fish and wildlife resources of the state, the following accomplishments were achieved by the Fish Kill Program during 2019:

Monitoring

Clear Creek Recovery Monitoring

Clear Creek in Barry and Lawrence counties experienced a heavy to total fish kill in May 2014. The fish kill was caused by Tyson Foods, who discharged a solution of Alimet to the Monett wastewater treatment plant which killed the plant's denitrifying microbes. This resulted in the discharge of waste water with a high ammonia concentration to Clear Creek. The ammonia caused a fish kill for over 5 stream miles, and fish morbidity & mortality was observed for several days. At least 108,809 fish and crayfish valued at \$130,988.26 died during this incident. Due to the severity of the kill, MDC began monitoring for live fish shortly after the kill. One year after the kill, MDC observed fish recolonization occurring throughout the entire 5-mile kill zone. Data analysis begun in late 2019 and will be completed in 2020.

Tunnel Dam Project

The Environmental Health Unit will be monitoring water quality in Lake Niangua and the Niangua River to assess baseline conditions prior to potential changes to management of Tunnel Dam during Federal Energy Regulatory Commission relicensing. Changes to management of Tunnel Dam may impact the federally listed Niangua Darter in the watershed and sports fisheries in Lake Niangua. Monitoring in 2019 in the lower Niangua River suggests low dissolved oxygen levels in middle segments of the river relative to upper segments of the river in past years are related to reduced stream flow. Additional monitoring effort was focused on river segments upstream and downstream of the generation station in 2019. These focused efforts indicated dissolved oxygen was lower at the generation station and downstream of the generation station relative to upstream of the generation station, suggesting the generation station may reduce dissolved oxygen levels in the river. The spatial extent of reduced dissolved oxygen increased when power was being generated during these focused efforts.

Predictive Modeling of Algal Toxins in Fish and waters in Missouri

The Environmental Health Unit began collaborating with the University of Missouri, DNR, and Missouri Department of Health and Senior Services to monitor for algal toxins in fish tissues and waters in Missouri. During 2017 we initiated a pilot project in University of Missouri's hyper-eutrophic Dairy Farm Lake number 1. The objective of the pilot project is to determine if Missouri needs to conduct statewide monitoring for algal toxins in fish to set fish consumption advisories. Samples were collected in 2018 by MDC, Missouri Department of Health and Senior Services, and MU. Lab and data analysis will be completed in 2020 by a PhD candidate in MU's Limnology Laboratory. In 2019, MDC and DNR began opportunistically collecting water samples and fish specimens during routine monitoring if an algal bloom was observed. These samples and specimens will be analyzed in 2020 and offered to the PhD candidate for a supplemental data source for interpretation of data collected in Dairy Farm Lake.

Aquatic Snail Distributional Monitoring

The Aquatic Systems and Environmental Health Unit began opportunistically collecting aquatic snails to begin improving the snail distributional map in Missouri. Improving the distributional map will ensure Clean Water regulators to have the best information when developing and implementing changing water quality standards in the future related to stream nutrient and ammonia.

Training

Fish Kill Procedures Training

Training on water pollution and fish kill investigation procedures was given to Conservation Agent trainees during summer 2019. This training is conducted to familiarize MDC field staff with investigation procedures which must be followed during investigations to ensure reliable collection of evidence and legal defensibility. MDC Protection and Fisheries divisions are invaluable to MDC's ability to respond to pollution problems statewide in a professional and timely manner. Without their assistance, the task would be overwhelming.

Limnology Training

The Fish Kill Program partnered with University of Missouri's Limnology staff to give Limnology 101 training to MDC staff in the summer of 2019. Freshwater limnology is the study of the structural and functional interrelationships of fresh water organisms as they are affected by their dynamic physical, chemical, and biotic environments. This was the third year limnology training was offered to MDC staff since the 1990s. A solid understanding of basic limnology and aquatic ecology assists fisheries management and hatchery staff with data interpretation and with troubleshooting water quality issues on the job.

Phytoplankton Workshop

The Environmental Health Unit assisted the Fisheries Division with identifying professional phycologists to teach an algal identification and ecology workshop for Fisheries staff. Fisheries staff receive numerous calls from Missouri citizens concerned with private pond algal blooms and hypoxia fish kills annually and are responsible for maintaining healthy fisheries statewide in state-managed reservoirs. The objective of this training was to equip fisheries staff with knowledge to assist them with advising private pond owners and managing algae blooms in reservoirs that MDC manages.

Presentations

Guest Lecturer- University of Missouri Water Quality Class

Presented Missouri fish kills and pollution types and case studies to University of Missouri's Water Quality students.

Guest Speaker- University of Missouri, Water Resources Center

Presented on the causes of and mitigation of fish kills in Missouri to students and faculty in the Engineering School's Water Resources Center.

Director's Conservation Roundtable- One Health; One Challenge; One Opportunity workshop

On behalf of Missouri's Interagency Algal Toxin Team, presented *Blue-green algae: working together to keep nature and people healthy*

Future Operational Changes

New Fish Kill Application and Database

In July 2018 MDC began working towards replacing the outdated fish kill and pollution database. The future database will be paired with three applications. The first application will provide the public the ability to directly report fish kills they observe through MDC's website. A new fish kill page on MDC's public website will host this first application in addition to providing the public a venue for learning about fish kill events around the state of Missouri, their causes, and how they can be part of the solution to prevent, reduce, and mitigate pollution. The second application automatically notifies regional fish kill responders when the public reports through MDC's website. The third application will allow MDC staff to directly enter their investigative data into the fish kill database which will eliminate data entry errors caused by re-entering data multiple times. The new application and database will be completed in 2020.

Harmful Algal Bloom Response

The Environmental Health Unit began drafting a harmful algal bloom notification and response protocol for MDC staff. The response protocol reflects the recommendations of the Missouri Department of Health and Senior Services, and also includes specifics related to fish and wildlife mortality response.

