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Aquatic Plant Control Research Program

Aquatic Dissipation of Triclopyr in a Whole-Pond Treatment

by David G. Petty, NDR Research
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WES

Prepared for Headquarters, U.S. Army Corps of Engineers
and Aquatic Ecosystem Restoration Foundation, Inc.

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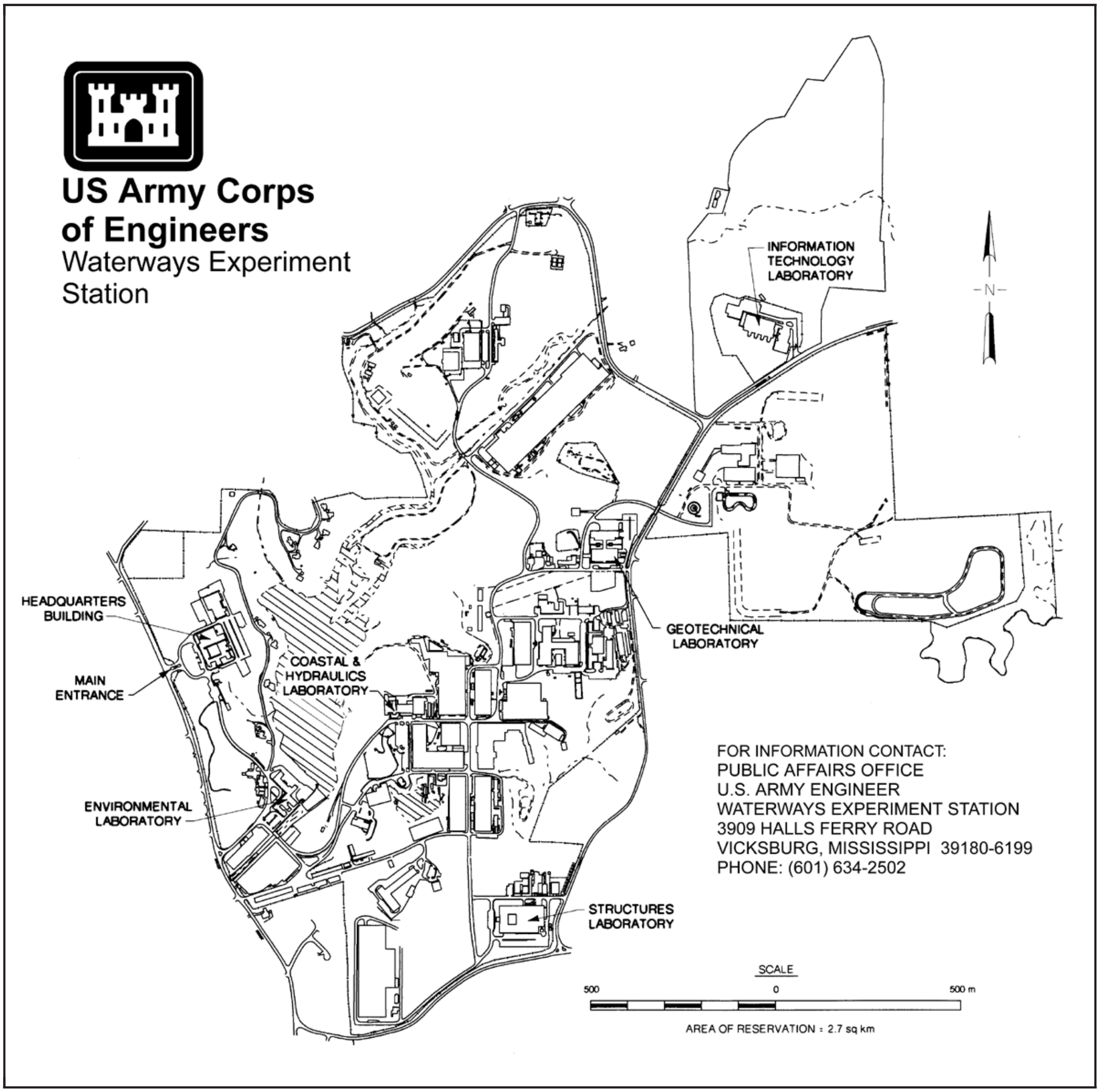

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Preface

The work reported herein was performed under a cooperative Research and Development Agreement between the Aquatic Ecosystem Restoration Foundation (AERF), Inc., and the U.S. Army Engineer Waterways Experiment Station (WES). Funding was provided under Department of the Army Appropriation No. 96X3122, Construction General and the AERF. The work was conducted as part of the Aquatic Plant Control Research Program (APCRP), Work Unit 32437. The APCRP is sponsored by the Headquarters, U.S. Army Corps of Engineers (HQUSACE), and is assigned to the WES under the purview of the Environmental Laboratory (EL). The APCRP is managed under the Center for Aquatic Plant Research and Technology (CAPRT), Dr. John W. Barko, Director. Mr. Robert C. Gunkel, Jr., was Assistant Director for the CAPRT. Program Monitors during this study were Mr. Timothy Toplisek and Ms. Cheryl Smith, HQUSACE.

The Principal Investigator of the study was Dr. Kurt D. Getsinger, Ecosystem Processes and Effects Branch (EPEB), Environmental Processes and Effects Division (EPED), EL, WES. This study was conducted and the report prepared by Mr. David G. Petty, NDR Research under contract to the AERF; Dr. Getsinger and Mr. John G. Skogerboe, EPEB; Mr. Dale R. Foster, Dow AgroSciences; Mr. James W. Fairchild, U.S. Geological Survey, Environmental and Contaminants Research Center (ECRC); and Dr. Lars W. Anderson, U.S. Department of Agriculture, Agricultural Research Service (USDA-ARS), Aquatic Weed Control Research Laboratory (AWCRL).

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This investigation was performed under the general supervision of Dr. John Harrison, Director, EL; Dr. Richard E. Price, Chief, EPED; and Dr. Robert Kennedy, Acting Chief, EPEB.

At the time of publication of this report, Director of WES was Dr. Robert W. Whalin. Commander was COL Robin R. Cababa, EN.

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1 Introduction

Triclopyr (3,5,6-trichloro-2-pyridinyloxyacetic acid) is a selective, systemic herbicide registered for use in the control of broadleaf weeds and woody plants on rights-of-way, rangeland and pastures, forests, industrial sites, and other noncrop areas. It is also registered for use in rice crop production.

Triclopyr is an auxin-type systemic herbicide with a mode of action and spectrum of weed control similar to that of phenoxy herbicides. It is taken up through the roots, stems, and leaf tissues of plants. It is transported throughout the plant via symplastic mobility processes and accumulates in the meristematic regions.

Investigations have shown that triclopyr can provide aquatic plant managers with a feasible alternative to 2,4-D (2,4-dichlorophenoxy acetic acid) for selectively controlling a variety of nuisance aquatic plants (Getsinger, Turner, and Madsen 1992). Formulated as the triethylamine (TEA) salt, triclopyr can selectively control aquatic nuisance plant species such as Eurasian watermilfoil (*Myriophyllum spicatum* L.), purple loosestrife (*Lythrum salicaria* L.), water-hyacinth (*Eichhornia crassipes* (Mart.) Solms) and alligatorweed (*Alternanthera philoxeroides* (Mart) Griseb.), among others (Getsinger and Westerdahl 1984; Langeland 1986; Green et al. 1989; Sisneros 1991; Anderson, Fellows, and Pirosko 1996; Getsinger et al. 1997; Petty et al. 1997). Studies conducted by the U.S. Army Corps of Engineers, Dow AgroSciences, Tennessee Valley Authority (TVA), U.S. Bureau of Reclamation, U.S. Department of Agriculture (USDA), and others have shown that triclopyr is rapidly degraded in water and at recommended use rates is not toxic to nontarget organisms (Gersich et al. 1984; Mayes et al. 1984; Gardner and Grue 1996; Petty et al. 1998).

Physiochemical Properties of Triclopyr

Triclopyr TEA is a white crystalline solid in appearance and has no discernible odor. It has a molecular weight of 357.67 g, with a melting point between 119 and 121 °C. Triclopyr acid has a molecular weight of 256.5 g/mol, water solubility of 440 mg/L at 25 °C, and a vapor pressure of 1.26×10^{-6} mm Hg at 25 °C.

Environmental Chemistry of Triclopyr

Upon application to an aquatic system, triclopyr TEA quickly hydrolyzes to triclopyr acid (CAS (Chemical Abstract Service) 55335-06-3). This acid subsequently degrades to 3,5,6-trichloropyridinol, or TCP (CAS 6515-38-4). In addition, 3,5,6-trichloro-2-methoxypyridine, or TMP (CAS 31557-34-3), is a common metabolic degradate found in terrestrial uses. It is uncertain whether TMP is a degradate of triclopyr, TCP, or both. Petty et al. (1998), reported concentrations of TMP found in water following an aquatic application of triclopyr and its subsequent accumulation in sediment, plants, fish, and shellfish. Figure 1 depicts the structures of triclopyr and its major metabolites.

Photolysis can be a significant route of triclopyr and TCP degradation in the environment. Triclopyr photodegrades at the 313-nm wavelength (ultraviolet light) and is further metabolized to carbon dioxide, water, and various organic acids by aquatic microorganisms (McCall and Gavit 1986). Woodburn et al. (1990) examined the aqueous photolysis of triclopyr in both buffered and natural river water under artificial and natural lights at 25 °C. In the sterile, buffered system, triclopyr degraded with an average half-life of 0.5 days, with 5-chloro-3,6-dihydroxy-2-pyridinyl-oxyacetic acid as the only significant photoproduct. Natural river water degradation yielded a half-life of 1.2 days, generating oxamic acid as the major photoproduct. If TCP is formed in the environment by either aerobic or anaerobic processes, it is also readily photodegradable. The photochemical half-life of TCP has been estimated to be 2 hr at a depth of 1 m in river water under 40° north latitude midsummer sunlight (Dilling et al. 1984).

Hydrolysis is not a significant route of degradation for triclopyr. Cleveland and Holbrook (1991) observed no significant degradation in a month-long study conducted at pH 5, 7, and 9. Similar results were observed in a previous hydrolysis study (Hamaker 1975). A study of triclopyr under aerobic aquatic conditions yielded a slow degradation rate of 4.7 months, with TCP as the only significant degradate (Woodburn and Cranor 1987). Laskowski and Bidlack (1984) showed that triclopyr is slowly degraded under anaerobic conditions, such as those that exist in deeper waters and associated with sediments. In that study, triclopyr degraded to TCP with a half-life of about 3.5 years.

The aquatic dissipation of triclopyr has been investigated previously (Getsinger and Westerdahl 1984; Solomon, Bowhey, and Stephenson1988; Woodburn 1988, 1989; Getsinger et al. 1996; Houtman et al. 1997; Petty et al. 1998). Results of these investigations indicate that triclopyr and its metabolites undergo rapid degradation in the aquatic environment, without adverse effect on the aquatic system. Upon application to natural waters, triclopyr degrades and dissipates through chemical, biological, and physical processes.

Following an application of 2.5 mg/L to Lake Minnetonka, Minnesota (Houtman et al. 1997; Petty et al. 1998), triclopyr dissipated from water with an average half-life of 3.7 days in an open bay, and 4.7 days in a bay with a restricted water exchange inlet. TCP half-lives in this study were 4.2 and

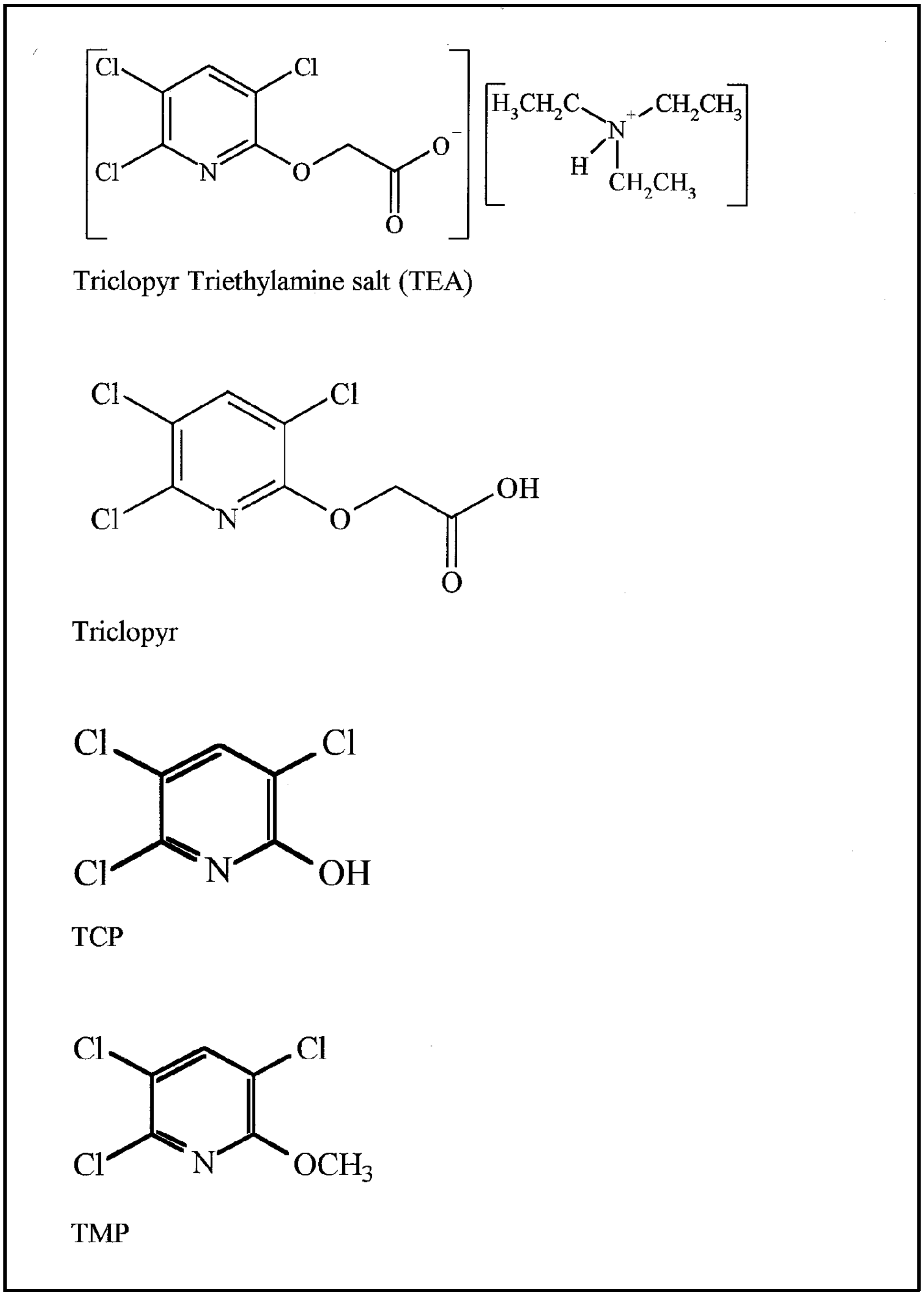

Figure 1. Structure of triclopyr triethylamine, triclopyr, 3,5,6-trichloropyridinol (TCP), and 3,5,6-trichloro-2-methoxypyridine (TMP)

7.9 days, respectively. Low levels (<5 µg/g) of the TMP metabolite were also detected. Triclopyr half-lives in sediment ranged from 5 to 5.8 days, and TCP half-lives were 10.7 to 11.3 days. Plant residue half-lives ranged from 2.5 to 3.4 days for triclopyr and 4 to 4.7 days for TCP. Half-lives in four species of fish ranged from 2.0 to 7.1 days for triclopyr, 3.9 to 11.9 days for TCP, and 3.1

to 11.6 days for TMP. Clam tissue half-lives ranged from 5.2 to 10.4 days for triclopyr, around 2.9 days for TCP, and 3.8 to 5.8 days for TMP. Crayfish edible tissue half-lives were 5.7 to 7.7 days for triclopyr, 5.4 to 10.6 days for TCP, and 2.3 to 5.1 days for TMP. Triclopyr, TCP, and TMP half-life values for crayfish visceral tissue were 8.5 to 9.5 days, 7.0 to 13.7 days, and 2.5 to 3.7 days, respectively.

In a dissipation study in Lake Seminole, Georgia (Woodburn 1988; Woodburn, Green, and Westerdahl 1993), triclopyr had an average first-order half-life of 0.5 to 3.6 days after being applied at a nominal concentration of 2.5 mg/L. The half-life for the TCP metabolite in Lake Seminole was less than 0.5 days. No accumulation of triclopyr or the TCP metabolite in sediment was observed. Only trace amounts of these compounds were found in fish, and the half-life of triclopyr in plants, crayfish, and clams was 3.4, 11.5, and 1.5 days, respectively.

A study conducted in Ontario, Canada, showed triclopyr levels in water treated at rates of 0.3 and 120 ng/mL triclopyr to fall below 5 percent of applied within 15 days and to be below detection limits by Day 42 (Solomon, Bowhey, and Stephenson 1988). This study suggests that natural waters may cause a quenching of the photoreaction of triclopyr relative to sterile, buffered waters. This quenching effect has been observed in other field studies (Woodburn 1988) and is thought to be caused by the presence of dissolved organic matter (Woodburn et al. 1990).

A study conducted on the Pend Orielle River, Washington, where triclopyr was applied at a rate of 2.5 mg/L yielded estimated half-lives of 19.4 hr (0.8 days) for a riverine plot, and 52.7 hr (2.2 days) in a protected cove plot with limited water exchange (Getsinger et al. 1996, 1997).

Toxicology of Triclopyr

Triclopyr shows a low order of toxicity to microbial communities and higher aquatic organisms (Getsinger and Westerdahl 1984; Petty et al. 1998). Mayes et al. (1984) tested the toxicity of triclopyr TEA salt on fathead minnow and concluded that it is relatively nontoxic and has little cumulative or chronic effect on this species.

The *Herbicide Handbook* (Humberg 1989) lists LC_{50} values of greater than 200 µg/g for Garlon 3A (the TEA formulation of triclopyr) for trout and almost 900 µg/g for shrimp. The mallard duck 8-day dietary LC_{50} is greater than 10,000 µg/g. Triclopyr does not accumulate in any organ of these species, being rapidly excreted.

TCP is minimally concentrated, readily metabolized, and rapidly cleared from the eastern oyster (Holmes and Smith 1991). The 48-hr LC_{50} for daphnia has been measured at 3.13 mg/L, and the 72-hr LC_{50} for fathead minnow has been measured at 14.31 m (Rhinehart and Bailey 1978). Wan, Moul, and Watts

(1987) investigated the 96-hr LC_{50} for six species of juvenile pacific salmonids and determined that the values for TCP ranged from 1.5 to 2.7 mg/L.

Wan, Moul, and Watts (1987) also determined 96-hr LC_{50} values on the juvenile salmonids for TMP and reported the range of 1.1 to 6.3 mg/L. The acute mammalian toxicity of TMP is relatively low. The oral LD_{50} in male rats is greater than 2,000 mg/kg of body weight (Vaughn and Keeler 1976), while the acute dermal LD_{50} in rabbits is greater than 795 mg/kg body weight (the highest dose tested) (Vaughn and Keeler 1976). TMP results in only slight eye and skin irritation when tested in rabbits (Rampy, Keeler, and Yakel 1974). Also, TMP is negative in the guinea pig skin sensitization test (Wall 1984). TMP has been tested in repeated-dose dietary studies in rats. A 2-week study was conducted at dose levels of 0 (control), 35, 75 125, 250, or 500 mg/kg/day. The highest dose level (500 mg/kg/day) resulted in decreased body-weight gain in males and females as well as a slight increase in relative liver weights in males. There were no microscopic changes in the liver of the rats. Males and females at lower dose levels had slightly decreased body-weight gains compared with the control groups (Gorzinski et al. 1982a). A 13-week dietary study in rats was conducted at dose levels of 0 (control), 50, 150, or 500 mg/kg/day. Decreased body-weight gain and increased relative liver weights were detected in male and female rats treated with 150 or 500 mg/kg/day (Gorzinski et al. 1982b). Male and female rats treated with 50 mg/kg/day had only a minimal decrease in body-weight gain. The no-adverse-effect level (NOAEL) was 50 mg/kg/day. The U.S. Environmental Protection Agency (USEPA) has reviewed the repeated-dose dietary studies in rats. These data were evaluated as part of the current reregistration process for triclopyr. The USEPA has concluded that these mammalian studies indicate that TMP is not more toxic than the parent compound, triclopyr.[1]

Study Objectives

In response to questions raised by the USEPA regarding triclopyr application to an entire water body, with its subsequent effects on water quality, and also to respond to their request for more geographical representation in test results for the aquatic dissipation of triclopyr, a study was initiated in 1995 by the U.S. Army Corps of Engineers (USACE) and Dow AgroSciences to investigate the aquatic dissipation of triclopyr in a whole-pond treatment at sites in California, Missouri, and Texas (Figure 2) (Petty 1995).

The specific objectives of this study were to establish the dissipation curves for triclopyr applied to an aquatic environment; follow the formation and decline of its TCP metabolite in water and sediment; establish residue levels of triclopyr and its TCP and TMP metabolites found in nontarget organisms such as fish; and to satisfy USEPA Guidelines 164-2, Field Dissipation Studies for Aquatic Uses and Aquatic Impact Uses, and 165-5, Field Accumulation Studies of Non-Target Organisms.

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[1] Personal Communication, July 9, 1997, S. A. McMaster, USEPA, to K. D. Getsinger, WES.

Figure 2. Location of test sites for triclopyr whole-pond treatments, 1995

2 Methods and Materials

General Methods and Materials

This section describes methods and materials that were common to all three geographic test sites. Immediately following this section, site-specific methods and materials will be provided.

Test substance

Triclopyr TEA salt, formulated as the product Garlon 3A, was the test material used (Table 1). Four 9.5-L containers of Garlon 3A were shipped to each of the site investigators in California, Missouri, and Texas, following standard chain-of-custody practices.

Plot layout and characterization

All three test sites were located at research facilities containing man-made, replicated outdoor ponds. Three ponds were used at each of the test sites. Ponds

Table 1
Details of the Test Material, Triclopyr Triethylamine (TEA)

Chemical Name	3,5,6-Trichloro-2-pyridinyloxyacetic acid, triethylamine salt
Common Name	Triclopyr TEA
Product Name	Garlon 3A Herbicide
EPA Registration No.	62719-37 (Garlon 3A)
Nominal Percent Active Ingredient	44.4%
Lot No.	JB03161104
TSN	TSN100766
Date of Assay	May 8, 1995
Percent Active Ingredient	45.0% Triclopyr TEA (32.3% a.e.)

A and B at each site were the triclopyr-treated ponds, and Pond C was the untreated reference pond. The untreated reference pond was located so as to minimize the possibility of cross-contamination from the treated ponds.

Each treated pond had three permanent stations established to mark sampling locations for water and sediment. These stations were identified with labeled, anchored buoys. The stations were located so as to best divide each pond into thirds, depending on the actual shape of the pond. Schematic diagrams of the ponds can be found in Figures 3-5. The untreated reference ponds each contained a single sampling station, located near pond center.

Each pond was labeled with a marker indicating study protocol number and pond identification. The ponds were measured for area and depth. Water depth in the ponds was measured for the duration of the study. Ponds were not refilled to counter evaporation, though natural filling from rain was not precluded.

Prior to application, sediment and water samples were collected from each pond for physiochemical characterization. Approximately 1,500 g of sediment was collected for each sample and was allowed to drain through a mesh screen. Samples were packed in plastic pails and shipped under ambient conditions to Dow AgroSciences (Indianapolis, IN). These samples were later shipped to A&L Great Lakes Laboratories (Fort Wayne, IN) for analysis. Approximately 3 L of water were collected from each pond at about the middepth point. These samples were shipped overnight, on ice, to A&L Great Lakes Laboratories for immediate analysis.

Meteorological measurements

A recording weather station was established at each site immediately prior to application. Weather stations were powered by internal lead-acid batteries that were continuously trickle charged through the use of an external solar panel. Measurement of all sensors occurred once each second, and stations performed summary statistics at the end of each 1-hr period and again at midnight for the entire the 24-hr period. These final data were transferred to solid-state storage modules at the end of each summary period. Storage modules were periodically replaced and the data retrieved and stored electronically.

Each weather station was comprised in part by a Campbell Scientific (Logan, UT) model 21XL micro data logger, which operated the connected sensors, and performed summary statistics and error checking on the data collected. The storage module also monitored its internal temperature and available power as part of a self-diagnostic routine.

Measurements made by each station included rainfall, using a Texas Electronics (Dallas, TX) TE525 tipping bucket; air temperature; relative humidity; wind speed and direction, using an RM Young (Traverse City, MI) wind sentry set; and solar radiation, using a LiCor (Lincoln, NE) LI200S silicon pyranometer.

Nontarget organisms

Cages containing test fish were located in each pond. Floating cages were used for the predatory fish, while the cages for the bottom feeders allowed contact with the pond bottom. Records were kept of the numbers of fish placed in each cage, those collected as samples, and those removed as dead or moribund individuals. Fish were occasionally fed with commercial feed preparations. Test fish species included bluegill and catfish.

Bluegill. The bluegill species used was *Lepomis macrochirus* (Rafinesque). The bluegill is a member of the sunfish family *Centrarchidae*, which includes 30 species. Members of the sunfish family are characterized by deep, laterally compressed bodies and spiny-rayed fins. The habits and life history of all sunfishes are basically alike. Most are rather sedentary fish, remaining much of the time near submerged cover or in shadows. They generally do not school, but may occur in loose aggregations. Individuals can show an affinity with a specific territory, often spending their entire life within a restricted area. Feeding is primarily by sight, and generally only mobile objects are attractive. Insects, crustaceans, and small fish are the primary foodstuffs. Feeding occurs both at the surface and bottom, and food may be captured by active foraging or by ambush. Feeding generally occurs in early morning and again in late evening.

The bluegill is a deep and slab-sided sunfish with a rather small mouth, and commonly reaches a length of 24 cm and a weight of 350 g. One of the more gregarious of the sunfish, it often moves in associations of 20 to 30 individuals. It feeds by sight, at all levels of the water column. Insects are the staple food for adults, but small fish, crayfish, and snails are also eaten. It may feed on vegetation when other foodstuffs are scarce (Pflieger 1975; Robison and Buchanan 1945).

Catfish. Catfish are classified as the family *Ictaluridae*, which includes 37 species restricted to North America. Catfish have smooth, scaleless skin, four pair of barbels located near the mouth, and a strong, sharp spine located at the front of the dorsal and pectoral fins. These spines may contain a mild venom that, while not dangerous, does cause a painful reaction. Catfish are most active at night and generally hide in shadowed areas during the daytime. Catfish have abundant external tastebuds, especially on the barbels. Feeding is in direct response to stimulation of these tastebuds. Catfish species are generally bottom feeders (Pflieger 1975; Robison and Buchanan 1945).

Application equipment testing

Since precise evenness of application is not as critical in an aquatic application, equipment calibrations were limited to an operational test of the sprayer. In each case, a measured quantity of water was timed as it was sprayed out of the equipment, and that time was used to estimate the duration it would take to complete the actual application to each of the treated ponds. This estimate was used to aid in providing for an even application throughout the treated ponds.

Application of test material

Application of the test material, Garlon 3A, was made to achieve a targeted in-water concentration of 2,500 ng/mL (2.5 mg/L), the maximum rate indicated by the proposed product label. Application was made utilizing a handgun-type sprayer, with variations in exact equipment type occurring at each study site. Care was taken to apply the test material only to the water, and not to the pond banks. Applications were made either from the pond edge or from a boat within the pond.

Confirmation of application rate

Prior to application, test substance containers were weighed and then reweighed after the tank mix had been prepared. These weights were used to calculate the total amount of material applied to each pond. Separate containers of material were used for each treatment.

Residue sampling

Water and sediment residue samples were stored in metal cans at the time of collection and placed on ice in a cooler. Fish samples were temporarily stored in canvas bags until undergoing initial processing, after which the processed samples (fillet and viscera) were stored in metal cans. Preprinted labels were applied to final sample containers, which included protocol number, unique sample ID number, plot and sample station identification, sample period, matrix, and depth, where appropriate. Disposable gloves were worn during all sample collection and handling activities. Samples were placed in frozen storage as soon as possible after collection.

As each sample was collected, data were recorded on a preprinted sampling sheet that contained the same information indicated on the sample label. Additional data recorded at this time included (a) indication the sample was collected; (b) date and time of collection; and (c) depth of sampling, in the case of water samples. Water and sediment samples were collected at pretreatment and for 12 weeks after application. Fish were collected at pretreatment and for 4 weeks except in those instances where the supply was exhausted. The complete residue sampling schedule is presented in Table 2.

Water sampling

Water samples for residue analysis were collected in duplicate from two depths at each sampling station at each indicated water sampling event. At each sampling event, an approximate 400-mL water sample was collected at one-third and two-thirds the total depth of the water column at that sampling point.

Table 2
Residue Sampling Schedule for the California, Missouri, and Texas Test Sites, Triclopyr Whole-Pond Treatment, 1995

Period	California	Missouri	Texas	Matrices Sampled
Pre	25-Jul-95	5-Jun-95	22-May-95	Water, sediment, fish
1 hr	26-Jul-95	6-Jun-95	31-May-95	Water, fish
3 hr	26-Jul-95	6-Jun-95	31-May-95	Water, fish
6 hr	26-Jul-95	6-Jun-95	31-May-95	Water, sediment, fish
12 hr	26-Jul-95	6-Jun-95	31-May-95	Water, sediment, fish
1 day	27-Jul-95	7-Jun-95	1-Jun-95	Water, sediment, fish
2 days	28-Jul-95	8-Jun-95	2-Jun-95	Water
3 days	29-Jul-95	9-Jun-95	3-Jun-95	Water, sediment, fish
5 days	31-Jul-95	11-Jun-95	5-Jun-95	Water
1 week	2-Aug-95	13-Jun-95	7-Jun-95	Water, sediment, fish
2 weeks	9-Aug-95	20-Jun-95	14-Jun-95	Water, sediment, fish
3 weeks	16-Aug-95	27-Jun-95	21-Jun-95	Water, sediment, fish
4 weeks	23-Aug-95	5-Jul-95	28-Jun-95	Water, sediment, fish
6 weeks	6-Sep-95	18-Jul-95	12-Jul-95	Water, sediment
12 weeks	18-Oct-95	29-Aug-95	31-Aug-95	Water

Water was collected by pumping water from the appropriate depth using an uncontaminated, battery-powered bilge pump and drinking water quality opaque hose. Two to three pump volumes were expelled prior to collection of the sample, and the sample container was then rinsed with water from the appropriate depth. Water was collected starting with the deepest depth and working toward the water surface. Hoses and pumps were changed after each sampling period to minimize the possibility of sample contamination.

Sediment sampling

Sediment samples were collected from approximately the top 5 cm of the pond bottom at each sampling station at each indicated sediment sampling event. Sediment samples of approximately 300 g were collected using standard clam-shell post-hole diggers, spread on a section of window screen to drain excess water and remove foreign objects, and sealed in a sample container.

Nontarget organism sampling

Fish were sampled from preestablished holding cages by net collection. In general, a sample was comprised of multiple individuals, depending upon size of the individuals collected. Fish samples were subsequently rinsed with distilled water in the preparation laboratory prior to initial processing. Dead or moribund individuals were not included in the samples.

Sample handling

All samples were stored on ice during the sampling procedure. Samples were transported from the study site to a nearby facility, and water and sediment samples were logged into frozen storage. Fish samples were refrigerated until the initial preparation was completed and then were transferred to frozen storage.

Field preparation of fish

Fish samples were transported to a preparation facility and maintained under refrigerated conditions during the initial sample preparation procedure. Upon receipt in the laboratory, fish were removed from the canvas bags they were stored in and rinsed with distilled water to remove excess pond water.

Each fish sample was separated into two new samples, one sample comprising the edible fillet portion of the fish, and the other sample comprising the inedible viscera, including skin. The prepared fractions were stored in clean metal containers and placed in frozen storage.

Sample shipping

Residue samples were routinely shipped to Dow AgroSciences (Indianapolis, IN) via overnight express. Samples were packaged frozen into insulated shipping boxes along with a supply of dry ice. Appropriate chain-of-custody forms accompanied the samples. Upon receipt by Dow AgroSciences, the condition of the samples was inspected and noted on the chain-of-custody forms; samples were logged into the sample tracking system and were placed into frozen storage.

Sample preparation

Samples were prepared by QMAS (Walhalla, ND) prior to analysis by the two analytical laboratories. Sediment and fish tissues were ground with dry ice and the prepared sample separated into analytical and long-term storage subsamples. Water underwent no preparation, the duplicate sample serving as the long-term sample.

Analytical laboratories

Analysis of water and sediment samples for physiochemical characterization was conducted by A&L Great Lakes Laboratories of Fort Wayne, IN. Residue analysis was conducted by QMAS and by the Dow AgroSciences Analytical Services Group (Indianapolis, IN).

Water characterization

Pond water was tested for alkalinity, total suspended solids, pH, hardness, conductivity, turbidity, chemical oxygen demand, and for sulfate, sodium, magnesium, and calcium levels.

Sediment characterization

Sediment analyses included pH, cation exchange capacity, organic matter, one-third and 15 bar water-holding capacity, and percent proportions of sand, silt, and clay.

Residue analysis

Methods of analysis for triclopyr residues in water, sediment, and fish have been described previously (Petty et al. 1998; Houtman et al. 1997). Water samples were analyzed utilizing Dow AgroSciences method GRM 95.18 (Olberding 1996), sediment by Dow AgroSciences method GRM 95.19 (Olberding, Foster, and McNett 1996), and fish by Dow AgroSciences method GRM 97.2 (Olberding and Foster 1997).

Calculations

Data were entered and calculations performed in commercial spreadsheet software. The precision of the calculations represent the internal precision of the spreadsheet, and numbers were rounded for reporting purposes. Selection of residue value ranges for half-life calculation was based on identification of the peak residue value, followed by an identifiable decline. In the case of the TCP and TMP metabolites, this peak often occurred well into the study, allowing only a few values for determination of the linear regression. This fact allows for the resultant artificially high r^2 values.

California Methods and Materials

The California study site was located at the California Department of Fish and Game Aquatic Toxicology Laboratory and Facilities, near Elk Grove, CA (38° 25′ N latitude 121° 22′ W longitude) (Figure 2). The study was conducted by personnel of the USDA Aquatic Weed Control Research Laboratory.

Elk Grove is located in Sacramento County, California. The lower Sacramento Valley is level to gently rolling, with elevations ranging from about sea level to about 120 m. The climate of the county is mild, characterized by hot, dry summers and cool, moist winters. It is shielded from climate extremes by the bordering mountain ranges (Tugel 1993). The test ponds at this facility were 0.12 ha in area and averaged 0.8 m in depth.

Preparation of the ponds occurred from 10 July to 24 July 1995, with activities including filling of the ponds, measurement of depth transects, placement of sampling stations and fish cages, and characterization sampling (Figure 3).

Aquatic organism assessment (biosurvey)

A non-GLP survey of the aquatic biological community was conducted pretreatment and 11.5-week posttreatment for each test pond. The primary purposes of this survey were to document that a viable, healthy biological community, comprising submersed plants, algae, and aquatic invertebrates, was present prior to the triclopyr application and to document any observed changes in that community following treatment.

Plants. Six line-intercept transects were established across each pond (north to south) and evenly spaced along the length (east to west) of each pond. These permanent transects were used to sample the frequency of submersed, floating, and emersed plants (higher, vascular species), members of the *Characeae* (charophyte) family, and other macroalgae. Species growing at intercept points located every meter along each transect line were identified and recorded, at both pretreatment (21 July 1995) and 12-week posttreatment (20 October 1995). Mean percent frequency (±SE) of each plant/algal type was calculated for both sampling periods.

Algae. Each pond was divided into four equivalent sections, and 20-L water samples were collected from the center of each quadrant for algae analyses at pretreatment (21 July 1995) and 12-week posttreatment (20 October 1995). Samples were filtered through a No. 20 Wisconsin plankton net, preserved in ethanol, and identified to genus.

Aquatic invertebrates. Aquatic invertebrates were sampled at six randomly selected locations in each pond at pretreatment (21 July 1995) and 12-week posttreatment (20 October 1995). Duplicate samples, taken by a single full sweep of a D-size net (1-mm mesh, 25-cm diam), were collected at each sampling location. Samples were preserved using ethanol and were identified to genus or family.

Water quality measurements

Water quality was measured in each of the ponds at residue sampling Station 1 using a Hydrolab Corporation (Austin, TX) Model Datasonde 3 positioned at middepth. Measurements of temperature, dissolved oxygen (DO), pH, and conductivity were taken every hour, starting on 21 July 1995 through 18 October

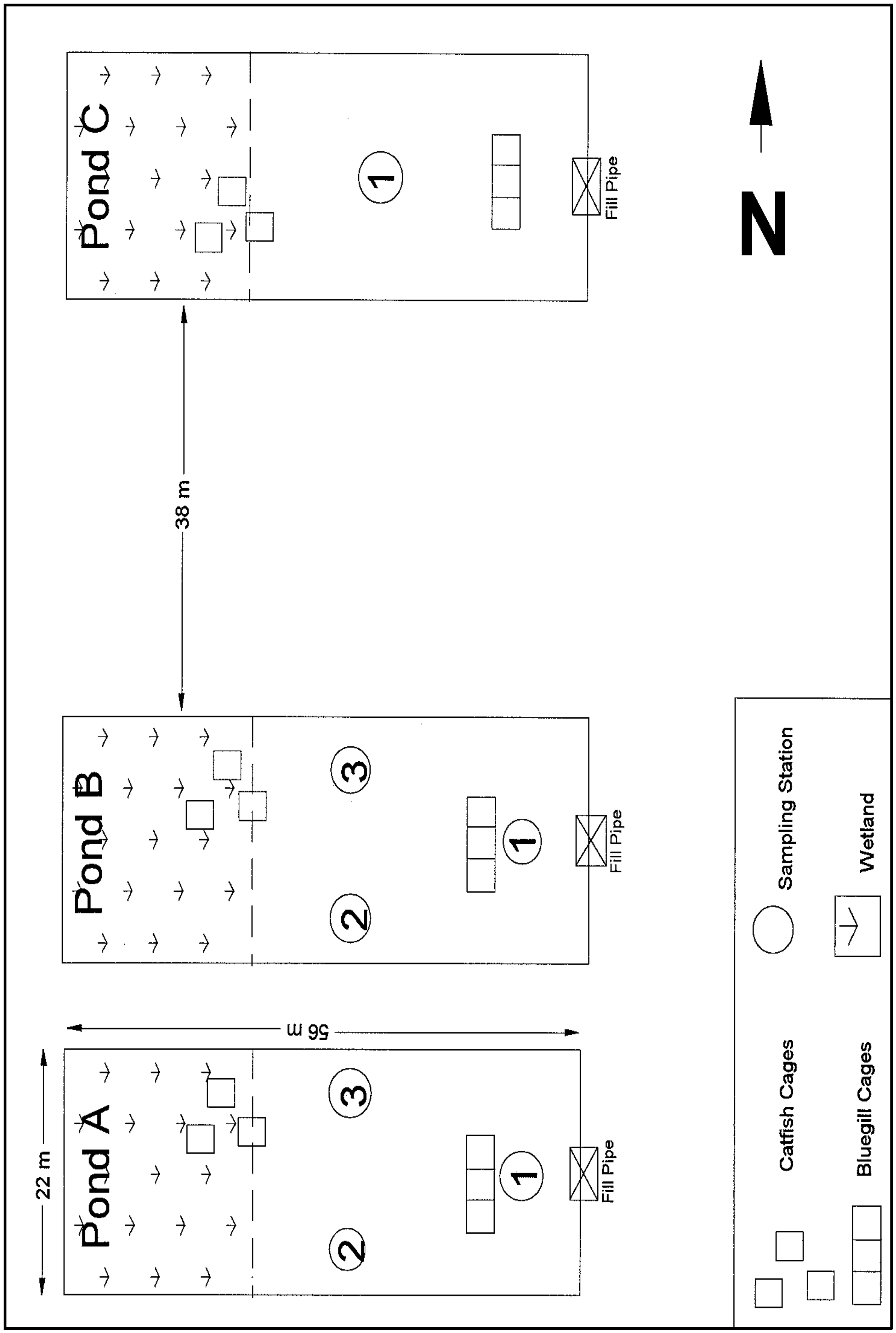


Figure 3. Layout of the test ponds at the Elk Grove, CA, test site

1995. The sonde devices were serviced routinely for battery replacement, data collection, and recalibration. Data were collected with a laptop computer through an interface cable.

Light intensity, spectral irradiance, and Secchi transparency

Light intensity, as percent surface light transmitted through the water column, was measured on 26 July 1995 using a LiCor Model 189 instrument at residue sampling Stations 1, 2, and 3 in Ponds A and B and at Station 1 in Pond C. In addition, light transparency measurements were taken in each pond using a standard Secchi disk at the same time and locations as the light intensity readings.

Application of test material

Application to both ponds occurred 26 July 1995, beginning about 0950 and completing about 1050. Completion of the actual application to each treated pond took approximately 10 min. Application was accomplished with a 20-L powered sprayer equipped with a hand wand. The sprayer was placed in a boat that traversed the test pond, with the test material being sprayed slightly above or just within the water surface. The sprayer was cleaned between applications. Skies were clear, and winds were light during the application process.

Both Ponds A and B had an area of 0.12 ha and an average depth of 0.80 m, giving a total volume of 984.75 m^3. An amount of 6.8 L of Garlon 3A was mixed with about 23 L of water and applied to achieve a target application rate of 2.5 mg/L.

Residue sampling proceeded according to the schedule in Table 2.

Missouri Methods and Materials

The Missouri study site was located at the U.S. Geological Survey (USGS) Environmental Contaminants Research Center (formerly the Midwest Science Center), located approximately 1.6 km (1 mile) east of Columbia, MO (39° N latitude, 92° W longitude) (Figure 2). The study was conducted by ABC Laboratories, Columbia, MO, with assistance from personnel of the USGS facility.

Columbia is located in Boone County, Missouri, near the central part of the State. The physiography of the land around Columbia is rolling, and elevation is about 230 m above sea level (Kusekopf and Scrivner 1962). The climate of Boone county is characterized by warm summers and cool winters. Precipitation is evenly distributed, but June and September are considered the wettest months (Kusekopf and Scrivner 1962).

The test ponds at the USGS site averaged 0.09 ha in area and 0.88 m in depth. They had not been treated with any pesticide since 1990.

The ponds were prepared during late May and early June 1995, with the installation of equipment and introduction of fish into the ponds (Figure 4).