Organizational Changes

Department Reorganization

MDC began transitioning to a new organizational model in the fall of 2019. The new organizational model shifts resource decision-making to a regional level and promotes better collaboration between traditional resource divisions of fisheries, forestry, and wildlife. The new organizational model also promotes focusing efforts on priority conservation geographies and connecting Missourians with nature through non-traditional resource uses like nature walking, wildlife watching, and citizen science. Under the reorganization, starting July 1st, 2020 the Environmental Health Unit will be placed in a larger Health Unit with Wildlife Health Unit, Forest Health Unit, and the Resource Assessment and Monitoring (RAM) program.

Appendix B. Summary of regulated source incidents during 2019. Data is listed alphabetically by county. ND= not determined, NC= not calculated

County	Waterbody	Incident Date	Source	Cause	Number Animals Killed	Value
Audrain	Lick Creek	2/28/2019	Agriculture	Ammonia toxicity and low dissolved oxygen from hog lagoon overflow	0	-
Audrain	West Fork Cuivre River	7/27/2019	Agriculture	Hypoxia & ammonia toxicity (suspect) from hog lagoon overflow	3,347	\$1,326.09
Benton	Lake of the Ozarks	5/15/2019	Municipal	Blunt force trauma & low dissolved oxygen (possible) from dam operations	117	11,628.56
Benton	Lake of the Ozarks	6/27/2019	Municipal	Blunt force trauma from dam operations	ND	NC
Boone	Bear Creek tributary	7/13/2019	Municipal	Chlorine toxicity from pool water leak	1,437	\$438.46
Boone	Flat Branch Creek	4/26/2019	Municipal	Chlorine toxicity from water main break	1,552	\$257.89
Boone	Flat Branch Creek	7/25/2019	Municipal	Chlorine toxicity (suspected) from water main break	6	\$0.72
Boone	Harmony Creek tributary	7/24/2019	Municipal	Chlorine toxicity from drinking water main break	403	\$52.08
Boone	Tributary to Hinkson Creek	7/16/2019	Municipal	Truck dumping raw sewage	0	-
Callaway	Tributary to Stinson Creek	5/1/2019	Agriculture	Animal waste from CAFO runoff	0	-
Camden	Little Niangua River	7/22/2019	Other	Silt from bridge construction	0	-
Cape Girardeau	Tributary to Cane Creek	4/1/2019	Transportation	Ammonia toxicity & potential petrochemical toxicity from auto accident	794	\$55.42
Cass	Tributary to Little Blue River	4/24/2019	Municipal	Domestic sewage; manhole vandalism	ND	NC
Cedar	Sac River	7/10/2019	Municipal	Low dissolved oxygen; intake pipe below thermocline	38	NC
Cole	Osage River	7/15/2019	Municipal	Blunt force trauma (suspected) from dam operations	4	NC
Franklin	Bourbeuse River	1/8/2019	Agriculture	Mechanical fluid leak from skidsteer stuck in river	0	-
Henry	Deepwater Creek	4/8/2019	Other	High fish population and temperatures causing low dissolved oxygen	86	\$2,799.58
Howard	Davisdale Conservation Area	12/3/2019	Transportation	Natural gas	0	-
Jackson	Big Creek	3/21/2019	Municipal	Chlorine toxicity from water main break	0	-

Appendix B. Continued

County	Waterbody	Incident Date	Source	Cause	Number Animals Killed	Value
Jefferson	La Barque Creek	12/13/2019	Industrial	waste oil from abandoned oil drums	0	-
Lewis	Spees Branch	10/4/2019	Agriculture	Lagoon runoff	0	-
Livingston	Tributary to Grand River	9/17/2019	Municipal	Chlorine toxicity (suspected) from fire suppression	6	NC
Macon	East Fork Little Chariton River	9/10/2019	Other	Hypoxia from dam operations	336	\$4,695.26
Maries	Gasconade River	2/12/2019	Industrial	petroleum	0	-
McDonald	Tributary to Elk River	5/17/2019	Agriculture	Land applied waste	0	-
Miller	Osage River	6/22/2019	Municipal	Blunt force trauma (suspected)	ND	NC
Moniteau	Private Pond	8/7/2019	Agriculture	Aerial crop dusting (suspected)	ND	NC
Newton	Hickory Creek	3/8/2019	Municipal	Chlorine toxicity from water main break	134	\$500.31
Phelps	Ber Juan Lake	7/13/2019	Municipal	Chlorine toxicity	ND	NC
Saline	Private Pond	5/23/2019	Agriculture	Fungicide	ND	NC
St. Charles	Mississippi River	2/6/2019	Transportation	Crude oil	0	-
St. Francois	St. Francis River & tributaries	9/11/2019	Municipal	Hypoxia (confirmed) & ammonia toxicity (suspected) from waste water spill	6,549	\$7,245.37
St. Louis	Tributary to Deer Creek	12/10/2019	Transportation	15% sodium hypochlorite solution (chlorine bleach)	16	\$34.50
St. Louis	Meramec River	1/25/2019	Industrial	Used cooking grease	0	-
St. Louis City	River Des Peres	10/7/2019	Municipal	Sewage	ND	NC

Appendix C. Summary of non-regulated source incidents during 2019. Data is listed alphabetically by county. ND=not determined

County	Waterbody	Incident Date	Cause	Number Animals Killed
Adair	Hazel Creek Lake	8/19/2019	Same species; disease(possible); some angling	ND
Adair	Private Lake	8/23/2019	Aquashade pond dye	85
Audrain	Lakeview Park Lake	7/28/2019	Cyanobacteria (suspected)	0
Audrain	Military Academy Pond	7/28/2019	Cyanobacteria (suspected)	0
Boone	Ashland Lake	9/15/2019	Cyanobacteria	0
Boone	Private Lake	8/9/2019	Low dissolved oxygen (suspected)	ND
Boone	Perche Creek	8/12/2019	Low dissolved oxygen	ND
Boone	Private Pond	6/5/2019	Low dissolved oxygen from planktonic algae die-off	400
Cape Girardeau	Private Pond	8/22/2019	Low dissolved oxygen	ND
Cole	Binder Lake	6/19/2019	Low dissolved oxygen (suspected)	30
DeKalb	Grindstone Reservoir	7/22/2019	Cyanobacteria (suspected)	0
Franklin	Private Pond	8/23/2019	Cyanotoxins (suspected)	0
Franklin	Port Hudson Lake	7/8/2019	Cyanobacteria	0
Jackson	Brush Creek	8/2/2019	Low dissolved oxygen from unconfirmed sewage leak	3
Jackson	Stormwater basins	12/26/2019	Low dissolved oxygen	ND
Jefferson	Briarwood Lake	11/26/2019	Cyanobacteria	0
Macon	Private Pond	8/29/2019	Algal toxins (suspected)	0

Appendix C. Continued

County	Waterbody	Incident Date	Cause	Number Animals Killed
Moniteau	Farm pond	6/6/2019	Spawning stress	10
Moniteau	Proctor Park Lake	8/26/2019	Low dissolved oxygen from algae die-off	ND
Osage	Ben Branch Lake	10/7/2019	Cyanobacteria	0
Osage	Farm pond	6/1/2019	Low dissolved oxygen	110
Phelps	Little Prairie Lake	9/17/2019	Cyanobacteria	0
Phelps	Little Prairie Lake	10/2/2019	Potential harmful algal bloom	0
Polk	Dunnegan Memorial Park Lake	8/14/2019	Potential harmful algal bloom	0
Ray	Ray County Lake	7/25/2019	Low dissolved oxygen, algal toxins	ND
Ray	Ray County Lake	8/28/2019	Low dissolved oxygen	5,627
Scotland	Lake ShowMe	6/6/2019	Cyanobacteria	0
Scott	Meyer Lake	6/24/2019	Algal toxins (suspected), low dissolved oxygen	100
St. Charles	Prairie Lake	8/28/2019	Cyanobacteria	0
St. Francois	Farm Pond	6/25/2019	Bacterial bloom (suspected)	0
St. Louis City	Horseshoe Lake	7/7/2019	Low dissolved oxygen (suspected)/copper sulfate vegetation management	ND
Texas	Austin Community Lake	7/3/2019	Cyanobacteria	0

Appendix D. Summary of incidents caused by unknown sources during 2019. Data is listed alphabetically by county. ND=not determined

County	Waterbody	Incident date	Cause	Number Animals Killed
Boone	Bonne Femme Creek	10/2/2019	Tumors/cysts on fish	0
Cape Girardeau	Apple Creek	9/22/2019	Low dissolved oxygen	500
Clay	Little Platte River	9/8/2019	Single species virus (possible)	ND
Cole	Wears Creek	7/11/2019	Unconfirmed	0
Dunklin	Far West Floodway Ditch	9/12/2019	High water temperatures/ low dissolved oxygen	0
Greene	Alpine Village Pond	6/25/2019	Unknown	0
Jasper	Opossum Creek	9/28/2019	Unknown	17
Lafayette	Private Pond	10/5/2019	Unknown	254
Maries	Bourbeuse River	6/14/2019	Lethargic fish	0
St. Louis	Fishpot Creek	10/23/2019	Chlorinated water (possible)	ND
Stone	Table Rock Lake	7/4/2019	Reported sewage smell	0

Appendix E. Summary of Clean Water Law settlements reached by the State of Missouri during 2019 for incidents involving MDC, including penalties and damages (monetary value of animals). Data is listed alphabetically by county. This table does not include investigative costs for DNR or stipulated penalties. Cr=creek

County	Waterbody	Event Date	Responsible Party	Cause	Reimbursements			Penalty (DNR calculates)**
					Damages*	MDC Investigative Costs	MDC Total	
Cole	Wears Cr trib	2/18/16	MO American Water Co.	chlorinated water line break	\$34.78	\$451.16	\$482.46	\$0
Lafayette	Dyer Rock Cr	7/17/15	Cedar Ridge Aviation	Pesticide poisoning	Not able to assess	\$1,391.21	\$1,391.21	\$0
St. Louis	Grand Glaize Cr	7/13/15	MO American Water Co.	chlorinated water line break	\$82.32	\$402.17	\$476.26	\$0
Vernon	Kitten Cr, Coal Cr, and tribs	June 2014	Kitten Creek Dairies (formerly Focal Dairies)	Livestock waste	\$39,292.17+	Not reimbursed	Not reimbursed	\$43,286

*Ten percent of damages are transferred to an emergency response fund at DNR.

**Includes suspended penalties and supplemental environmental project costs.

+Water quality damages calculated by DNR. Fish damages not reimbursed.

Appendix F. Brief descriptions of closed and open cases listed alphabetically by county for 2019.

Closed Cases (resolution achieved)

Callaway County (1/3/17), City of Holts Summit

The City of Holts Summit reported a grease blockage caused a manhole overflow sometime on January 3rd or 4th resulting in a discharge of 134,000 gallons of raw sewage into a tributary of Rivaux Creek. MDC was notified of the overflow and fish kill on January 10th, six to seven days after the initial spill. The MDC responder found very few dead fish during the investigation due to the delay in notification, ice cover, and leaf litter in the stream. Thirty darters and minnows were observed and valued at \$6.20. At the time of this incident, the City of Holts Summit was already under an enforcement action. A Notice of Violation was issued by the DNR regional office and the pollutant was removed from the affected site. The City performed quarterly site inspections of the pipe that caused the sanitary sewer overflow. Penalties and cost recovery were not pursued for this incident.