Aquatic organism assessment (biosurvey)

A survey of the aquatic biological community was conducted pretreatment and 11.5-week posttreatment for each test pond. The primary purposes of this survey were to document that a viable, healthy biological community, comprising submersed plants, algae, and aquatic invertebrates, was present prior to the triclopyr application and to document any observed changes in that community following treatment.

Plants. Six line-intercept transects were established across each pond (north to south) and evenly spaced at intervals of one-sixth the length (east to west) of each pond. These permanent transects were used to sample the frequency of submersed and emersed plants (higher vascular species), members of the *Characeae* (charophyte) family, and filamentous algae occurring in the ponds. Plant species growing at intercept points located at every meter along each transect line were identified and recorded at both pretreatment (2 June 1995) and 11.5-week posttreatment (25 August 1995). Mean percent frequency (± SE) of each plant type was calculated for both sampling periods.

Algae. Each pond was divided into four equivalent areal sections, and 20-L water samples were collected using a polyvinyl chloride (PVC) water column sampler from the center of each quadrant for algae analyses at pretreatment (2 June 1995) and 11.5-week posttreatment (25 August 1995). Samples were filtered through a No. 20 Wisconsin plankton net, preserved in ethanol, and identified to genus or family.

Aquatic invertebrates. Aquatic invertebrates were sampled at six randomly selected locations in each pond at pretreatment (2 June 1995) and 11.5-week posttreatment (25 August 1995). Duplicate samples, taken by a single full sweep of a D-size net (1-mm mesh, 25-cm diam), were collected at each sampling location. Samples were preserved using ethanol and were identified to genus or family.

Vertebrates. Visual surveys of vertebrates were conducted on all ponds during daylight hours on 2 June (pretreatment) and on posttreatment days 8, 11, 19, and 24 June; 3, 6, and 20 July; and 10 and 24 August 1995.

Water quality measurements

Water quality was measured in each of the ponds using a Hydrolab Corporation (Austin, TX) Model Datasonde 3 positioned about middepth near the

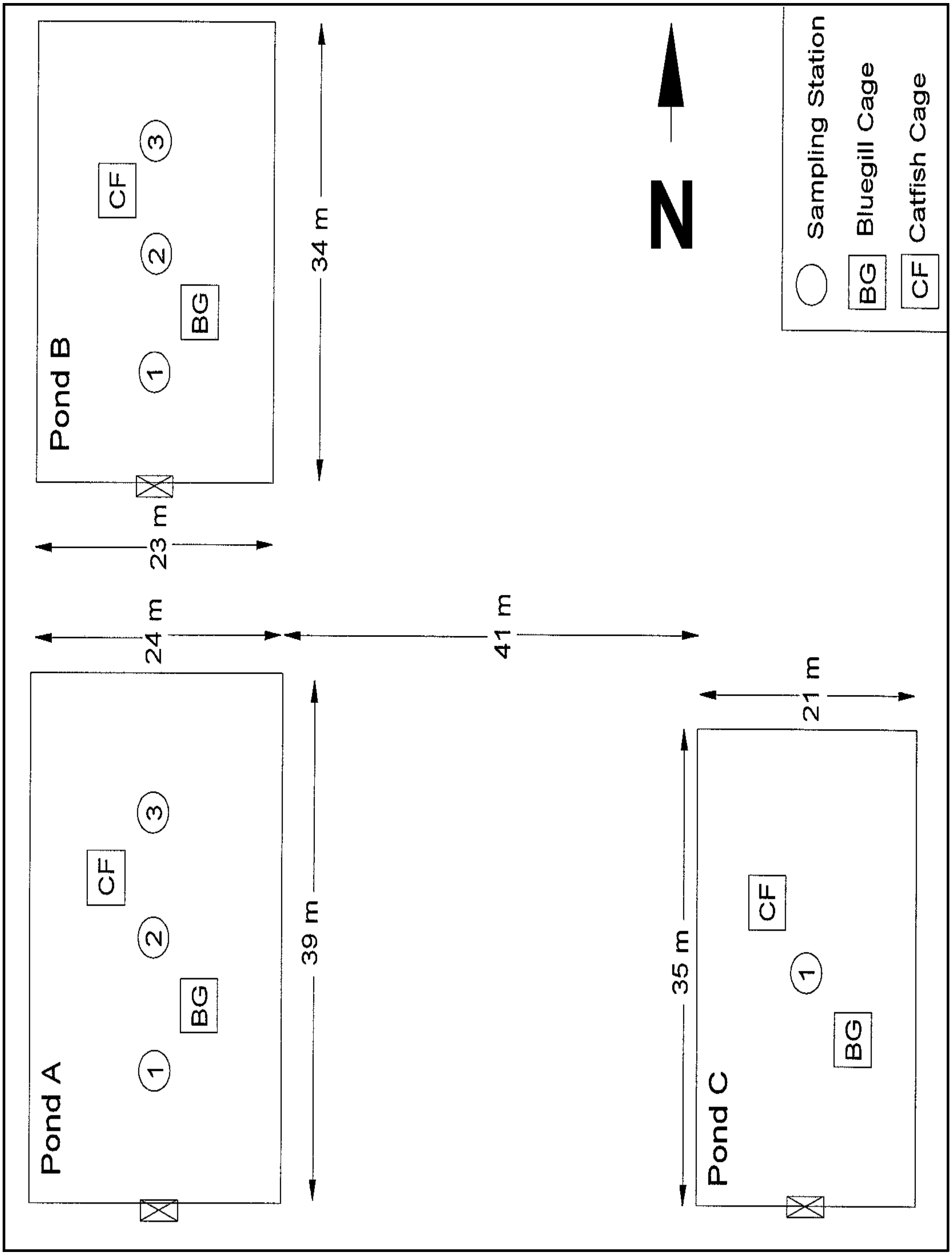


Figure 4. Layout of the test ponds at the Columbia, MO, test site

bluegill holding cages. Measurements of temperature, DO, pH, specific conductance (conductivity), and total dissolved solids (TDS) were taken every hour, starting on 3 June 1995 and continuing until 31 August 1995. The sonde devices were serviced routinely for battery replacement, data collection, and recalibration. Data were collected with a laptop computer through an interface cable.

Light intensity, spectral irradiance, and Secchi transparency

Light intensity, as percent of surface light transmitted through the water column (mean depth = 1.35 m), was measured on 12 and 22 June, 6 and 14 July, and 10 and 24 August 1995 in each of the ponds at a point near residue sampling Station 1. In order to determine transmission of ultraviolet (UV) solar energy (<400 nm) in the pond water, spectral irradiance was measured through the water column on 12 and 13 July 1995 in the triclopyr-treated ponds (A and B) at the same location as the light intensity readings. Surface readings were made using a LiCor (Lincoln, NE) Quantum Sensor Model LI-190SB attached to a LiCor Quantum/Radiometer/Photometer Model LI-185B, SR Q7517. Underwater readings were made using a LiCor Underwater Quantum Sensor SR UWQ 5057 attached to a LiCor Quantum/Radiometer/Photometer Model LI-189. Light transparency measurements were taken in each pond using a Secchi disk at the same time intervals and same location as the light intensity readings.

Application of test material

Application to both ponds occurred on 6 June 1995, beginning about 0700, with both ponds being completed at about 0810. Completion of the actual application required approximately 15 min for each treated pond. Application was accomplished by driving a truck-mounted powered sprayer around the circumference of the pond, while an applicator walked the pond's edge, spraying the test material onto the water surface. The sprayer was cleaned between applications.

Pond A had a measured area of 0.10 ha and an average depth of 0.93 m, giving a total volume of 891.30 m^3. An amount of 6.2 L of Garlon 3A was mixed with about 95 L of water and applied to achieve a target application rate of 2.5 mg/L.

Pond B had a measured area of 0.08 ha and an average depth of 0.80 m, giving a total volume of 622.4 m^3. An amount of 4.3 L of Garlon 3A was mixed with about 95 L of water and applied to achieve a target application rate of 2.5 mg/L.

Residue sampling proceeded according to the schedule in Table 2.

Texas Methods and Materials

Test site

The Texas study site was located at the U.S. Army Engineer Waterways Experiment Station (WES) Lewisville Aquatic Ecosystem Research Facility (LAERF), located in Denton County, near Lewisville, TX (33° N latitude, 97° W latitude) (Figure 2). The facility was developed by the Corps of Engineers (CE) Aquatic Plant Control Research Program (APCRP) to support studies of the biology, ecology, and management of aquatic plants (Smart et al. 1995). The study was conducted by WES personnel.

The climate of Denton County is characterized as humid subtropical (Ford and Pauls 1980). Prevailing winds are southerly throughout the year. Precipitation averages about 81 cm (32 in.) evenly distributed throughout the year (Ford and Pauls 1980).

The test ponds at the Texas site averaged 0.32 ha in area and 0.90 m in depth. The ponds had not been treated with any pesticide for at least 3 years prior to the test application. The pond bottoms had been compacted in February 1995, and aquatic plants including elodea, Eurasian watermilfoil, and pondweed were reestablished in March and May of 1995 (Figure 5)

Aquatic organism assessment (biosurvey)

A survey of the aquatic biological community was conducted pretreatment and 6-week posttreatment for each test pond. The primary purposes of this survey were to document that a viable, healthy biological community, comprising submersed plants, algae, and aquatic invertebrates, was present prior to the triclopyr application and to document any observed changes in that community following treatment.

Plants. Four line-intercept transects were established across each pond (north to south) and evenly spaced at intervals of 0.2, 0.4, 0.6, and 0.8 the length (east to west) of each pond. These permanent transects were used to sample the diversity of submersed and emersed plants (higher vascular species) and members of the *Characeae* (charophyte) family occurring in the ponds. Plant species growing at intercept points located at every meter along each transect line were identified and recorded, at both pretreatment (18 May 1995) and 6-week posttreatment (13 July 1995). Mean percent frequency ($\pm$SE) of each species was calculated for both sampling periods.

Algae. Each pond was divided into four equivalent areal sections, and 20-L water samples were collected just below the surface from the center of each quadrant for algae analyses at pretreatment (15 May 1995) and 6-week posttreatment (12 July 1995). Samples were filtered through a No. 20 Wisconsin plankton net, preserved in 10-percent formalin, and identified to genus or family.

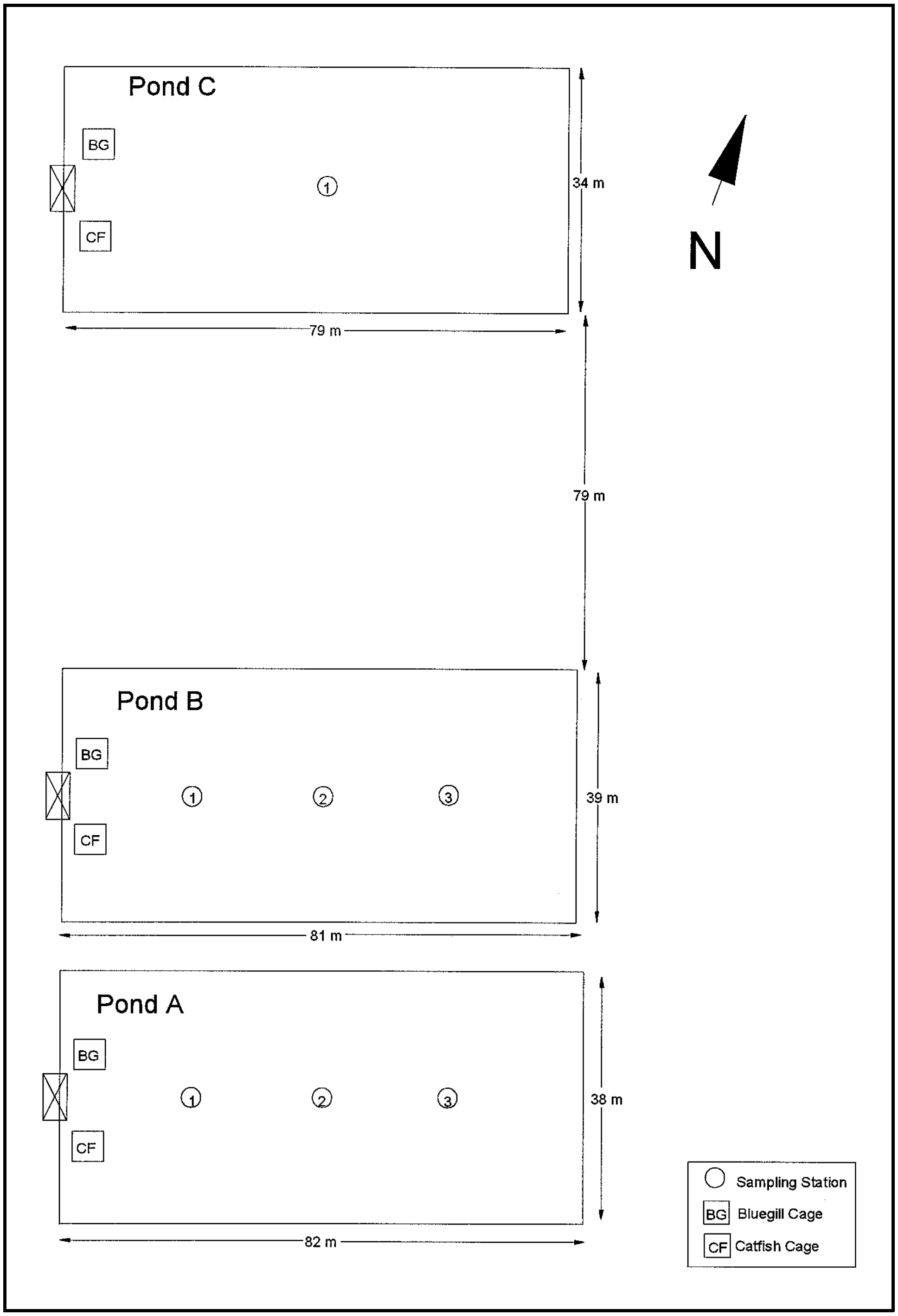


Figure 5. Layout of the test ponds at Lewisville, TX, test site

Aquatic invertebrates. Aquatic invertebrates were sampled at the same locations as described above for algae at pretreatment (15 May 1995) and 6-week posttreatment (12 July 1995). Duplicate samples, taken by a single full sweep of a D-size net (1-mm mesh, 25-cm diam), were collected at each sampling location.

sampling location. Samples were preserved using 10-percent formalin and were identified to genus or family.

Water quality measurements

Water quality was measured in each of the ponds at the deep-water sampling location (Station 1) using a Hydrolab Corporation (Austin, TX) Model Data-sonde 3 positioned at about middepth. Measurements of temperature, DO, pH, and specific conductance (conductivity) were taken every hour, starting on 11 May 1995 and continuing through 14 July 1995. The sonde devices were serviced routinely for battery replacement, data collection, and recalibration. Data were collected with a laptop computer through an interface cable.

Light intensity and spectral irradiance

Light intensity, as percent of surface light transmitted through the water column, was measured on 22 May 1995 and 1 June 1995 in each of the ponds at the deep-water station. This percent light transmission data were generated using a LiCor (Lincoln, NE) Model LI-1000 submersible photometer, which measured light in the photosynthetically active range (PAR) of 400 to 700 nm. In order to determine transmission of UV solar energy (<400 nm) in the pond water, spectral irradiance was measured through the water column on 22 May 1995 in the triclopyr-treated ponds (A and B) at the deep-water station. This UV transmission data were generated using a LiCor Model LI-1800UW underwater spectroradiometer.

Application of test material

Application to the test ponds occurred on 31 May 1995, beginning about 0600 and completing about 0710. Completion of the actual application required approximately 20 min for each treated pond. Application was accomplished by towing a 95-L sprayer around the circumference of the pond, while an applicator walked the pond's edge, spraying the test material onto the water surface. The sprayer was cleaned between applications.

Pond A had a measured area of 0.31 ha and an average depth of 0.91 m, giving a total volume of 2,844.14 m^3. An amount of 18.93 L of Garlon 3A was mixed with about 87 L of water and applied to achieve a target application rate of 2.5 mg/L.

Pond B had a measured area of 0.32 ha and an average depth of 0.88 m, giving a total volume of 2,784.57 m^3. An amount of 18.93 L of Garlon 3A was mixed with about 87 L of water and applied to achieve a target application rate of 2.5 mg/L.

Residue sampling proceeded according to the schedule in Table 2.

3 Results

California Results

Meteorological conditions

The National Oceanographic and Atmospheric Administration (NOAA) station at the Sacramento, CA, Airport reports a long-term average air temperature of 21.3 °C for the months of August to October, with a total precipitation amount of 3.86 cm for the same period (NOAA 1992a). The test site weather station recorded an average air temperature of 21.0 °C and no rainfall for the same period. Accordingly, air temperatures were about normal (-0.3 °C), while conditions were very dry (-3.86 cm). The daily weather conditions recorded at the study site are presented in Table 3.

Biological survey

Plants. Mean percent frequency of vascular plants and macro- and filamentous algae found during the study in each of the ponds are presented in Table 4.

Based on the pretreatment survey (21 July 1995), the ponds contained a community of aquatic plants typical to that expected in constructed impoundments of the western United States. Predominate vascular macrophytes included southern naiad, spikerush (*Eleocharis* spp.), coontail (*Ceratophyllum demersum*), and duckweed (*Lemna* spp.). Predominant macro- and filamentous algae included *Chara* spp., *Nostoc* spp. (bluegreen), and a mixture of greens.

By 12-week posttreatment (20 October 1995), all of the test ponds still contained a healthy plant community, although some shifting of species had occurred. Southern naiad increased in all ponds, but particularly in the triclopyr-treated ones. Spikerush decreased in all ponds, including the untreated reference. The bluegreen alga, *Nostoc*, decreased in the triclopyr-treated ponds, while green filamentous algae increased in all ponds. There was no clear pattern of shifts in species that could be attributed to the use of triclopyr, with the exception of coontail, which is susceptible to triclopyr at high use rates and was absent in Pond A at the 12-week evaluation period. The fluctuations observed in these

Table 3
Daily Weather Conditions Measured at the California Study Site, 1995

Date	Precip cm	Average Air Temp °C	Max Air Temp °C	Min Air Temp °C	% RH	Wind Speed kph	Wind Dir	SD Dir	Solar Rad kw/m^2
26-Jul	0	24.1	35.8	13.1	49.7	2.7	316	21.7	31,081
27-Jul	0	27.5	39.0	16.9	41.2	2.9	282	23.1	29,454
28-Jul	trace	26.2	37.8	17.5	43.0	4.9	240	27.5	25,571
29-Jul	0	23.0	33.3	14.4	55.0	5.2	237	24.8	30,475
30-Jul	0	26.0	35.4	15.8	48.5	5.2	336	17.7	30,149
31-Jul	0	28.4	39.9	17.0	43.9	2.7	269	25.7	29,931
1-Aug	0	28.0	39.1	19.1	42.3	3.2	271	24.6	28,794
2-Aug	0	27.4	38.9	18.6	43.6	3.4	260	24.8	28,828
3-Aug	0	26.0	36.6	17.6	48.5	3.6	237	27.4	28,980
4-Aug	0	23.2	33.3	15.8	57.3	5.3	238	28.1	28,678
5-Aug	0	22.0	32.0	15.1	62.4	5.7	227	28.3	28,087
6-Aug	0	22.4	33.7	14.2	59.1	6.0	224	27.9	28,827
7-Aug	0	23.4	32.1	15.7	54.6	7.0	250	25.2	28,335
8-Aug	0	25.0	34.5	17.5	36.2	6.7	337	17.5	29,221
9-Aug	0	25.4	36.1	16.1	44.0	4.1	234	30.2	28,108
10-Aug	0	20.2	27.5	15.0	55.6	8.8	216	29.9	28,360
11-Aug	0	21.0	30.4	12.8	54.0	3.5	258	26.0	28,285
12-Aug	0	24.3	34.4	13.8	46.9	3.8	329	17.5	28,074
13-Aug	0	26.0	36.9	15.4	41.9	3.1	297	24.1	28,114
14-Aug	0	27.1	37.5	16.6	39.7	2.1	257	27.7	27,425
15-Aug	0	23.9	31.7	17.4	45.6	6.3	234	29.7	27,127
16-Aug	0	20.4	28.0	15.5	51.1	8.8	216	31.0	27,020
17-Aug	0	19.5	27.4	12.6	54.5	5.9	264	21.7	27,182
18-Aug	0	22.2	33.1	12.1	48.1	3.5	313	21.0	27,435
19-Aug	0	25.4	36.4	14.8	38.5	1.9	280	27.5	26,757
20-Aug	0	26.0	37.0	16.9	41.4	3.5	265	27.0	25,888
21-Aug	0	23.3	33.7	15.9	54.2	5.0	222	27.6	24,962
22-Aug	0	25.7	36.7	18.6	46.6	3.0	240	26.8	20,882
23-Aug	0	25.7	35.8	19.6	36.7	5.1	223	30.2	25,112
24-Aug	0	22.2	30.5	16.3	44.6	5.8	216	29.5	25,639
25-Aug	0	19.9	28.7	13.1	55.3	5.5	224	28.3	26,027
26-Aug	0	20.4	30.7	12.2	55.0	4.1	234	25.0	25,977
27-Aug	0	20.7	29.8	13.5	49.1	5.1	220	29.0	26,126
28-Aug	0	19.5	28.4	11.7	57.3	4.8	210	29.9	25,767
29-Aug	0	21.3	30.6	13.0	56.6	3.2	308	21.8	25,043

(Sheet 1 of 3)

Table 3 (Continued)

Date	Precip cm	Average Air Temp °C	Max Air Temp °C	Min Air Temp °C	% RH	Wind Speed kph	Wind Dir	SD Dir	Solar Rad kw/m^2
30-Aug	0	22.1	32.3	13.0	48.3	2.9	274	24.4	25,459
31-Aug	0	22.1	33.8	12.3	51.8	2.8	252	27.9	24,734
1-Sep	0	20.5	30.8	13.1	59.5	4.3	240	26.9	24,628
2-Sep	0	20.7	31.1	13.3	57.3	4.2	244	27.6	24,153
3-Sep	0	19.9	28.9	13.9	58.9	5.6	207	28.7	24,823
4-Sep	0	19.8	30.4	11.7	61.0	3.5	255	27.1	24,233
5-Sep	0	22.3	32.7	12.0	53.1	5.2	336	17.7	23,994
6-Sep	0	24.5	35.8	14.0	43.0	1.5	283	26.1	23,397
7-Sep	0	25.3	35.0	15.8	40.0	2.4	222	26.8	23,184
8-Sep	0	22.8	34.1	15.1	52.1	2.9	246	28.3	22,894
9-Sep	0	18.9	27.0	13.6	67.1	5.3	235	29.6	22,629
10-Sep	0	19.9	29.4	13.0	64.7	3.9	251	27.1	22,342
11-Sep	0	21.8	32.4	13.9	58.9	2.5	242	26.9	22,069
12-Sep	0	22.4	33.5	13.5	54.9	3.0	257	26.0	22,032
13-Sep	0	20.6	32.1	13.1	63.0	3.3	249	25.9	21,637
14-Sep	0	20.9	32.3	13.7	65.0	3.7	245	26.5	21,472
15-Sep	0	20.9	30.6	14.4	64.9	4.6	226	27.9	21,179
16-Sep	0	19.3	26.5	14.3	63.5	6.8	217	29.5	21,536
17-Sep	0	21.0	31.3	12.8	61.3	2.6	300	21.4	21,074
18-Sep	0	23.7	36.2	14.9	55.6	1.1	238	30.0	20,847
19-Sep	0	26.2	36.9	16.9	48.1	0.9	248	29.2	20,398
20-Sep	0	24.4	35.1	16.6	51.7	2.7	251	25.8	20,514
21-Sep	0	22.5	33.1	15.1	58.4	2.5	231	28.3	19,847
22-Sep	0	19.3	27.6	14.4	67.3	5.0	220	27.5	19,988
23-Sep	0	19.2	29.4	12.4	66.1	3.6	229	26.6	20,332
24-Sep	0	19.6	27.9	14.6	65.8	4.5	224	26.8	16,410
25-Sep	0	19.7	27.5	14.5	66.2	3.7	241	26.5	18,487
26-Sep	0	19.5	28.3	13.9	63.0	3.1	242	26.6	19,423
27-Sep	0	19.3	27.8	13.1	64.8	4.9	215	28.5	19,563
28-Sep	0	18.0	25.2	13.1	64.4	4.1	196	26.3	17,641
29-Sep	0	18.1	26.3	10.4	57.3	6.7	330	17.3	19,217
30-Sep	0	18.4	28.2	9.7	57.1	1.8	319	23.6	17,864
1-Oct	0	19.2	28.6	10.7	54.3	3.8	339	19.1	18,871
2-Oct	0	20.9	32.4	11.7	48.2	1.2	317	23.4	18,461
3-Oct	0	22.2	32.1	13.0	43.9	2.4	314	24.8	18,381
4-Oct	0	21.3	27.2	15.5	23.2	22.6	343	17.4	18,430
5-Oct	0	18.9	29.1	11.9	36.9	1.0	273	23.7	17,439

(Sheet 2 of 3)

Table 3 (Concluded)

Date	Precip cm	Average Air Temp °C	Max Air Temp °C	Min Air Temp °C	% RH	Wind Speed kph	Wind Dir	SD Dir	Solar Rad kw/m^2
6-Oct	0	18.6	28.3	10.1	41.6	1.9	246	24.5	17,599
7-Oct	0	17.9	27.9	10.7	53.4	2.3	311	21.1	17,295
8-Oct	0	17.5	28.0	9.7	61.8	1.8	269	24.0	17,044
9-Oct	0	17.8	27.6	8.7	58.6	1.9	322	21.5	16,845
10-Oct	0	19.4	30.4	11.0	53.0	0.9	223	28.5	16,863
11-Oct	0	18.7	26.0	13.3	64.2	5.4	222	27.5	16,424
12-Oct	0	17.8	24.7	11.7	40.0	10.7	341	16.2	17,045
13-Oct	0	17.8	28.0	8.7	48.1	1.3	327	24.3	16,724
14-Oct	0	19.5	32.1	10.4	52.4	0.4	312	31.5	16,645
15-Oct	0	16.3	22.6	11.5	74.2	5.7	224	28.7	15,798
16-Oct	0	16.7	23.3	12.0	72.1	2.9	257	21.7	15,479
17-Oct	0	17.3	28.2	10.2	67.5	1.1	218	25.6	15,645
18-Oct	0	19.3	29.8	10.8	58.7	3.1	338	18.9	15,468

(Sheet 3 of 3)

Table 4
Mean Percent Frequency of Plant Species in Triclopyr Whole-Pond Dissipation Study, Elk Grove, CA—Pretreatment and 12-Week Posttreatment

	Pretreatment			Posttreatment		
Species	**Pond A**	**Pond B**	**Pond C**	**Pond A**	**Pond B**	**Pond C**
Najas guadalupensis	17 ± 5	0 ± 0	1 ± 1	51 ± 16	9 ± 6	4 ± 3
Elocharis spp.	53 ± 11	52 ± 16	76 ± 11	21 ± 11	25 ± 16	55 ± 13
Chara spp.	28 ± 13	3 ± 2	5 ± 3	16 ± 5	5 ± 2	9 ± 6
Ceratophyllum spp.	23 ± 9	0 ± 0	9 ± 7	0 ± 0	0 ± 0	19 ± 12
Typa spp.	1 ± 1	0 ± 0	1 ± 1	0 ± 0	0 ± 0	0 ± 0
Nostoc spp.	33 ± 20	18 ± 16	0 ± 0	0 ± 0	0 ± 0	0 ± 0
Cyperus spp.	18 ± 7	0 ± 0	0 ± 0	12 ± 8	0 ± 0	0 ± 0
Filamentous algae	17 ± 7	13 ± 6	42 ± 8	47 ± 13	21 ± 9	57 ± 15
Zannechellia palustris	5 ± 3	0 ± 0	15 ± 7	0 ± 0	1 ± 1	1 ± 1
Cladophora spp.	0 ± 0	0 ± 0	0 ± 0	4 ± 2	0 ± 0	0 ± 0
Spyrogyra spp.	0 ± 0	0 ± 0	0 ± 0	3 ± 2	33 ± 13	0 ± 0
Hydrodityon spp.	0 ± 0	0 ± 0	7 ± 4	3 ± 2	0 ± 0	7 ± 4
Lemna spp.	0 ± 0	20 ± 16	16 ± 15	0 ± 0	0 ± 0	1 ± 1
Pilularia spp.	0 ± 0	0 ± 0	0 ± 0	0 ± 0	1 ± 1	0 ± 0
Calitriche spp.	2 ± 2	0 ± 0	0 ± 0	0 ± 0	0 ± 0	1 ± 1

Note: ± standard error.

plant communities were most likely influenced by normal phenological cycles and interspecific competition that occur in small ponds.

Algae. Occurrence of algae as phytoplankton is shown in Tables 6 and 8. These data demonstrate that a healthy and diverse phytoplankton community was maintained throughout the evaluation period. Generally, bluegreens declined (particularly in the triclopyr-treated ponds), whereas diatoms and greens increased in all ponds by 12-week posttreatment.

Aquatic invertebrates. Occurrence of aquatic invertebrates is presented in Tables 5 and 7. Invertebrates noticeably increased (frequency and orders/families) in all ponds during the course of the study, indicating that the shifts in these organisms were unaffected by the triclopyr applications. Since these increases were similar across all ponds (including the untreated reference), it is likely that the changes in invertebrates during the evaluation period were caused by normal phenological events.

Table 5
Occurrence of Invertebrates in Triclopyr Whole-Pond Dissipation Study, Elk Grove, CA—Pretreatment

	Pond A						Pond B						Pond C					
Organisms	**1**	**2**	**3**	**4**	**5**	**6**	**1**	**2**	**3**	**4**	**5**	**6**	**1**	**2**	**3**	**4**	**5**	**6**
Culicidae																		
Libellulidae																		
Ceratopogonidae																		
Gastropoda	X	X	X	X		X	X		X			X		X	X	X	X	X
Daphnia spp.																		
Notonectidae	X	X	X	X		X		X	X	X	X	X	X	X	X	X	X	X
Corixidae								X										
Aeshnidae									X									
Baetidae		X							X					X				
Coenagrionidae				X							X	X		X	X	X	X	X
Chironomidae		X												X			X	X
Ostracoda spp.																		
Gammaridae																		
Tipulidae																		
Conchostaca spp.																		
Arrenuroidea								X	X									
Oligochaeta																		
Nematode																		
Hydrophilidae																		
Leech																		

Table 6
Occurrence of Algae in Triclopyr Whole-Pond Dissipation Study, Elk Grove, CA—Pretreatment

Species	Pond A				Pond B				Pond C			
	A	B	C	D	E	F	G	H	I	J	K	L
Anabaena	X		X	X		X						
Calothrix		X			X	X		X			X	X
Gloeotrichia		X			X	X		X				
Merismopedia		X										
Oscillatoria						X						
Nitzschia	X	X	X	X	X	X		X	X	X	X	X
Gomphonema	X	X	X	X	X		X	X	X	X	X	X
Pinnularia		X			X	X	X		X	X	X	X
Epithemia										X		
Rhopalodia				X					X			
Navicula					X		X					
Cocconeis									X			X
Synedra									X			
Cymbella												X
Achnathes												
Rhoicosphenia												
Fragilaria												
Phacus	X											
Euglena		X										
Trachlemonas												
Pediastrum	X	X	X						X	X	X	
Monoraphidium	X	X										
Ankistrodesmus	X											X
Oocystis	X											
Crucigeniella	X	X	X						X			
Tetrastrum	X	X										
Scenedesmus	X	X	X		X				X	X	X	X
Lagerheimia	X											

(Continued)

Table 6 (Concluded)

Species	Pond A				Pond B				Pond C			
	A	B	C	D	E	F	G	H	I	J	K	L
Spirogyra		X	X	X	X	X	X		X	X	X	X
Coelastrum		X	X									
Cosmarium		X										
Botryococcus				X			X	X				
Mougeotia					X		X					
Sphaerocystis					X							
Volvox									X	X	X	X
Eudorina									X	X	X	X
Pandorina										X		X
Gymnodinium											X	
Oedogonium												
Nephtocytium												
Characium												
Chlamydomonas												
Tetraedron												

Water quality and characterization

The pH values of natural waters are usually in the range of 6.5 to 8.5 (Federal Water Pollution Control Administration (FWPCA) 1968). Higher incident values (pH 9 to 11) may occur due to photosynthetic activities of aquatic plants. The carbonate system is the major buffering system in natural waters, as well as providing the carbon reservoir for photosynthesis.

Water hardness is usually attributed to the presence of calcium and magnesium, although other minerals also affect the measure of hardness. Biological productivity is often correlated to water hardness, but there is no direct link. In fact, some of the contributing factors can be toxic at higher levels, so water hardness is not generally a consistent measure of quality for aquatic life.

Turbidity is caused by the presence of suspended matter, such as clay, silt, organic matter, and minute organisms. Excessive turbidity reduces light penetration and, therefore, photosynthesis by phytoplankton, algae, and submersed plants.

The data generated from water characterization analyses are presented in Table 9. In general, the water from the California test site ponds can be

Table 7
Occurrence of Invertebrates in Triclopyr Whole-Pond Dissipation Study, Elk Grove, CA—Posttreatment

Organisms	Pond A						Pond B						Pond C					
	1	**2**	**3**	**4**	**5**	**6**	**1**	**2**	**3**	**4**	**5**	**6**	**1**	**2**	**3**	**4**	**5**	**6**
Culicidae	X				X	X												
Libellulidae	X		X	X	X	X					X			X		X	X	X
Ceratopogonidae				X	X								X	X				
Gastropoda	X	X	X	X	X	X			X	X	X	X	X	X	X	X	X	X
Daphnia spp.	X	X	X	X	X	X		X	X	X	X		X	X	X	X	X	X
Notonectidae		X	X	X	X	X									X	X	X	
Corixidae					X	X			X									X
Aeshnidae	X	X		X	X	X			X	X	X	X		X	X	X	X	X
Baetidae	X	X	X	X	X	X			X	X			X		X	X	X	
Coenagrionidae	X	X	X	X	X	X	X	X	X	X	X		X		X	X	X	X
Chironomidae	X	X	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X
Ostracoda spp.	X	X	X	X	X	X		X	X	X		X	X	X	X	X	X	X
Gammaridae	X	X	X	X	X	X		X	X	X			X	X	X	X	X	X
Tipulidae						X					X	X						
Conchostaca spp.	X	X	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X
Arrenuroidea	X												X					
Oligochaeta	X	X	X	X	X	X			X	X	X	X	X	X	X	X	X	X
Nematode																X	X	
Hydrophilidae																		X
Leech													X					

characterized as basic, with a USGS classification of hard (Van der Leeden, Troise, and Todd 1990).

Pretreatment and posttreatment water quality data (temperature, DO, pH, and conductivity) are presented in Figures 6-9. Water quality changed over time, and in a diurnal pattern, in a fashion typical with that expected for small, constructed impoundments in the western United States. Generally, similar trends in water quality patterns were observed in all ponds, although amplitudes of some

Table 8
Occurrence of Algae in Triclopyr Whole-Pond Dissipation Study, Elk Grove, CA—Posttreatment

	Pond A				Pond B				Pond C			
Species	**O**	**P**	**Q**	**R**	**S**	**T**	**U**	**V**	**W**	**X**	**Y**	**Z**
Anabaena												
Calothrix		X	X	X			X	X	X	X	X	X
Gloeotrichia												
Merismopedia												
Oscillatoria	X											
Nitzschia	X	X				X						
Gomphonema	X	X	X	X	X	X	X	X	X	X	X	X
Pinnularia												
Epithemia	X	X	X	X	X	X	X	X	X	X	X	X
Rhopalodia	X			X	X			X	X	X		X
Navicula								X				
Cocconeis		X	X	X	X	X		X	X	X	X	X
Synedra	X	X	X	X	X	X	X	X	X	X	X	X
Cymbella												
Achnathes												
Rhoicosphenia	X				X				X	X		
Fragilaria			X	X	X	X	X	X	X	X		
Phacus	X	X										
Euglena												
Trachlemonas					X							
Pediastrum			X	X	X	X		X	X	X	X	X
Monoraphidium												
Ankistrodesmus						X						
Oocystis	X											
Crucigeniella	X						X					
Tetrastrum												
Scenedesmus		X	X	X					X	X		X

(Continued)

Table 8 (Concluded)												
	Pond A				**Pond B**				**Pond C**			
Species	**O**	**P**	**Q**	**R**	**S**	**T**	**U**	**V**	**W**	**X**	**Y**	**Z**
Lagerheimia												
Spirogyra						X	X	X	X	X	X	X
Coelastrum	X	X	X	X	X				X		X	
Cosmarium				X	X						X	
Botryococcus			X				X					
Mougeotia	X	X	X	X	X	X	X	X	X	X	X	X
Sphaerocystis			X	X						X		
Volvox												
Eudorina		X			X							
Pandorina		X										
Gymnodinium												
Oedogonium		X	X	X								
Nephtocytium		X		X	X				X			
Characium			X	X								
Chlamydomonas					X							
Tetraedron	X											

Table 9
Results of Water Characterization Analyses from the California, Missouri, and Texas Study Sites, 1995

Site	Pond	Alkalinity	TSS	pH	Hardness	Conductivity	Turbidity	Sulfate	Na	Ca	Mg	COD
CA	A	173	8	7.8	144	0.35	11	1	23	23	19	34
CA	B	168	0	8.1	142	0.33	8	0	22	24	19	9
CA	C	155	0	8.3	138	0.32	4	1	20	24	18	8
MO	A	80	3	9.4	74	0.25	5	0	11	12	8	16
MO	B	72	8	9.5	70	0.16	5	9	12	21	10	18
MO	C	108	43	7.9	104	0.25	22	5	12	20	10	60
TX	A	89	18	8	100	0.3	25	28	17	30	4	10
TX	B	100	16	8	112	0.33	38	29	15	31	3	45
TX	C	92	4	8	94	0.33	42	27	16	31	4	40

parameters varied between ponds. This similarity in trends indicates that triclopyr applications had no significant effect on water quality conditions in this study.

Water temperatures ranged from 19 to 31 °C during the evaluation period, with warmest temperatures occurring in August and cooler temperatures returning in September/October (Figure 6). Temperatures were slightly warmer in Ponds A and B than in Pond C—possibly due to the greater occurrence of algae in those ponds.

The DO levels measured in all ponds ranged from near zero (nighttime) to >16 mg/L during the day (Figure 7). In Pond C, DO fell to $\leq$6 mg/L during the latter stages of the evaluation period (mid-August to September); whereas, during that same period in the triclopyr-treated ponds (A and B), DO remained high during the day and low at night. These wide fluctuations in diurnal DO amplitude were probably due to the great occurrence of algae in these ponds, particularly after mid-August.

A gradual increase in pH was measured through the course of the study in Ponds A and B (Figure 8), with values ranging from approximately 7.5 to nearly 10. These elevated pH levels were likely a result of photosynthetic activity by the abundance of algae in those ponds. In contrast, the pH of Pond C remained more constant through time (7.5 to 9.0) and decreased to a steady level of 7.2 to 7.7 from late August through the end of September.

Conductivity was somewhat variable in all of the ponds with a general upward trend apparent through mid-August to late August (Figure 9). In Pond A, conductivity peaked at 480 mS/cm in late August and exhibited two minima of 330 mS/cm in mid-September and October. In Pond B, conductivity peaked at nearly 480 mS/cm in late August and declined steadily to <300 mS/cm by mid-September. In Pond C, a peak was reached in mid-September (440 mS/cm), followed by a decline to approximately 350 mS/cm in late September.

Light intensity and spectral irradiance

Light intensity measurements indicated that, with the exception of one sampling station, 65 to 90 percent of surface light was quenched at depths greater than 75 cm in all ponds (Figure 10).

Secchi transparency readings ranged from 91.5 to 107 cm in Pond A, and the disk was visible to the bottom in Ponds B (110 to 160 cm) and C (107 to 137 cm).

Sediment characterization

Results of the physical characterization of the bottom sediment is presented in Table 10. Generally, the sediments were characterized as clay loams, with a

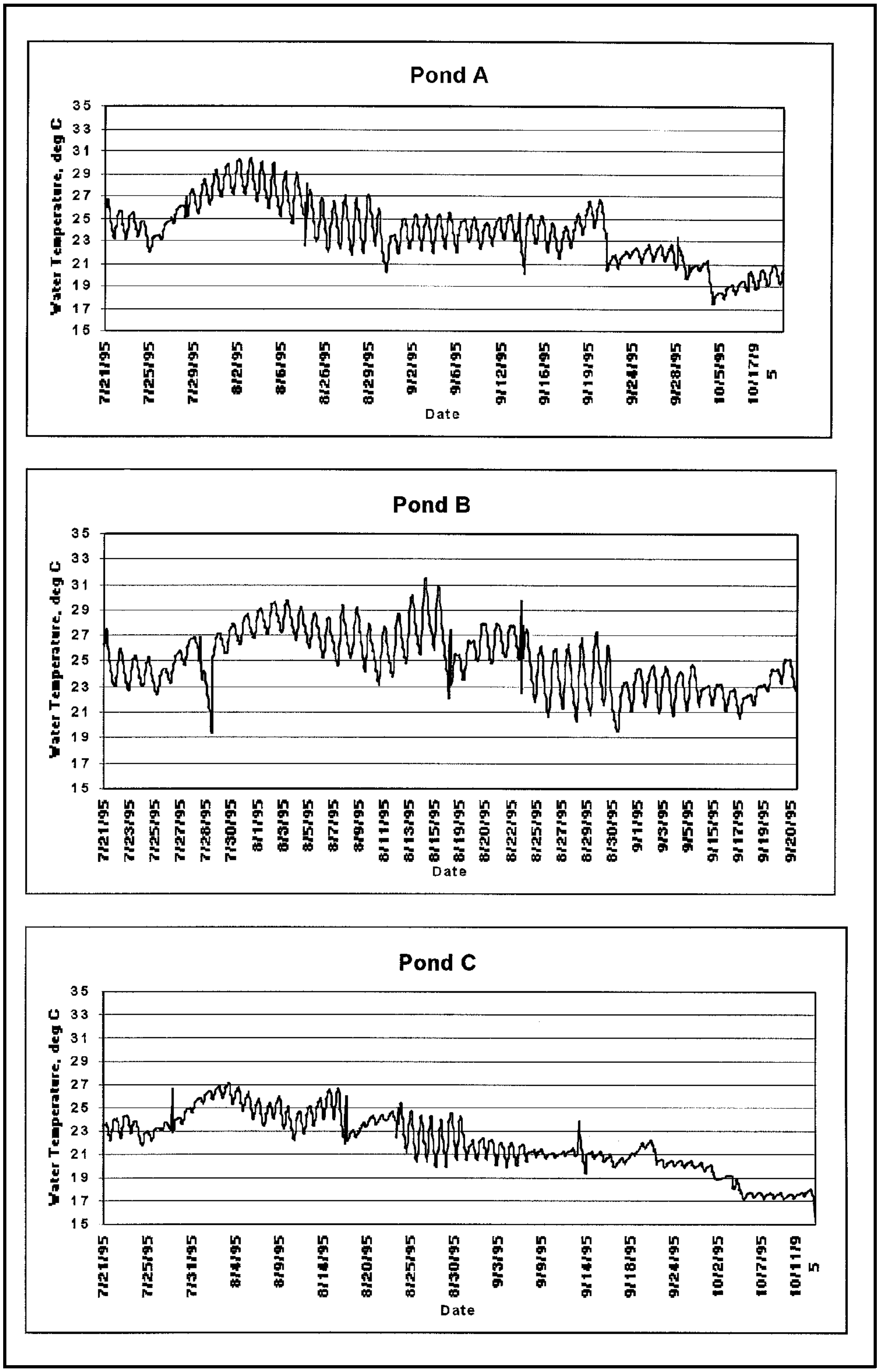


Figure 6. Water temperature measurements from the Elk Grove, CA, study site, 1995

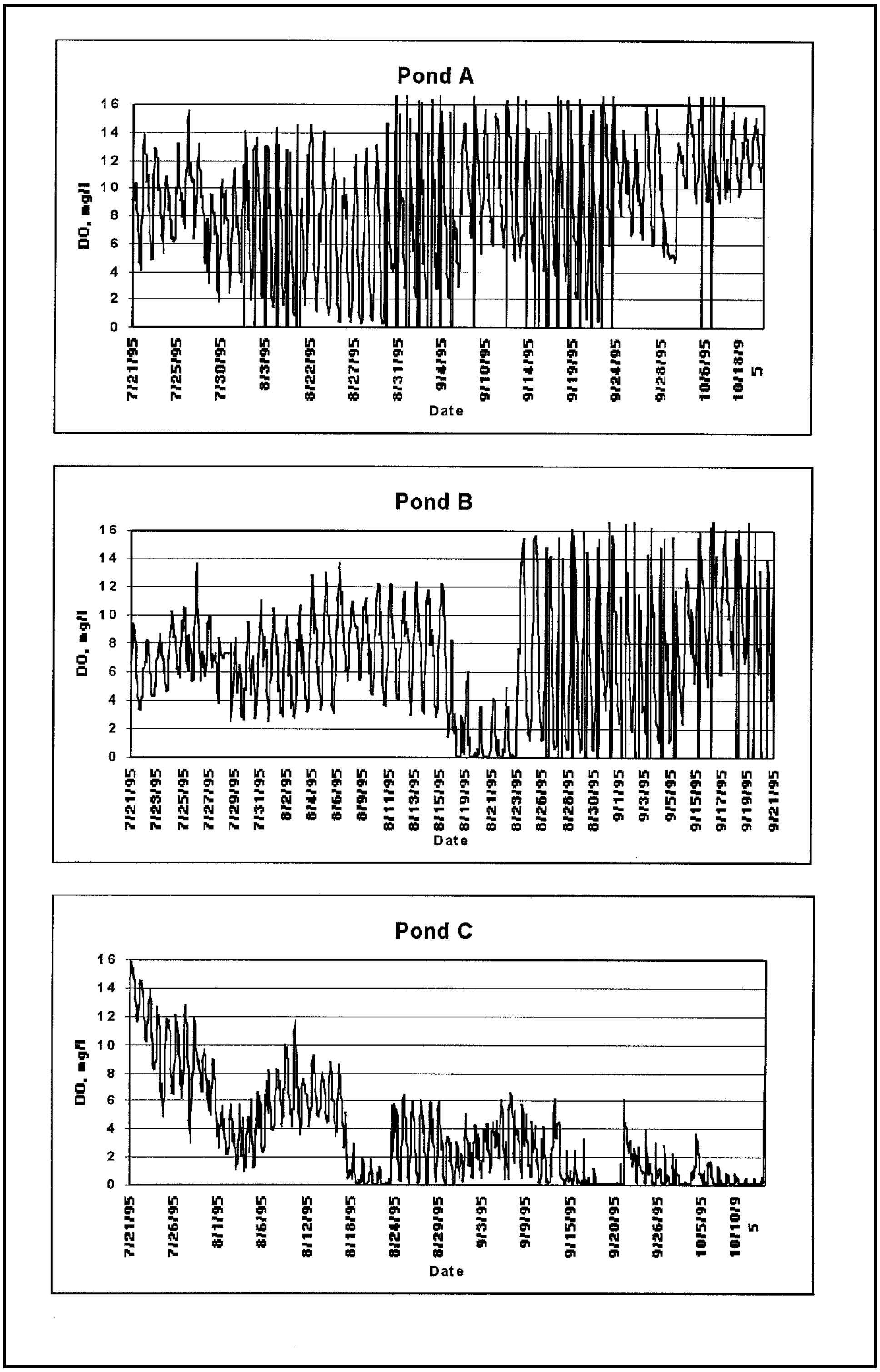


Figure 7. Dissolved oxygen measurements from the Elk Grove, CA, study site, 1995

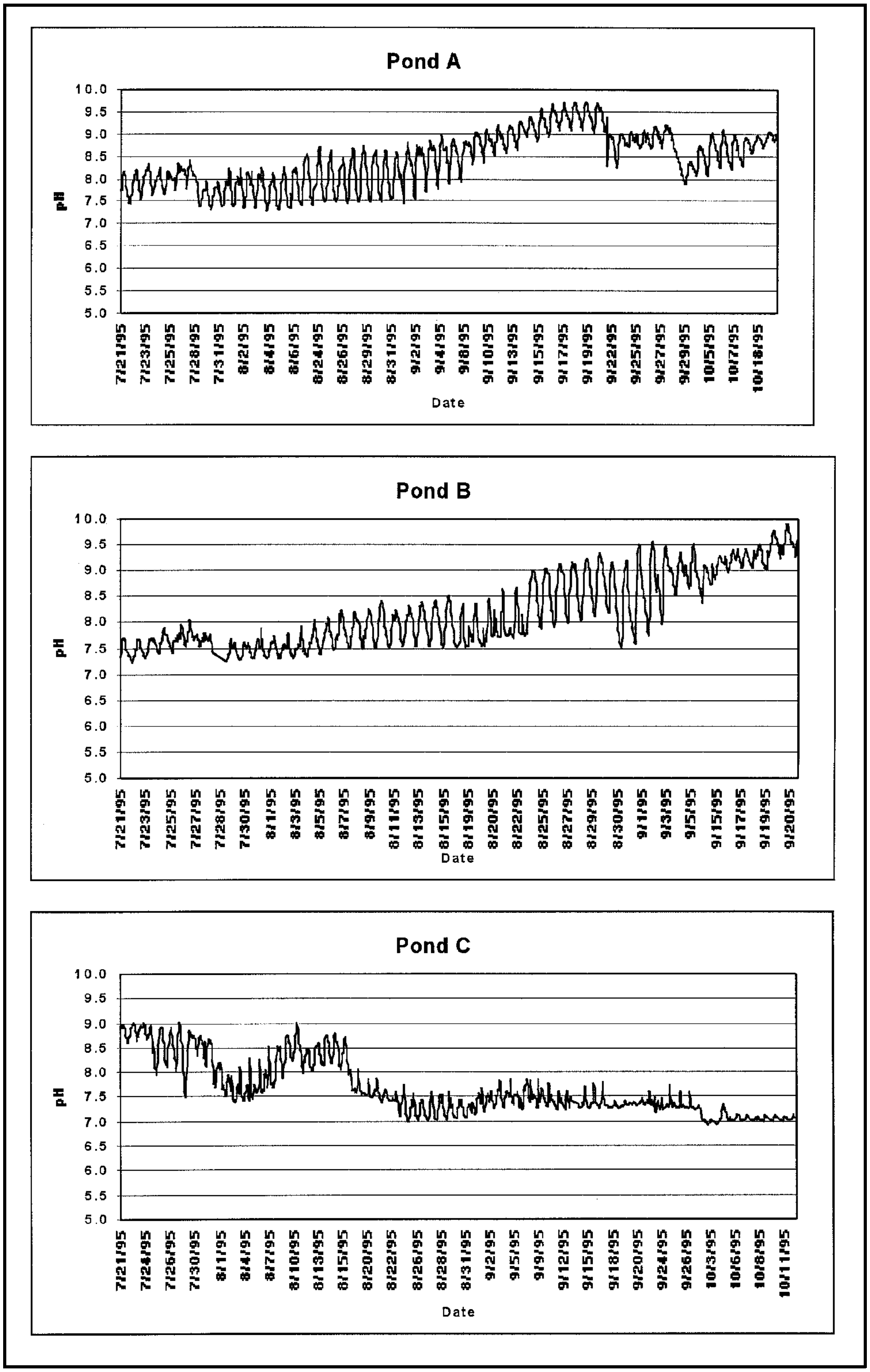


Figure 8. pH measurements from the Elk Grove, CA, study site, 1995

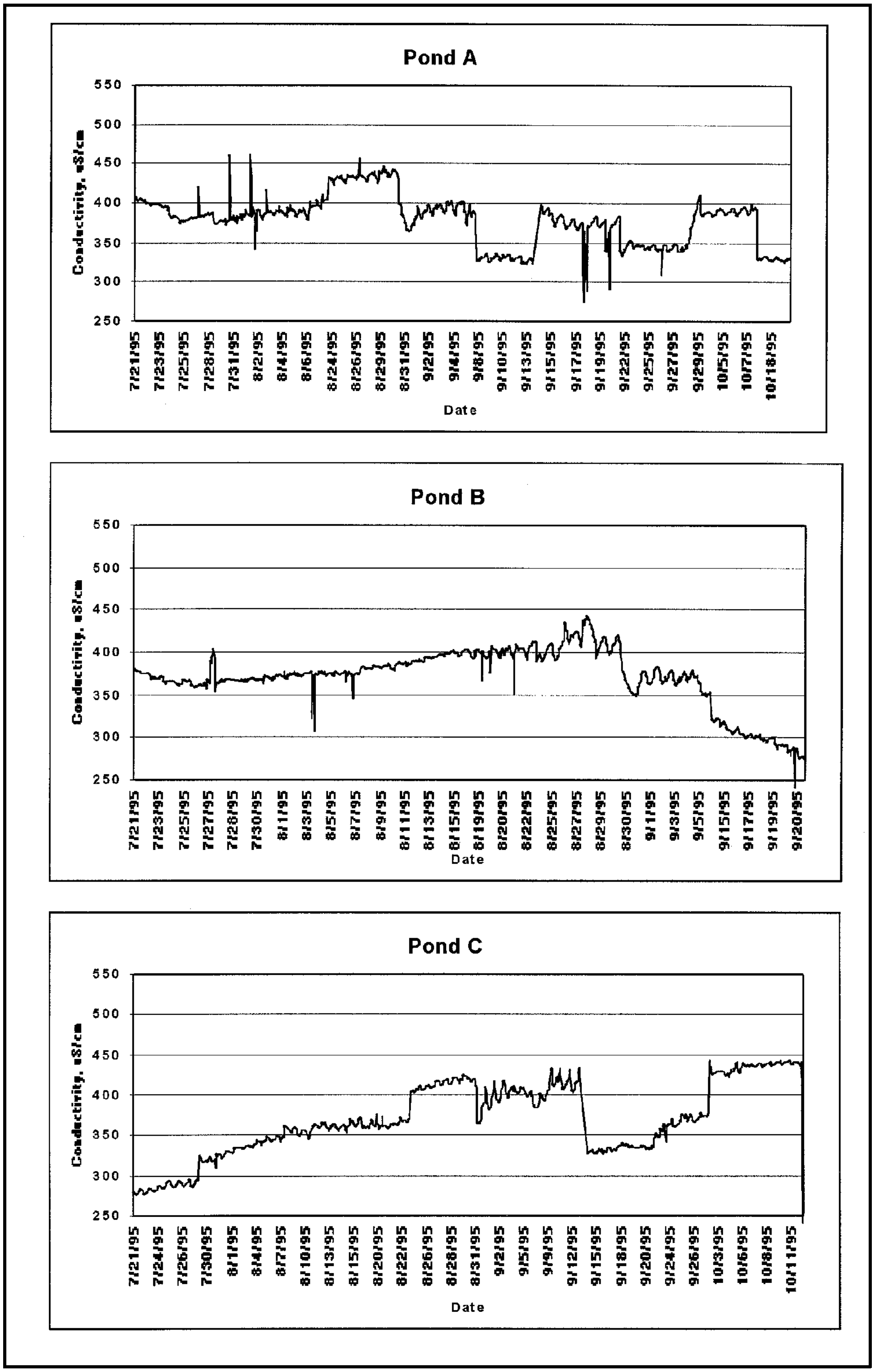


Figure 9. Conductivity measurements from the Elk Grove, CA, study site, 1995

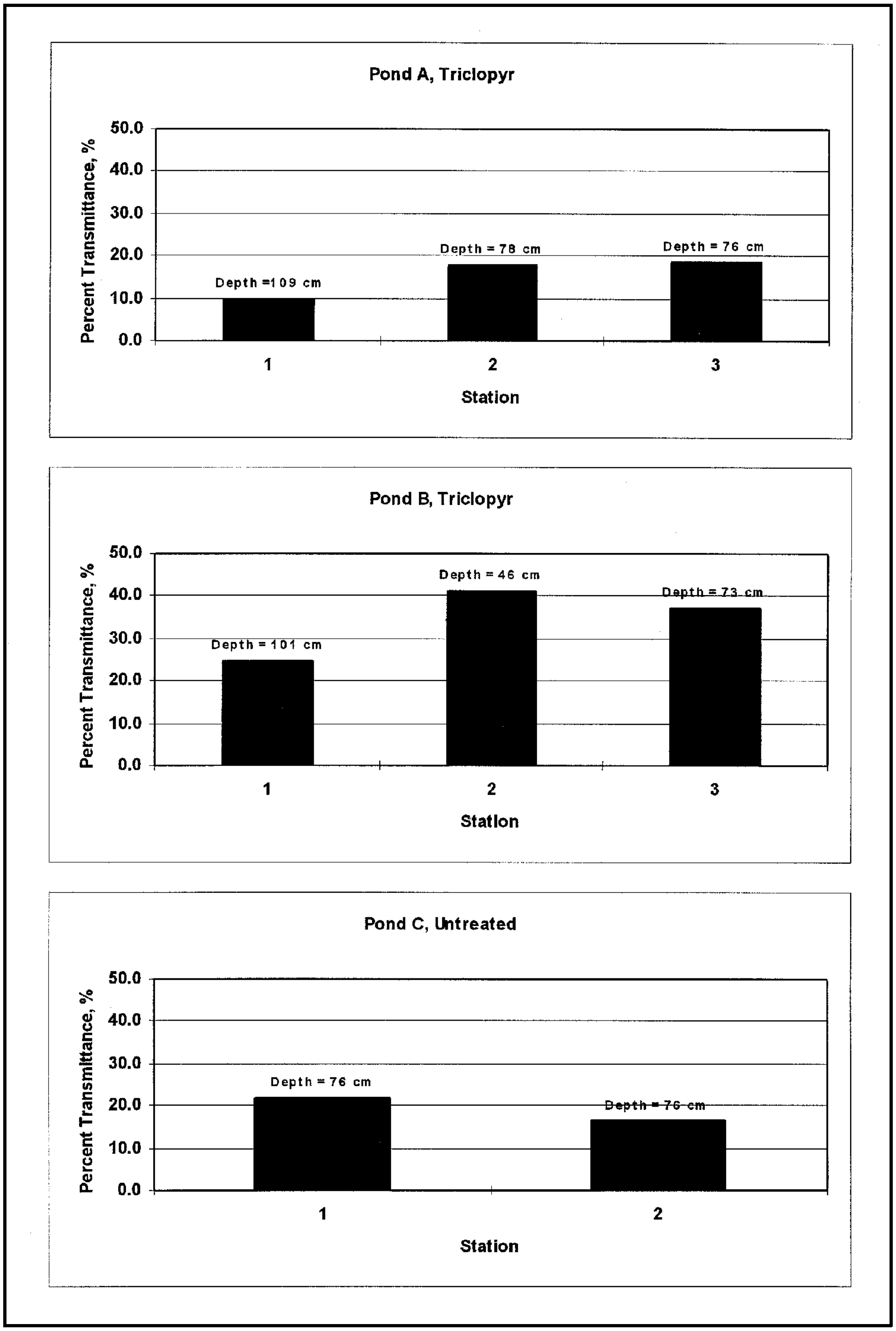


Figure 10. Percent light transmission profiles from the test ponds at the Elk Grove, CA, study site, 1995

Table 10
Results of Sediment Characterization Analyses from the California, Missouri, and Texas Study Sites, 1995

Site	Pond	Stn	pH	CEC	% OM	1/3 Bar Moisture-Holding Capacity	15 Bar Moisture-Holding Capacity	% Sand	% Silt	% Clay	Texture
CA	A	1	7.2	11.83	1.06	17.37	8.37	67.6	14	18.4	Loam
CA	A	2	7	14.39	1.01	23.63	10.54	55.6	20	24.4	Sandy clay loam
CA	A	3	6.8	17.75	1.44	29.02	12.25	39.6	30	30.4	Clay loam
CA	B	1	7	15.33	0.8	23.57	10.55	45.6	30	24.4	Loam
CA	B	2	6.7	16.59	2.4	28.26	11.73	37.6	34	28.4	Clay loam
CA	B	3	6.8	16.21	2.5	28.65	11.85	37.6	34	28.4	Clay loam
CA	C	1	6.8	13.97	0.8	26.54	10.1	35.6	36	28.4	Clay loam
MO	A	1	7.6	21.04	3.41	40.26	16.57	9.2	54.4	36.4	Silty clay loam
MO	A	2	7.8	20.79	2.49	38.1	15.41	9.2	52.4	38.4	Silty clay loam
MO	A	3	7.8	20.69	3.24	40.35	15.44	9.2	54.4	36.4	Silty clay loam
MO	B	1	7.7	20.37	3.35	41.79	16.96	9.2	54.4	36.4	Silty clay loam
MO	B	2	7.8	20.69	2.65	39.15	14.83	13.2	50.4	36.4	Silty clay loam
MO	B	3	7.7	20.13	3.03	40.32	15.34	13.2	52.4	34.4	Silty clay loam
MO	C	1	7.8	20.2	2	38	14.59	9.2	56.4	34.4	Silty clay loam
TX	A	1	7.9	16.84	2.05	28.19	11.55	49.2	22.4	28.4	Sandy clay loam
TX	A	2	7.8	17.36	2.81	29.13	12.52	53.2	20.4	26.4	Sandy clay loam
TX	A	3	7.3	18.2	3.51	28.46	12.66	51.2	20.4	28.4	Sandy clay loam
TX	B	1	7.6	18.52	2.38	30.31	13.33	45.2	22.4	32.4	Sandy clay loam
TX	B	2	7.8	23.8	3.84	32.61	14.71	41.2	24.4	34.4	Clay loam
TX	B	3	7.4	23.24	3.62	30.85	13.87	45.2	22.4	32.4	Sandy clay loam
TX	C	1	7.8	16.66	2.7	27.19	11.01	51.2	22.4	26.4	Sandy clay loam

few exceptions. Organic matter was relatively low, ranging from 0.8 to 2.5 percent. The pH of the sediment was slightly acidic to neutral.

Triclopyr dissipation

Results of analysis for triclopyr and its metabolites in the matrices examined in this study have been reported separately (Foster, Getsinger, and Petty 1997).

A summary of average residue values from the California study site is presented in Appendix A. Table 11 lists the reported limits of detection (LOD) and limits of quantification (LOQ) for each sample matrix. Any value falling below the LOD is considered to be nondetectable (ND). A value falling between the LOD and LOQ is considered to be nonquantifiable (NQ) and is referred to as a "trace" value in this report. Half-lives for all matrices are summarized in Table 12.

Table 11
Calculated Limits of Detection (LOD) and Limits of Quantification (LOQ) for the Residue Analysis Methods

Matrix	Triclopyr LOD	TCP LOD	TMP LOD	Triclopyr LOQ	TCP LOQ	TMP LOQ
Water, ng/mL	0.043	0.155	0.0320	0.145	0.516	0.107
Sediment, µg/g	0.003	0.003	0.0020	0.011	0.008	0.006
Bluegill fillet, µg/g	0.0039	0.0039	0.0060	0.013	0.013	0.020
Bluegill viscera, µg/g	0.0034	0.0022	0.0048	0.011	0.007	0.016
Catfish fillet, µg/g	0.0044	0.0070	0.0051	0.015	0.023	0.017
Catfish viscera, µg/g	0.0058	0.0043	0.0037	0.019	0.014	0.013

Water

Triclopyr and its metabolites dissipated rapidly from water in this study, and results from the replicate ponds matched well. Pond A showed initial triclopyr levels of 2,087 ng/mL, and Pond B showed levels of 2,518 ng/mL, indicating that the applications were near or at the nominal level of 2,500 ng/mL. In Pond A, triclopyr dissipated with a half-life of 6.9 days, TCP with a half-life of 4.2 days, and TMP with a half-life of 5.3 days (Figure 11). In Pond B, triclopyr had a half-life of 7.5 days, the TCP half-life was 4.5 days, and the TMP half-life was 7.7 days (Figure 12). The triclopyr half-lives in these whole-pond evaluations were similar to, or slightly greater than, those reported from field studies conducted in Georgia, Minnesota, and Washington (Woodburn, Green, and Westerdahl 1993; Petty et al. 1998; Getsinger et al. 1997). TCP levels at the first sampling event were about 0.5 percent of the applied triclopyr, which is consistent with the reported levels present in the Garlon 3A formulation. After this initial concentration, TCP levels peaked between 5 and 7 days in each pond, between 8 and 10 ng/mL, respectively. The TCP levels measured in this study were similar to those found in Lake Minnetonka, Minnesota (Petty et al. 1998), but somewhat greater than those measured in Lake Seminole, Georgia (Woodburn, Green, and Westerdahl 1993). TMP levels peaked at about 4 ng/mL at Day 5 in each pond. The reference pond showed no detectable residues of any of the compounds of interest.

Table 12
Summary of Calculated Half-Lives from the Examined Matrices from the California, Missouri, and Texas Triclopyr Study Sites

		California				Missouri				Texas			
		Pond A		Pond B		Pond A		Pond B		Pond A		Pond B	
Matrix		Half-Life	r^2	Half-Life	r^2	Half-Life	r^2	Half-Life	r^2	Half-Life	r^2	Half-Life	r^2
Water	Tric	6.9	0.94	7.5	0.86	5.9	0.98	6.1	0.96	6.5	0.98	6.3	0.97
	TCP	4.2	0.95	4.5	0.99	4.0	0.97	5.9	0.99	5.7	0.94	10.0	0.80
	TMP	5.3	0.96	7.7	0.89	4.0	0.95	4.8	0.93	6.5	0.98	5.7	0.97
Sediment	Tric	3.4	0.99	3.6	0.94	2.8	0.97	3.2	0.97	4.6	0.95	4.6	0.98
	TCP	5.6	0.98	3.8	0.99	6.2	0.99	7.0	0.91	13.3	0.95	12.3	0.93
	TMP	-	-	-	-	-	-	-	-	-	-	-	-
Bluegill Fillet	Tric	5.4	0.56	2.7	0.89	6.7	0.62	-	-	-	-	6.2	0.77
	TCP	-	-	-	-	-	-	-	-	-	-	15.1	0.96
	TMP	4.4	0.99	-	-	5.1	0.98	5.5	0.90	5.3	0.97	4.3	0.96
Bluegill Viscera	Tric	7.4	0.90	5.0	0.99	6.0	0.99	5.0	0.91	8.0	0.97	5.6	0.96
	TCP	5.1	0.99	12.5	0.79	8.8	0.94	5.0	0.99	8.7	0.99	8.5	0.98
	TMP	2.9	0.99	2.5	0.77	5.6	0.99	5.7	0.97	11.5	0.81	13.3	0.98
Catfish Fillet	Tric	-	-	-	-	5.0	0.94	-	-	12.9	0.73	-	-
	TCP	-	-	-	-	-	-	-	-	-	-	5.2	0.99
	TMP	-	-	-	-	4.9	0.99	5.7	0.99	6.5	0.95	7.7	0.98
Catfish Viscera	Tric	10.2	0.99	7.7	0.99	8.4	0.82	9.5	0.72	5.7	0.91	3.7	0.90
	TCP	4.9	0.90	4.8	0.99	7.0	0.91	8.6	0.92	-	-	9.2	0.99
	TMP	-	-	-	-	4.8	0.93	6.9	0.95	7.4	0.98	8.1	0.92

Sediment

Sediment samples were analyzed for triclopyr and TCP, and approximately 10 percent of the samples were additionally analyzed for TMP. Triclopyr half-lives in Ponds A and B, respectively, were 3.3 and 3.6 days. TCP half-lives were 5.6 and 3.8 days. These values were less than those reported for Lake Minnetonka, Minnesota, levels (Petty et al. 1998) and greater than those found in Lake Seminole, Georgia (Woodburn, Green, and Westerdahl 1993). TMP was generally not present, although two of the analyzed samples showed trace amounts. Levels of triclopyr and TCP in the sediment were relatively low, with triclopyr levels approaching 1 µg/g, and TCP levels rising no higher than 0.15 µg/g (Figures 13 and 14). The reference pond showed no detectable residues of triclopyr or TCP.

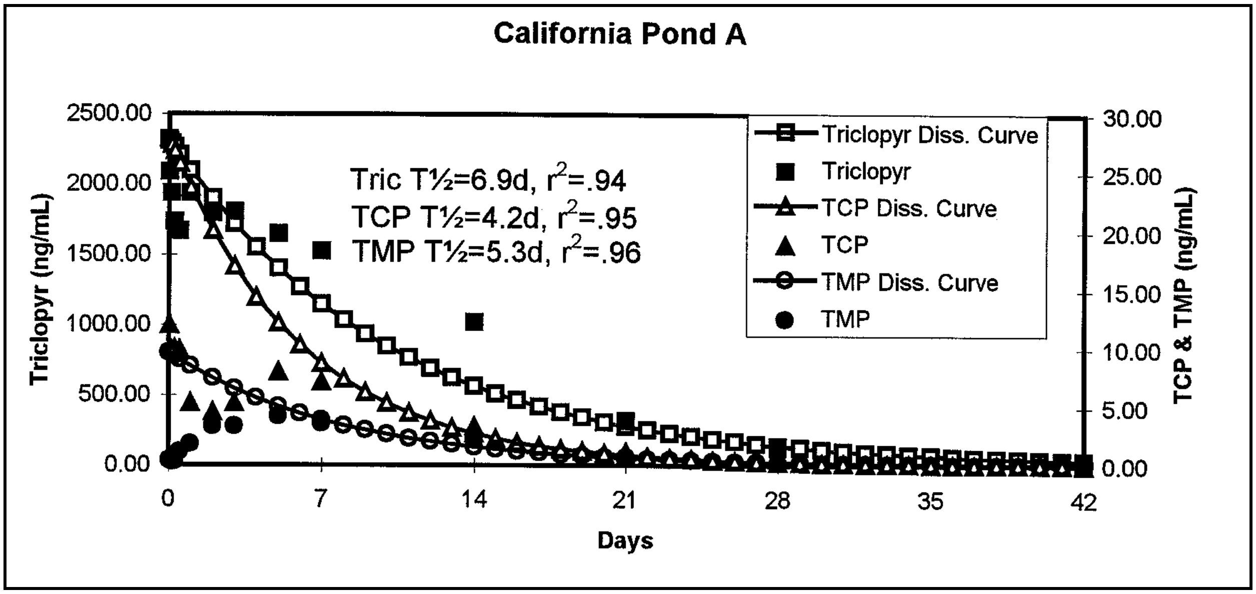


Figure 11. Dissipation of triclopyr, TCP, and TMP in water from Pond A of the Elk Grove, CA, study site

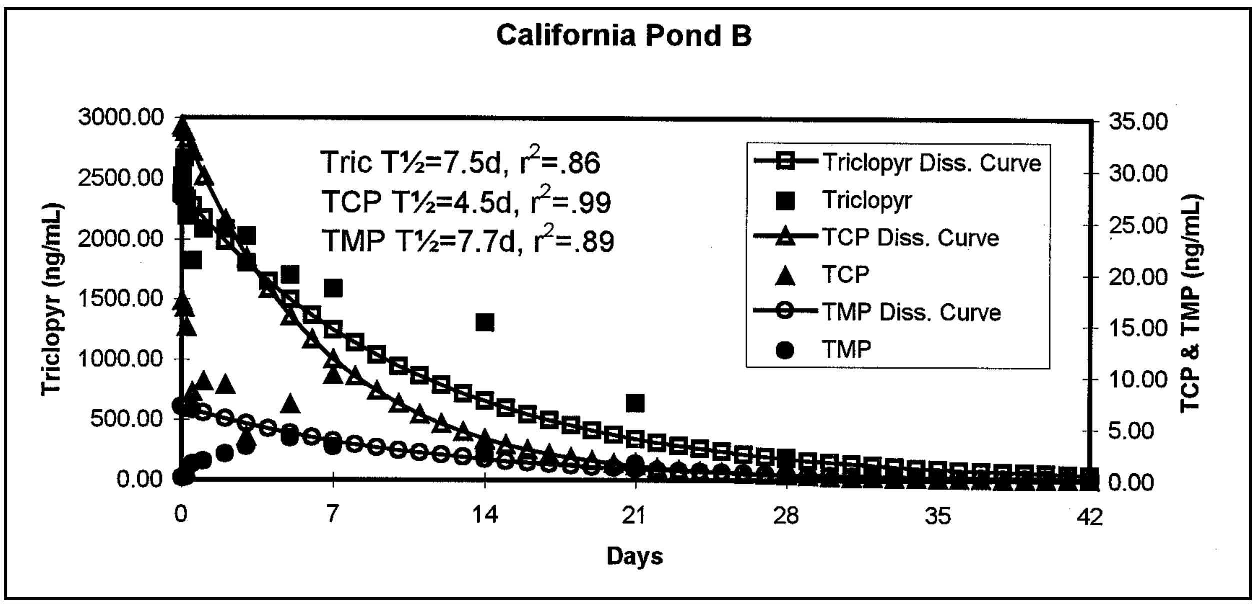


Figure 12. Dissipation of triclopyr, TCP, and TMP in water from Pond B of the Elk Grove, CA, study site

Fish

All fish tissue samples (fillet and viscera) were analyzed for triclopyr, TCP, and TMP. Results of these analyses were often somewhat variable, making the calculation of half-lives difficult. A summary of the calculable half-lives appears in Table 12. In general, where the compounds accumulated in fish

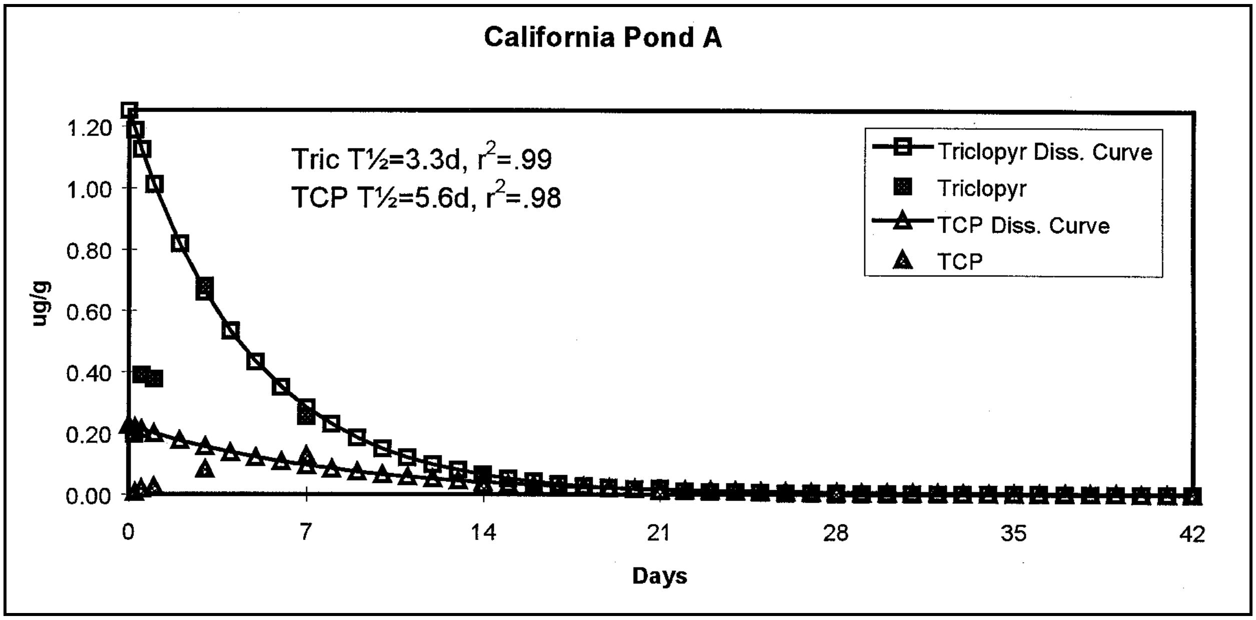


Figure 13. Dissipation of triclopyr and TCP in sediment from Pond A of the Elk Grove, CA, study site

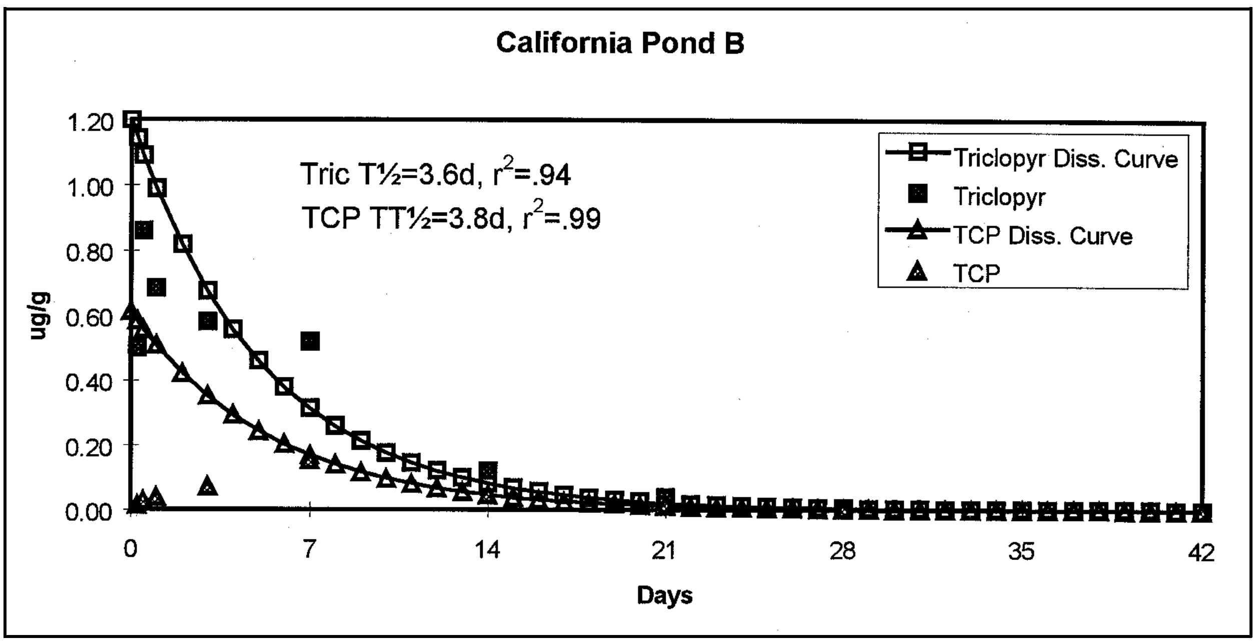


Figure 14. Dissipation of triclopyr and TCP in sediment from Pond B of the Elk Grove, CA, study site

tissues, they also cleared relatively quickly, with the levels present being driven by that present in the water column (Appendix A). Similar trends were seen in the Lake Minnetonka study (Petty et al. 1998). The low amounts of residues found in the Lake Seminole fish would be expected, as these fish were not confined in cages, as in Lake Minnetonka, and could roam in and out of the treated areas (Woodburn, Green, and Westerdahl 1993). As seen in a previous study (Petty et al. 1998), TMP accumulated in fish tissues at concentrated levels, with levels in the visceral tissue being higher than those in the fillet portions. Data from fish analysis are also presented graphically in Figures 15 to 18.