Camden County (7/11/17), Sho-Me Power

MDC staff observed mussel and fish stranding while conducting normal work duties in the Niangua River below Tunnel Dam. The stranding was caused by an abrupt reduction in flow over Tunnel Dam for a spillway inspection. Stranded mussels were translocated to water, but many fish and stream macroinvertebrates died as the result of this dewatering event (60,666 dead fish and macroinvertebrates valued at \$7,954.92). Survival of the translocated mussels in the days and weeks following this event are unknown. Sho-Me Power is cooperating with MDC to mitigate for fish and wildlife stranding when lowering water levels for dam inspection and maintenance.

Cole County (8/21/11), Jefferson City Wastewater Utility Services

A sewage overflow occurred in a tributary to Moreau Creek due to a power failure at a pumping station. At least 1,289 fish valued at \$173.13 were killed. The Environmental Protection Agency executed a Findings of Violation and Administrative Order for Compliance on Consent.

Cole County (2/14/13), City of Jefferson

Roughly 3,500 gallons of raw sewage flowed from a manhole into Wears Creek. At least 376 fish valued at \$52.19 died in a 2,000-foot section of stream. The Environmental Protection Agency executed a Findings of Violation and Administrative Order for Compliance on Consent.

Cole County (2/18/16), Missouri American Water

A water line broke in Jefferson City which discharged chlorinated water into a tributary of Wears Creek. Chlorine is extremely toxic to gill breathing aquatic organisms. Our Conservation Agent observed 266 dead fish as a result of this discharge. The dead fish were valued at \$34.78. An Abatement Order on Consent was signed in March 2019. Missouri American Water agreed to pay the state's investigative costs and damages in the amount of \$485.94.

Franklin County (1/8/19), unidentified responsible party

A skid steer slid into the Bourbouse River during removal of trees from the shoreline and streambank. The skid steer remained in the river, lodged under gravel and sediment for several months, threatening a federally listed mussel via potential habitat alteration of gravel beds and flow. Local, state, and federal officials struggled to determine a responsible party due to the skid steer being stolen property, the contractors using the stolen property being unable to be located, and the renters on the property adjacent to the stream contracting out the work and being served an eviction notice. The owners of the

property adjacent to the river, who were residents in another state, eventually hired a contractor to remove the skid steer.

Lafayette County (7/17/15), Cedar Ridge Aviation

A trailer containing a mixture of pesticides went off road. A large volume of its contents, which included 8-gal mustang maxx, 63 gal crobkarb, 20-gal quilt xcel reached Dyer Rock Creek and caused a severe kill of fish, crayfish, and amphibians. An Abatement order on Consent was signed in 2019 requiring the responsible party to reimburse the state for costs incurred during the response to the incident.

St. François County (9/11/19), City of Farmington (suspected)

Discharges from the Farmington West WWTP resulted in hypoxic conditions in the St. Francis River and one of its tributaries on the 11th of September in St. Francois County. MDC staff observed dead fish in 1.5 miles of stream and documented 6,549 dead fish and other aquatic organisms. These organisms are valued at \$7,245.37. This event was of concern due to the downstream presence of federally listed aquatic species. DNR is not pursuing enforcement action on this incident because the WWTF was discharging within permit limits and DNR cannot prove the source of low dissolved oxygen is nutrient-rich discharge from the WWTP. The WWTP will receive nutrient limits in its next permit due to the new Lake Nutrient Criteria (Lake Wappello). The St. Francois River in this section will also receive a Total Maximum Daily Load (TMDL) which will be factored into the permit.

St. Louis County (8/10/10), St. Louis Metropolitan Sewer District

Sewage overflowed from a manhole into Martiginey Creek killing an unknown number of fish. There is a federal Consent Decree issued by the Environmental Protection Agency and the Missouri Coalition for the Environment to St. Louis Metropolitan Sewer District (MSD) 2015 regarding MSD's collection system. MSD is required to fix its system to prevent future SSOs/CSOs. A civil penalty of \$1.2M was included in the consent decree.

St. Louis County (7/9/13), St. Louis Metropolitan Sewer District

Raw sewage from a discharge pipe impacted 2,500 feet of Deer Creek causing the death of at least 546 fish valued at \$386.08. There is a federal Consent Decree issued by the Environmental Protection Agency and the Missouri Coalition for the Environment to St. Louis Metropolitan Sewer District (MSD) 2015 regarding MSD's collection system. MSD is required to fix its system to prevent future SSOs/CSOs. A civil penalty of \$1.2M was included in the consent decree.

St. Louis County (7/13/15), Missouri American Water

A chlorinated water release occurred in Grand Glaize Creek. Chlorine is highly toxic to gill-breathing organisms. MDC observed at least 308 dead fish valued at \$82.32. An Abatement Order on Consent was signed in March 2019. Missouri American Water agreed to pay the state's investigative costs and damages in the amount of \$660.58.

Vernon County (3/8/10, 12/14/10, 4/1/11, 6/8/14), Kitten Creek Dairies (formerly Focal Dairies)

Water pollution and foul odors have been observed in Kitten Creek, Coal Branch, and their tributaries dating back to 2007. A settlement agreement was signed in 2008 to resolve these issues, but MDC continued to receive complaints from the public about pollution in the area. MDC also observed and documented water pollution on site, a few fish kills, and tributaries dominated with pollution tolerance macroinvertebrates. DNR continued to inspect the facility after MDC's last reported fish kill in 2014. These inspections led to a Consent Judgment being signed between the Attorney General, Missouri Clean Water Commission, DNR, and the responsible party in March 2019. *The responsible party was*

ordered to pay \$99,000.14, which included \$43,286 in penalties, \$39,292 in natural resource damages, and \$16,421.97 for costs incurred during the state's investigation. Reimbursements for natural resource damages are going to be used to remove manure from streams and regrade stream banks.