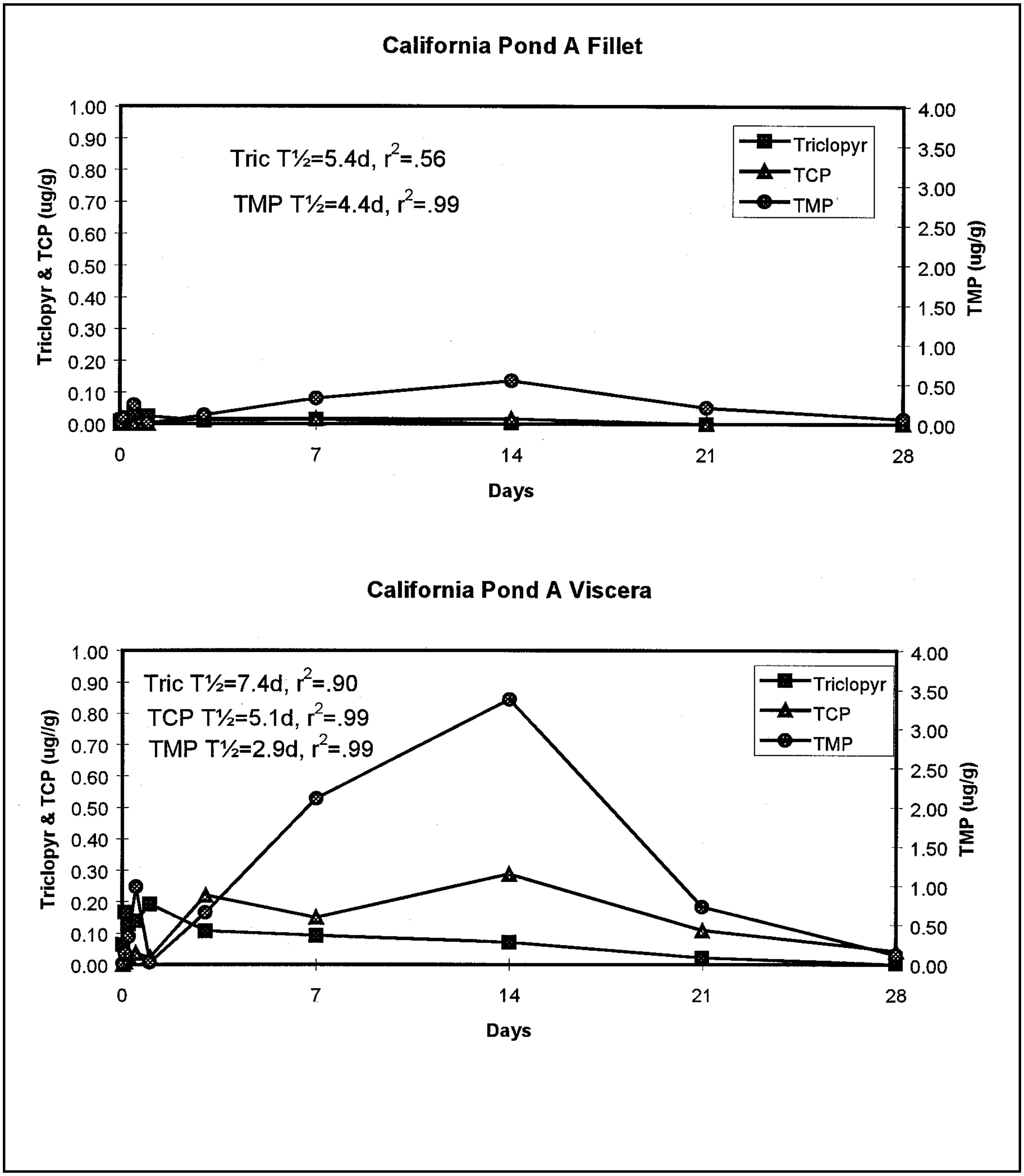


Figure 15. Dissipation of triclopyr, TCP, and TMP in bluegill fillet and viscera tissues from Pond A of the Elk Grove, CA, study site

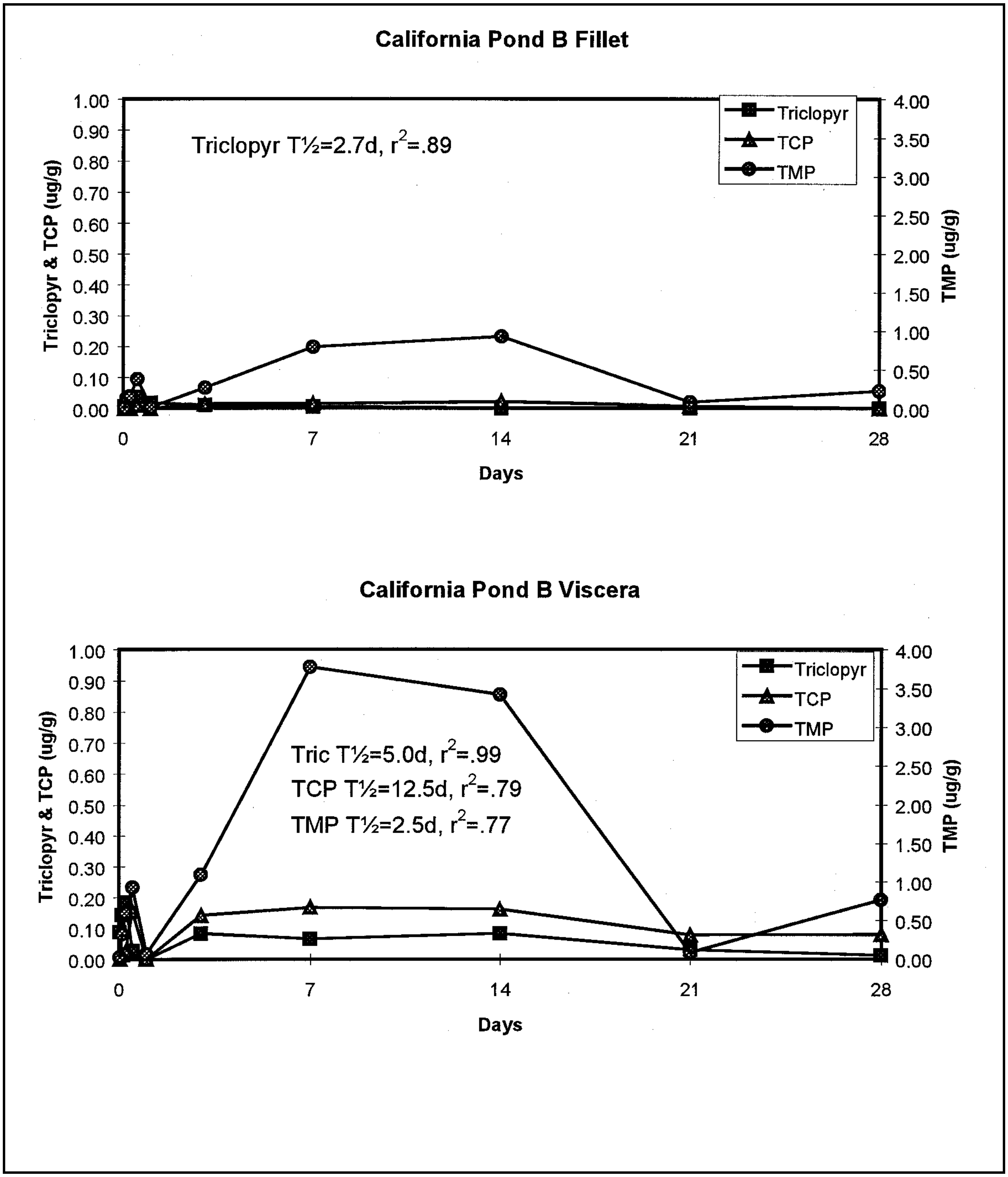


Figure 16. Dissipation of triclopyr, TCP, and TMP in bluegill fillet and viscera tissues from Pond B of the Elk Grove, CA, study site

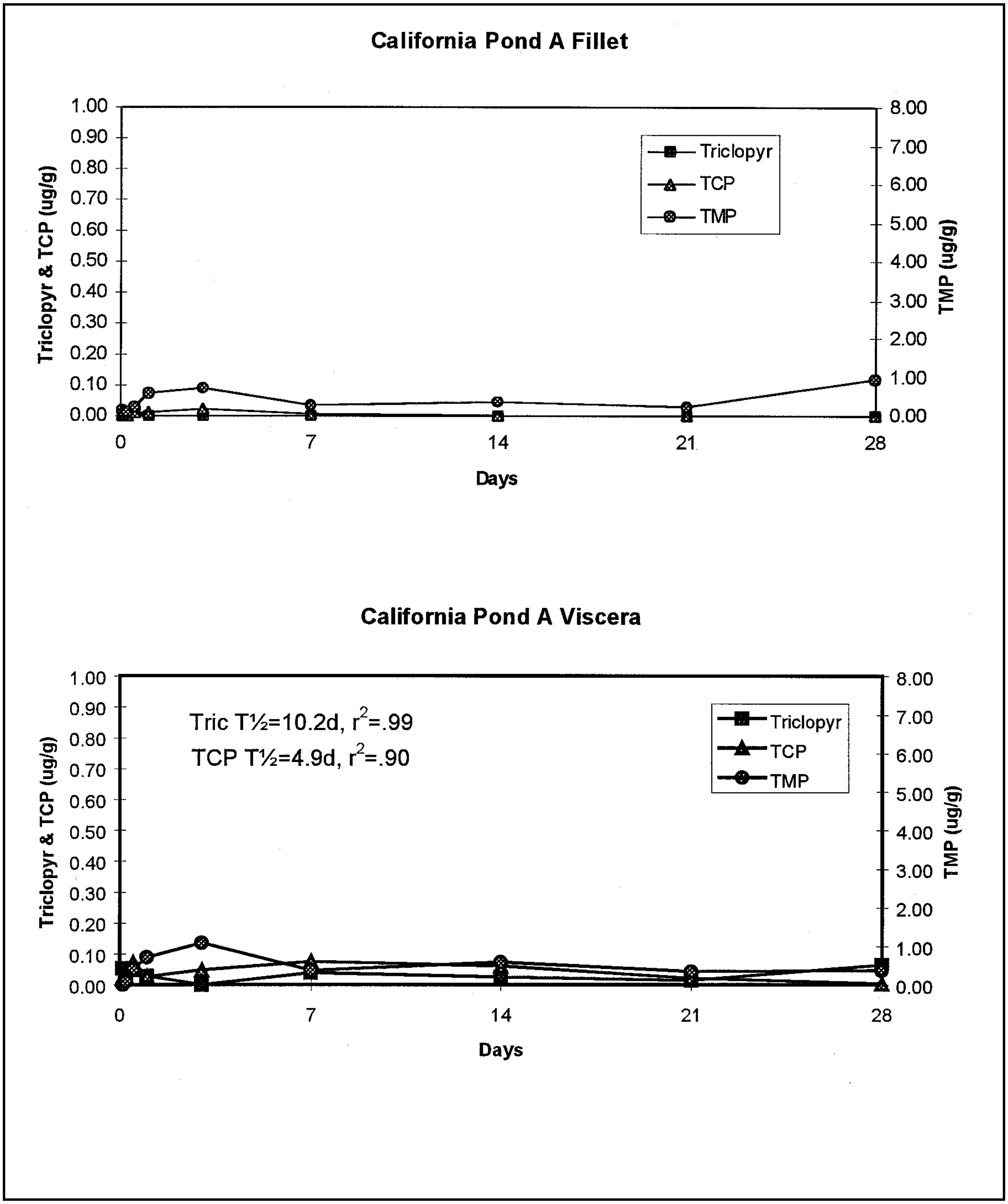
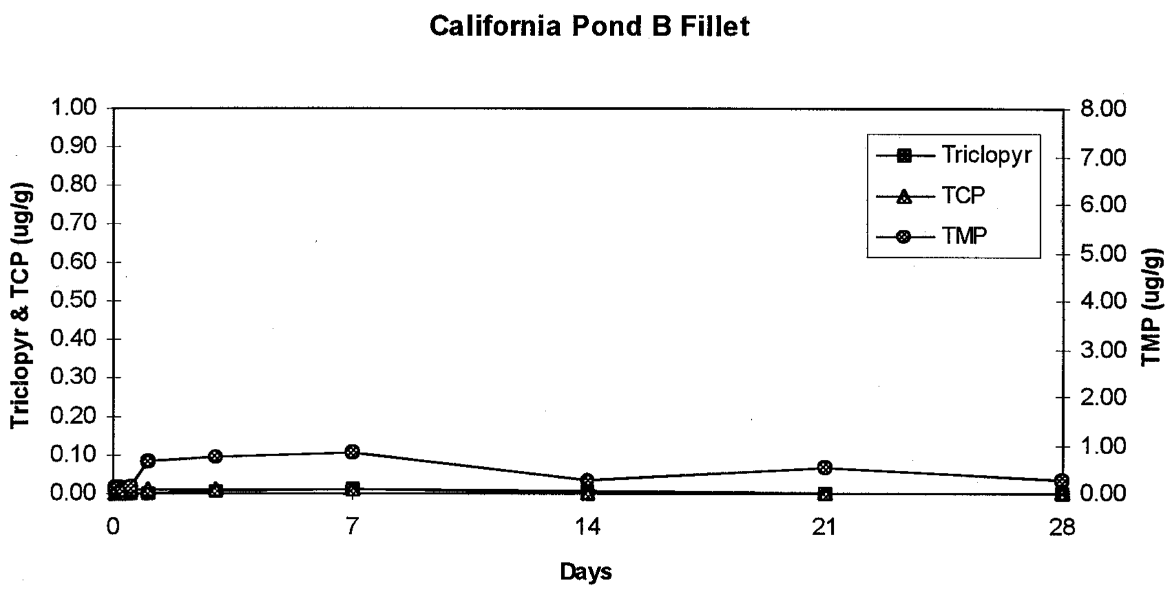


Figure 17. Dissipation of triclopyr, TCP, and TMP in catfish fillet and viscera tissues from Pond A of the Elk Grove, CA, study site



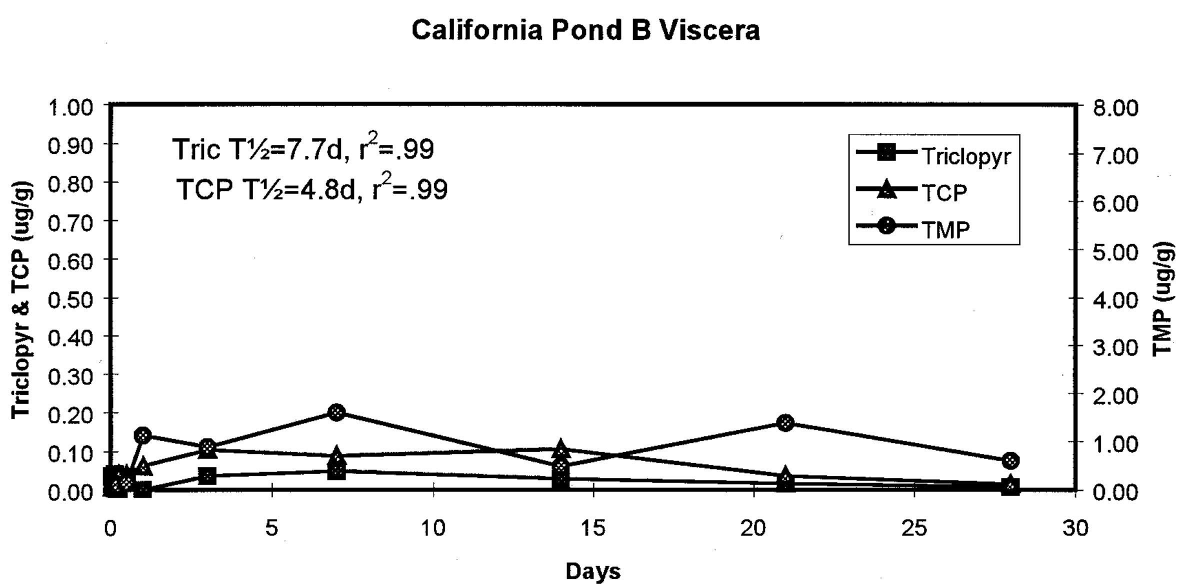


Figure 18. Dissipation of triclopyr, TCP, and TMP in catfish fillet and viscera tissues from Pond B of the Elk Grove, CA, study site

Missouri Results

Meteorological conditions

The NOAA station at Columbia, MO, reports a long-term average air temperature of 23.8 °C for the months of June to August, with a total precipitation amount of 28.63 cm for the same period (NOAA 1992b). The test site weather station recorded an average air temperature of 24.5 °C and 26.55 cm of rainfall for the same period. Accordingly, air temperatures were about normal (+0.7 °C), while conditions were slightly drier than would be expected (-2.08 cm). The daily weather conditions recorded at the study site are presented in Table 13.

Aquatic organism assessment (biosurvey)

This non-GLP type survey provided documentation that a viable, healthy biological community (e.g., submersed plants, algae, aquatic invertebrates, and some vertebrates) was present in each pond prior to triclopyr applications, and that a similar community was maintained in each test pond for over 11-week posttreatment.

Plants. Only one genus of higher aquatic plants was observed in the ponds, *Najas* (naiads). The macroalga, *Chara* spp. (charophytes), and two genera of filamentous green algae, *Spirogyra* spp. and *Mougeotia* spp., were also observed in the ponds. Mean percent frequency of each plant genera found during the study in each of the ponds is presented in Table 14. Although plant species diversity was low, it is not unusual for this situation to occur in small ponds of the central United States. The naiads remained abundant in all three test ponds during the evaluation period, with a slight increase in frequency measured at 11-week posttreatment. However, the charophytes, which were fairly abundant at pretreatment, essentially disappeared from the ponds (including the untreated reference pond) by 11-week posttreatment. This reduction in the frequency of charophytes is most likely due to the normal phenological senescence of this genera and interspecific competition from the naiads. The frequency of filamentous algae decreased by fourfold in Pond A during the evaluation period, but increased slightly in Ponds B and C over that time period.

Algae. Occurrence of algae is shown in Tables 15 and 16. Pretreatment algae in all ponds was dominated by greens: filamentous (*Spirogyra* and *Mougeotia*) and colonial (*Volvox*). The blue-green, *Anabaena*, was also frequently observed. By 11.5-week posttreatment, the ponds still maintained green-dominated algal communities, including *Spirogyra*, *Volvox*, the desmid *Closterium* and the planktonic *Scenedesmus*. The maintenance of a green-dominated algal community exhibited in these ponds is indicative of moderate and relatively stable spring/summer maximum water temperatures (25 to 30 °C).

Table 13
Daily Weather Conditions Measured at the Missouri Study Site, 1995

Date	Precip, cm	Average Air Temp °C	Max Air Temp, °C	Min Air Temp, °C	% RH	Wind Speed kph	Wind Dir	SD Dir	Solar Rad kw/m^2
5-Jun	0.69	23.0	29.3	18.3	73.5	0.1	15	90	20,148
6-Jun	0	22.5	27.1	19.4	74.5	0.2	26	93	20,660
7-Jun	0.41	23.6	29.0	19.2	79.5	0.2	15	93	16,633
8-Jun	1.09	21.4	24.0	18.6	81.8	3.8	95	36	10,856
9-Jun	0.58	22.1	27.9	17.3	80.0	4.6	175	22	18,946
10-Jun	0.25	20.3	24.1	18.2	77.0	5.0	279	21	15,133
11-Jun	0	17.0	21.4	13.4	70.4	6.0	14	29	19,965
12-Jun	0	17.8	23.9	11.6	66.9	4.4	19	28	27,001
13-Jun	0	18.5	25.4	10.5	63.7	2.3	264	21	27,658
14-Jun	0	21.0	27.6	13.2	63.9	3.2	217	25	24,729
15-Jun	0	23.1	28.9	18.6	65.0	4.9	195	28	24,145
16-Jun	0	23.6	29.5	18.6	65.2	4.6	214	25	23,621
17-Jun	0	23.9	29.5	18.3	64.2	3.4	238	19	26,481
18-Jun	0	24.4	31.3	17.5	63.1	2.1	242	20	26,784
19-Jun	0	24.5	30.9	18.3	66.7	1.9	263	21	25,333
20-Jun	0	25.5	32.0	18.6	65.3	2.6	20	29	25,729
21-Jun	0	25.1	31.1	19.0	65.7	2.8	103	20	22,093
22-Jun	0	25.0	30.7	19.2	70.1	3.5	84	19	25,492
23-Jun	0	25.1	32.1	19.2	69.9	2.2	67	21	20,570
24-Jun	0	24.0	30.3	18.7	73.1	2.7	281	25	20,773
25-Jun	1.02	21.2	27.9	18.0	83.7	3.7	63	18	13,373
26-Jun	2.26	20.4	25.9	18.5	87.9	2.6	39	21	11,683
27-Jun	0.36	21.0	24.7	18.6	84.9	6.4	274	19	13,083
28-Jun	0.08	21.8	26.7	17.8	79.3	3.6	264	22	17,678
29-Jun	0.03	23.0	27.9	17.8	76.0	4.2	343	31	21,803
30-Jun	0	20.9	25.2	16.9	66.0	6.4	29	22	22,205
1-Jul	0	17.9	23.1	12.4	66.2	4.9	40	17	27,129
2-Jul	0	19.8	25.4	15.0	64.3	2.3	219	24	21,524
3-Jul	0	21.3	25.2	17.7	75.3	6.2	195	31	19,906
4-Jul	1.75	23.4	29.7	18.1	79.8	7.3	201	33	16,039
5-Jul	1.91	22.7	28.5	18.2	71.4	9.2	244	19	25,796
6-Jul	0	23.0	28.7	17.8	71.3	4.4	287	24	27,861
7-Jul	0	24.5	30.1	17.8	65.9	2.9	89	19	27,665
8-Jul	3.51	22.4	30.6	18.2	81.1	4.4	216	27	19,804

(Sheet 1 of 3)

Table 13 (Continued)

Date	Precip, cm	Average Air Temp °C	Max Air Temp, °C	Min Air Temp, °C	% RH	Wind Speed kph	Wind Dir	SD Dir	Solar Rad kw/m^2
9-Jul	0	25.0	31.3	18.9	72.8	5.7	29	20	25,496
10-Jul	0	23.7	29.9	17.1	73.1	1.9	254	20	21,633
11-Jul	0	27.3	33.9	20.1	71.2	2.9	213	29	26,184
12-Jul	0	29.5	35.4	23.7	71.2	4.3	240	18	26,539
13-Jul	0	30.1	36.5	25.2	72.6	3.4	248	18	26,185
14-Jul	0	29.2	34.5	24.1	69.9	2.9	242	20	25,482
15-Jul	0	28.4	33.6	23.5	70.9	3.7	248	17	24,428
16-Jul	0.03	26.2	32.3	22.1	75.8	4.4	261	18	20,009
17-Jul	0	25.0	30.0	19.7	70.0	4.3	14	28	25,643
18-Jul	0	23.7	31.0	16.3	66.5	3.0	304	25	25,112
19-Jul	0	25.4	31.8	17.7	62.9	2.8	223	24	24,852
20-Jul	1.02	23.7	28.5	20.4	79.6	2.9	275	21	15,328
21-Jul	0	24.9	30.8	19.2	78.3	2.1	248	22	20,891
22-Jul	0.08	25.5	30.6	22.1	78.0	4.2	233	20	18,176
23-Jul	0.71	24.5	29.6	19.6	79.8	4.1	265	21	15,267
24-Jul	0	24.0	27.3	19.9	81.9	3.9	253	18	15,342
25-Jul	0.10	24.8	31.9	18.8	74.4	4.3	248	23	24,309
26-Jul	0	24.7	31.4	18.8	72.3	4.0	252	18	25,609
27-Jul	0	28.2	35.2	20.9	70.2	4.0	235	22	24,926
28-Jul	0	27.2	31.9	21.9	66.3	5.4	42	14	26,567
29-Jul	0	27.3	34.2	20.2	65.5	2.3	152	30	25,308
30-Jul	0	27.7	34.2	21.5	68.8	2.3	207	29	23,949
31-Jul	0.03	28.0	34.3	22.4	67.1	2.6	202	30	23,178
1-Aug	0.79	23.5	28.3	21.0	85.8	4.8	73	14	11,543
2-Aug	1.30	23.3	28.6	21.6	88.5	2.3	152	24	12,257
3-Aug	0.08	24.2	27.3	22.4	86.6	3.1	54	13	9,782
4-Aug	1.52	23.3	26.8	21.2	85.6	8.8	64	12	12,220
5-Aug	0	24.8	30.4	21.8	82.6	4.8	54	13	17,145
6-Aug	5.72	23.7	30.7	21.4	87.4	3.1	138	26	11,717
7-Aug	0	24.8	32.2	21.0	84.7	2.4	140	26	18,521
8-Aug	0	27.2	33.2	21.3	76.5	4.5	236	19	23,001
9-Aug	0	28.5	33.7	23.7	76.6	3.8	248	17	22,609
10-Aug	0.30	27.2	32.9	22.5	74.0	4.5	249	18	23,607

(Sheet 2 of 3)

Table 13 (Concluded)									
Date	Precip, cm	Average Air Temp °C	Max Air Temp, °C	Min Air Temp, °C	% RH	Wind Speed kph	Wind Dir	SD Dir	Solar Rad kw/m^2
11-Aug	0	27.3	34.2	20.1	73.0	2.5	244	19	23,624
12-Aug	0	28.7	34.6	23.2	74.9	2.8	240	19	22,436
13-Aug	0	28.7	33.7	23.8	73.0	4.1	239	18	22,701
14-Aug	0	28.2	34.8	23.2	73.7	2.9	241	20	21,679
15-Aug	0.91	26.5	33.6	22.5	80.3	3.1	229	22	17,517
16-Aug	0	27.1	33.3	22.0	78.3	4.6	232	19	21,770
17-Aug	0	28.4	33.9	23.6	72.0	3.4	252	17	23,185
18-Aug	0	29.3	36.0	23.2	71.1	1.3	253	20	22,888
19-Aug	0	28.4	34.5	23.6	75.6	4.4	15	23	21,490
20-Aug	0	24.2	29.1	20.2	78.2	5.6	36	13	20,271
21-Aug	0	24.2	29.3	19.6	72.3	4.5	57	12	23,551
22-Aug	0	24.8	32.0	18.3	68.2	3.7	105	23	23,273
23-Aug	0.05	25.0	32.2	17.3	65.4	2.2	113	23	23,705
24-Aug	0	24.5	31.3	18.6	61.5	2.3	130	23	24,007
25-Aug	0	25.2	32.2	17.9	68.7	2.5	147	27	20,740
26-Aug	0	27.0	34.2	21.5	69.0	1.8	238	23	21,196
27-Aug	0	26.7	33.2	20.7	69.4	1.7	112	21	20,956
28-Aug	0	26.7	33.9	20.3	70.2	1.3	176	28	21,611
29-Aug	0	27.1	33.8	21.4	65.7	2.2	202	25	21,635
									(Sheet 3 of 3)

Table 14
Mean Percent Frequency (±SE) of Plant Species in Triclopyr Whole-Pond Dissipation Study, Columbia, MO (Pretreatment (2 June 1995) and 11.5-Week Posttreatment (25 August 1995))

Pond	***Chara* spp.**	***Najas* spp.**	**Filamentous Algae**
	Pretreatment		
A (Triclopyr)	62.7 ± 8.2	92.2 ± 2.0	97 ± 1.4
B (Triclopyr)	91.5 ± 2.5	87.2 ± 5.2	71 ± 6.9
C (Reference)	47.3 ± 10.7	92.7 ± 3.7	88 ± 9.2
	Posttreatment		
A (Triclopyr)	0.0 ± 0.0	97.3 ± 0.9	25 ± 2.2
B (Triclopyr)	2.8 ± 2.9	97.8 ± 2.2	78 ± 8.8
C (Reference)	0.8 ± 0.8	100.0 ± 0.0	94 ± 2.3

Aquatic invertebrates. Occurrence of aquatic invertebrates are shown in Tables 15 and 16. In general, the aquatic invertebrate community was relatively diverse, ranging from small planktonic organisms (e.g., water fleas, cladocerans) to larger types (e.g., juvenile dragonflies, snails). This invertebrate community also remained stable during the study period in each test pond.

At pretreatment (2 June 1995), a total of 14 genera/families of invertebrates were recorded for all ponds, while at posttreatment week 11 (25 August 1995), a total of 13 genera/families were found for all ponds. When compared across treatments, invertebrate genera/family totals decreased from 12 in the untreated reference (Pond C) at pretreatment, to 9 genera/families at 11.5-week posttreatment. During that same time, invertebrate genera/families decreased in the triclopyr-treated ponds (A and B) from 12.5 pretreatment to 11.5 posttreatment.

The number of samples containing invertebrates decreased by 12 percent from pretreatment to posttreatment when measured across all ponds. However, the number of samples containing organisms in the untreated reference pond decreased by 20 percent from pretreatment to posttreatment measurements; whereas, the same comparison showed that the number of samples with invertebrates only decreased by 8 percent in the triclopyr-treated ponds.

Vertebrates. Visual surveys indicated that bullfrogs (*Rana pipiens*), both adults and tadpoles, were common on all of the test ponds from pretreatment (2 June 1995) through 11-week posttreatment (24 August 1995).

Water quality and characterization

Factors of water quality are discussed in the California water characterization results section of this report. The data generated from Missouri water characterization analyses are presented in Table 9. In general, the water from the Missouri test site ponds can be characterized as basic, with a USGS classification of moderately hard (Van der Leeden, Troise, and Todd 1990).

Pretreatment and posttreatment water quality data (temperature, DO, pH, conductivity, and TDS) are presented in Figures 19-23. Water quality changed over time, and in a diurnal pattern, in a fashion typical with that expected for small, constructed impoundments in the central United States. Generally, water quality trends were similar for all ponds compared during the evaluation period. This indicates that triclopyr applications had little to no significant effect on water quality conditions in this study.

Maximum water temperatures in all ponds increased from the 23-27 °C range predominating in June to the 30-33 °C range measured in July, and decreased to near pretreatment levels (26 °C) by 11.5-week posttreatment (Figure 19). This type of water temperature pattern can be driven by weather-related factors imposed upon ponds in the spring and summer months.

Table 15
Occurrence of Invertebrates and Algae in Triclopyr Whole-Pond Dissipation Study, Columbia, MO—Pretreatment

Species	**Pond A**						**Pond B**						**Pond C**					
Sample Points	**2**	**4**	**5**	**8**	**9**	**10**	**1**	**3**	**4**	**5**	**9**	**10**	**2**	**3**	**4**	**6**	**7**	**10**
Organisms																		
Physa (pond snail)	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Gyrinidae		X									X							
Haliplus (diving beetle)	X	X			X			X	X	X		X		X	X	X		
Ephemeroptera (mayfly)		X	X	X			X	X			X		X	X	X	X		
Libellulidae (dragonfly)	X	X		X	X		X			X	X	X			X	X	X	X
Gomphidae (dragonfly)				X	X										X			
Aeshnidae									X									
Cordulindae		X		X	X					X			X	X				
Lestidae	X	X		X			X		X			X		X	X			X
Ranatra							X							X			X	
Notonectidae	X	X	X	X	X	X	X	X	X	X	X		X	X	X	X	X	X
Gerris																		
Abedus																		

Species	**Pond A**				**Pond B**				**Pond C**			
Sample Points	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**
Organisms												
Daphnia spp.	X	X	X	X	X	X	X	X	X	X	X	X
Cladocera	X		X	X	X	X	X	X	X	X	X	X
Cyclops	X				X	X			X		X	
Rotifera												
Spirogyra	X	X	X	X	X	X	X	X	X	X	X	X
Mougeotia	X	X		X			X					X
Volvox	X	X	X	X			X	X	X	X	X	X
Closterium												
Sceredesmus												
Anabaem		X			X	X	X	X		X	X	X
Selerastrum			X	X								
Zygnenia												

Table 16
Occurrence of Invertebrates and Algae in Triclopyr Whole-Pond Dissipation Study, Columbia, MO—Posttreatment

Species	Pond A						Pond B						Pond C					
Sample Points	**2**	**4**	**5**	**8**	**9**	**10**	**1**	**3**	**4**	**5**	**9**	**10**	**2**	**3**	**4**	**6**	**7**	**10**
Organisms																		
Physa (pond snail)	X	X	X		X	X	X	X		X	X	X	X	X	X	X	X	X
Gyrinidae		X																
Haliplus (diving beetle)		X	X		X	X			X	X			X	X				X
Ephemeroptera (mayfly)		X	X	X		X				X			X	X		X	X	
Libellulidae (dragonfly)	X	X	X	X	X	X		X	X	X	X		X		X	X	X	X
Gomphidae (dragonfly)																		
Aeshnidae																		
Cordulindae																		
Lestidae	X		X	X		X		X	X	X		X		X			X	X
Ranatra																		
Notonectidae	X	X	X		X	X	X	X	X	X		X	X	X		X		X
Gerris		X											X					
Abedus				X					X	X								

Species	Pond A				Pond B				Pond C			
Sample Points	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**
Organisms												
Daphnia spp.	X	X	X	X	X	X	X	X	X	X	X	X
Cladocera	X	X	X			X	X		X	X	X	
Cyclops		X				X						
Rotifera					X	X	X					
Spirogyra	X	X	X	X	X	X	X	X	X	X	X	X
Mougeotia												
Volvox	X	X			X			X		X	X	
Closterium	X	X	X	X	X	X	X	X		X	X	X
Sceredesmus	X	X				X			X			
Anabaem												
Selerastrum												
Zygnenia			X									

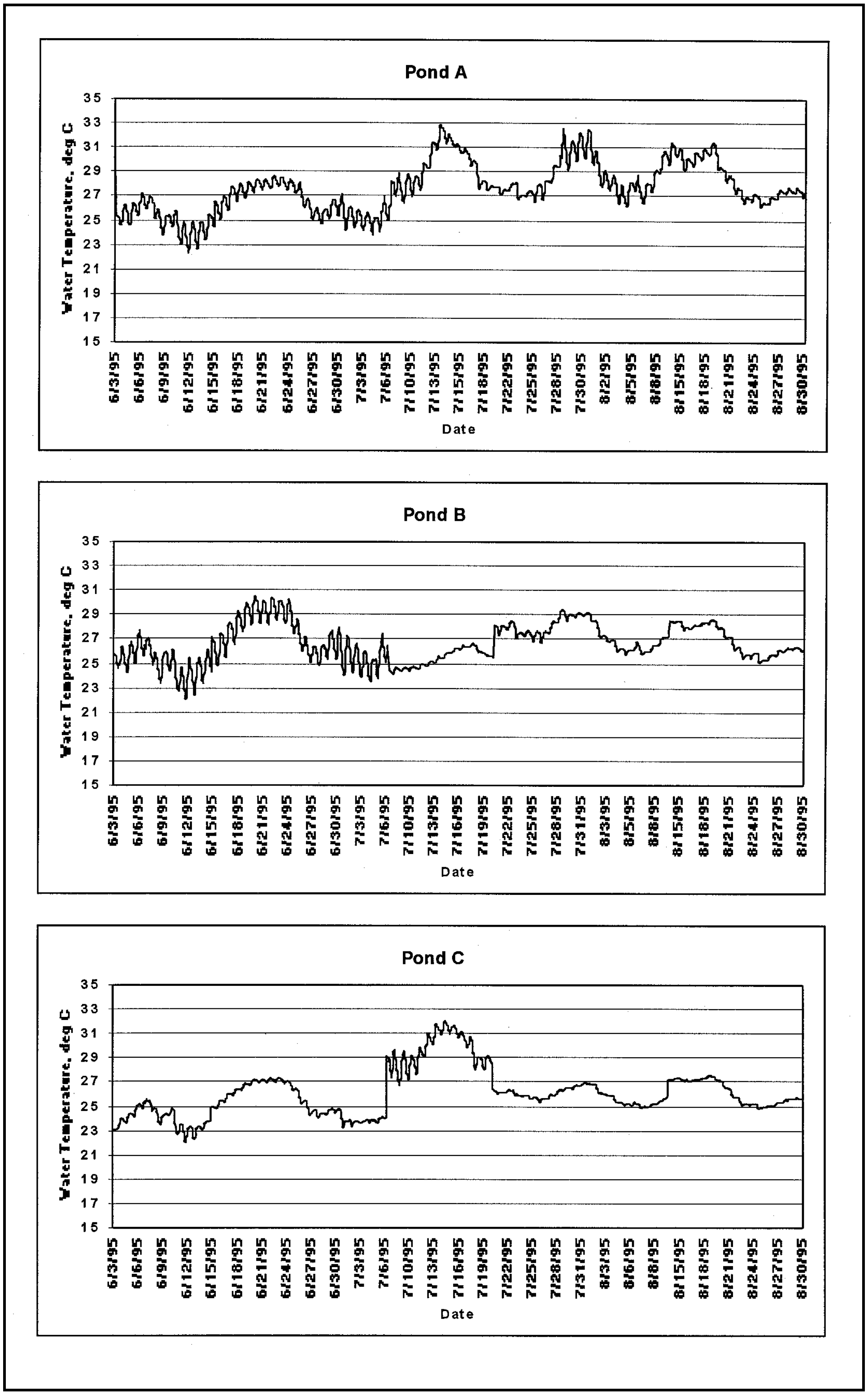


Figure 19. Water temperature measurements from the Columbia, MO, study site 1995

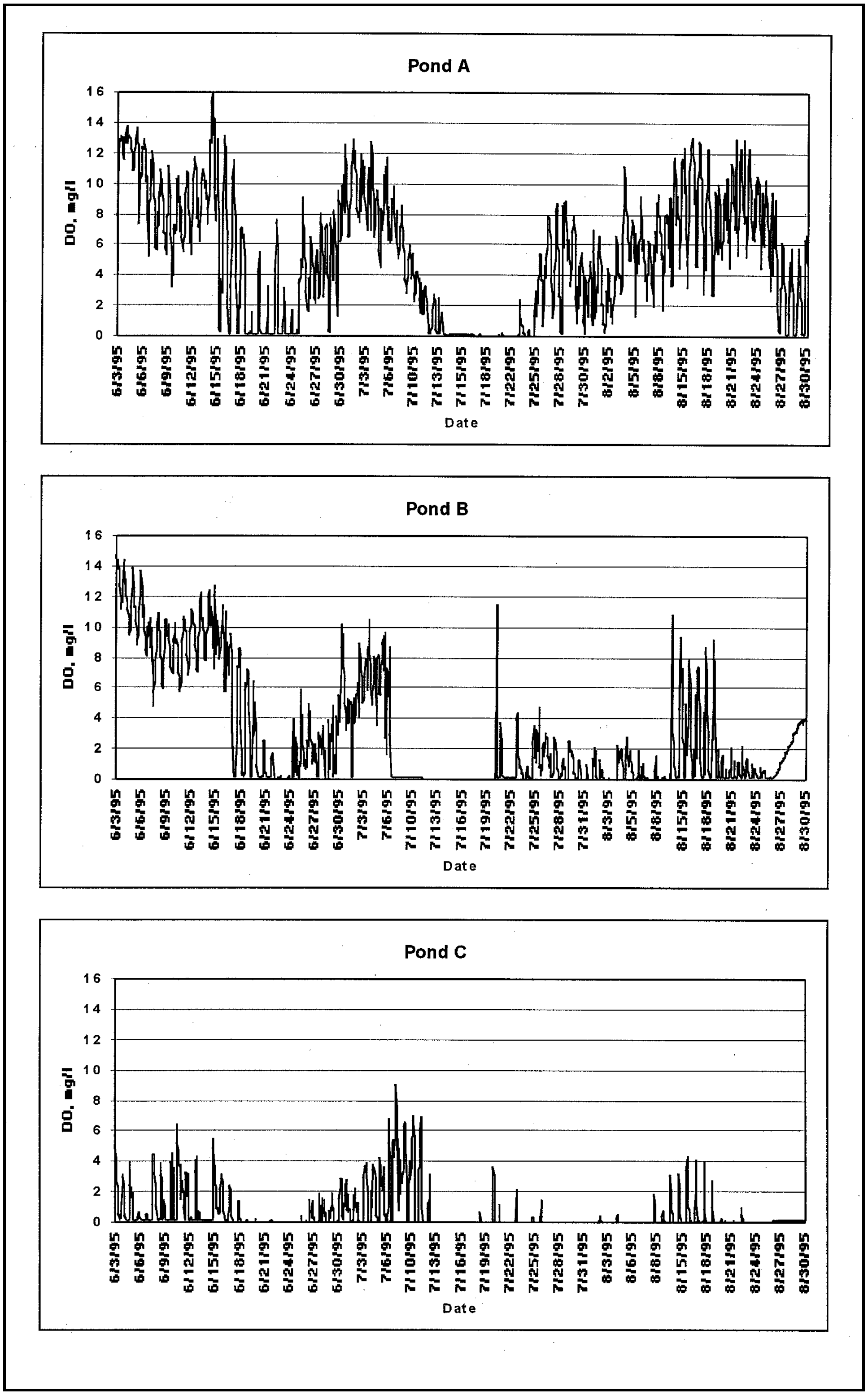


Figure 20. Dissolved oxygen measurements form the Columbia, MO, study site, 1995

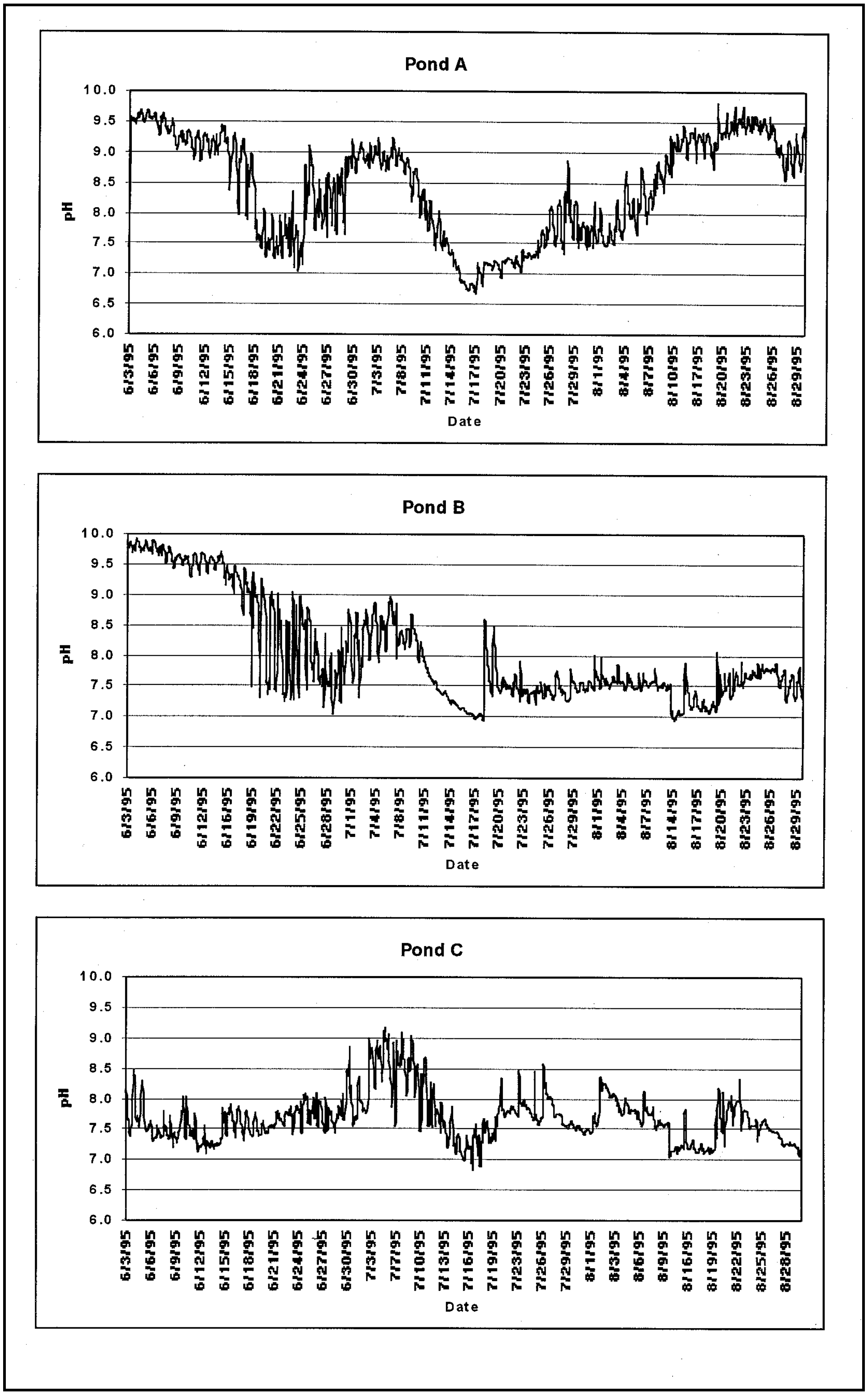


Figure 21. pH measurements from the Columbia, MO, study site, 1995

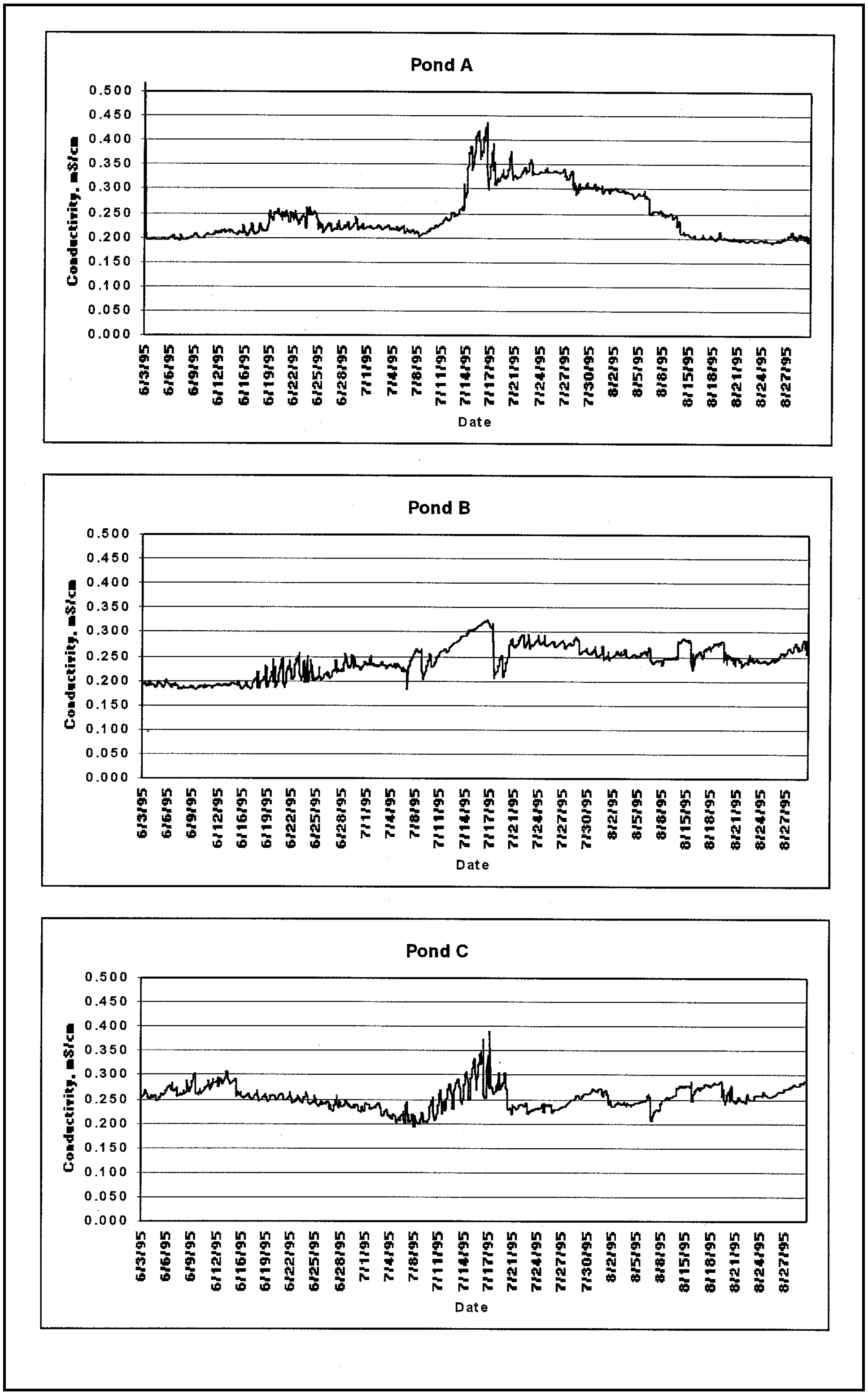


Figure 22. Conductivity measurements from the Columbia, MO, study site, 1995

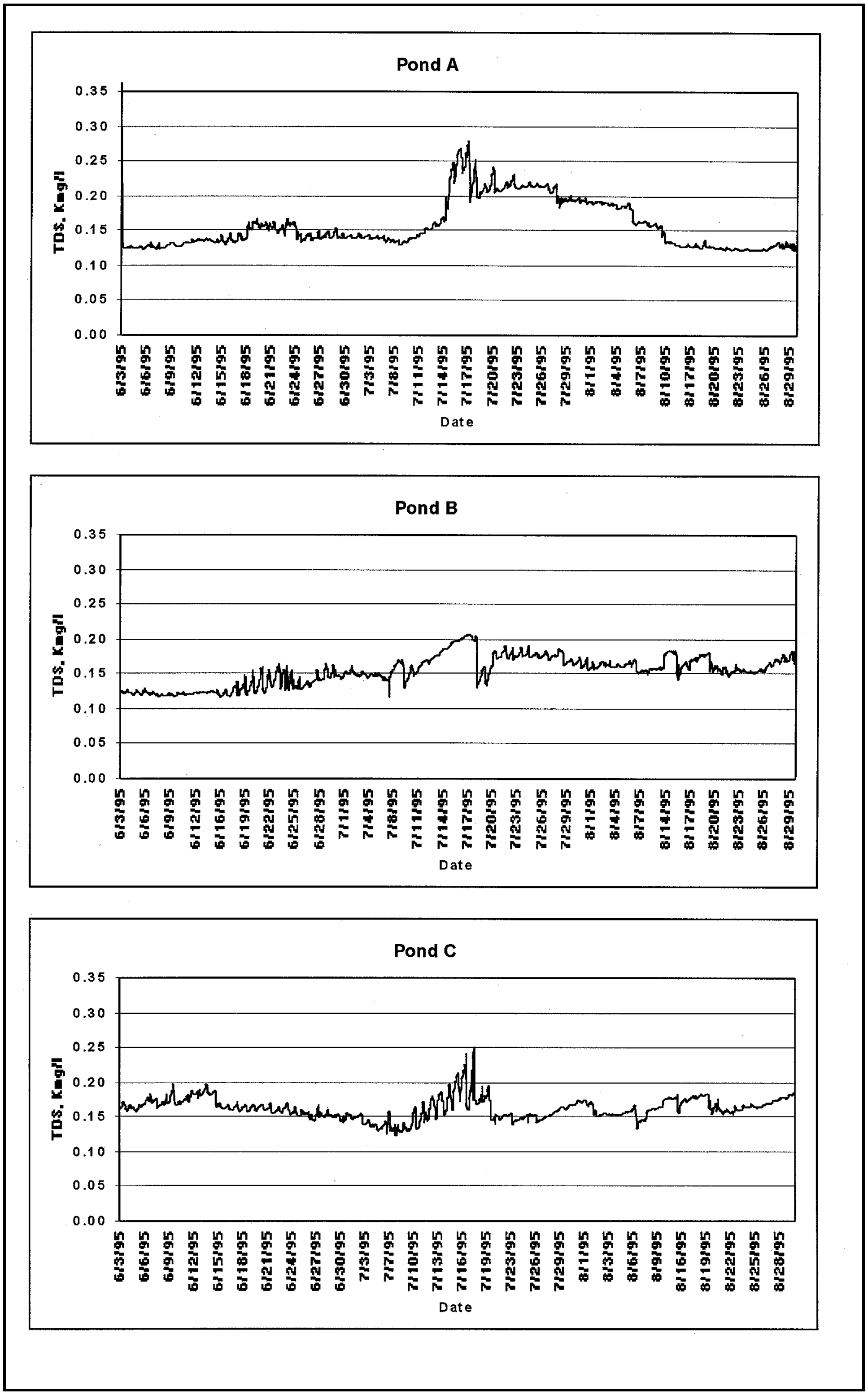


Figure 23. Total dissolved solids measurements from the Columbia, MO, study site, 1995

The DO measured in all ponds ranged from nighttime levels approaching 0 mg/L to daytime levels approaching 14 mg/L (Figure 20). Two prolonged periods (2-3 days) of low DO (daytime and nighttime) occurred in all ponds in mid-June and mid-July. The lowest daily DO conditions occurred in the untreated reference (Pond C) from mid-July through the end of August. These low values may have been caused by high community metabolism rates in this pond, possibly related to nighttime respiration of abundant filamentous algae in the pond during this time period (Table 16).

Of all the water quality parameters measured, pH showed the greatest variability when compared across ponds (Figure 21). Data indicated that pH values peaked during daylight hours and reached *diel minima* at night. In Pond A (triclopyr-treated), declines of pH were recorded in mid-June and mid-July to late June and July, where values decreased from peaks of approximately 9.5-7.5 to 9.0-7.0, respectively. This pattern was followed by a gradual increase in pH from late July through late August, when peak values reached pretreatment levels (9.0-9.5). In the other triclopyr-treated site (Pond B), pH values gradually declined throughout the evaluation period, from daytime peaks of approximately 9.7 to 7.7. In the untreated reference site (Pond C), pH values varied between 7.5 and 8.5, with the notable exception of a 2-week period (30 June through 14 July) where peak pH levels ranged between 8.5 and 9.5.

Little variability was observed in conductivity and TDS values in all ponds during most of the evaluation period (Figures 22 and 23). Generally, conductivity held between 200 and 300 mS/cm, except for a short period in mid-July in Ponds B (triclopyr-treated) and C (untreated reference) when levels increased to approximately 400 mS/cm. Levels of TDS remained between 0.1 and 0.2 K mg/L in all ponds, except for peaks of approximately 0.25 K mg/L in Pond A (triclopyr-treated) and Pond C (untreated reference) in mid-July.

Light intensity and spectral irradiance

Light intensity measurements indicated that light was quenched by approximately 50 percent in the upper 0.8 m of the water column in each pond (Figures 24-26). In addition, spectral irradiance measurements showed that most of the triclopyr-degrading UV light (<400 nm) was absorbed in the top 25 cm of the water column in the triclopyr-treated ponds (A and B) (Figures 27 and 28). This rapid near-surface quenching of UV light is typical for natural waters (Wetzel 1975) and suggests that photolysis may play a limited role in the degradation of triclopyr in pond and other surface water situations. Mean secchi transparency ranged from 1.03 ($\pm$0.07SE) to 1.14 ($\pm$0.05SE) m in the triclopyr-treated Ponds (A and B, respectively) and was 0.98 ($\pm$0.07) m in the untreated reference pond (Figure 29). Overall, Secchi transparency decreased slightly in Ponds A (triclopyr) and C (untreated) and remained rather constant in Pond B (triclopyr) during the evaluation period.

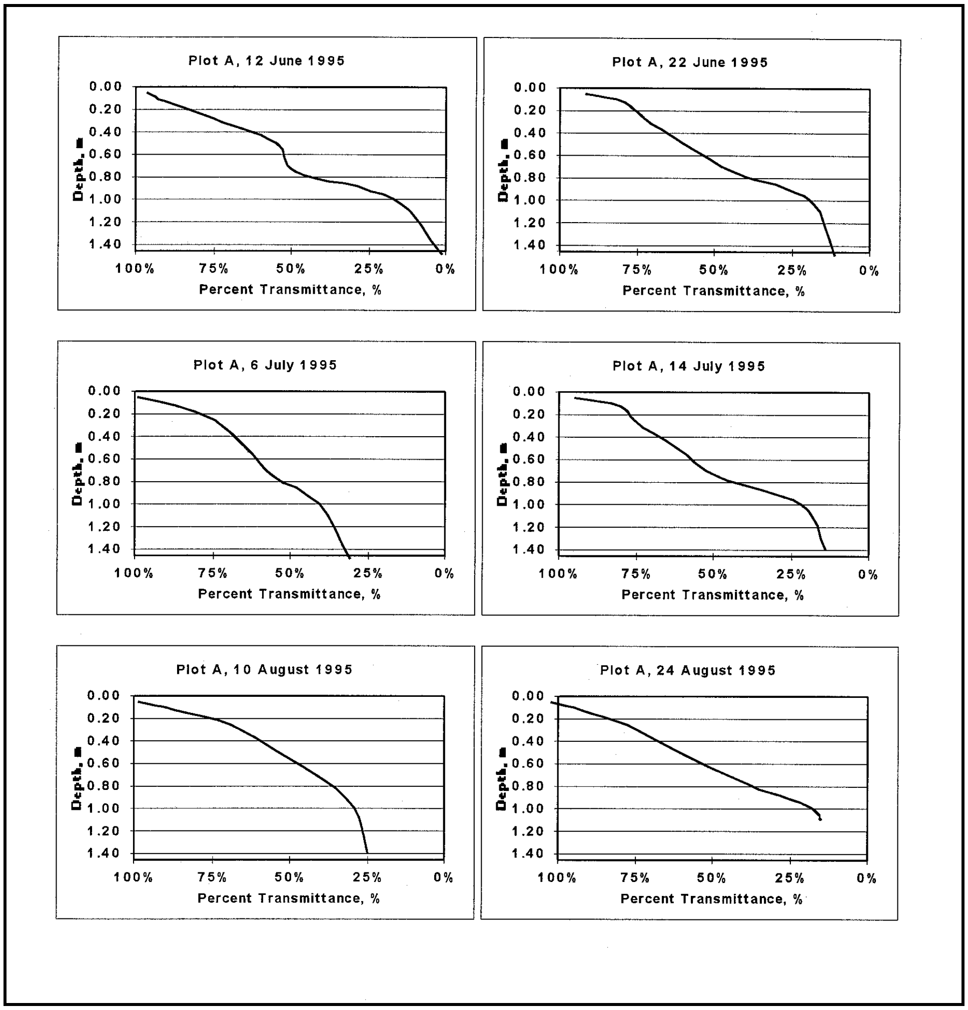


Figure 24. Percent light transmission profiles for Plot A at the Columbia, MO, study site

Sediment characterization

Results of the physical characterization of the bottom sediment are presented in Table 10. The sediment was classified as a silty clay loam in all ponds. Organic matter ranged from 2.0 to 3.4 percent. The pH of the sediment was slightly alkaline.

Triclopyr dissipation

Results of analysis for triclopyr and its metabolites in the matrices examined in this study have been reported separately (Foster, Getsinger, and Petty 1997). A summary of average residue values from the Missouri study site is presented in Appendix B. Table 11 lists the reported LOD and LOQ for each sample matrix. Any value falling below the LOD is considered to be ND. A value

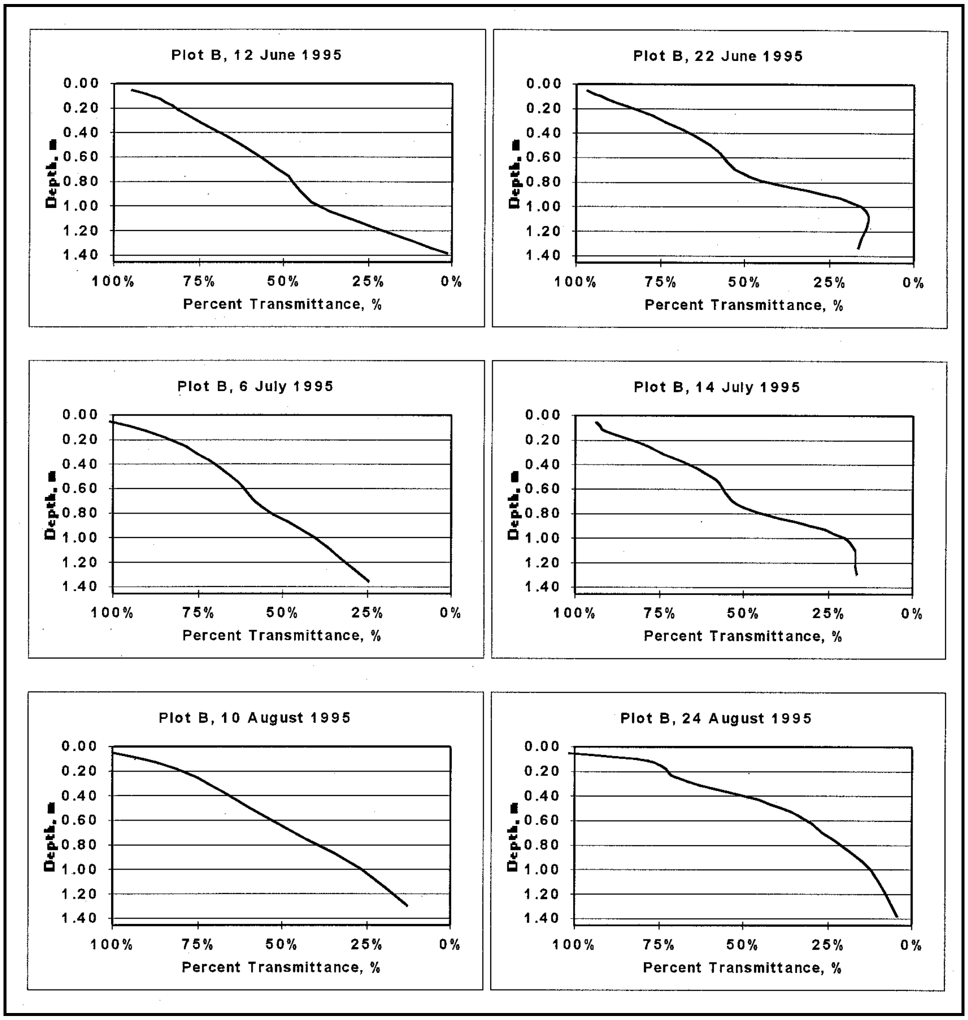


Figure 25. Percent light transmission profiles for Plot B at the Columbia, MO, study site

falling between the LOD and LOQ is considered to be NQ and is referred to as a "trace" value in this report. Half-lives for all matrices are summarized in Table 12.

Water

Triclopyr and its metabolites dissipated rapidly from water in this study, and results from the replicate ponds matched well. Pond A showed triclopyr levels of 2,799 ng/mL, and Pond B showed levels of 2,281 ng/mL on Day 1 after application, indicating that the applications were near or at the nominal level of 2,500 ng/mL. In Pond A, triclopyr dissipated with a half-life of 5.9 days, TCP with a half-life of 4.0 days, and TMP with a half-life of 4.0 days (Figure 30). In Pond B, triclopyr had a half-life of 6.1 days, the TCP half-life was 5.9 days, and the TMP half-life was 4.8 days (Figure 31). These residue half-lives were consistent with the ones measured at the California study site. TCP levels

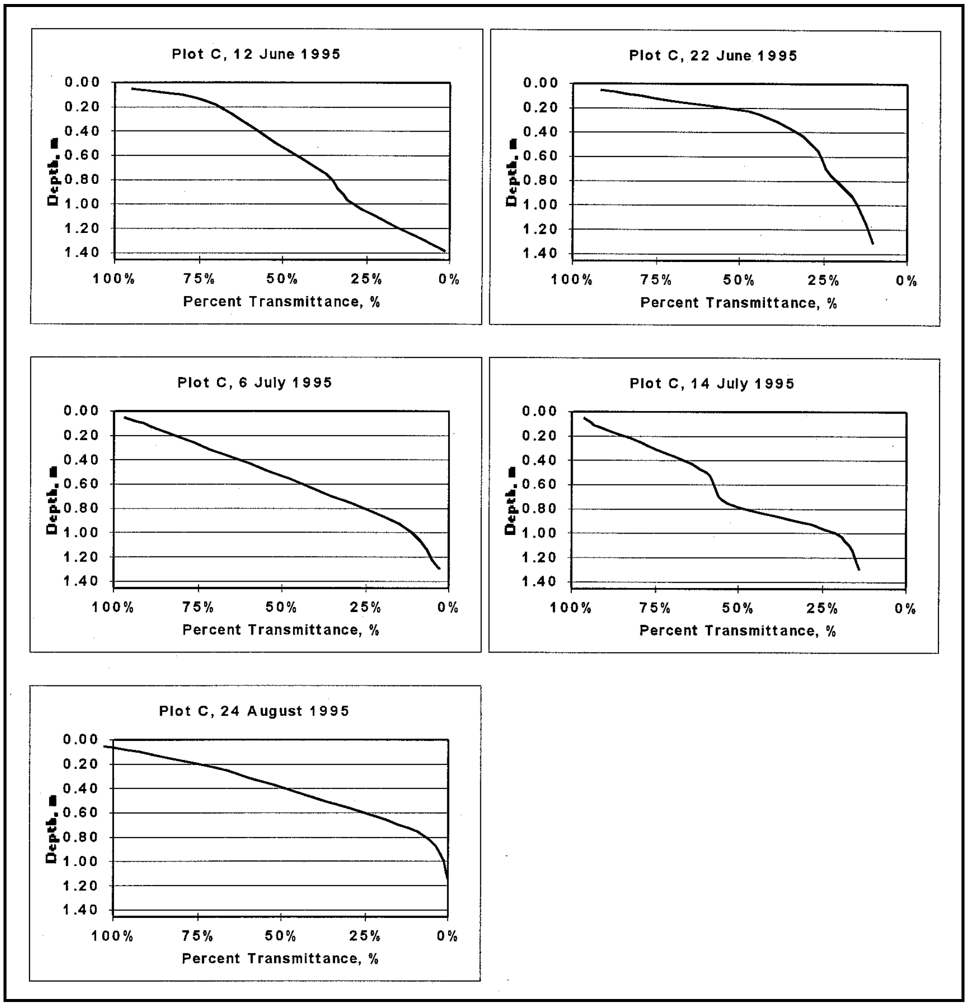


Figure 26. Percent light transmission profiles for Plot C at the Columbia, MO, study site

peaked at 1 week in each pond, following the initial concentrations associated with application. TCP peak levels were 7.0 ng/mL in Pond A and 3.7 ng/mL in Pond B. TMP levels peaked at about 6.8 ng/mL at Day 5 in Pond A and at 7.4 ng/mL in Pond B. The TCP and TMP peaks were similar in concentration and time as those observed at the California study site. The reference pond showed no detectable residues of any of the compounds of interest.

Sediment

Sediment samples were analyzed for triclopyr and TCP, and approximately 10 percent of the samples were additionally analyzed for TMP. Triclopyr half-lives in Ponds A and B, respectively, were 2.8 and 4.2 days, similar to the half-lives found in the California study. TCP half-lives were 6.8 and 12.4 days, somewhat higher than those in the California ponds. TMP was not detected in any of the analyzed samples. Levels of triclopyr and TCP in the sediment were

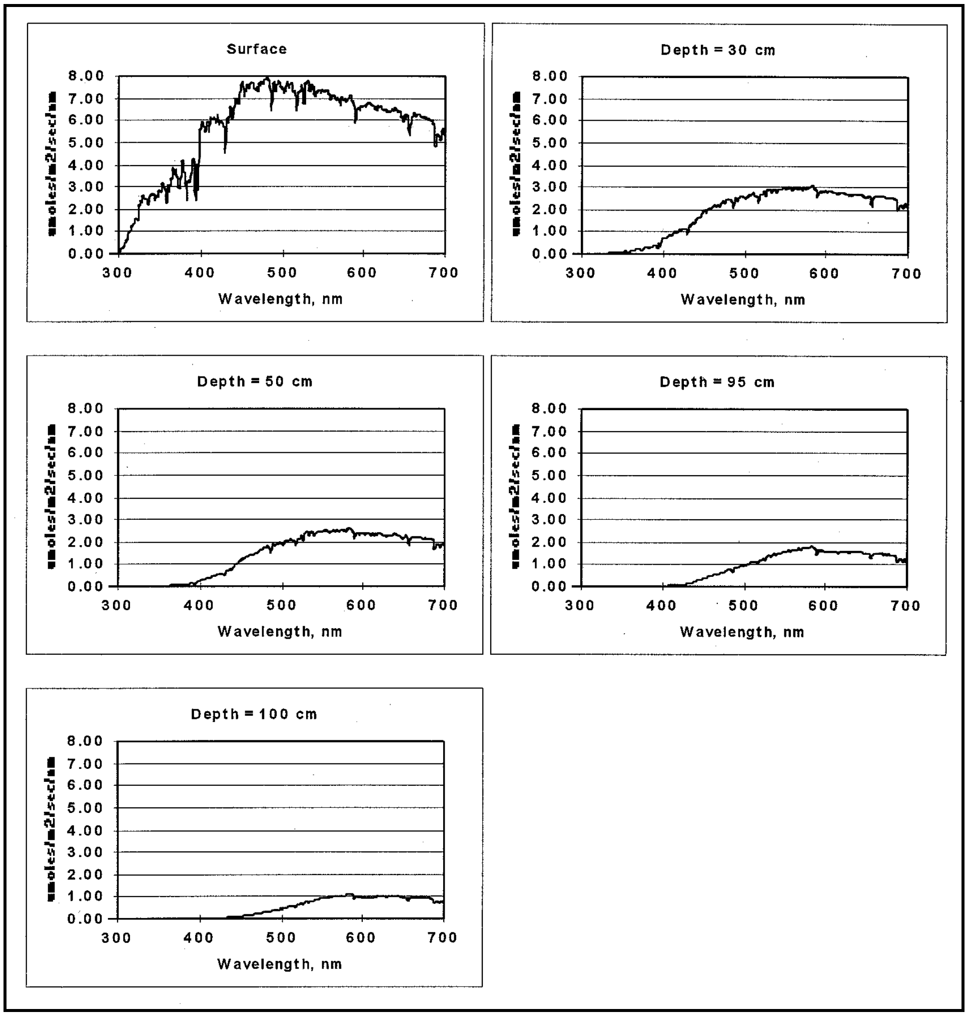


Figure 27. Spectral irradiance measurements (µm/m^2/sec/nm) collected at different depths in Pond A, Columbia, MO, on 13 July 1995

relatively low, with triclopyr levels approaching 0.1 µg/g, and TCP levels rising no higher than 0.08 µg/g (Figures 32 and 33). These sediment levels were very similar to those measured in the California study. The reference pond showed no detectable residues of triclopyr or TCP.

Fish

All fish tissue samples (fillet and viscera) were analyzed for triclopyr, TCP, and TMP. Results of these analyses were often somewhat variable, making the calculation of half-lives difficult. A summary of the calculable half-lives appears in Table 12. In general, where the compounds accumulated in fish tissues, they also cleared relatively quickly, with the levels present being driven by that present in the water column (Appendix B). As seen in a previous study (Petty et al. 1998) and in fish from the California study site, TMP accumulated

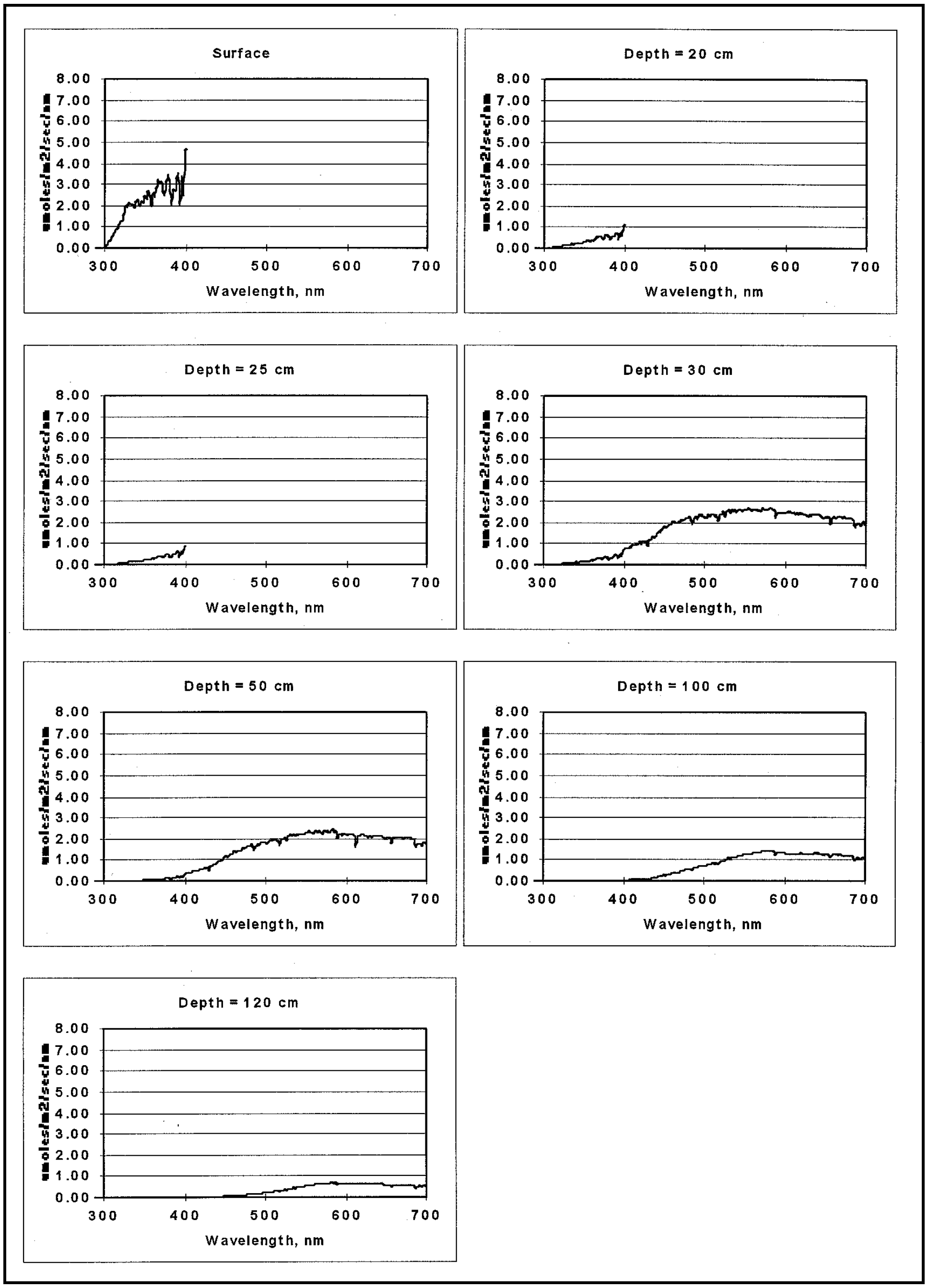


Figure 28. Spectral irradiance measurements (µm/m^2/sec/nm) collected at different depths in Pond B, Columbia, MO, on 12 July 1995

in fish tissues at concentrated levels, with levels in the visceral tissue being higher than those in the fillet portions. Data from fish analysis are also presented graphically in Figures 34 to 37.

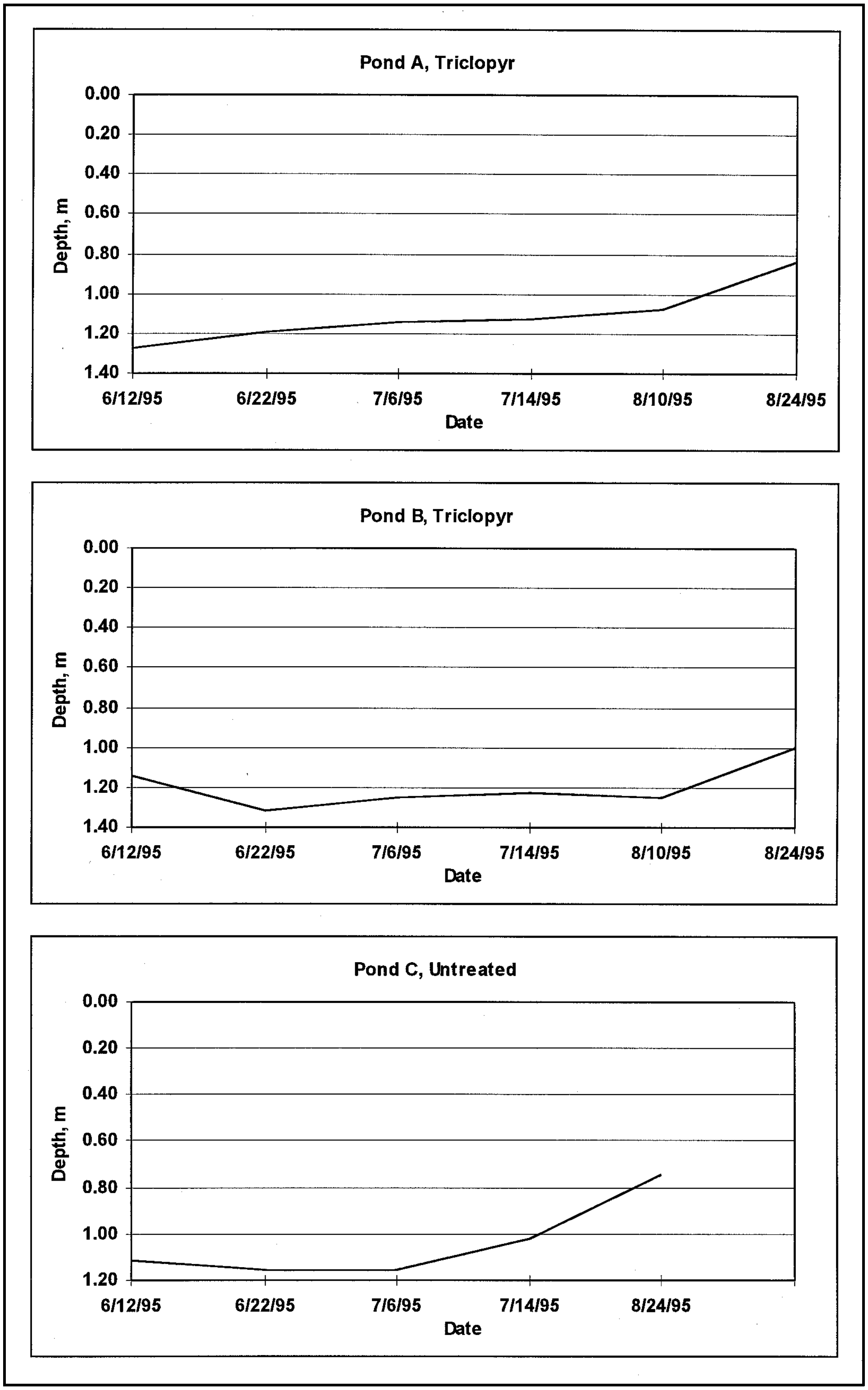


Figure 29. Average Secchi disk data for 1995 Columbia, MO, pond study

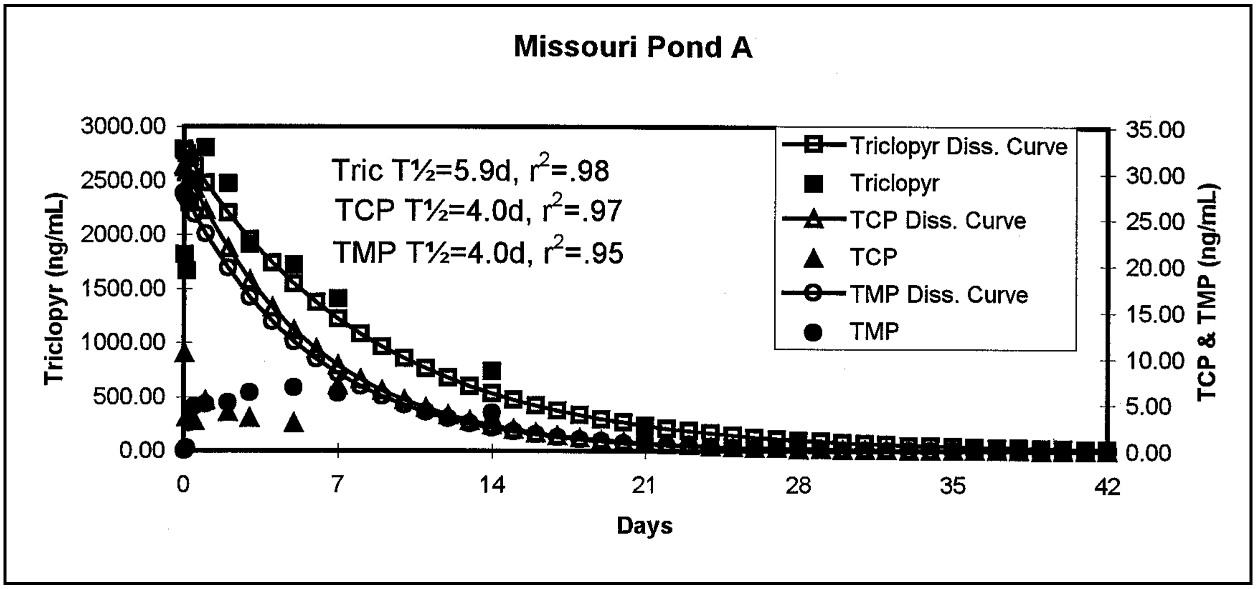


Figure 30. Dissipation of triclopyr, TCP, and TMP in water from Pond A of the Columbia, MO, study site

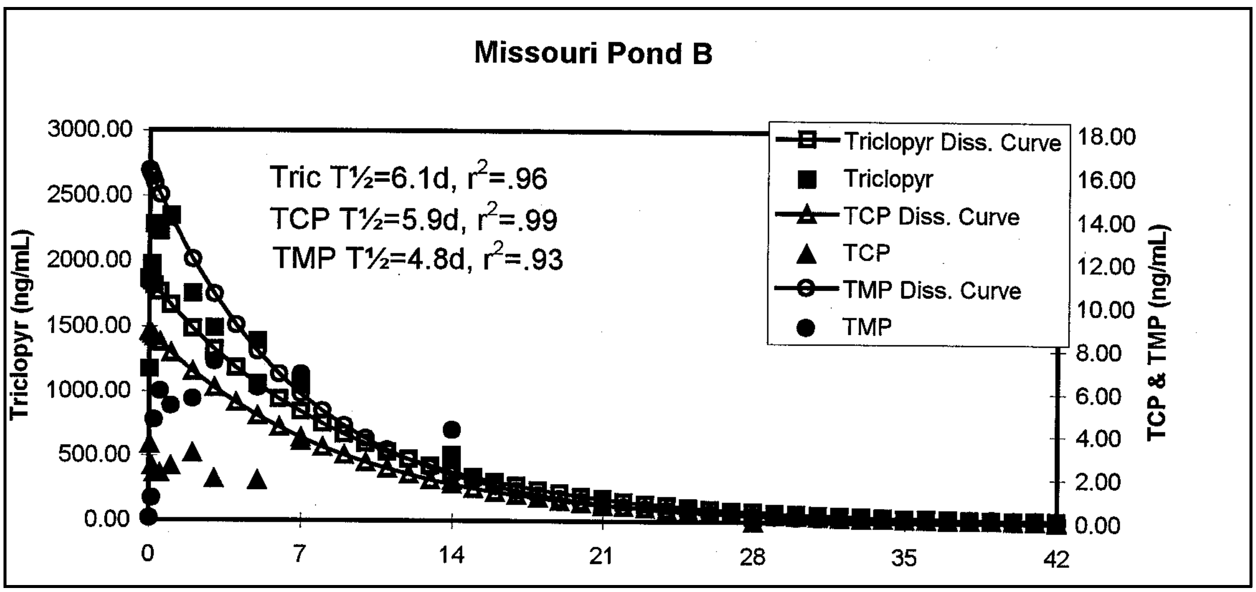


Figure 31. Dissipation of triclopyr, TCP, and TMP in water from Pond B of the Columbia, MO, study site

Texas Results

Meteorological conditions

The NOAA station at Denton, TX, reports a long-term average air temperature of 27.5 °C for the months of June to August, with a total precipitation amount of 19.66 cm for the same period (NOAA 1992c). The test site weather

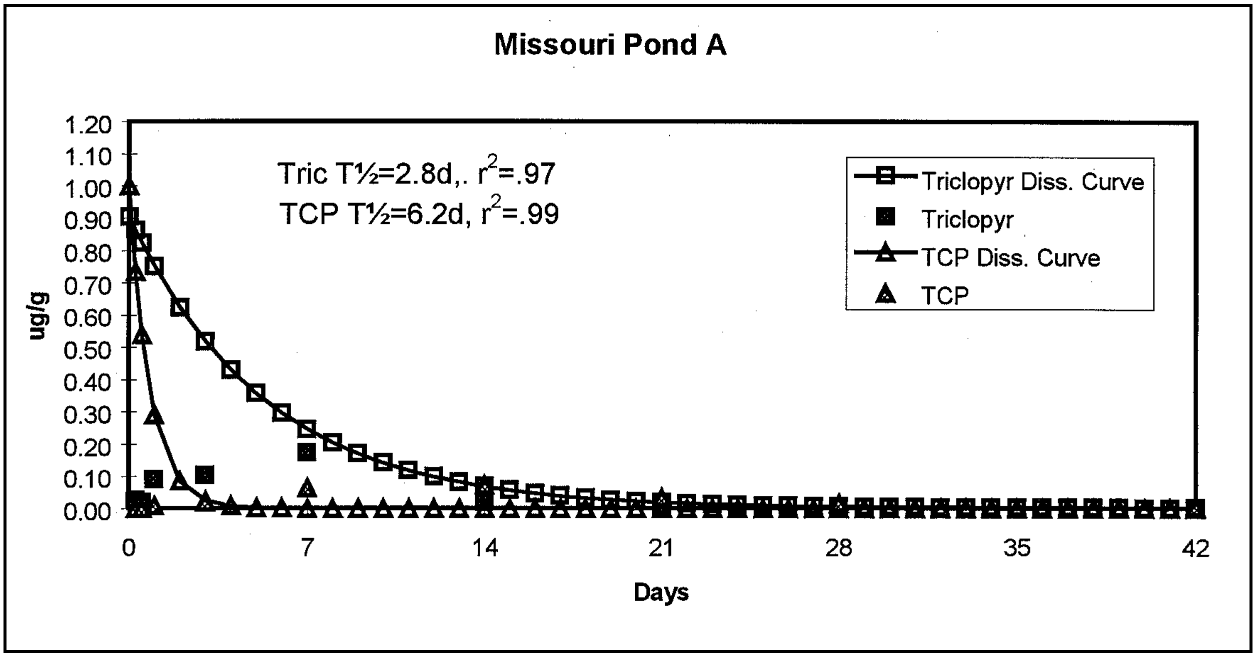


Figure 32. Dissipation of triclopyr and TCP in sediment from Pond A of the Columbia, MO, study site

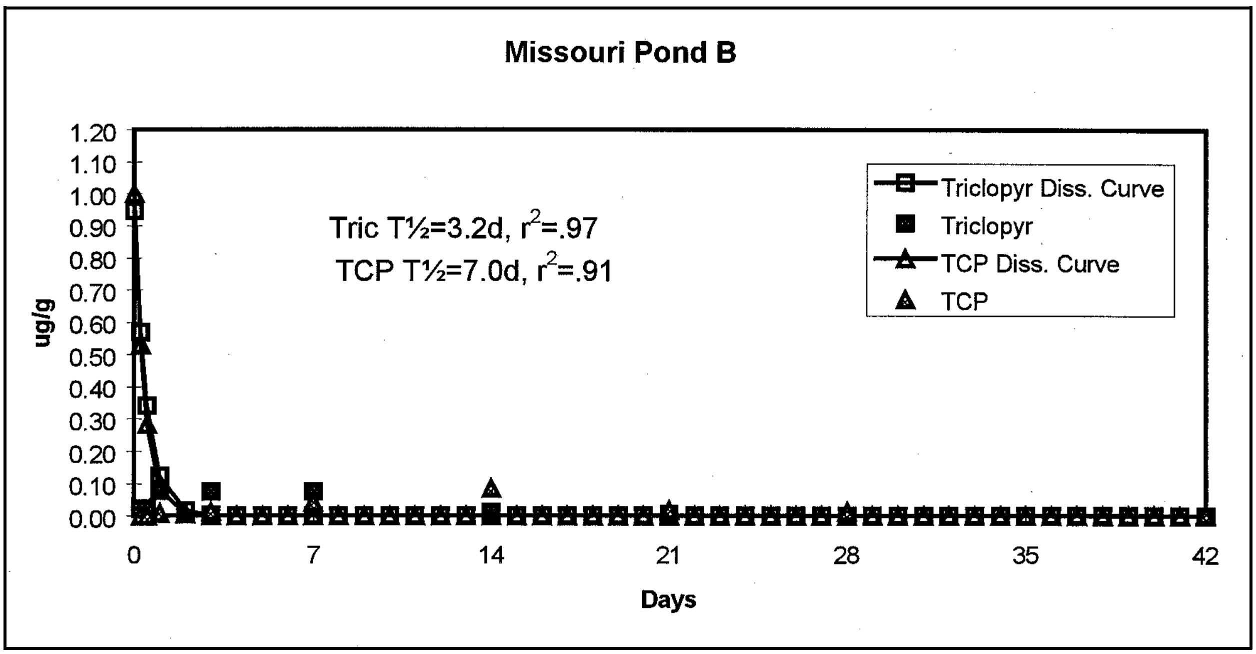


Figure 33. Dissipation of triclopyr and TCP in sediment from Pond B of the Columbia, MO, study site

station recorded an average air temperature of 27.8 °C and 16.41 cm of rainfall for the same period. Accordingly, air temperatures were about normal (+0.3 °C), while conditions were drier than would be expected (-3.25 cm). The daily weather conditions recorded at the study site are presented in Table 17.