Closed Cases (no resolution achieved)

Boone County (7/3/14), University of Missouri

Runoff from land applied manure in the areas adjacent to Dairy Farm Lake No. 3 depleted oxygen. MDC staff observed 3,945 dead fish valued at \$7,808.26. There is a history of kills of this nature at this lake and Dairy Farm Lake No. 1 dating back to 2005 in our records. MDC awarded money from the Fish Kill Grant Fund to purchase and install an efficient aeration system at lakes 1 and 3. MU has not accepted funding for the purchase and installation at Lake No. 1. This case was closed because causation could not be determined by DNR and the statute of limitations has expired.

Boone County (5/18/14), University of Missouri

Runoff from land applied manure in the areas adjacent to Dairy Farm Lake No. 1 depleted oxygen. MDC staff observed 50 dead fish valued at \$150.46 during May 2014. There is a history of kills of this nature at this lake and Dairy Farm Lake No. 3 dating back to 2005 in our records. This incident is one of five fish kills resulting from land application of manure at this site. An effective aeration system and a vegetated buffer zone, or removal of nutrient-rich sediments is needed to avoid future fish kills. MDC awarded money from the Fish Kill Grant Fund to purchase and install an efficient aeration system at lakes 1 and 3. MU did not accept funding for the purchase and installation at Lake No. 1. This case was closed because causation could not be determined by DNR and the statute of limitations has expired.

Boone County (8/22/15), University of Missouri

Runoff from land applied manure in the areas adjacent to Dairy Farm Lake No. 1 depleted oxygen. MDC staff observed 410 dead fish valued at \$822.42 during August 2015. There is a history of kills of this nature at this lake and Dairy Farm Lake No. 3 dating back to 2005 in our records. This incident is one of five fish kills resulting from land application of manure at this site. An effective aeration system and a vegetated buffer zone, or removal of nutrient-rich sediments is needed to avoid future fish kills. MDC awarded money from the Fish Kill Grant Fund to purchase and install an efficient aeration system at lakes 1 and 3. MU did not accept funding for the purchase and installation at Lake No. 1. This case was closed because causation could not be determined by DNR.

Boone County (7/25/19), City of Columbia (suspected)

MDC staff investigated a fish kill in Flat Branch Creek in Columbia. Chlorine was detected in the stream, however, evidence linking the chlorine in the stream to a recent water line break was inconclusive. This reach of stream also experienced a fish kill caused by chlorinated water (line break suspected) three months prior to this event. This case was closed because regional DNR could not verify the source and responsible party of the pollutant.

Boone County (7/24/19), City of Columbia (suspected)

MDC staff investigated a fish kill in a tributary of Harmony Creek in Columbia. Staff documented 403 dead fish valued at \$52.08. MDC suspects two separate water main breaks on the 22nd and 24th of July resulted in chlorinated water entering the stream killing the fish. Evidence linking the dead fish to the water main breaks was inconclusive. This case was closed because regional DNR could not verify the source and responsible party of the pollutant.

Cole County (12/19/17), Missouri American Water

MDC was notified by DNR-EER of a fish kill in a tributary of Wears Creek near Central Dairy in Jefferson City. Chlorine was detected by DNR in the tributary. MDC observed 160 fish valued at \$345 as a result of this chlorinated water discharge. This case was closed because DNR's Northeast Regional investigator was unable to determine the source of pollution.

Henry County (6/30/17), Kansas City Power and Light (suspected)

MDC was notified in August about a fish kill on Montrose Lake that had occurred in late June. By the time MDC learned of the fish kill, all evidence was gone. MDC suspects low dissolved oxygen discharged in the warmwater discharge channel from plant caused the fish kill. The suspected responsible party signed an agreement recently that stated any fish kill caused by dam operations would prompt installation of automated water quality equipment to measure dissolved oxygen and temperature conditions in real-time. DNR is currently evaluating this incident for compliance action. This case was closed because no state officials were able to make observations of the dead fish and water quality issue.

Henry County (4/8/19), Evergy (formerly Kansas City Power and Light Company)

The department received calls from anglers at two department offices regarding dead fish below Montrose Dam on April 8th. Observations on-site and correspondence with Kansas City Power and Light's Environmental Coordinator confirmed that fish mortality was the result of insufficient/lack of flow through Montrose Dam. Insufficient flow resulted in low dissolved oxygen (1 ppm) and fish becoming stranded and dying in an isolated pool in Deepwater Creek. Investigators documented 85 dead fish valued at \$2,771.68. It is suspected that more fish died during this incident, but were flushed downstream on private property prior to investigators arriving on site. DNR is not pursuing enforcement action on this incident.

Jackson County (6/13/17), City of Independence

A fire hydrant rupture resulted in a chlorinated water discharge to Camp Creek. MDC responders observed 4,411 fish valued at \$4,780.93 as the result of the discharge. The responsible party was originally believed to be the City of Independence; however, it was later discovered that a circus company was responsible for the fire hydrant rupture. A circus truck of elephants backed into the fire hydrant causing the rupture. The DNR has been unsuccessful collecting damages and investigative time for this case due to the circus company being difficult to locate at any given point of time. DNR attorneys do not believe DNR will be able to collect costs, so this case has been closed.

Phelps County (7/13/19), City of Rolla (suspected)

Staff investigated a significant fish kill in Ber Juan Lake. Ber Juan Lake is not classified as a water of the state, but MDC stocks sports fish for anglers in the lake. DNR assisted with the investigation and found levels of chlorine that are toxic to aquatic life. The City of Rolla has undergone testing in an attempt to locate the source of chlorine contamination, but testing has been inconclusive. The City of Rolla has offered to pay for the restocking of the lake. This case was closed because the source of the pollutant could not be determined.

Ste. Genevieve County (7/22/17), Mississippi Lime Company

MDC received complaints from several residents in the area about a smell and sheen in the creek near Mississippi Lime Company. Upon investigation MDC found a sheen in South Gabouri Creek. Mississippi Lime was contacted and instructed to place boom in the creek. MDC did not observe any stress wildlife. The case was referred to DNR for compliance and/or enforcement action.

Open Cases

The following cases are currently being evaluated for enforcement actions by DNR, MDC, or the Attorney General's Office.

Audrain County (4/17/18), Harold Kroft

A large volume of hog lagoon effluent was discharged into Sandy Creek, depleting oxygen and introducing levels of ammonia that were toxic to gilled aquatic life. A 4-mile long dead zone was observed from the beginning to end of the investigation which concluded after four days. Staff did not revisit the site after the fourth day of investigation to determine when water quality improved. An estimated 47,887 aquatic animals valued at \$43,959.91 died due to this release. This case is pending enforcement action.

Audrain County (7/28/19), Wayne Windmann (suspected)

The Audrain County Conservation Agent received a water pollution complaint from a landowner. Upon inspection, the Agent identified the pollution originating from confined animal feeding operation upstream owned by Wayne Windmann. Windmann indicated a pipe had been damaged on July 27th resulting in the release of an unknown volume of manure from one of his lagoons. Manure entered a tributary of West Fork Cuivre River. The Agent observed discolored (black) water for approximately 1.5 stream miles from the point of entry. We estimate at least 3,347 fish valued at \$1,326.09 were killed during this incident. This case is pending enforcement action.

Benton County (5/29/13), U.S. Army Corps of Engineers under direction of Southwest Power Administration

A hypolimnetic release of low dissolved oxygen water caused a fish kill in Lake of the Ozarks. Trauma from passing through Truman Dam and physical injury from flood gate releases also contributed to the kill. An estimated 2,723 fish valued at \$15,196.71 died. Discussions between DNR, MDC, Southwest Power Administration, and U.S. Army Corps of Engineers are ongoing.

Benton County (8/26/13), U.S. Army Corps of Engineers

An emergency shutdown and dewatering of a turbine chute in Truman Dam caused the death of at least 3,368 fish worth \$4,950.97. The trapped fish likely died from overcrowding and subsequent low dissolved oxygen. Discussions between DNR, MDC, and U.S. Army Corps of Engineers are ongoing.

Benton County (5/25/16), U.S. Army Corps of Engineers under direction of Southwest Power Administration

A U.S. Army Corps of Engineers employee notified MDC of a fish kill below Truman Dam consisting of approximately 40 fish. The fish were primarily hybrid striped bass. Lengths were not recorded for these dead fish; therefore, we were unable to calculate a monetary value. Discussions between DNR, MDC, Southwest Power Administration, and U.S. Army Corps of Engineers are ongoing.

Benton County (5/6/17), U.S. Army Corps of Engineers under direction of Southwest Power Administration

There was a large fish kill below Truman Dam caused by releases of flood waters. Paddlefish were the most commonly observed injured and/or dead fish during this fish kill. The fish kill lasted nearly two months. Preliminary estimates of damages are over \$146,000. This should be considered an underestimate because MDC staff actively searched for only 36 hours during this two-month period.

Boone County (6/9/16, 9/1/17, 1/10/18, 7/17/18, 4/26/19), City of Columbia

Five open City of Columbia fish kills caused by drinking water were combined into one enforcement action. Descriptions of each fish kill follow:

- 1) 6/9/16- City of Columbia drinking water lift station malfunctioned discharging 320,000 gallons of chlorinated water into Mill Creek. The release of chlorinated water killed over 10,000 fish and aquatic worms valued at \$3,295.36.
- 2) 9/1/17- A drinking water line ruptured discharging an unknown volume of chlorinated water into Mill Creek. Staff observed nearly 2,000 dead fish and tadpoles valued at \$573.69. It is unlikely the fish community in this stream had recovered since the previous kill in June 2016.
- 3) 1/10/18- A failure at a drinking water lift station caused the release of 38,000 gallons of chlorinated water. The chlorinated water entered Mill Creek causing a fish kill. Dead fish were observed for approximately 1-mile downstream of the release. An estimated 5,320 fish and aquatic worms valued at \$2,362.62 died because of the release. This was the third chlorinated water fish kill occurring since June 2016 in this reach of Mill Creek. The first fish kill in June 2016 was also caused by a failure at the lift station.
- 4) 7/17/18- A broken water line released a large volume of chlorinated water into Hominy Branch in the City of Columbia. Investigators documented at least 2,595 dead fish throughout 1.2 stream miles. Dead fish were valued at \$693.43.
- 5) 4/26/19- Chlorine detected in Flat Branch Creek in Columbia resulted in a fish kill. Investigators counted 1,552 aquatic organisms valued at \$257.89. It is suspected that chlorine detected in the stream originated from a water main break identified upstream of the kill zone.

Boone County (7/13/19), City of Columbia

A cap on a pipe which diverted water from Albert-Oakland Aquatic Center from the storm water system to the waste water system cracked resulting in chlorinated water being discharged into a tributary of Bear Creek in Columbia. Investigators counted 1,437 fish valued at \$438.46. The City of Columbia will be required to permanently direct flows from the aquatic center into the sanitary sewer. Enforcement action is pending.

Callaway County (6/4/17), Frederick Kerr Atkinson

A large volume of liquid nitrogen was discharged into McKinney Creek killing all aquatic life for 8 stream miles. Dead fish, crayfish, macroinvertebrates, aquatic worms, and tadpoles were observed during the investigation. These animals are valued at \$19,351.60. During follow up visits, toxic levels of ammonia were detected for miles downstream of the initial kill zone and for weeks after the initial discharge. Based on previous kills of this severity, the aquatic life in this stream will not fully recover for several years. This case is pending enforcement action.

Cape Girardeau County (4/1/19), Shawneetown Feed and Seed Company

A truck hauling liquid nitrogen tipped over releasing 1,000 gallons of 32% liquid nitrogen and 50 gallons of diesel fuel which entered a tributary of Cane Creek. Investigators counted a total of 794 fish valued at \$55.42. DNR is still discussing whether to pursue this case for reimbursements for damages and investigative costs.