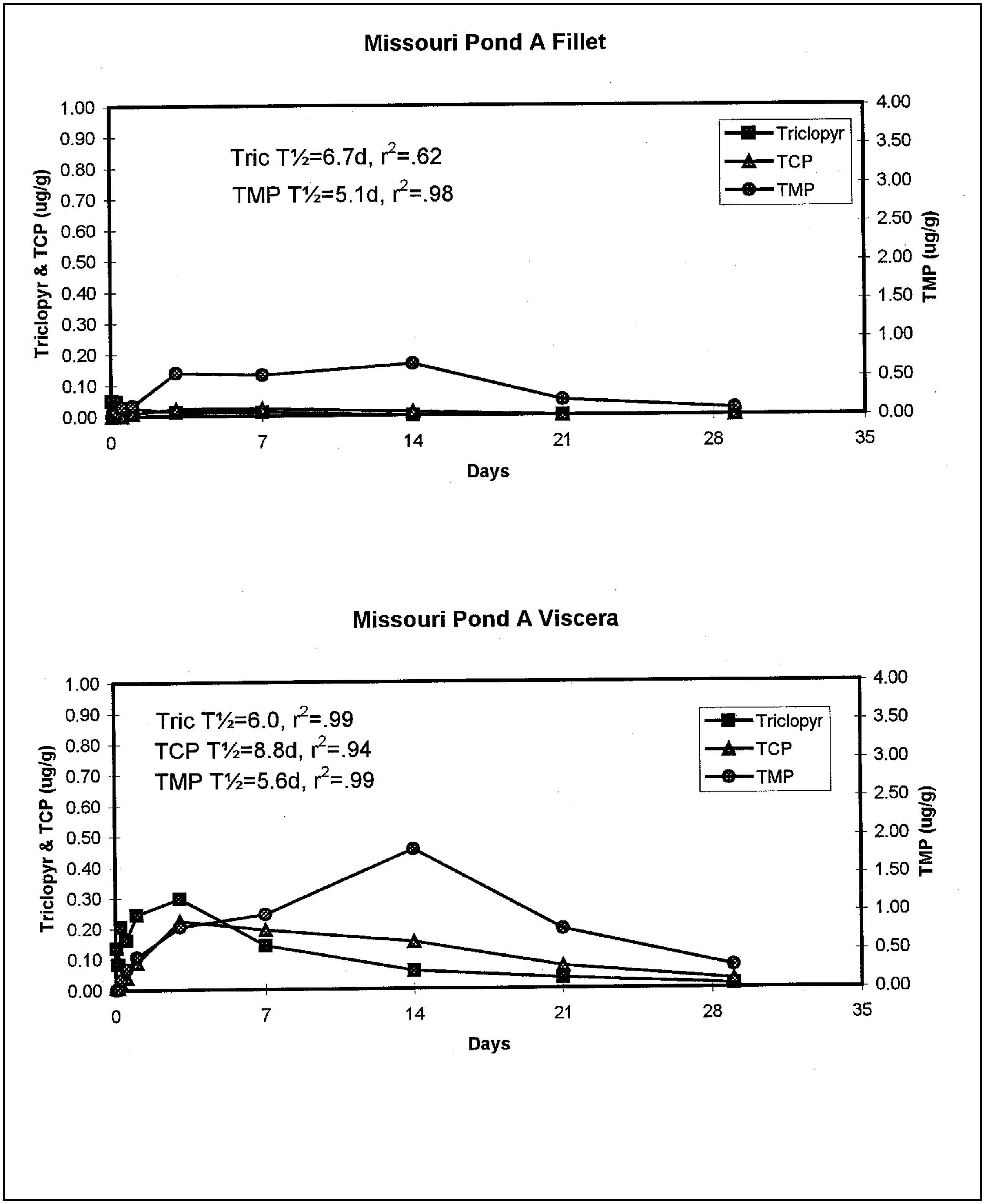


Figure 34. Dissipation of triclopyr, TCP, and TMP in bluegill fillet and viscera tissues from Pond A of Columbia, MO, study site

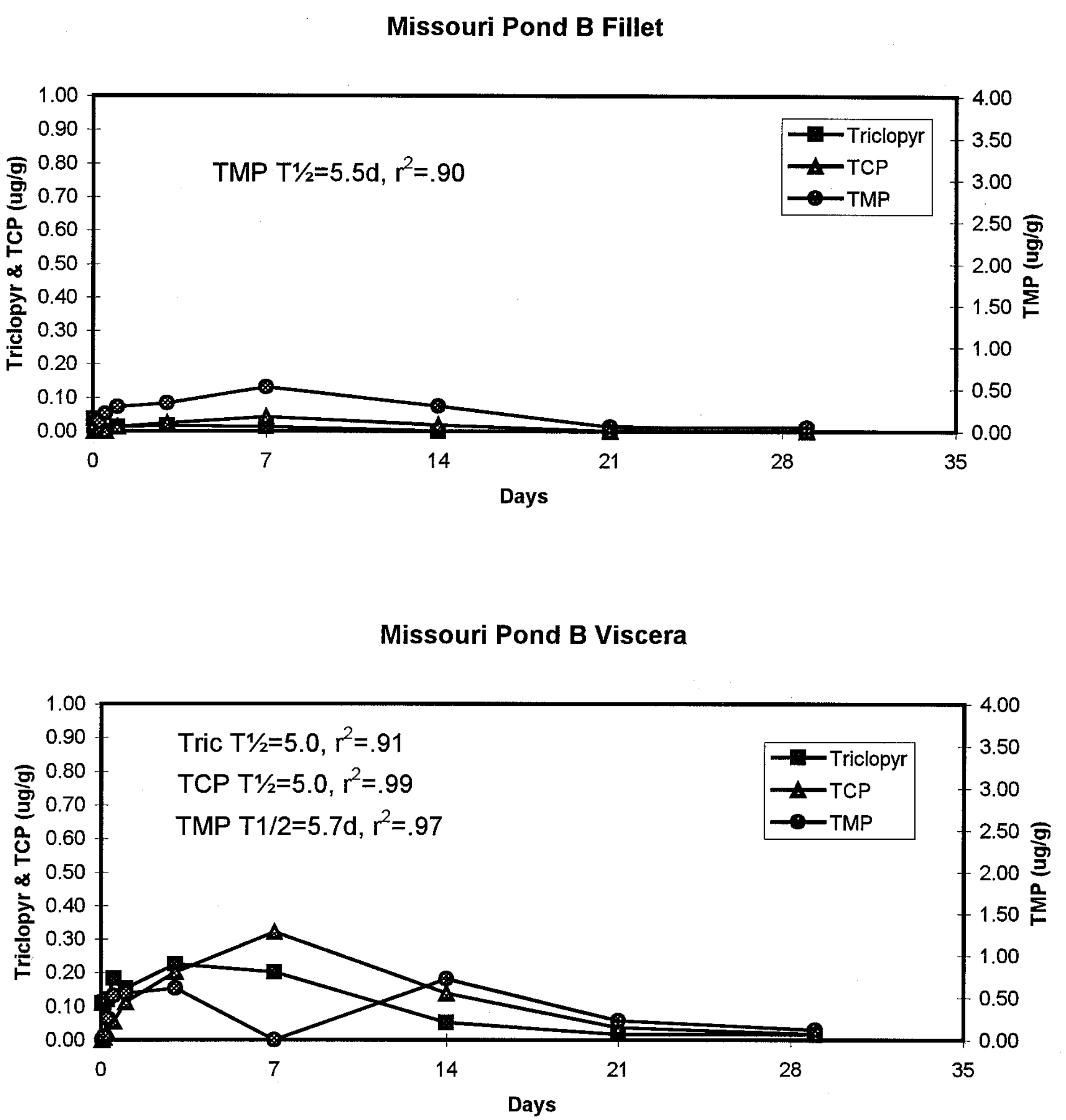
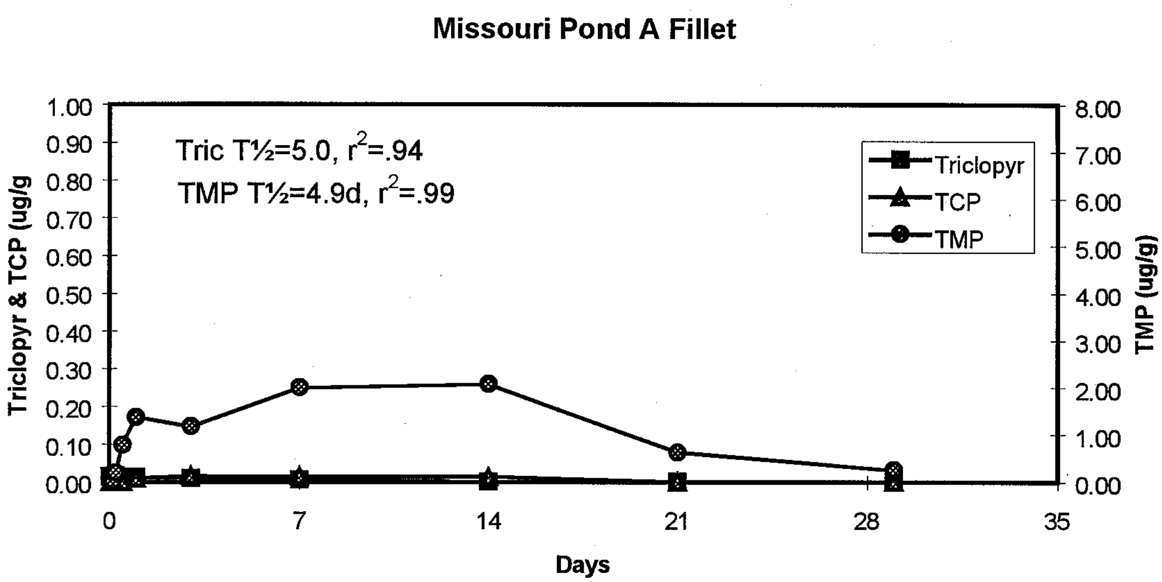


Figure 35. Dissipation of triclopyr, TCP, and TMP in bluegill fillet and viscera tissues from Pond B of the Columbia, MO, study site



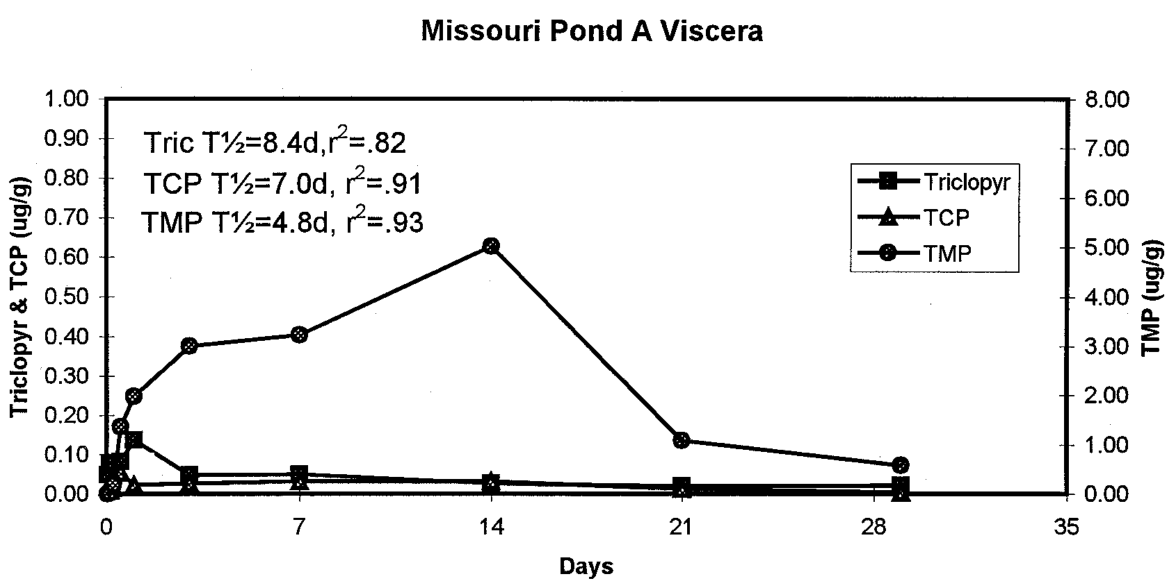


Figure 36. Dissipation of triclopyr, TCP, and TMP in catfish fillet and viscera tissues from Pond A of the Columbia, MO, study site

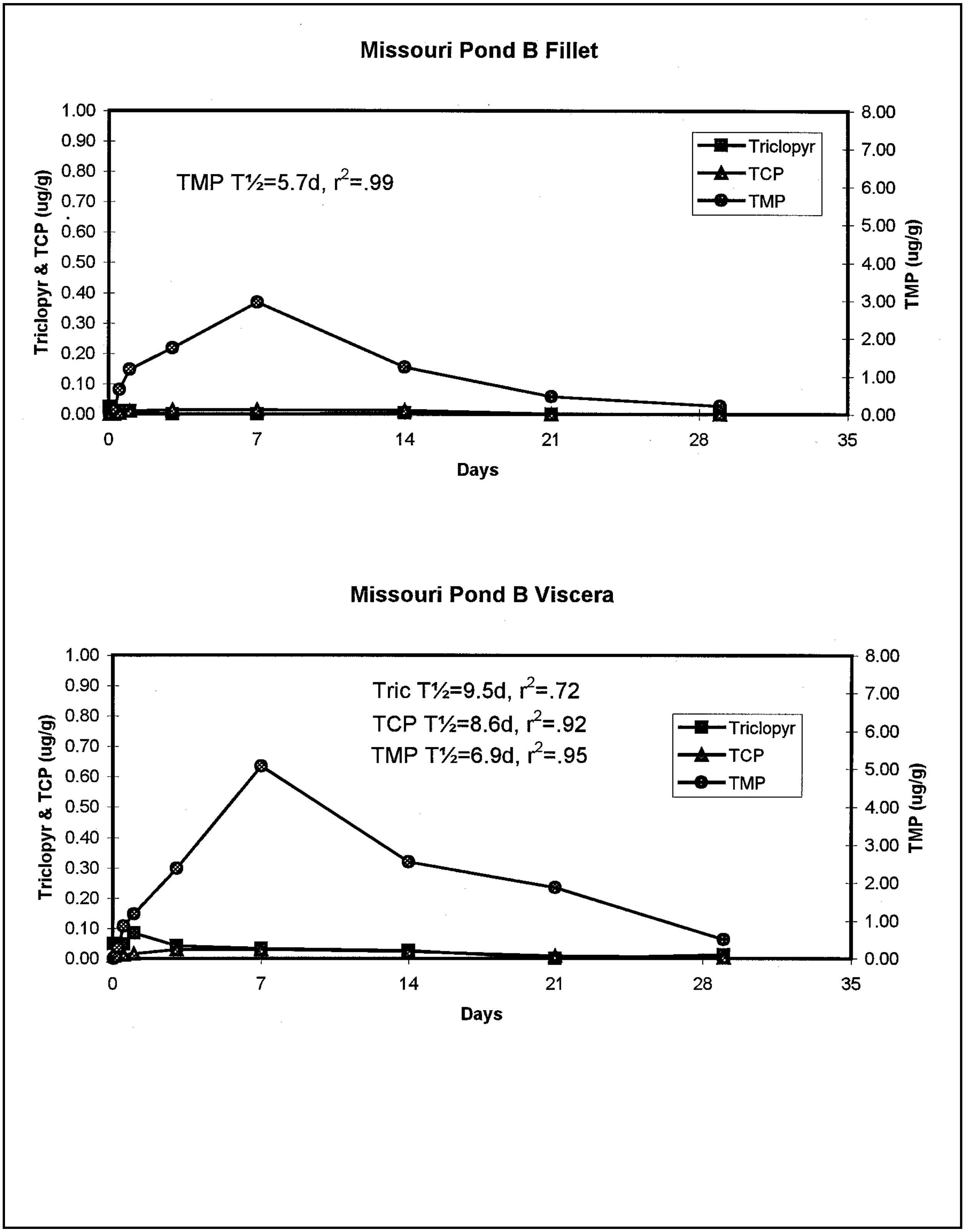


Figure 37. Dissipation of triclopyr, TCP, and TMP in catfish fillet and viscera tissues from Pond B of the Columbia, MO, study site

Table 17
Daily Weather Conditions Measured at the Texas Study Site, 1995

Date	Precip, cm	Average Air Temp °C	Max Air Temp, °C	Min Air Temp, °C	% RH	Wind Speed kph	Wind Dir	SD Dir	Solar Rad kw/m^2
31-May	0	22.3			80				
1-Jun	0	23.1			72				
2-Jun	0	26.6			75				
3-Jun	0	27.4			70				
4-Jun	0	27.0			68				
5-Jun	0	26.1			64				
6-Jun									
7-Jun									
8-Jun									
9-Jun	0	29.6			70				
10-Jun	3.25	25.2			85				
11-Jun	1.45	21.3			72				
12-Jun	0.08	21.6			63				
13-Jun	0.03	22.4			70				
14-Jun	0	24.6			63				
15-Jun	0	25.3			61				
16-Jun	0	25.5	30.2	20.5	65	8.3	162	10.6	26,080
17-Jun	0	25.6	30.7	20.9	64	7.7	126	9.5	23,394
18-Jun	0	25.2	31.0	19.0	65	6.6	140	10.8	21,585
19-Jun	0	25.9	31.7	19.5	66	3.9	79	12.8	24,178
20-Jun	0	25.8	32.7	19.3	66	4.0	79	12.9	27,115
21-Jun	0	26.4	32.9	19.8	68	3.4	43	12.5	27,204
22-Jun	0	27.2	34.1	20.6	68	2.8	16	14.4	26,615
23-Jun	0	27.7	34.0	21.2	66	3.2	221	14.8	23,962
24-Jun	0	26.7	32.2	21.5	73	5.3	29	12.6	25,730
25-Jun	0	25.6	30.6	20.8	63	13.6	352	17.5	27,849
26-Jun	0	26.5	33.7	18.5	64	3.8	33	13.6	25,693
27-Jun	0	24.3	29.8	20.5	76	5.4	210	13.8	10,781
28-Jun	0	26.9	33.3	20.0	74	8.2	181	12.7	25,176
29-Jun	0.18	26.2	30.5	21.7	74	6.4	158	13.6	16,741
30-Jun	0.03	24.5	28.3	21.4	80	13.4	12	14.4	22,243
1-Jul	0	24.9	29.3	20.6	70	12.3	32	11.7	26,513

(Sheet 1 of 3)

Table 17 (Continued)									
Date	Precip, cm	Average Air Temp °C	Max Air Temp, °C	Min Air Temp °C	% RH	Wind Speed, kph	Wind Dir	SD Dir	Solar Rad kw/m^2
2-Jul	0	26.1	31.1	21.0	74	6.4	166	12.6	18,342
3-Jul	0	29.7	34.5	24.8	63	17.7	189	13.5	27,670
4-Jul	0	29.2	33.3	24.6	61	20.5	192	13.8	23,051
5-Jul	3.07	23.5	32.6	18.5	77	8.9	188	13.7	20,043
6-Jul	0	26.3	33.6	20.6	80	5.9	150	11.8	23,989
7-Jul	0	27.5	35.2	20.3	72	3.7	213	14.8	28,996
8-Jul	0	28.3	35.5	21.8	70	3.0	248	16.5	28,764
9-Jul	0	29.4	35.9	23.0	65	5.2	234	13.9	28,756
10-Jul	0	29.6	37.9	21.7	65	1.9	265	16.0	28,737
11-Jul	0	30.4	38.6	23.3	65	2.2	342	15.2	28,072
12-Jul	0	30.7	37.5	23.5	64	3.7	53	10.9	27,567
13-Jul	0	30.6	36.9	24.4	64	4.9	137	13.0	23,089
14-Jul	0	29.4	34.5	24.4	69	6.7	154	10.9	23,352
15-Jul	0	27.9	32.9	23.5	71	4.7	163	13.3	19,024
16-Jul	0	27.8	33.8	23.1	73	4.3	137	13.2	26,537
17-Jul	0	28.2	34.9	22.7	74	3.9	39	14.9	23,319
18-Jul	1.37	28.3	35.4	23.6	76	7.2	38	11.9	27,101
19-Jul	0	27.8	33.6	23.3	77	5.5	98	11.0	23,781
20-Jul	0.08	28.9	35.7	25.0	70	6.2	167	10.9	15,177
21-Jul	0	30.7	36.1	25.9	60	8.8	178	13.3	26,370
22-Jul	0	31.1	36.1	26.4	60	10.4	197	13.7	25,073
23-Jul	2.34	29.4	34.2	24.0	71	10.9	186	13.6	20,155
24-Jul	0	30.0	35.1	23.9	59	13.0	170	13.5	25,363
25-Jul	0	30.3	35.2	25.1	62	7.9	190	13.8	24,265
26-Jul	0	30.8	35.8	25.9	65	10.2	164	12.7	26,213
27-Jul	0	31.8	37.9	26.6	56	8.6	189	13.4	26,751
28-Jul	0	32.2	39.7	25.2	58	4.2	204	13.9	27,546
29-Jul	0	30.1	34.9	25.4	66	9.7	130	11.2	24,792
30-Jul	0	29.3	33.3	25.3	63	11.1	89	10.2	20,348
31-Jul	1.32	25.8	29.0	24.3	87	16.9	87	10.2	6,896
1-Aug	1.80	26.0	29.4	23.1	88	14.0	122	10.6	12,720
2-Aug	0	26.7	30.6	25.0	83	13.5	153	12.4	14,425
3-Aug	0	28.0	32.9	24.1	77	6.2	162	12.8	26,203
4-Aug	0	28.0	32.9	24.6	81	5.0	18	14.1	24,645
									(Sheet 2 of 3)

Table 17 (Concluded)									
Date	Precip, cm	Average Air Temp °C	Max Air Temp, °C	Min Air Temp, °C	% RH	Wind Speed, kph	Wind Dir	SD Dir	Solar Rad kw/m^2
5-Aug	0	29.4	34.2	24.4	75	4.2	15	13.1	25,216
6-Aug	0	29.6	34.2	25.0	73	5.9	185	13.6	23,696
7-Aug	0	29.2	33.9	25.2	72	6.8	184	13.7	24,750
8-Aug	0	29.2	33.7	25.5	73	11.5	195	14.5	21,503
9-Aug	0	28.6	34.3	23.2	64	7.4	193	13.6	26,025
10-Aug	0	28.0	35.3	20.3	69	3.2	192	15.3	25,036
11-Aug	0	29.4	35.3	23.5	70	2.9	173	15.5	20,578
12-Aug	0	29.2	34.1	24.5	70	5.1	190	13.9	23,284
13-Aug	0	29.6	34.6	24.5	69	7.1	191	12.9	22,527
14-Aug	0	28.3	34.4	24.8	73	10.7	183	12.9	22,216
15-Aug	0	28.8	34.4	24.4	71	10.2	191	13.8	19,660
16-Aug	0	29.3	34.7	24.7	66	9.0	188	12.9	24,212
17-Aug	0	29.6	35.4	24.3	64	6.4	185	13.0	23,727
18-Aug	0	29.4	36.4	23.1	69	3.4	203	15.0	24,247
19-Aug	0	29.4	36.5	24.2	71	7.1	333	15.3	20,815
20-Aug	1.07	29.2	37.3	23.8	74	9.5	6	12.6	23,259
21-Aug	0	30.8	37.2	25.6	68	7.2	5	12.2	24,836
22-Aug	0	29.8	34.8	25.6	64	8.5	61	9.7	23,445
23-Aug	0	29.6	34.8	24.9	60	9.0	64	10.6	24,121
24-Aug	0	27.9	34.4	21.4	63	3.9	4	15.1	20,252
25-Aug	0.36	28.2	35.3	23.9	76	3.8	54	15.5	20,555
26-Aug	0	29.6	36.0	24.2	73	3.6	1	14.2	21,250
27-Aug	0	30.0	37.2	24.1	70	2.9	334	14.5	22,018
28-Aug	0	29.8	37.9	22.7	67	2.8	17	14.9	21,782
29-Aug	0	29.2	36.7	24.1	70	2.8	321	14.9	19,168
30-Aug	0	27.6	35.7	23.5	75	4.5	175	14.9	15,175
31-Aug	0	27.5	34.6	21.5	74	3.2	3	16.7	21,920
									(Sheet 3 of 3)

Aquatic organism assessment (biosurvey)

This non-GLP type survey provided documentation that a viable, healthy biological community (e.g., submersed/emersed plants, algae/plankton, aquatic invertebrates) was present in each pond prior to triclopyr applications, and that a similar community was maintained in each test pond for 6-week posttreatment.

Plants. Mean percent frequency of each plant species found during the study in each of the ponds is presented in Table 18.

Table 18
Mean Percent Frequency (±SE) of Plant Species in Triclopyr Whole-Pond Dissipation Study, Lewisville, TX—Pretreatment (22-23 May 1995) and 6-Week Posttreatment (13 July 1995)

	Pond A	Pond B	Pond C
Pretreatment			
Myriophyllum spicatum	24 ± 5.5	15 ± 7.0	6 ± 3.0
Elodea canadensis	31 ± 7.0	19 ± 5.5	9 ± 3.0
Chara spp.	77 ± 9.0	4 ± 3.0	1 ± 1.0
Paspalm flutans	16 ± 3.5	28 ± 2.0	16 ± 2.5
Najas guadalupensis	47 ± 9.0	0	0
Heteranthera dubia	0	0	0
Potamogeton nodosus	0	1 ± 1.5	0
Posttreatment			
Myriophyllum spicatum	0	0	22 ± 3.0
Elodea canadensis	2 ± 1.5	0	17 ± 3.0
Chara spp.	97 ± 2.0	98 ± 2.0	99 ± 0.5
Paspalm flutans	5 ± 1.0	7 ± 1.5	12 ± 3.5
Najas guadalupensis	0	0	17 ± 3.0
Heteranthera dubia	0	0	3 ± 1.5
Potamogeton nodosus	0	1 ± 0.5	0

Based on the pretreatment survey, the ponds contained a community of aquatic plants typical to those expected in constructed impoundments of the Southeastern United States. Predominant species recorded at both pretreatment and posttreatment sampling intervals included the exotic submersed weed (and a primary target plant of triclopyr) Eurasian watermilfoil (*Myriophyllum spicatum* L.), the native submersed species elodea (*Elodea canadensis* Rich.) and southern naiad (*Najas guadalupensis* (Spreng.) Magnus), the submersed charophyte *Chara* spp., and the emersed grass, water paspalum (*Paspalum fluitans* (Ell.) Kunth).

Although a shift in species frequency had occurred by the 6-week posttreatment evaluation, all ponds still contained a variety of submersed plants. The application of triclopyr effectively controlled Eurasian watermilfoil in Ponds A and B, while an increase in Eurasian watermilfoil frequency ensued in the untreated reference pond (C). Frequency of elodea and southern naiad increased in the reference pond, but decreased in one or both of the treated ponds, possibly due to the high rate of triclopyr (2.5 mg/L) used in these tests. Water paspalum had decreased in all ponds by 6-week posttreatment, probably due to increasing water temperatures. The posttreatment frequency of *Chara* spp. was very high in all three of the test ponds.

Algae. Occurrence of algae is shown in Tables 19 and 20. No algae was observed in samples collected during the pretreatment evaluation period. However, two genera of filamentous green algae, *Spirogyra* and *Cladophora*, were recorded in approximately 40 percent of the samples collected at 6-week posttreatment and were present in at least one quadrant in each pond. The emergence of filamentous algae in small ponds is primarily due to increases in water temperature during the growing season, which is the event that most likely triggered increased algae growth in these ponds during the last half of the posttreatment evaluation period.

Table 19
Occurrence of Invertebrates and Algae in Triclopyr Whole-Pond Dissipation Study, Lewisville, TX—Pretreatment (18 May 1995)

	Pond A				Pond B				Pond C			
Organisms	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**
Apus (tadpole shrimp)		X		X	X	X		X	X	X	X	
Eubranchipus (fairy shrimp)	X	X	X	X	X	X	X	X	X	X	X	X
Physa (pond snail)		X	X				X				X	
Libellulidae (dragonfly)												
Chaoboridae (phantom midge)												
Haliplus (diving beetle)		X										
Hydrachnidae (water mite)												
Daphnia spp.	X	X	X	X	X	X	X	X	X	X	X	X
Diaptomus spp.	X	X	X			X	X			X		
Spirogyra												
Cladophora												

Table 20
Occurrence of Invertebrates and Algae in Triclopyr Whole-Pond Dissipation Study, Lewisville, TX—Posttreatment (18 May 1995)

	Pond A				Pond B				Pond C			
Organisms	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**
Apus (tadpole shrimp)												
Eubranchipus (fairy shrimp)												
Physa (pond snail)	X	X			X				X	X		X
Libellulidae (dragonfly)			X		X	X	X			X	X	
Chaoboridae (phantom midge)	X	X	X	X	X	X	X	X	X	X	X	X
Haliplus (diving beetle)	X	X			X					X		
Hydrachnidae (water mite)	X	X								X		
Daphnia spp.				X		X		X			X	
Diaptomus spp.												
Spirogyra		X		X		X			X			X
Cladophora		X	X	X					X			X

Aquatic invertebrates. Occurrence of aquatic invertebrates are shown in Tables 19 and 20. A distinct shift in the aquatic invertebrate community occurred in all ponds during the study and, as the case with algae (above), was most likely due to warmer water temperatures in the later phase of the study period. At pretreatment, sampling indicated that the predominant invertebrates were tadpole shrimp (*Apus*), fairy shrimp (*Eubranchipus*), and water flea (*Daphnia*). By 6-week posttreatment, the predominant organisms were pond snails (*Physa*), juvenile dragonflies (Libellulidae), and phantom midges (Chaoboridae).

Water quality and characterization

Factors of water quality are discussed in the California water characterization results section of this report. The data generated from Texas water characterization analyses are presented in Table 9. In general, the water from the Texas test site ponds can be characterized as basic, with a USGS classification of moderately hard (Van der Leeden, Troise, and Todd 1990).

Pretreatment and posttreatment water quality data (temperature, DO, pH, and conductivity) are presented in Figures 38-41. Water quality changed over time, and in a diurnal pattern, in a fashion typical with that expected for small, constructed impoundments in the Southeastern United States. Generally, measurements of all parameters differed only slightly when compared across

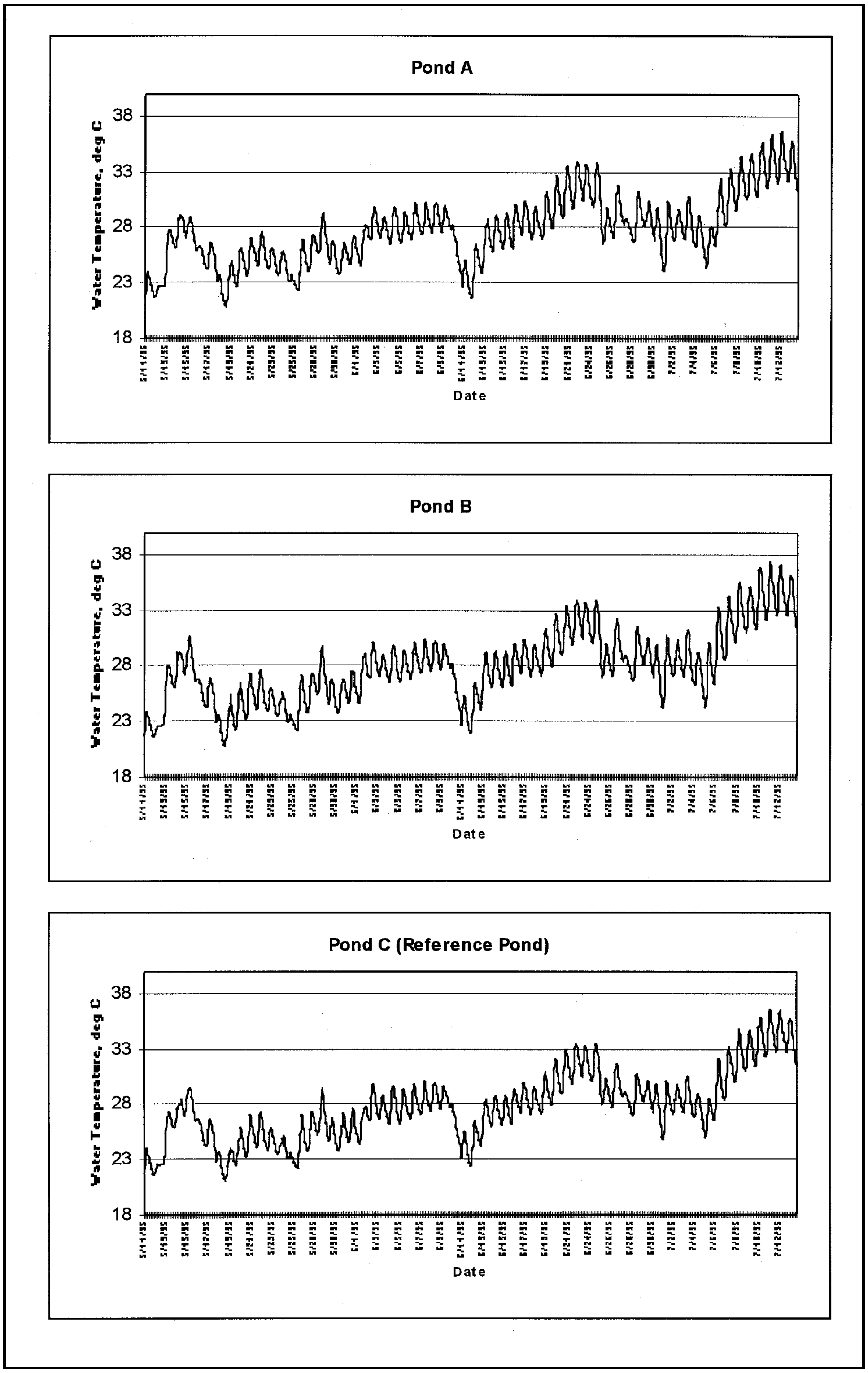


Figure 38. Water temperature measurements from the Lewisville, TX, study site, 1995

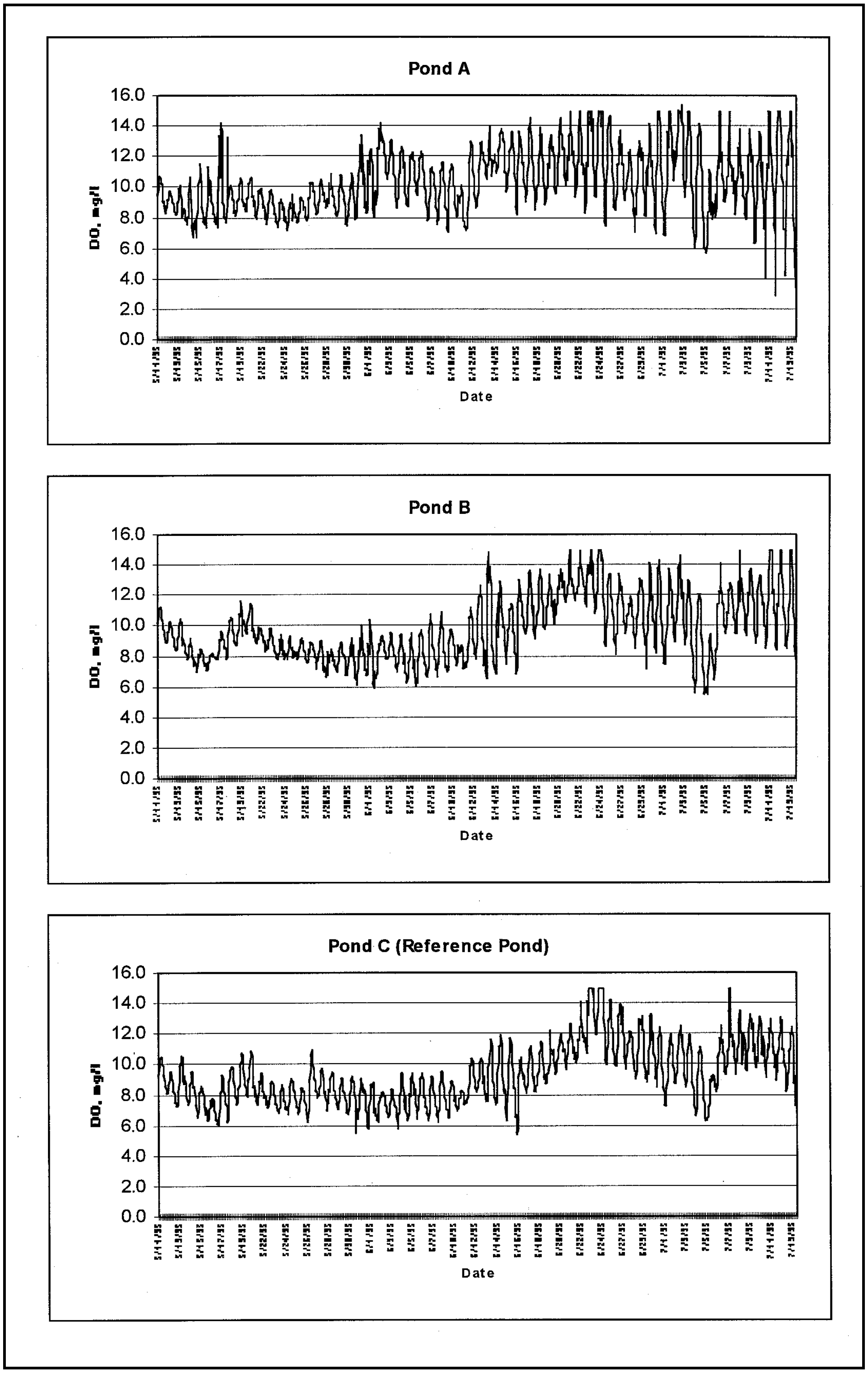


Figure 39. Dissolved oxygen measurements form the Lewisville, TX, study site, 1995

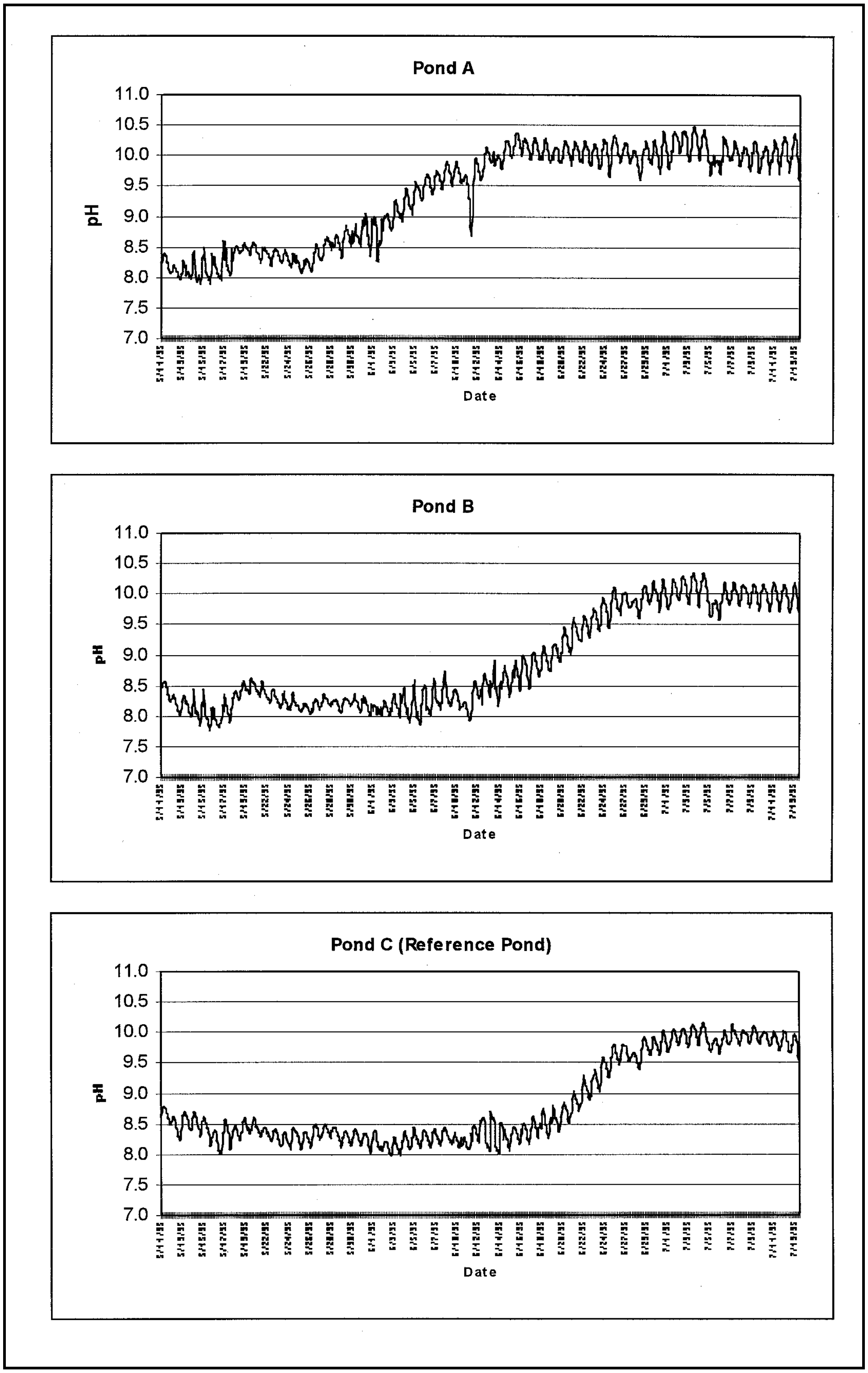


Figure 40. pH measurements from the Lewisville, TX, study site, 1995

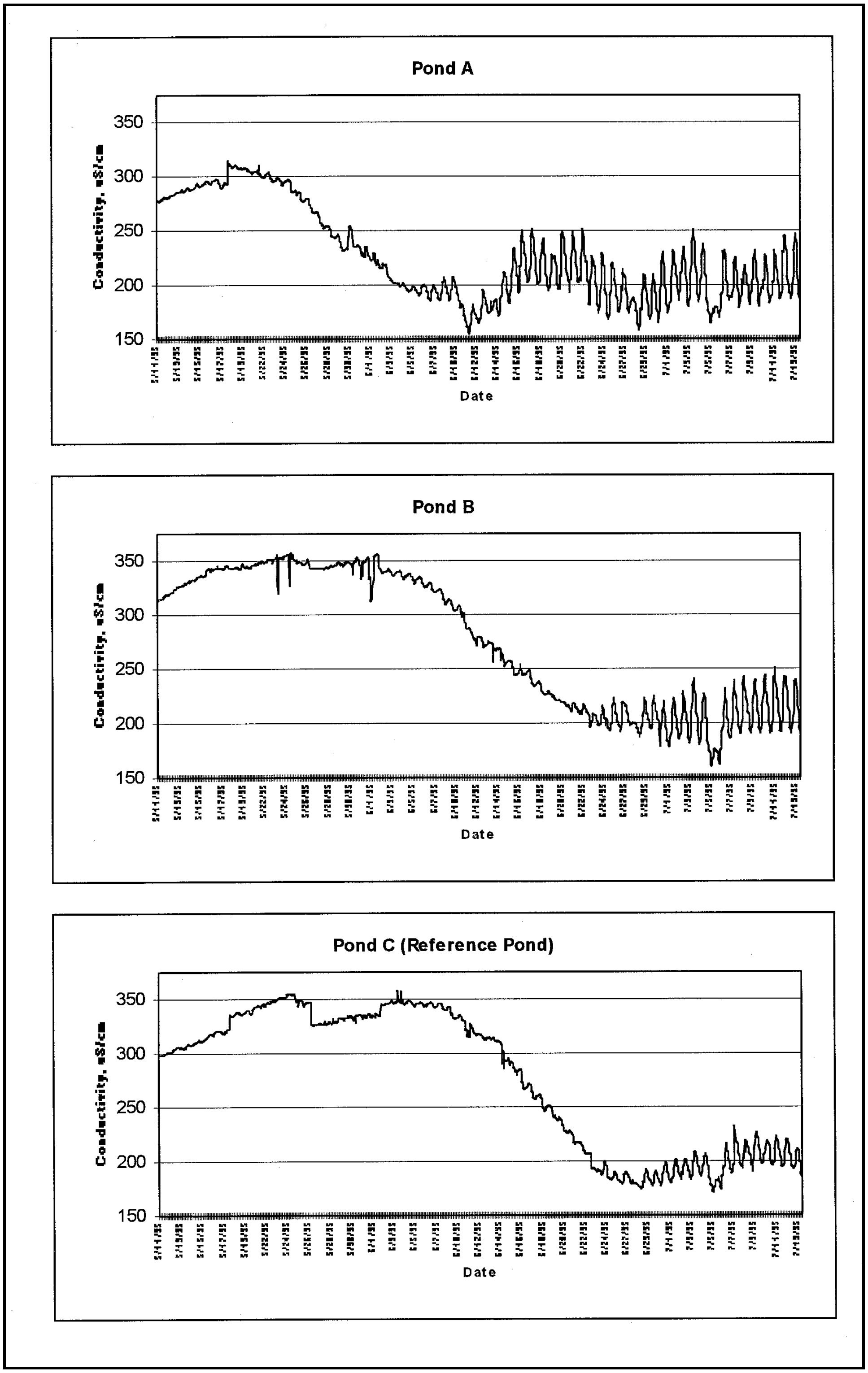


Figure 41. Conductivity measurements from the Lewisville, TX, study site, 1995

treatment ponds (A, B, and C). This indicates that triclopyr applications had little to no significant effect on water quality conditions in this study.