Cedar County (6/9/17), United States Army Corps of Engineers

MDC received a call from a private citizen on June 12th concerning Stockton Dam lowering water levels in the receiving waters of the Sac River and its tributaries. The private citizen lives on Bear Creek, a tributary of the Sac River and reported that when generation was altered on the 9th that mussels were

left stranded out of the water in Bear Creek. The caller indicated this had occurred on other occasions. Discussions between MDC, DNR, and U.S. Army Corps of Engineers are ongoing.

Clay County (11/15-16/12), City of Kansas

A sewage sludge release from a Kansas City sewage treatment facility caused a heavy fish kill in 5.5 miles of Fishing River. Low dissolved oxygen conditions and suspected ammonia toxicity led to the death of at least 1,520 fish. Total fish damages were \$8,055.52.

Cooper County (8/29/15), Missouri Better Beans

A fire at the Missouri Better Beans facility resulted in the release of 50,000 gallons chlorinated water and over 27,000 gallons of various chemicals, including glycerin. This release resulted in oxygen depletion in Stephen's Branch for at least 16 days. MDC observed 4,332 dead fish valued at \$829.99 during this incident. This case is pending enforcement action by the Missouri Attorney General's Office.

Franklin County (3/7/13), local manufacturer

A dark brown oily chemical was found in the city of Union's wastewater treatment plant. Sorbent booms were placed at the treatment plant outfall on Bourbeuse River as a preventative measure. No dead fish or mussels were found. This case is still pending enforcement action against the responsible party, Cloud Manufacturing.

Macon County (9/10/19), US Army Corps of Engineers

Dam operators ceased flow through Long Branch Dam while conducting maintenance and repairs. This dewatering event led to oxygen depletion in the receiving waters resulting in a significant fish kill. Multiple fish species were observed dead, including channel catfish, freshwater drum, gizzard shad, bluegill, crappie, and hybrid striped bass. MDC investigators were able to enumerate only a small fraction of the dead fish. Damages for the 366 fish that MDC investigators were able to count totaled \$4,695.26. DNR is not pursuing enforcement actions because the cause of fish mortality was low dissolved oxygen. However, because low dissolved oxygen was caused by actions of the U. S. Army Corps of Engineers, MDC continues discussions on mitigating future fish kills of this origin with U.S. Army Corps of Engineers.

Newton County (3/8/19), City of Neosho

A broken water main resulted in the discharge of chlorinated water into Hickory Creek resulting in a fish kill of at least 134 fish valued at \$500.31.

Platte County (6/7/16, 11/22/18), City of Kansas

DNR is pursuing enforcement action with two City of Kansas cases:

- 1) 6/7/16- A Kansas City Wastewater lift station failure resulted in the discharge of wastewater into a tributary of Rush Creek. MDC observed 108 dead fish valued at \$28.29 as a result of this discharge.
- 2) 11/22/18- An estimated 549,000 gallons of raw sewage was discharged into a tributary of Walnut Creek by a Kansas City Wastewater Treatment facility during a sewer bypass. Sewage that entered the tributary resulted in lethal levels of ammonia causing a fish kill. Investigators observed dead fish in 4 miles of stream but were unable to determine the most downstream extent of the fish kill. Water clarity was poor during the investigation due to the pollutant, and fish injury and damages of 6,828 fish valued at \$1,500.22 are considered underestimates.

Ralls County (7/8/13, 7/21/14; 2015: 6/22, 8/3, 8/8, 9/8; 6/14/17), U.S. Army Corps of Engineers under direction of Southwest Power Administration

Since the 1980s, hypolimnetic releases of poor quality water have been the cause of recurring fish kills below Clarence Cannon Dam, which impounds Mark Twain Lake. Water released from the dam does not contain enough dissolved oxygen to support aquatic life. Within the last five years MDC staff documented six fish kills at this location, four of these fish kills occurred during 2015. Dam operations during 2015 resulted in at least 23,174 dead fish valued at \$40,687.11. Since 2010, there have been efforts to mitigate fish injury for low dissolved oxygen levels below the Clarence Cannon Dam; however, none of these efforts have produced a permanent long-term solution. Discussions between MDC, DNR, and the U.S. Army Corps of Engineers are ongoing.

Stone County (3/1/18), Partridge Sand and Gravel

MDC conducted a site visit of Partridge Sand and Gravel in Stone County to monitor improvements or further decline of conditions in Railey Creek, James River, and Table Rock Lake. MDC and DNR have been monitoring this site since the 1990's and working to prevent future injury and stop the destruction of habitat. Documented negative impacts include destruction of stream habitat, changes in hydrology, and sediment pollution of downstream water. Efforts have included verbal and written requests from MDC to the responsible party and Notices of Violation from DNR. In 2019 DNR issued an order for payment of penalties and remediation of the area, but the respondent failed to follow the order. Case is still pending further enforcement action.

Appendix G. Summary of pollution investigation, fish kills, and estimated mortality (1970-2019) Data are incomplete prior to 1988. I=number incidents, K=number kills, #=number of dead animals, N/A=not available or not applicable