Water temperatures increased from 24 °C in the mid-May pretreatment period to 35 °C by 6-week posttreatment in mid-July in all ponds (Figure 38). This seasonal increase in water temperature probably stimulated algal growth and contributed to the observed shift in the aquatic invertebrate community observed in the ponds.

The DO levels measured in all ponds ranged from 6 to 11 mg/L through mid-June and then expanded to a range of 4 to 15 mg/L during the last 3 to 6 weeks of the study (Figure 39). The greatest diurnal DO fluctuations were observed in Pond A, which may have been caused by the higher levels of filamentous algae (daytime oxygen production via photosynthesis and nighttime oxygen consumption via respiration) recorded in that pond.

A gradual increase in pH was measured through the course of the study in all of the ponds (Figure 40). Pretreatment levels ranged from approximately 8.0 to 8.5, while pH values were measured in the 9.5 to 10.5 range by 6-week posttreatment. These elevated pH levels most likely represent increased photosynthetic activity by algae, as these plants became more abundant during the later half of the evaluation. Although high pH levels ($\geq$10) for extended periods of time can be detrimental to some aquatic organisms, water pH during this study was well within the normal physiological exposure range of aquatic biota (Wetzel 1975).

As observed with the other water quality indices, conductivity levels showed similar patterns when compared across all test ponds (Figure 41). Pretreatment levels ranged from 275 to 350 mS/cm, decreasing to 160 to 250 mS/cm during 4- to 6-week posttreatment. This decline in conductivity was probably related to the decrease in dissolved cations, caused by increased algal production in the later stages of the evaluation period.

Light intensity and spectral irradiance

Light intensity measurements indicated that PAR was quenched by approximately 50 percent in the upper 0.5 m of the water column in each pond (Figure 42). In addition, spectral irradiance measurements showed that most of the triclopyr-degrading UV light ($<$400 nm) was absorbed in the top 10 to 15 cm of the water column in the triclopyr-treated ponds (A and B) (Figures 43 and 44). This rapid near-surface quenching of UV light is typical for natural waters (Wetzel 1975) and suggests that photolysis may play a limited role in the degradation of triclopyr in pond and other surface water situations.

Sediment characterization

Results of the physical characterization of the bottom sediment is presented in Table 10. The sediments were mostly classified as sandy clay loams. Organic

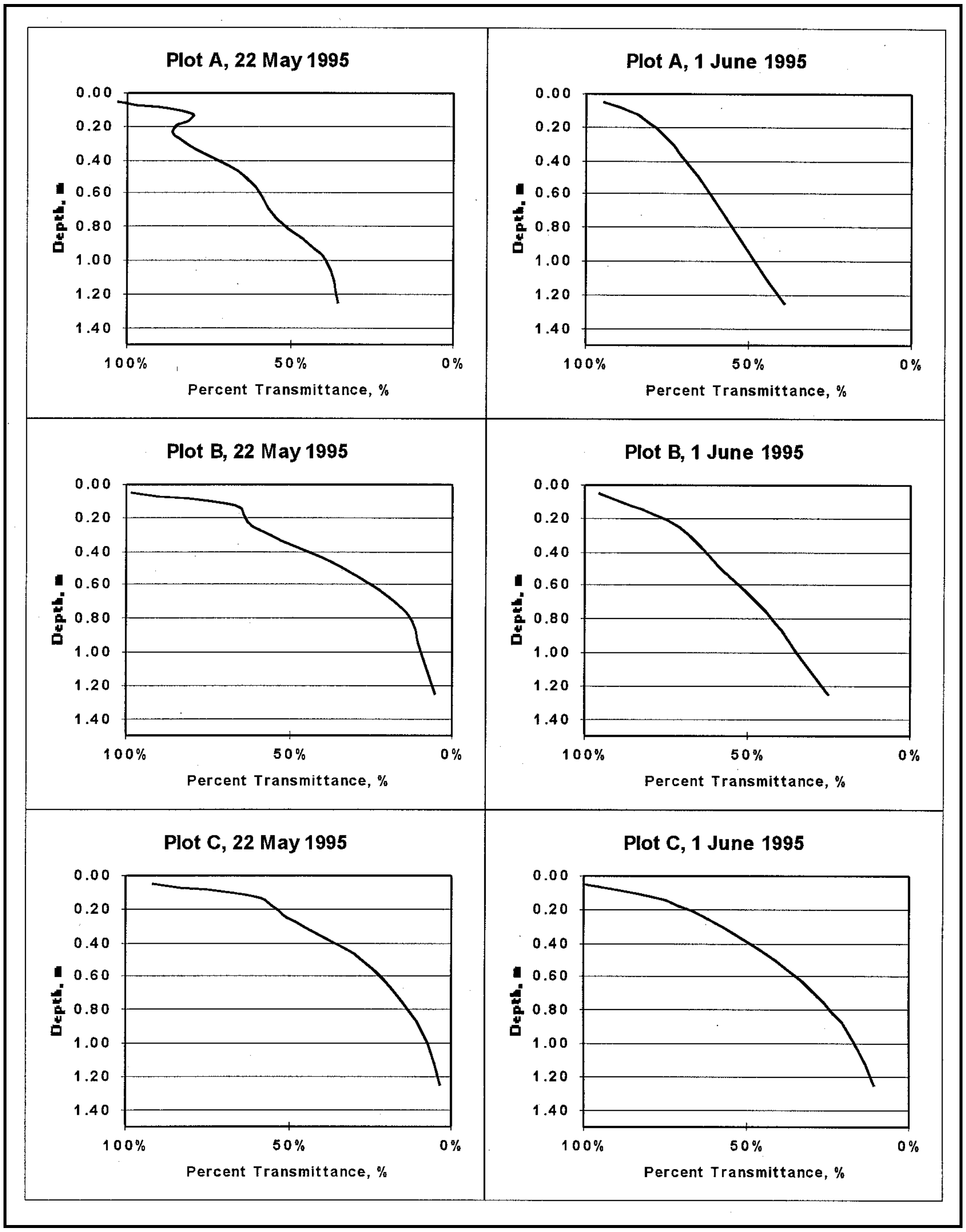


Figure 42. Percent light transmission profiles for the test ponds at the Lewisville, TX, study site, 1995

matter ranged from 2.1 to 3.8 percent. The pH of the sediment was slightly alkaline.

Triclopyr dissipation

Results of analysis for triclopyr and its metabolites in the matrices examined in this study have been reported separately (Foster, Getsinger, and Petty 1997). A summary of average residue values from the Texas study site is presented in

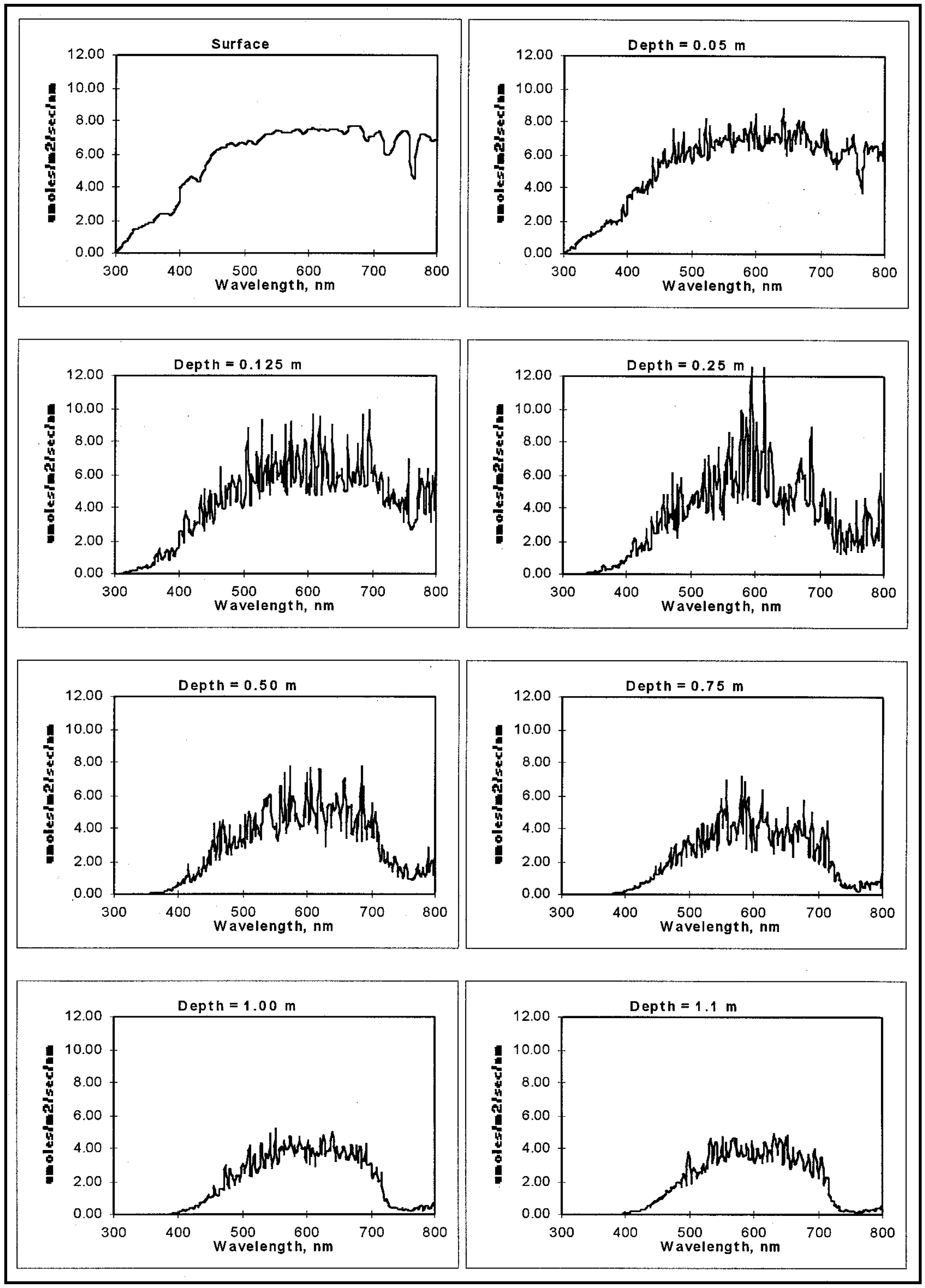


Figure 43. Spectral irradiance measurements collected at different depths in Pond A, Lewisville, TX, on 22 May 1995

Appendix C. Table 11 lists the reported LOD and LOQ for each sample matrix. Any value falling below the LOD is considered to be ND. A value falling between the LOD and LOQ is considered to be NQ and is referred to as a “trace” value in this report. Half-lives for all matrices are summarized in Table 12.

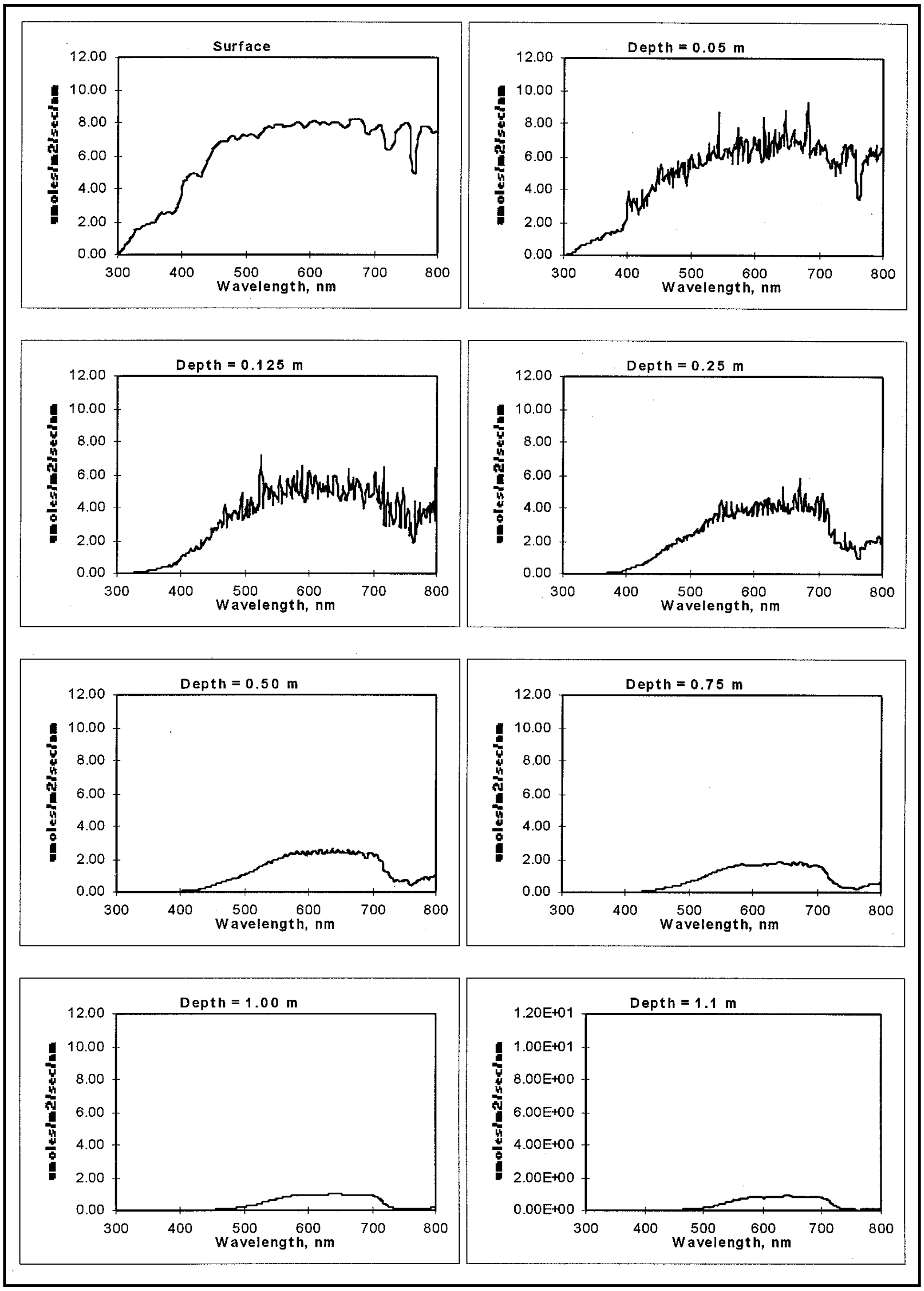


Figure 44. Spectral irradiance measurements collected at different depths in Pond B, Lewisville, TX, on 22 May 1995

Water

Triclopyr and its metabolites dissipated rapidly from water in this study, and results from the replicate ponds matched well. Pond A showed initial triclopyr levels of 2,310 ng/mL, and Pond B showed levels of 2,743 ng/mL at 6 hr after application, indicating that the applications were near or at the nominal level of 2,500 ng/mL. In Pond A, triclopyr dissipated with a half-life of 6.5 days, TCP with a half-life of 5.7 days, and TMP with a half-life of 6.5 days (Figure 45). In Pond B, triclopyr had a half-life of 6.3 days, the TCP half-life was 10 days, and the TMP half-life was 5.7 days (Figure 46). In most cases, these residue half-lives were slightly greater than those measured in the California and Missouri study sites. TCP levels peaked around 1 or 2 days after application, following the initial application levels, and declined after that. TMP levels peaked at about 7 ng/mL at Day 2 in each pond. The TCP and TMP peaks were similar to those found in the California and Missouri studies. The reference pond showed no detectable residues of any of the compounds of interest.

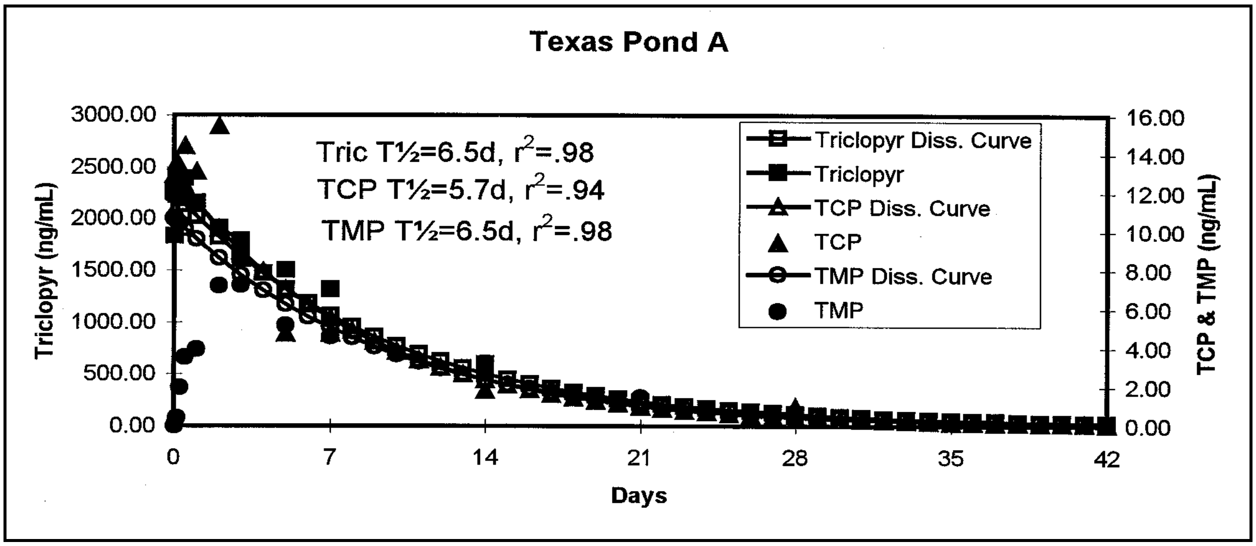


Figure 45. Dissipation of triclopyr, TCP, and TMP in water from Pond A of the Lewisville, TX, study site

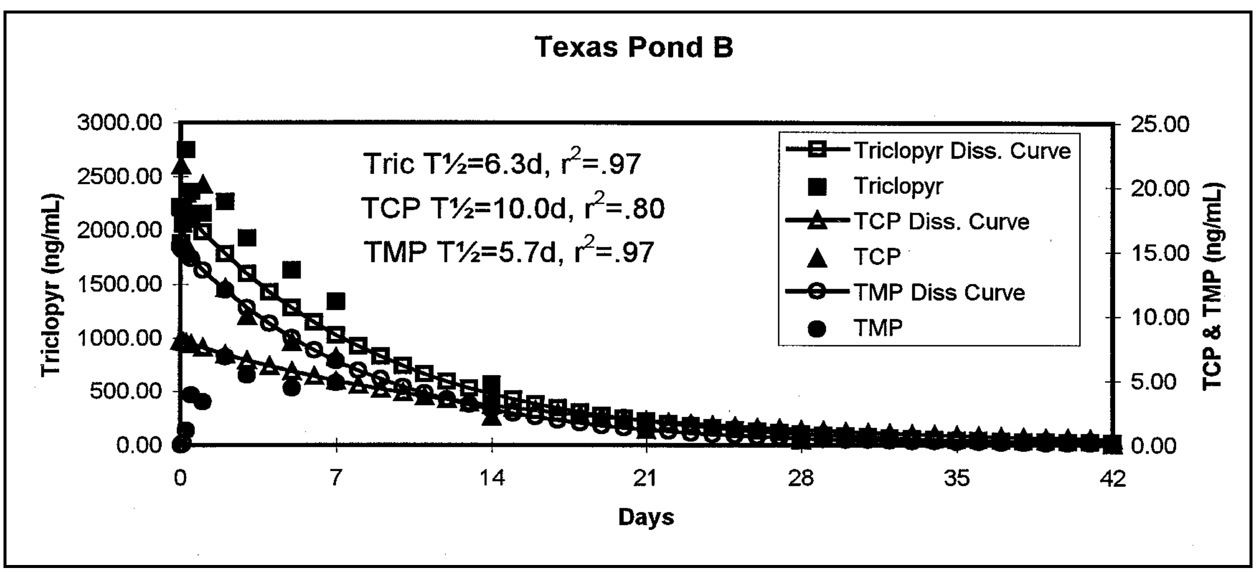


Figure 46. Dissipation of triclopyr, TCP, and TMP in water from Pond B of the Lewisville, TX, study site

Sediment

Sediment samples were analyzed for triclopyr and TCP, and approximately 10 percent of the samples were additionally analyzed for TMP. Triclopyr half-lives in Ponds A and B each were 4.6 days, similar to those measured in the California and Missouri sites. TCP half-lives were 13.3 and 12.3 days, somewhat higher than the California and Missouri sites. TMP was not detected in any of the analyzed samples. Levels of triclopyr and TCP in the sediment were relatively low, with triclopyr levels approaching 0.5 µg/g, and TCP levels rising no higher than 0.16 µg/g (Figures 47 and 48). These levels were slightly greater than those observed in the California and Missouri sites. The reference pond showed no detectable residues of triclopyr or TCP.

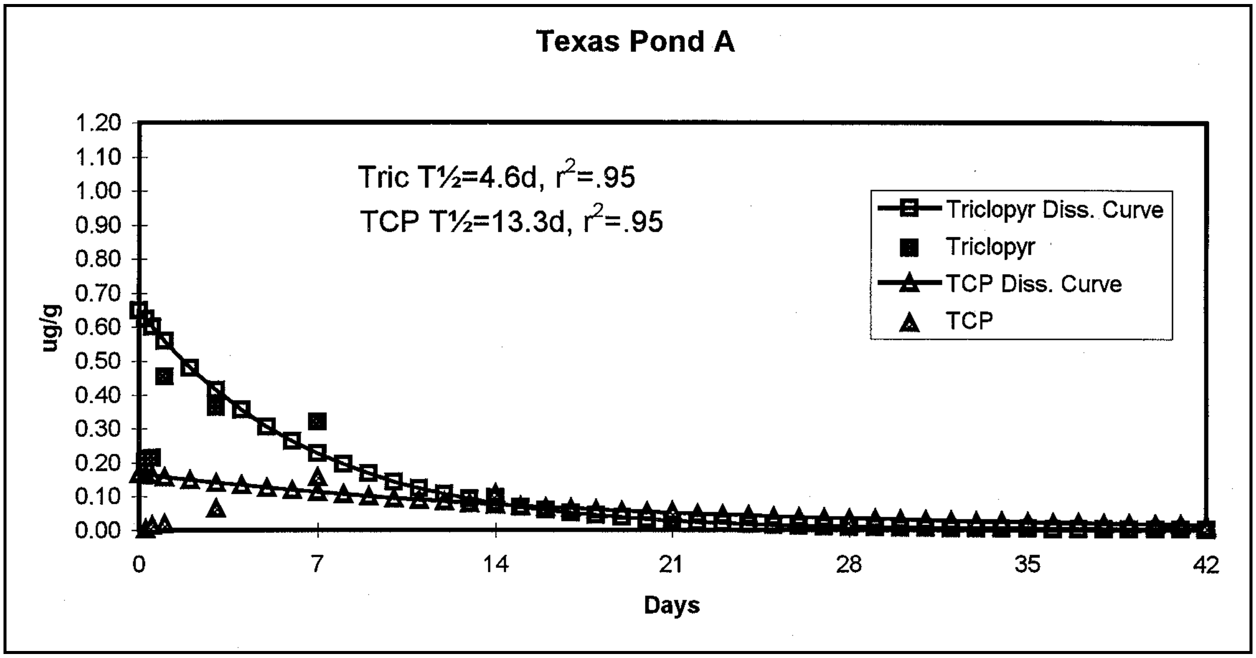


Figure 47. Dissipation of triclopyr and TCP in sediment from Pond A of the Lewisville, TX, study site

Fish

All fish tissue samples (fillet and viscera) were analyzed for triclopyr, TCP, and TMP. Results of these analyses were often somewhat variable, making the calculation of half-lives difficult. A summary of the calculable half-lives appears in Table 12. In general, where the compounds accumulated in fish tissues, they also cleared relatively quickly, with the levels present being driven by that present in the water column (Appendix C). As seen in a previous study (Petty et al. 1998) and in fish from the California and Missouri study sites, TMP accumulated in fish tissues at concentrated levels, with levels in the visceral tissue being higher than those in the fillet portions. Data from fish analysis are also presented graphically in Figures 49 to 52.

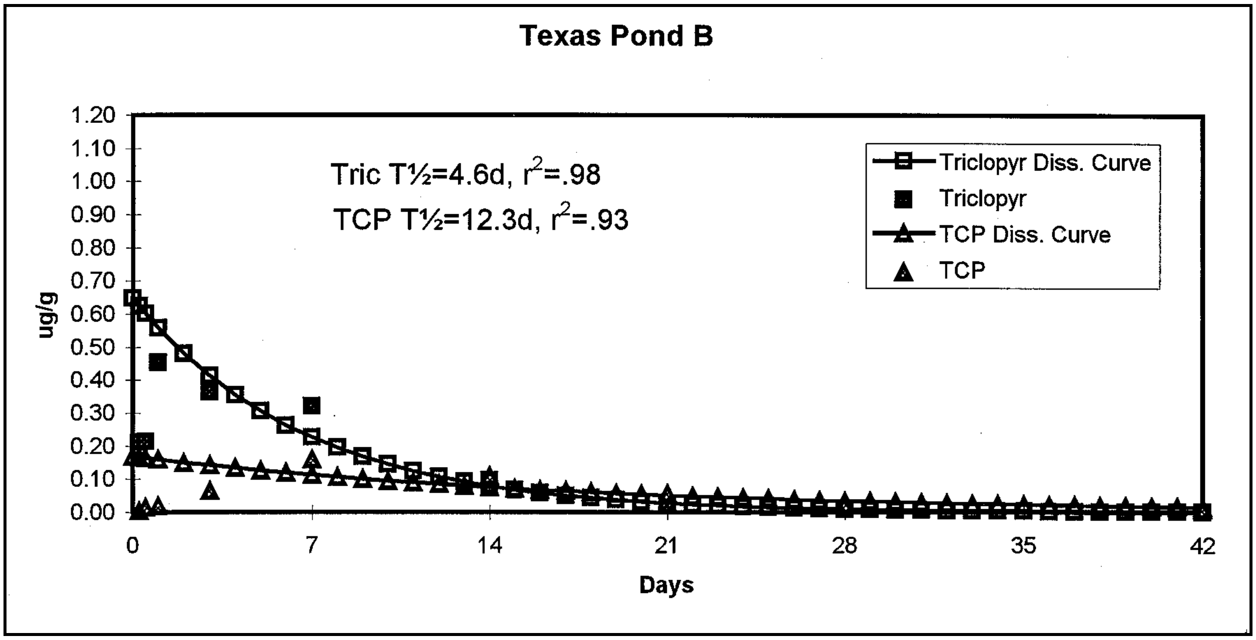


Figure 48. Dissipation of triclopyr and TCP in sediment from Pond B of the Lewisville, TX, study site

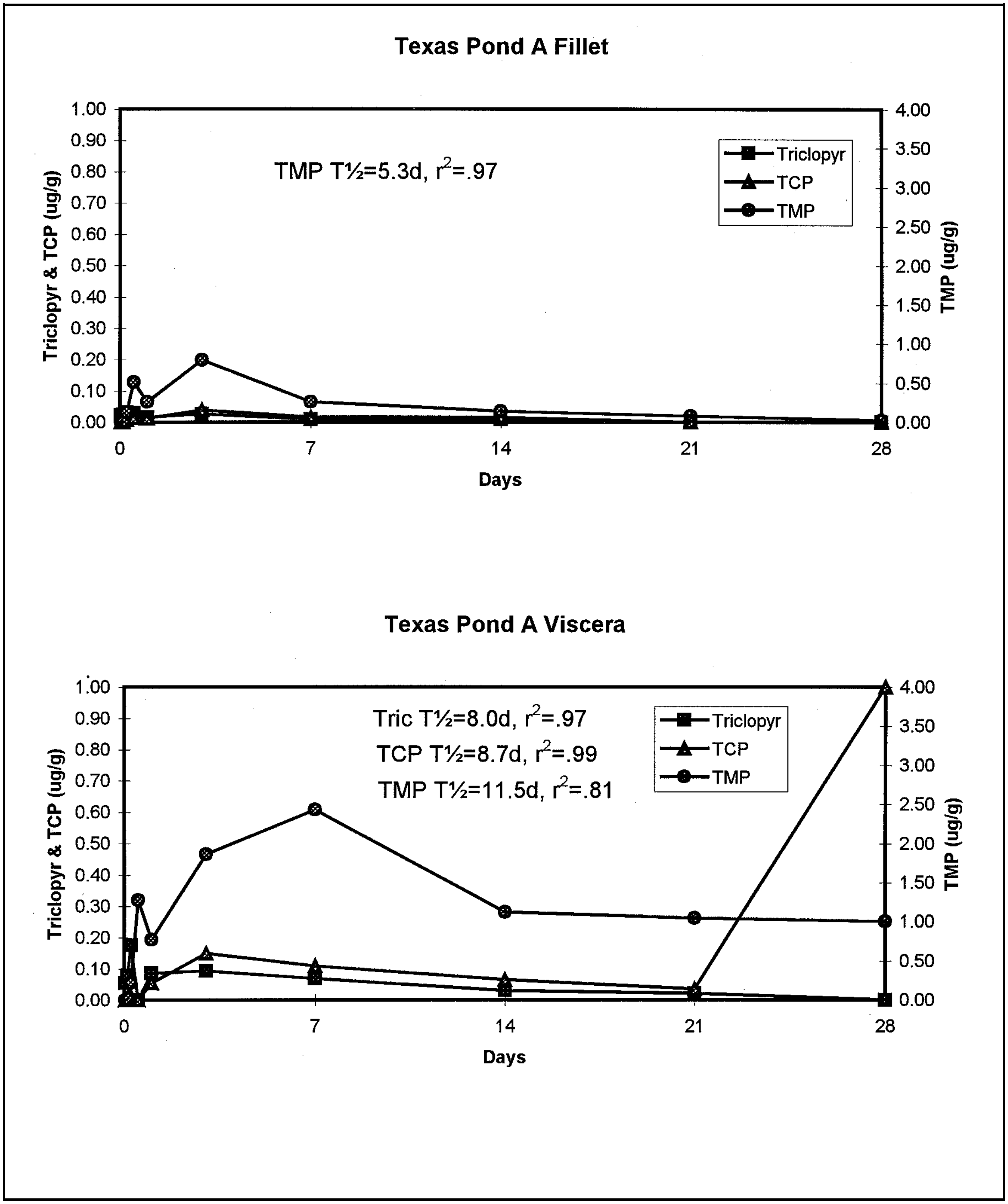


Figure 49. Dissipation of triclopyr, TCP, and TMP in bluegill fillet and viscera tissues from Pond A of the Lewisville, TX, study site

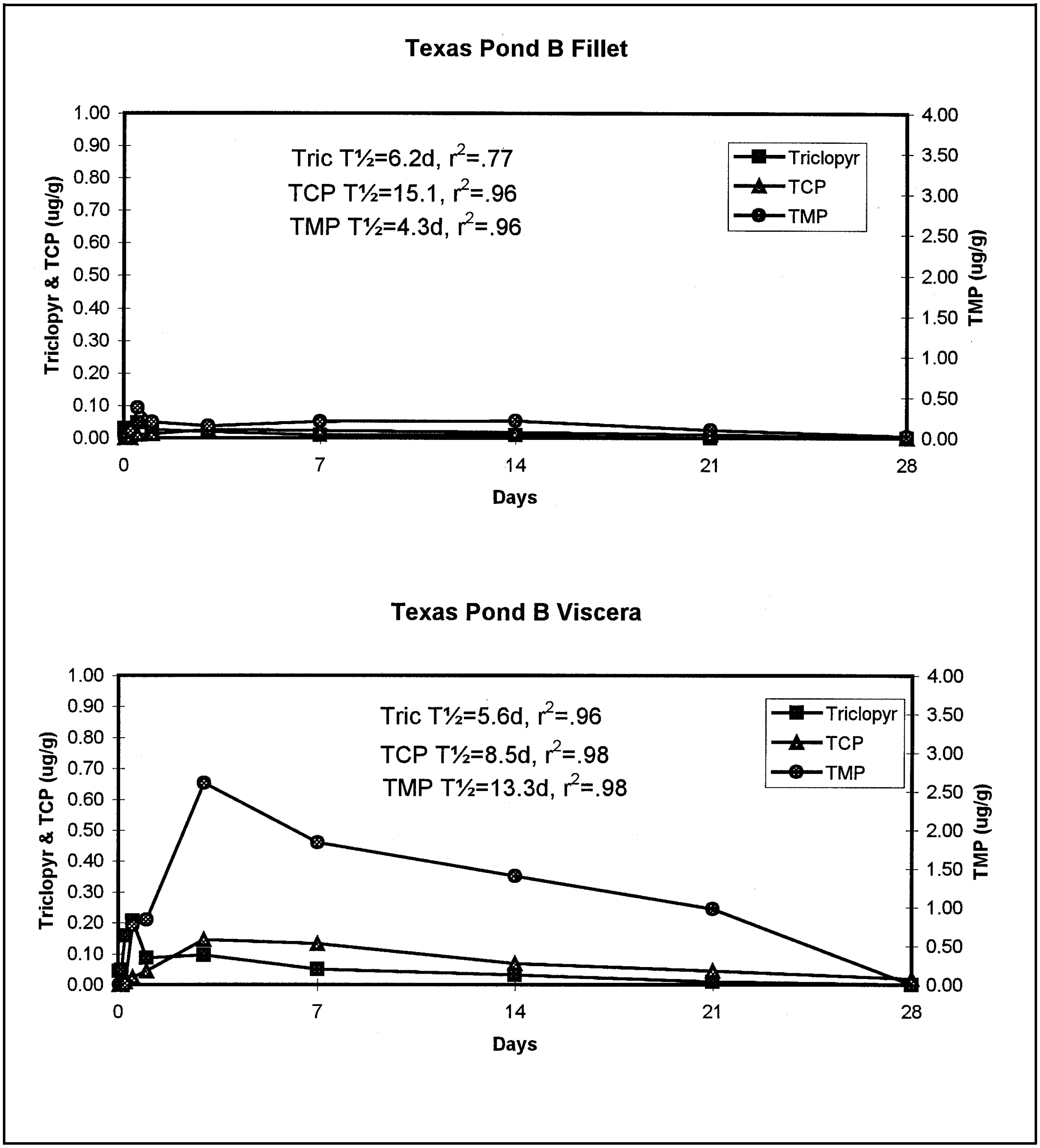


Figure 50. Dissipation of triclopyr, TCP, and TMP in bluegill fillet and viscera tissues from Pond B of the Lewisville, TX, study site

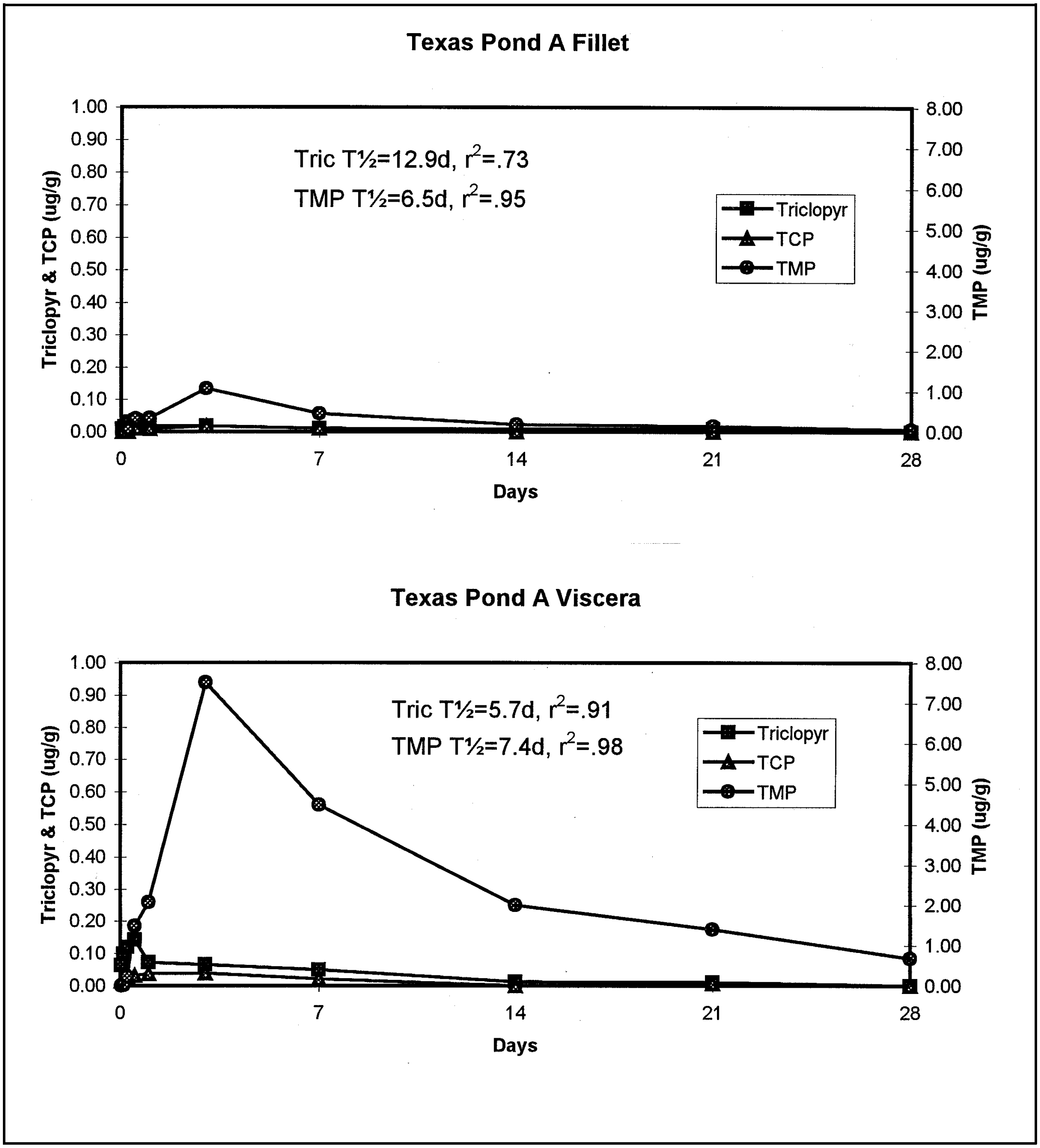


Figure 51. Dissipation of triclopyr, TCP, and TMP in catfish fillet and viscera tissues from Pond A of the Lewisville, TX, study site

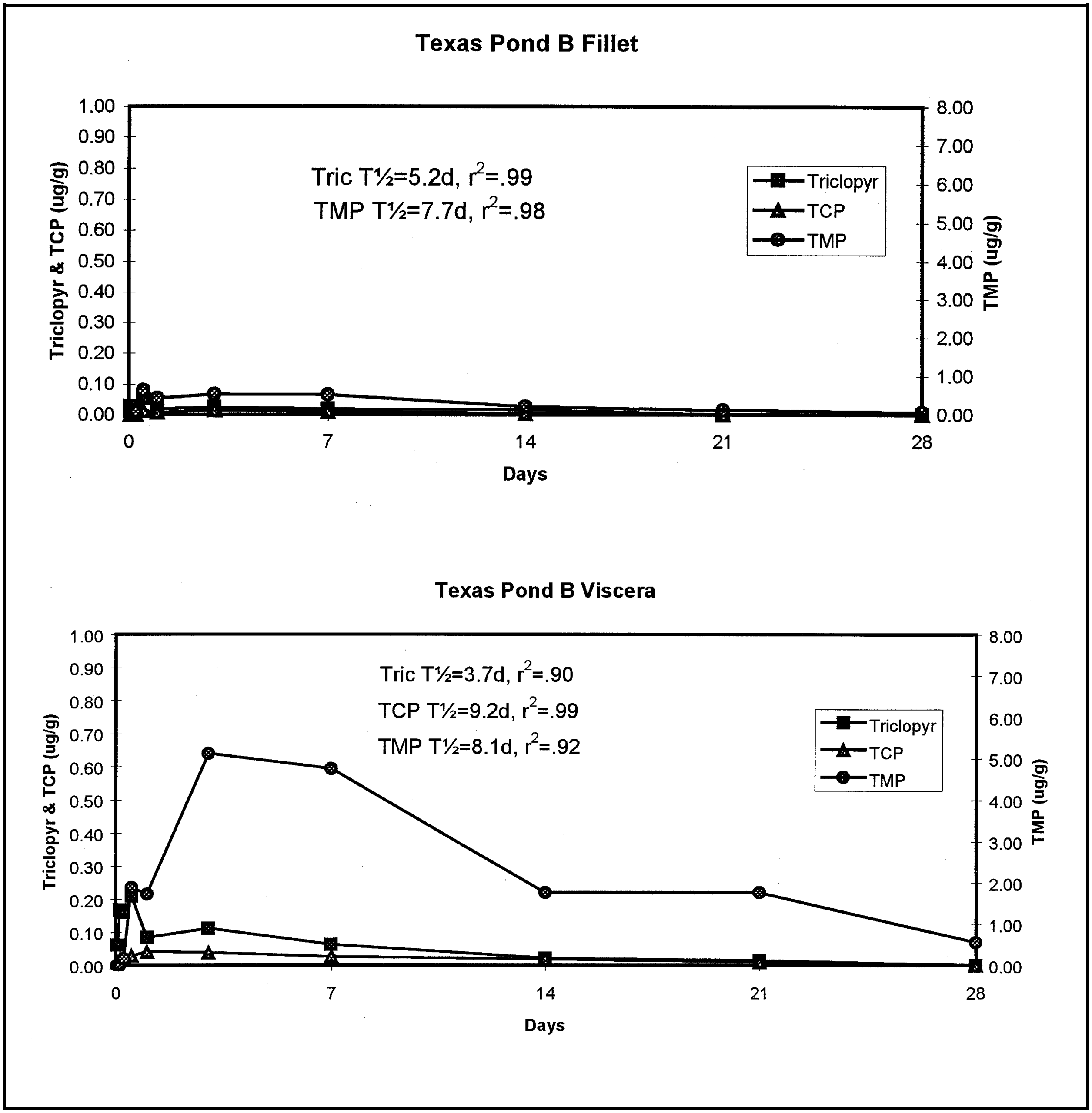


Figure 52. Dissipation of triclopyr, TCP, and TMP in catfish fillet and viscera tissues from Pond B of the Lewisville, TX, study site

4 Summary and Conclusions

Triclopyr, as the herbicide product Garlon 3A, applied to a whole-pond system readily degraded to its primary metabolites, TCP and TMP. These metabolites, along with the parent triclopyr, were temporarily sequestered by various matrices such as sediment and fish in relation to the quantities present in the water column. However, these compounds all dissipated quickly from all matrices examined. Concentration of these compounds in the water column was the driving force for accumulation in the other matrices.