Year	MUNICIPAL			AGRICULTURAL			INDUSTRIAL			TRANSPORTATION			OTHER			NON-REGULATED		
	I	K	#	I	K	#	I	K	#	I	K	#	I	K	#	I	K	#
1970		7	72,850		10	353,482		8	218,075		3	605		2	6,035			
1971		9	306,050		9	93,856		6	70,050		3	40,750		10	46,081			
1972		11	9,960		8	9,322		8	494,801		5	626		2	22,171			
1973		6	46,125		4	8,203		9	49,355		3	5,455		8	11,965			
1974		10	20,242		8	13,730		10	120,637		4	4,472		6	4,145			
1975		9	43,035		9	118,564		8	109,713		6	29,500		7	10,535			
1976		10	9,323		3	2,260		6	14,400		N/A	N/A		5	3,825		1	52,000
1977		9	8,017		3	500		6	1,568		3	130,907		1	N/A		5	226,000
1978		8	436,206		12	16,739		7	13,953		3	855		8	11,008		20	16,003
1979		17	25,057		15	14,442		6	89,314		3	44,733		17	161,772		29	9,155
1980		14	114,817		10	16,476		5	98,729		N/A	N/A		10	39,953		35	26,443
1981		10	200,463		20	22,366		4	2,317		2	37,000		10	17,213		39	9,495
1982		8	4,728		12	14,693		2	4,424		1	N/A		12	20,462		18	7,074
1983		9	20,023		9	6,328		6	12,730		4	6,227		21	10,834		9	4,765
1984		13	12,433		10	65,522		3	853		3	1,285		12	43,635		11	105,578
1985	22	9	3,854	24	13	41,599	25	2	2,843	22	3	21,118	18	13	15,277	21	19	52,817
1986	40	18	68,010	25	13	12,086	26	7	4,236	28	2	N/A	44	18	955	42	41	28,848
1987	39	18	38,333	22	8	11,033	19	7	7,915	24	1	200	39	19	19,679	45	43	45,641
1988	17	4	13,006	10	5	32,263	17	7	20,925	15	3	1,112	23	10	12,286	35	35	113,016
1989	25	9	1,015	21	11	27,546	24	6	13,684	11	1	186	16	12	5,991	37	36	35,122
1990	33	11	7,462	25	11	49,983	22	4	36,496	16	5	12,334	25	14	17,089	31	28	281,161
1991	21	8	20,436	28	14	14,639	38	12	55,114	15	3	2,952	36	23	5,962	223	220	60,864
1992	33	16	16,018	22	6	14,063	24	6	31,006	17	2	57	20	8	69,211	207	203	30,934
1993	36	9	6,288	23	9	26,234	42	8	17,646	17	3	5,500	17	8	23,950	137	135	89,748
1994	50	18	78,385	23	9	59,603	33	8	106,743	24	2	9,684	23	8	247,272	206	196	83,017
1995	40	20	30,419	25	12	293,642	21	7	16,176	13	N/A	N/A	33	17	17,080	238	236	87,718
1996	36	14	10,875	37	9	54,999	22	10	373	12	2	10,875	30	11	3,899	139	136	105,031

Appendix G continued.

Year	MUNICIPAL			AGRICULTURAL			INDUSTRIAL			TRANSPORTATION			OTHER			NON-REGULATED		
	I	K	#	I	K	#	I	K	#	I	K	#	I	K	#	I	K	#
1997	37	15	8,481	25	8	1,504	17	5	2,404	9	1	14	31	22	7,127	229	222	55,984
1998	15	6	5,155	22	6	92,052	16	6	40	9	4	13,206	27	12	24,905	148	146	31,893
1999	22	11	28,841	13	5	3,038	10	4	22,993	5	1	43	18	7	31,589	192	187	42,829
2000	16	8	36,405	7	4	55,160	4	3	524	6	2	1,042	11	7	43,206	153	153	163,051
2001	18	10	22,711	12	7	1,588	7	6	1,043	13	5	4,696	10	9	14,752	233	233	68,829
2002	18	12	81,960	9	6	45,028	12	4	3,615	5	2	74	6	5	1,519	121	121	33,461
2003	10	4	1,022	5	2	8,068	10	1	523	2	1	1,374	12	9	15,821	113	113	163,179
2004	17	10	82,183	5	N/A	N/A	1	N/A	N/A	3	1	1,146	1	1	18,476	71	71	8,253
2005	7	4	73,785	5	4	12,020	5	1	3,436	1	N/A	N/A	1	1	4,334	154	154	69,466
2006	7	7	22,643	3	3	4,489	6	2	10,479	2	N/A	N/A	3	2	10,822	3	3	2,957
2007	8	7	26,582	4	3	11,599	2	2	25,796	1	1	477	4	4	3,771	5	5	1,460
2008	8	7	2,504	3	2	381	N/A	N/A	N/A	N/A	N/A	N/A	6	6	2,144	5	5	2,232
2009	5	2	2,231	3	3	509	2	N/A	N/A	2	2	116	5	5	433	4	4	3,207
2010	10	7	3,373	7	4	2,625	1	1	41	3	1	N/A	12	9	270,926	20	18	2,537
2011	15	11	4,888	4	3	11,175	N/A	N/A	N/A	3	1	4,822	15	12	13,186	28	27	11,008
2012	4	4	5,063	4	4	7,067	4	3	1,230	2	1	1,286	17	15	77,790	36	35	43,462
2013	11	9	7,703	2	2	647	3	2	108	N/A	N/A	N/A	7	6	3,154	33	31	9,760
2014	9	6	4,311	8	7	11,758	7	4	109,733	2	1	2,720	8	5	1,177	50	47	10,330
2015	7	6	28,746	2	2	41,273	N/A	N/A	N/A	6	2	238	10	4	5,397	32	26	21,553
2016	11	7	12,438	5	4	9,328	1	N/A	N/A	N/A	N/A	N/A	10	7	275	27	21	7,540
2017	15	12	70,479	9	8	15,932	2	N/A	N/A	2	N/A	N/A	5	1	140	32	27	4,571
2018	4	3	14,743	2	1	47,887	1	N/A	N/A	N/A	N/A	N/A	3	N/A	N/A	40	26	1,706
2019	17	15	10,246	8	3	3,347	3	N/A	N/A	4	2	810	3	2	422	32	16	6,365
TOTAL	683	487	2,179,923	452	353	1,780,648	427	222	1,796,041	294	98	398,497	549	443	1,399,651	3,122	3,186	2,236,333
YEARLY AVG	14	10	44,488	9	7	36,340	9	5	36,654	6	2	8,133	11	9	28,564	64	65	45,639
Avg # per kill	4,448			5,191			7,270			4,067			3,174			702		