Half-lives for triclopyr were somewhat longer in the closed ponds (water half-lives = 6.0 to 7.5 days) than in Lakes Minnetonka and Seminole and the Pend Orielle River (water half-lives = 2.2 to 4.7 days). This was expected, as there was no method of dilution of the material as in the open systems. In fact, rainfall amounts at the pond study sites were below average, resulting in less dilution than could be expected.

No adverse effects on water quality or on the nontarget biotic community were found following triclopyr applications. In several cases, water quality improved, or the biotic community increased, though this cannot necessarily be correlated to the triclopyr treatment.

Although photolysis via ultraviolet light can be a significant route of triclopyr degradation in the aquatic environment, the results of this study showed that UV wavelengths are quenched in the surface waters, though triclopyr degraded rapidly, possibly due to microbial action. This would indicate that a rapid decline of triclopyr would be observed in natural waters of various indices of light transmission.

Dissipation rates for triclopyr, TCP, and TMP were similar at each of the study sites (California, Missouri, Texas), despite differences in such variables as weather, water quality, biotic community, light transmission, and geographic location. The results of this study are also similar for studies conducted in reservoir, lake, and riverine systems in Georgia, Minnesota, and Washington. Based on these evaluations, it is predictable that the degradation of triclopyr and its metabolites would be similar throughout the continental United States.

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Appendix A
Summary of Average Residue Values from the Elk Grove, CA, Site

Matrix[1]	Pond	Sample Period	Date	Triclopyr	TCP	TMP
Water	A	Pre	25-Jul-95	ND	ND	ND
Water	A	1 Hr	26-Jul-95	2,086.750	12.000	0.443
Water	A	3 Hr	26-Jul-95	1,933.833	9.917	0.316
Water	A	6 Hr	26-Jul-95	1,729.583	10.000	0.275
Water	A	12 Hr	26-Jul-95	1,666.000	9.917	1.148
Water	A	1 Day	27-Jul-95	1,935.167	5.333	1.845
Water	A	2 Days	28-Jul-95	1,791.917	4.583	3.352
Water	A	3 Days	29-Jul-95	1,800.833	5.333	3.333
Water	A	5 Days	31-Jul-95	1,646.500	8.000	4.167
Water	A	1 Week	02-Aug-95	1,523.333	7.167	3.573
Water	A	2 Weeks	09-Aug-95	1,020.667	3.333	2.326
Water	A	3 Weeks	16-Aug-95	320.083	1.167	0.717
Water	A	4 Weeks	23-Aug-95	119.750	0.568	0.203
Water	A	6 Weeks	06-Sep-95	6.667	ND	ND
Water	A	12 Weeks	18-Oct-95	1.000	ND	ND
Water	B	Pre	25-Jul-95	ND	ND	ND
Water	B	1 Hr	26-Jul-95	2,517.667	17.333	0.180
Water	B	3 Hr	26-Jul-95	2,663.167	16.667	0.242
Water	B	6 Hr	26-Jul-95	2,188.833	14.833	0.263
Water	B	12 Hr	26-Jul-95	1,817.833	8.500	1.497
Water	B	1 Day	27-Jul-95	2,083.333	9.500	1.785
Water	B	2 Days	28-Jul-95	2,082.583	9.167	2.532
Water	B	3 Days	29-Jul-95	2,024.833	4.167	3.200
Water	B	5 Days	31-Jul-95	1,699.667	7.333	4.016
Water	B	1 Week	02-Aug-95	1,588.083	10.167	3.233
Water	B	2 Weeks	09-Aug-95	1,306.667	3.833	2.517
Water	B	3 Weeks	16-Aug-95	641.000	1.667	1.568
Water	B	4 Weeks	23-Aug-95	192.708	0.525	0.403
Water	B	6 Weeks	06-Sep-95	3.000	ND	ND
Water	B	12 Weeks	18-Oct-95	3.000	ND	ND
Water	C	Pre	25-Jul-95	ND	ND	ND
Water	C	1 Week	02-Aug-95	ND	ND	ND
Water	C	4 Weeks	23-Aug-95	ND	ND	ND

Note: ND = Nondetectable; NQ = Nonquantifiable.
[1] Water in nanograms per milliliter; all other matrices in micrograms per gram.

Matrix	Pond	Sample Period	Date	Tricolpyr	TCP	TMP
Sediment	A	Pre	25-Jul-95	ND	ND	
Sediment	A	6 Hr	26-Jul-95	0.196	NQ	ND
Sediment	A	12 Hr	26-Jul-95	0.388	0.018	ND
Sediment	A	1 Day	27-Jul-95	0.375	0.024	
Sediment	A	3 Days	29-Jul-95	0.680	0.084	ND
Sediment	A	1 Week	02-Aug-95	0.253	0.128	ND
Sediment	A	2 Weeks	09-Aug-95	0.061	0.032	ND
Sediment	A	3 Weeks	16-Aug-95	0.019	0.012	
Sediment	A	4 Weeks	23-Aug-95	ND	0.008	ND
Sediment	A	6 Weeks	06-Sep-95	ND	ND	
Sediment	A	12 Weeks	18-Oct-95	ND	ND	
Sediment	B	Pre	25-Jul-95	ND	ND	
Sediment	B	6 Hr	26-Jul-95	0.500	0.016	ND
Sediment	B	12 Hr	26-Jul-95	0.860	0.028	ND
Sediment	B	1 Day	27-Jul-95	0.684	0.038	ND
Sediment	B	3 Days	29-Jul-95	0.581	0.072	
Sediment	B	1 Week	02-Aug-95	0.520	0.154	ND
Sediment	B	2 Weeks	09-Aug-95	0.119	0.048	ND
Sediment	B	3 Weeks	16-Aug-95	0.039	0.016	
Sediment	B	4 Weeks	23-Aug-95	ND	ND	
Sediment	B	6 Weeks	06-Sep-95	ND	ND	
Sediment	B	12 Weeks	18-Oct-95	ND	ND	
Sediment	C	Pre	25-Jul-95	ND	ND	
Sediment	C	1 Week	02-Aug-95	ND	ND	ND
Sediment	C	4 Weeks	23-Aug-95	ND	ND	ND
Bluegill Fillet	A	Pre	25-Jul-95	ND	ND	ND
Bluegill Fillet	A	1 Hr	26-Jul-95	NQ	ND	NQ
Bluegill Fillet	A	3 Hr	26-Jul-95	NQ	ND	0.079
Bluegill Fillet	A	6 Hr	26-Jul-95			
Bluegill Fillet	A	12 Hr	26-Jul-95	0.032	ND	0.237
Bluegill Fillet	A	1 Day	27-Jul-95	0.025	ND	NQ
Bluegill Fillet	A	3 Days	29-Jul-95	NQ	0.016	0.114
Bluegill Fillet	A	1 Week	02-Aug-95	NQ	0.016	0.326
Bluegill Fillet	A	2 Weeks	09-Aug-95	ND	0.016	0.546
Bluegill Fillet	A	3 Weeks	16-Aug-95	ND	ND	0.206
Bluegill Fillet	A	4 Weeks	23-Aug-95	ND	ND	0.060

Matrix	Pond	Sample Period	Date	Triclopyr	TCP	TMP
Bluegill Fillet	B	Pre	25-Jul-95	ND	ND	ND
Bluegill Fillet	B	1 Hr	26-Jul-95	NQ	ND	NQ
Bluegill Fillet	B	3 Hr	26-Jul-95	0.020	ND	0.138
Bluegill Fillet	B	6 Hr	26-Jul-95	0.016	ND	0.161
Bluegill Fillet	B	12 Hr	26-Jul-95	0.037	NQ	0.376
Bluegill Fillet	B	1 Day	27-Jul-95	0.019	ND	NQ
Bluegill Fillet	B	3 Days	29-Jul-95	NQ	0.014	0.264
Bluegill Fillet	B	1 Week	02-Aug-95	NQ	0.015	0.789
Bluegill Fillet	B	2 Weeks	09-Aug-95	ND	0.022	0.927
Bluegill Fillet	B	3 Weeks	16-Aug-95	ND	NQ	0.082
Bluegill Fillet	B	4 Weeks	23-Aug-95	ND	ND	0.223
Bluegill Fillet	C	Pre	25-Jul-95	ND	ND	ND
Bluegill Fillet	C	1 Week	02-Aug-95	ND	ND	ND
Bluegill Fillet	C	4 Weeks	23-Aug-95			
Bluegill Viscera	A	Pre	25-Jul-95	ND	ND	ND
Bluegill Viscera	A	1 Hr	26-Jul-95	0.063	ND	NQ
Bluegill Viscera	A	3 Hr	26-Jul-95	0.167	0.008	0.143
Bluegill Viscera	A	6 Hr	26-Jul-95	0.128	0.025	0.355
Bluegill Viscera	A	12 Hr	26-Jul-95	0.139	0.036	0.984
Bluegill Viscera	A	1 Day	27-Jul-95	0.192	0.023	0.024
Bluegill Viscera	A	3 Days	29-Jul-95	0.107	0.220	0.663
Bluegill Viscera	A	1 Week	02-Aug-95	0.092	0.149	2.108
Bluegill Viscera	A	2 Weeks	09-Aug-95	0.071	0.287	3.379
Bluegill Viscera	A	3 Weeks	16-Aug-95	0.021	0.108	0.732
Bluegill Viscera	A	4 Weeks	23-Aug-95	ND	0.042	0.120

Matrix	Pond	Sample Period	Date	Triclopyr	TCP	TMP
Bluegill Viscera	B	Pre	25-Jul-95	ND	ND	ND
Bluegill Viscera	B	1 Hr	26-Jul-95	0.088	ND	0.029
Bluegill Viscera	B	3 Hr	26-Jul-95	0.143	0.015	0.324
Bluegill Viscera	B	6 Hr	26-Jul-95	0.184	0.026	0.593
Bluegill Viscera	B	12 Hr	26-Jul-95	0.028	0.155	0.933
Bluegill Viscera	B	1 Day	27-Jul-95	ND	ND	0.072
Bluegill Viscera	B	3 Days	29-Jul-95	0.084	0.141	1.090
Bluegill Viscera	B	1 Week	02-Aug-95	0.066	0.167	3.771
Bluegill Viscera	B	2 Weeks	09-Aug-95	0.084	0.161	3.421
Bluegill Viscera	B	3 Weeks	16-Aug-95	0.029	0.077	0.083
Bluegill Viscera	B	4 Weeks	23-Aug-95	0.012	0.079	0.765
Bluegill Viscera	C	Pre	25-Jul-95	ND	ND	ND
Bluegill Viscera	C	1 Week	02-Aug-95	ND	ND	ND
Bluegill Viscera	C	4 Weeks	23-Aug-95			
Catfish Fillet	A	Pre	25-Jul-95	ND	ND	ND
Catfish Fillet	A	1 Hr	26-Jul-95	NQ	ND	0.131
Catfish Fillet	A	3 Hr	26-Jul-95	NQ	ND	ND
Catfish Fillet	A	6 Hr	26-Jul-95	NQ	ND	0.086
Catfish Fillet	A	12 Hr	26-Jul-95	NQ	NQ	0.227
Catfish Fillet	A	1 Day	27-Jul-95	ND	NQ	0.558
Catfish Fillet	A	3 Days	29-Jul-95	ND	NQ	0.725
Catfish Fillet	A	1 Week	02-Aug-95	ND	NQ	0.288
Catfish Fillet	A	2 Weeks	09-Aug-95	ND	ND	0.361
Catfish Fillet	A	3 Weeks	16-Aug-95	ND	ND	0.221
Catfish Fillet	A	4 Weeks	23-Aug-95	ND	ND	0.940
Catfish Fillet	B	Pre	25-Jul-95	ND	ND	ND
Catfish Fillet	B	1 Hr	26-Jul-95	NQ	ND	0.068
Catfish Fillet	B	3 Hr	26-Jul-95	NQ	NQ	NQ
Catfish Fillet	B	6 Hr	26-Jul-95	NQ	ND	0.054
Catfish Fillet	B	12 Hr	26-Jul-95	ND	NQ	0.126
Catfish Fillet	B	1 Day	27-Jul-95	ND	NQ	0.646
Catfish Fillet	B	3 Days	29-Jul-95	NQ	NQ	0.758
Catfish Fillet	B	1 Week	02-Aug-95	NQ	NQ	0.841
Catfish Fillet	B	2 Weeks	09-Aug-95	NQ	ND	0.251
Catfish Fillet	B	3 Weeks	16-Aug-95	ND	ND	0.519
Catfish Fillet	B	4 Weeks	23-Aug-95	ND	ND	0.269

Matrix	Pond	Sample Period	Date	Triclopyr	TCP	TMP
Catfish Fillet	C	Pre	25-Jul-95	ND	ND	ND
Catfish Fillet	C	1 Week	02-Aug-95	ND	ND	ND
Catfish Fillet	C	4 Weeks	23-Aug-95	ND	ND	ND
Catfish Viscera	A	Pre	25-Jul-95	ND	ND	ND
Catfish Viscera	A	1 Hr	26-Jul-95			
Catfish Viscera	A	3 Hr	26-Jul-95	0.053	0.020	ND
Catfish Viscera	A	6 Hr	26-Jul-95	0.032	0.026	0.082
Catfish Viscera	A	12 Hr	26-Jul-95	0.048	0.072	0.422
Catfish Viscera	A	1 Day	27-Jul-95	0.029	0.028	0.714
Catfish Viscera	A	3 Days	29-Jul-95	ND	0.048	1.082
Catfish Viscera	A	1 Week	02-Aug-95	0.039	0.076	0.371
Catfish Viscera	A	2 Weeks	09-Aug-95	0.025	0.061	0.593
Catfish Viscera	A	3 Weeks	16-Aug-95	NQ	0.022	0.347
Catfish Viscera	A	4 Weeks	23-Aug-95	0.065	ND	0.372
Catfish Viscera	B	Pre	25-Jul-95	ND	ND	ND
Catfish Viscera	B	1 Hr	26-Jul-95	0.035	NQ	ND
Catfish Viscera	B	3 Hr	26-Jul-95	0.041	0.034	NQ
Catfish Viscera	B	6 Hr	26-Jul-95	ND	0.040	0.103
Catfish Viscera	B	12 Hr	26-Jul-95	0.033	0.040	0.133
Catfish Viscera	B	1 Day	27-Jul-95	ND	0.061	1.121
Catfish Viscera	B	3 Days	29-Jul-95	0.035	0.103	0.872
Catfish Viscera	B	1 Week	02-Aug-95	0.047	0.087	1.595
Catfish Viscera	B	2 Weeks	09-Aug-95	0.029	0.105	0.478
Catfish Viscera	B	3 Weeks	16-Aug-95	NQ	0.036	1.371
Catfish Viscera	B	4 Weeks	23-Aug-95	NQ	NQ	0.591
Catfish Viscera	C	Pre	25-Jul-95	NQ	ND	ND
Catfish Viscera	C	1 Week	02-Aug-95	ND	ND	ND
Catfish Viscera	C	4 Weeks	23-Aug-95	NQ	NQ	ND

Appendix B
Summary of Average Residue Values from the Columbia, MO, Site

Matrix[1]	Pond	Sample Period	Date	Triclopyr	TCP	TMP
Water	A	Pre	05-Jun-95	ND	ND	ND
Water	A	1 Hr	06-Jun-95	1,816.417	10.500	ND
Water	A	3 Hr	06-Jun-95	1,664.167	3.667	0.328
Water	A	6 Hr	06-Jun-95	2,288.167	4.167	3.023
Water	A	12 Hr	06-Jun-95	2,505.333	3.250	4.817
Water	A	1 Day	07-Jun-95	2,798.667	5.417	4.997
Water	A	2 Days	08-Jun-95	2,466.917	4.167	5.153
Water	A	3 Days	09-Jun-95	1,908.833	3.528	6.262
Water	A	5 Days	11-Jun-95	1,712.167	3.000	6.793
Water	A	1 Week	13-Jun-95	1,407.000	7.000	6.145
Water	A	2 Weeks	20-Jun-95	732.833	3.600	4.117
Water	A	3 Weeks	27-Jun-95	227.667	1.052	1.122
Water	A	4 Weeks	05-Jul-95	67.167	NQ	0.340
Water	A	6 Weeks	18-Jul-95	7.167	ND	ND
Water	A	12 Weeks	29-Aug-95	0.230	ND	ND
Water	B	Pre	05-Jun-95	ND	ND	ND
Water	B	1 Hr	06-Jun-95	1,169.750	3.500	0.092
Water	B	3 Hr	06-Jun-95	1,976.667	2.500	1.022
Water	B	6 Hr	06-Jun-95	2,281.000	2.167	4.633
Water	B	12 Hr	06-Jun-95	2,225.600	2.167	5.997
Water	B	1 Day	07-Jun-95	2,345.000	2.500	5.290
Water	B	2 Days	08-Jun-95	1,748.500	3.083	5.617
Water	B	3 Days	09-Jun-95	1,485.667	1.917	7.358
Water	B	5 Days	11-Jun-95	1,386.000	1.833	6.165
Water	B	1 Week	13-Jun-95	1,044.667	3.667	6.772
Water	B	2 Weeks	20-Jun-95	502.333	1.833	4.167
Water	B	3 Weeks	27-Jun-95	136.500	0.703	0.922
Water	B	4 Weeks	05-Jul-95	31.750	ND	0.158
Water	B	6 Weeks	18-Jul-95	4.000	ND	ND
Water	B	12 Weeks	29-Aug-95	0.302	ND	ND
Water	C	Pre	05-Jun-95	ND	ND	ND
Water	C	1 Week	13-Jun-95	ND	ND	ND
Water	C	4 Weeks	05-Jul-95	ND	ND	ND

Note: ND = Nondetectable; NQ = Nonquantifiable.
[1] Water in nanograms per milliliter; all other matrices in micrograms per gram.

Matrix	Pond	Sample Period	Date	Triclopyr	TCP	TMP
Sediment	A	Pre	05-Jun-95	ND	ND	
Sediment	A	6 Hr	06-Jun-95	0.025	ND	
Sediment	A	12 Hr	06-Jun-95	0.020	ND	ND
Sediment	A	1 Day	07-Jun-95	0.090	0.009	
Sediment	A	3 Days	09-Jun-95	0.102	0.019	ND
Sediment	A	1 Week	13-Jun-95	0.173	0.063	ND
Sediment	A	2 Weeks	20-Jun-95	0.018	0.071	
Sediment	A	3 Weeks	27-Jun-95	NQ	0.032	ND
Sediment	A	4 Weeks	05-Jul-95	ND	0.015	
Sediment	A	6 Weeks	18-Jul-95	ND	ND	ND
Sediment	A	12 Weeks	29-Aug-95	ND	ND	
Sediment	B	Pre	05-Jun-95	ND	ND	
Sediment	B	6 Hr	06-Jun-95	0.021	ND	ND
Sediment	B	12 Hr	06-Jun-95	0.021	ND	ND
Sediment	B	1 Day	07-Jun-95	0.080	NQ	
Sediment	B	3 Days	09-Jun-95	0.073	0.012	ND
Sediment	B	1 Week	13-Jun-95	0.075	0.041	ND
Sediment	B	2 Weeks	20-Jun-95	NQ	0.085	
Sediment	B	3 Weeks	27-Jun-95	NQ	0.017	
Sediment	B	4 Weeks	05-Jul-95	ND	0.013	
Sediment	B	6 Weeks	18-Jul-95	ND	NQ	ND
Sediment	B	12 Weeks	29-Aug-95	ND	ND	
Sediment	C	Pre	05-Jun-95	ND	ND	
Sediment	C	1 Week	13-Jun-95	ND	ND	
Sediment	C	4 Weeks	05-Jul-95	ND	ND	
Bluegill Fillet	A	Pre	05-Jun-95	ND	ND	ND
Bluegill Fillet	A	1 Hr	06-Jun-95	0.050	ND	ND
Bluegill Fillet	A	3 Hr	06-Jun-95	0.021	ND	NQ
Bluegill Fillet	A	6 Hr	06-Jun-95	0.048	ND	0.048
Bluegill Fillet	A	12 Hr	06-Jun-95	NQ	ND	0.114
Bluegill Fillet	A	1 Day	07-Jun-95	0.026	NQ	0.134
Bluegill Fillet	A	3 Days	09-Jun-95	NQ	0.023	0.551
Bluegill Fillet	A	1 Week	13-Jun-95	NQ	0.024	0.524
Bluegill Fillet	A	2 Weeks	20-Jun-95	ND	NQ	0.665
Bluegill Fillet	A	3 Weeks	27-Jun-95	ND	ND	0.197
Bluegill Fillet	A	4 Weeks	05-Jul-95	ND	ND	0.084

Matrix	Pond	Sample Period	Date	Triclopyr	TCP	TMP
Bluegill Fillet	B	Pre	05-Jun-95	ND	ND	ND
Bluegill Fillet	B	1 Hr	06-Jun-95	0.036	ND	ND
Bluegill Fillet	B	3 Hr	06-Jun-95	0.022	ND	0.032
Bluegill Fillet	B	6 Hr	06-Jun-95	0.020	ND	0.109
Bluegill Fillet	B	12 Hr	06-Jun-95	ND	ND	0.207
Bluegill Fillet	B	1 Day	07-Jun-95	0.014	NQ	0.286
Bluegill Fillet	B	3 Days	09-Jun-95	0.017	0.025	0.330
Bluegill Fillet	B	1 Week	13-Jun-95	0.014	0.043	0.522
Bluegill Fillet	B	2 Weeks	20-Jun-95	ND	0.019	0.298
Bluegill Fillet	B	3 Weeks	27-Jun-95	ND	ND	0.052
Bluegill Fillet	B	4 Weeks	05-Jul-95	ND	ND	0.043
Bluegill Fillet	C	Pre	05-Jun-95	ND	ND	ND
Bluegill Fillet	C	1 Week	13-Jun-95	ND	ND	ND
Bluegill Fillet	C	4 Weeks	05-Jul-95	ND	ND	ND
Bluegill Viscera	A	Pre	05-Jun-95	ND	ND	ND
Bluegill Viscera	A	1 Hr	06-Jun-95	0.135	0.008	ND
Bluegill Viscera	A	3 Hr	06-Jun-95	0.083	NQ	NQ
Bluegill Viscera	A	6 Hr	06-Jun-95	0.205	0.023	0.126
Bluegill Viscera	A	12 Hr	06-Jun-95	0.161	0.041	0.269
Bluegill Viscera	A	1 Day	07-Jun-95	0.243	0.088	0.418
Bluegill Viscera	A	3 Days	09-Jun-95	0.296	0.222	0.815
Bluegill Viscera	A	1 Week	13-Jun-95	0.141	0.193	0.975
Bluegill Viscera	A	2 Weeks	20-Jun-95	0.057	0.153	1.819
Bluegill Viscera	A	3 Weeks	27-Jun-95	0.034	0.071	0.774
Bluegill Viscera	A	4 Weeks	05-Jul-95	0.013	0.029	0.284
Bluegill Viscera	B	Pre	05-Jun-95	ND	ND	ND
Bluegill Viscera	B	1 Hr	06-Jun-95	0.109	ND	ND
Bluegill Viscera	B	3 Hr	06-Jun-95	0.110	0.008	0.034
Bluegill Viscera	B	6 Hr	06-Jun-95	0.120	0.022	0.261
Bluegill Viscera	B	12 Hr	06-Jun-95	0.183	0.056	0.520
Bluegill Viscera	B	1 Day	07-Jun-95	0.152	0.113	0.551
Bluegill Viscera	B	3 Days	09-Jun-95	0.224	0.201	0.613
Bluegill Viscera	B	1 Week	13-Jun-95	0.201	0.320	0.000
Bluegill Viscera	B	2 Weeks	20-Jun-95	0.052	0.138	0.724
Bluegill Viscera	B	3 Weeks	27-Jun-95	0.016	0.037	0.231
Bluegill Viscera	B	4 Weeks	05-Jul-95	0.017	0.017	0.116

Matrix	Pond	Sample Period	Date	Triclopyr	TCP	TMP
Bluegill Viscera	C	Pre	05-Jun-95	ND	ND	ND
Bluegill Viscera	C	1 Week	13-Jun-95	ND	ND	ND
Bluegill Viscera	C	4 Weeks	05-Jul-95	0.013	ND	ND
Catfish Fillet	A	Pre	05-Jun-95	ND	ND	ND
Catfish Fillet	A	1 Hr	06-Jun-95	0.016	ND	ND
Catfish Fillet	A	3 Hr	06-Jun-95	NQ	ND	NQ
Catfish Fillet	A	6 Hr	06-Jun-95	0.018	ND	0.194
Catfish Fillet	A	12 Hr	06-Jun-95	NQ	ND	0.787
Catfish Fillet	A	1 Day	07-Jun-95	NQ	NQ	1.367
Catfish Fillet	A	3 Days	09-Jun-95	NQ	NQ	1.169
Catfish Fillet	A	1 Week	13-Jun-95	NQ	NQ	1.992
Catfish Fillet	A	2 Weeks	20-Jun-95	ND	NQ	2.062
Catfish Fillet	A	3 Weeks	27-Jun-95	ND	ND	0.621
Catfish Fillet	A	4 Weeks	05-Jul-95	ND	ND	0.246
Catfish Fillet	B	Pre	05-Jun-95	ND	ND	ND
Catfish Fillet	B	1 Hr	06-Jun-95	0.025	ND	ND
Catfish Fillet	B	3 Hr	06-Jun-95	0.016	ND	0.118
Catfish Fillet	B	6 Hr	06-Jun-95	ND	ND	0.116
Catfish Fillet	B	12 Hr	06-Jun-95	NQ	ND	0.645
Catfish Fillet	B	1 Day	07-Jun-95	NQ	NQ	1.184
Catfish Fillet	B	3 Days	09-Jun-95	ND	NQ	1.734
Catfish Fillet	B	1 Week	13-Jun-95	ND	NQ	2.941
Catfish Fillet	B	2 Weeks	20-Jun-95	ND	0.012	1.226
Catfish Fillet	B	3 Weeks	27-Jun-95	ND	ND	0.460
Catfish Fillet	B	4 Weeks	05-Jul-95	ND	ND	0.206
Catfish Fillet	C	Pre	05-Jun-95	ND	ND	ND
Catfish Fillet	C	1 Week	13-Jun-95	ND	ND	ND
Catfish Fillet	C	4 Weeks	05-Jul-95	ND	ND	ND

Matrix	Pond	Sample Period	Date	Triclopyr	TCP	TMP
Catfish Viscera	A	Pre	05-Jun-95	ND	ND	ND
Catfish Viscera	A	1 Hr	06-Jun-95	0.049	0.017	ND
Catfish Viscera	A	3 Hr	06-Jun-95	0.078	0.008	0.017
Catfish Viscera	A	6 Hr	06-Jun-95	0.076	0.016	0.180
Catfish Viscera	A	12 Hr	06-Jun-95	0.083	0.055	1.363
Catfish Viscera	A	1 Day	07-Jun-95	0.136	0.022	1.980
Catfish Viscera	A	3 Days	09-Jun-95	0.048	0.026	3.003
Catfish Viscera	A	1 Week	13-Jun-95	0.049	0.032	3.219
Catfish Viscera	A	2 Weeks	20-Jun-95	0.027	0.031	5.022
Catfish Viscera	A	3 Weeks	27-Jun-95	NQ	NQ	1.084
Catfish Viscera	A	4 Weeks	05-Jul-95	0.021	ND	0.569
Catfish Viscera	B	Pre	05-Jun-95	ND	ND	ND
Catfish Viscera	B	1 Hr	06-Jun-95	0.049	NQ	ND
Catfish Viscera	B	3 Hr	06-Jun-95	0.049	NQ	0.039
Catfish Viscera	B	6 Hr	06-Jun-95	0.039	NQ	0.281
Catfish Viscera	B	12 Hr	06-Jun-95	0.047	NQ	0.859
Catfish Viscera	B	1 Day	07-Jun-95	0.084	0.015	1.175
Catfish Viscera	B	3 Days	09-Jun-95	0.042	0.030	2.377
Catfish Viscera	B	1 Week	13-Jun-95	0.034	0.029	5.078
Catfish Viscera	B	2 Weeks	20-Jun-95	0.027	0.024	2.548
Catfish Viscera	B	3 Weeks	27-Jun-95	ND	NQ	1.878
Catfish Viscera	B	4 Weeks	05-Jul-95	NQ	ND	0.502
Catfish Viscera	C	Pre	05-Jun-95	ND	ND	ND
Catfish Viscera	C	1 Week	13-Jun-95	ND	ND	ND
Catfish Viscera	C	4 Weeks	05-Jul-95	NQ	ND	ND

Appendix C
Summary of Average Residue Values from the Lewisville, TX, Site

Matrix[1]	Pond	Sample Period	Date	Triclopyr	TCP	TMP
Water	A	Pre	22-May-95	ND	ND	ND
Water	A	1 Hr	31-May-95	1,830.500	11.167	ND
Water	A	3 Hr	31-May-95	2,384.167	13.583	0.393
Water	A	6 Hr	31-May-95	2,310.083	13.333	1.977
Water	A	12 Hr	31-May-95	2,389.083	14.417	3.540
Water	A	1 Day	01-Jun-95	2,153.667	13.083	3.935
Water	A	2 Days	02-Jun-95	1,907.333	15.417	7.178
Water	A	3 Days	03-Jun-95	1,788.167	8.583	7.215
Water	A	5 Days	05-Jun-95	1,500.917	4.750	5.162
Water	A	1 Week	07-Jun-95	1,314.000	4.750	4.577
Water	A	2 Weeks	14-Jun-95	597.667	1.833	3.232
Water	A	3 Weeks	21-Jun-95	220.083	1.000	1.452
Water	A	4 Weeks	28-Jun-95	85.500	1.000	0.497
Water	A	6 Weeks	12-Jul-95	9.167	ND	NQ
Water	A	12 Weeks	31-Aug-95	0.190	ND	ND
Water	B	Pre	22-May-95	ND	ND	ND
Water	B	1 Hr	31-May-95	1,882.000	21.667	ND
Water	B	3 Hr	31-May-95	2,054.167	16.000	0.145
Water	B	6 Hr	31-May-95	2,743.000	19.500	1.086
Water	B	12 Hr	31-May-95	2,361.000	14.833	3.862
Water	B	1 Day	01-Jun-95	2,152.500	20.167	3.358
Water	B	2 Days	02-Jun-95	2,262.833	12.167	6.828
Water	B	3 Days	03-Jun-95	1,922.833	10.000	5.393
Water	B	5 Days	05-Jun-95	1,624.000	8.000	4.382
Water	B	1 Week	07-Jun-95	1,331.833	6.833	4.811
Water	B	2 Weeks	14-Jun-95	566.333	2.167	3.218
Water	B	3 Weeks	21-Jun-95	192.333	1.167	1.843
Water	B	4 Weeks	28-Jun-95	70.250	NQ	0.412
Water	B	6 Weeks	12-Jul-95	6.333	ND	NQ
Water	B	12 Weeks	31-Aug-95	0.169	ND	ND
Water	C	Pre	22-May-95	ND	ND	ND
Water	C	1 Week	07-Jun-95	ND	ND	ND
Water	C	4 Weeks	28-Jun-95	ND	ND	ND

Note: ND = Nondetectable; NQ = Nonquantifiable.
[1] Water in nanograms per milliliter; all other matrices in micrograms per gram.

Matrix	Pond	Sample Period	Date	Triclopyr	TCP	TMP
Sediment	A	Pre	22-May-95	ND	ND	
Sediment	A	6 Hr	31-May-95	0.152	ND	
Sediment	A	12 Hr	31-May-95	0.135	0.011	ND
Sediment	A	1 Day	01-Jun-95	0.264	0.015	ND
Sediment	A	3 Days	03-Jun-95	0.261	0.059	
Sediment	A	1 Week	07-Jun-95	0.210	0.131	ND
Sediment	A	2 Weeks	14-Jun-95	0.069	0.134	
Sediment	A	3 Weeks	21-Jun-95	NQ	0.085	
Sediment	A	4 Weeks	28-Jun-95	NQ	0.033	
Sediment	A	6 Weeks	12-Jul-95	ND	0.014	
Sediment	A	12 Weeks	31-Aug-95	ND	ND	
Sediment	B	Pre	22-May-95	ND	ND	ND
Sediment	B	6 Hr	31-May-95	0.211	NQ	ND
Sediment	B	12 Hr	31-May-95	0.213	0.014	ND
Sediment	B	1 Day	01-Jun-95	0.453	0.020	ND
Sediment	B	3 Days	03-Jun-95	0.363	0.066	ND
Sediment	B	1 Week	07-Jun-95	0.320	0.159	
Sediment	B	2 Weeks	14-Jun-95	0.097	0.108	
Sediment	B	3 Weeks	21-Jun-95	0.023	0.057	
Sediment	B	4 Weeks	28-Jun-95	NQ	0.022	
Sediment	B	6 Weeks	12-Jul-95	ND	NQ	
Sediment	B	12 Weeks	31-Aug-95	ND	ND	
Sediment	C	Pre	22-May-95	ND	ND	
Sediment	C	1 Week	07-Jun-95	ND	ND	
Sediment	C	4 Weeks	28-Jun-95	ND	ND	ND
Bluegill Fillet	A	Pre	22-May-95	ND	ND	ND
Bluegill Fillet	A	1 Hr	31-May-95	0.022	ND	ND
Bluegill Fillet	A	3 Hr	31-May-95	0.025	ND	NQ
Bluegill Fillet	A	6 Hr	31-May-95	0.031	NQ	0.124
Bluegill Fillet	A	12 Hr	31-May-95	0.029	0.014	0.510
Bluegill Fillet	A	1 Day	01-Jun-95	0.016	NQ	0.260
Bluegill Fillet	A	3 Days	03-Jun-95	0.026	0.039	0.792
Bluegill Fillet	A	1 Week	07-Jun-95	NQ	0.015	0.257
Bluegill Fillet	A	2 Weeks	14-Jun-95	NQ	0.017	0.140
Bluegill Fillet	A	3 Weeks	21-Jun-95	ND	ND	0.074
Bluegill Fillet	A	4 Weeks	28-Jun-95	ND	ND	0.021

Matrix	Pond	Sample Period	Date	Triclopyr	TCP	TMP
Bluegill Fillet	B	Pre	22-May-95	ND	ND	ND
Bluegill Fillet	B	1 Hr	31-May-95	0.029	ND	ND
Bluegill Fillet	B	3 Hr	31-May-95	0.015	ND	ND
Bluegill Fillet	B	6 Hr	31-May-95	0.028	ND	0.074
Bluegill Fillet	B	12 Hr	31-May-95	0.047	NQ	0.369
Bluegill Fillet	B	1 Day	01-Jun-95	0.027	NQ	0.198
Bluegill Fillet	B	3 Days	03-Jun-95	0.019	0.026	0.149
Bluegill Fillet	B	1 Week	07-Jun-95	NQ	0.022	0.202
Bluegill Fillet	B	2 Weeks	14-Jun-95	NQ	0.018	0.208
Bluegill Fillet	B	3 Weeks	21-Jun-95	ND	NQ	0.099
Bluegill Fillet	B	4 Weeks	28-Jun-95	ND	ND	0.022
Bluegill Fillet	C	Pre	22-May-95	ND	ND	ND
Bluegill Fillet	C	1 Week	07-Jun-95	ND	ND	ND
Bluegill Fillet	C	4 Weeks	28-Jun-95	ND	ND	ND
Bluegill Viscera	A	Pre	22-May-95	ND	ND	ND
Bluegill Viscera	A	1 Hr	31-May-95	0.054	ND	ND
Bluegill Viscera	A	3 Hr	31-May-95	0.078	0.008	NQ
Bluegill Viscera	A	6 Hr	31-May-95	0.176	0.012	0.218
Bluegill Viscera	A	12 Hr	31-May-95	0.000	ND	1.273
Bluegill Viscera	A	1 Day	01-Jun-95	0.086	0.055	0.774
Bluegill Viscera	A	3 Days	03-Jun-95	0.093	0.149	1.860
Bluegill Viscera	A	1 Week	07-Jun-95	0.068	0.109	2.434
Bluegill Viscera	A	2 Weeks	14-Jun-95	0.029	0.065	1.121
Bluegill Viscera	A	3 Weeks	21-Jun-95	0.021	0.035	1.043
Bluegill Viscera	A	4 Weeks	28-Jun-95	ND	1.000	1.000
Bluegill Viscera	B	Pre	22-May-95	ND	ND	ND
Bluegill Viscera	B	1 Hr	31-May-95	0.044	ND	ND
Bluegill Viscera	B	3 Hr	31-May-95	0.048	ND	ND
Bluegill Viscera	B	6 Hr	31-May-95	0.158	0.009	ND
Bluegill Viscera	B	12 Hr	31-May-95	0.205	0.023	0.764
Bluegill Viscera	B	1 Day	01-Jun-95	0.087	0.044	0.838
Bluegill Viscera	B	3 Days	03-Jun-95	0.095	0.146	2.611
Bluegill Viscera	B	1 Week	07-Jun-95	0.050	0.132	1.838
Bluegill Viscera	B	2 Weeks	14-Jun-95	0.032	0.069	1.402
Bluegill Viscera	B	3 Weeks	21-Jun-95	NQ	0.045	0.975
Bluegill Viscera	B	4 Weeks	28-Jun-95	ND	0.019	ND

Matrix	Pond	Sample Period	Date	Triclopyr	TCP	TMP
Bluegill Viscera	C	Pre	22-May-95	ND	ND	ND
Bluegill Viscera	C	1 Week	07-Jun-95	ND	ND	ND
Bluegill Viscera	C	4 Weeks	28-Jun-95	ND	ND	ND
Catfish Fillet	A	Pre	22-May-95	ND	ND	ND
Catfish Fillet	A	1 Hr	31-May-95	NQ	ND	NQ
Catfish Fillet	A	3 Hr	31-May-95	0.016	ND	ND
Catfish Fillet	A	6 Hr	31-May-95	0.029	ND	0.070
Catfish Fillet	A	12 Hr	31-May-95	0.033	NQ	0.326
Catfish Fillet	A	1 Day	01-Jun-95	0.017	NQ	0.338
Catfish Fillet	A	3 Days	03-Jun-95	0.017	NQ	1.069
Catfish Fillet	A	1 Week	07-Jun-95	NQ	NQ	0.451
Catfish Fillet	A	2 Weeks	14-Jun-95	NQ	ND	0.187
Catfish Fillet	A	3 Weeks	21-Jun-95	NQ	ND	0.145
Catfish Fillet	A	4 Weeks	28-Jun-95	ND	ND	0.060
Catfish Fillet	B	Pre	22-May-95	ND	ND	ND
Catfish Fillet	B	1 Hr	31-May-95	0.028	ND	ND
Catfish Fillet	B	3 Hr	31-May-95	NQ	ND	ND
Catfish Fillet	B	6 Hr	31-May-95	0.028	ND	0.059
Catfish Fillet	B	12 Hr	31-May-95	0.053	NQ	0.629
Catfish Fillet	B	1 Day	01-Jun-95	0.019	NQ	0.433
Catfish Fillet	B	3 Days	03-Jun-95	0.024	NQ	0.536
Catfish Fillet	B	1 Week	07-Jun-95	0.018	NQ	0.519
Catfish Fillet	B	2 Weeks	14-Jun-95	0.017	ND	0.204
Catfish Fillet	B	3 Weeks	21-Jun-95	ND	ND	0.122
Catfish Fillet	B	4 Weeks	28-Jun-95	ND	ND	0.064
Catfish Fillet	C	Pre	22-May-95	ND	ND	ND
Catfish Fillet	C	1 Week	07-Jun-95	ND	ND	ND
Catfish Fillet	C	4 Weeks	28-Jun-95	ND	ND	ND

Matrix	Pond	Sample Period	Date	Triclopyr	TCP	TMP
Catfish Viscera	A	Pre	22-May-95	ND	ND	ND
Catfish Viscera	A	1 Hr	31-May-95	0.063	NQ	ND
Catfish Viscera	A	3 Hr	31-May-95	0.099	0.024	0.015
Catfish Viscera	A	6 Hr	31-May-95	0.120	0.028	0.223
Catfish Viscera	A	12 Hr	31-May-95	0.142	0.031	1.485
Catfish Viscera	A	1 Day	01-Jun-95	0.073	0.037	2.076
Catfish Viscera	A	3 Days	03-Jun-95	0.065	0.039	7.503
Catfish Viscera	A	1 Week	07-Jun-95	0.050	0.022	4.485
Catfish Viscera	A	2 Weeks	14-Jun-95	NQ	ND	2.006
Catfish Viscera	A	3 Weeks	21-Jun-95	NQ	NQ	1.391
Catfish Viscera	A	4 Weeks	28-Jun-95	ND	ND	0.669
Catfish Viscera	B	Pre	22-May-95	ND	ND	ND
Catfish Viscera	B	1 Hr	31-May-95	0.062	NQ	ND
Catfish Viscera	B	3 Hr	31-May-95	0.169	0.018	ND
Catfish Viscera	B	6 Hr	31-May-95	0.161	0.022	0.163
Catfish Viscera	B	12 Hr	31-May-95	0.210	0.028	1.884
Catfish Viscera	B	1 Day	01-Jun-95	0.085	0.041	1.721
Catfish Viscera	B	3 Days	03-Jun-95	0.112	0.038	5.120
Catfish Viscera	B	1 Week	07-Jun-95	0.063	0.027	4.752
Catfish Viscera	B	2 Weeks	14-Jun-95	0.021	0.018	1.763
Catfish Viscera	B	3 Weeks	21-Jun-95	NQ	NQ	1.764
Catfish Viscera	B	4 Weeks	28-Jun-95	ND	ND	0.548
Catfish Viscera	C	Pre	22-May-95	ND	ND	ND
Catfish Viscera	C	1 Week	07-Jun-95	ND	ND	ND
Catfish Viscera	C	4 Weeks	28-Jun-95	ND	ND	ND

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The aquatic fate of the triethylamine formulation of triclopyr (3,5,6-trichloro-2-pyridinyloxyacetic acid) was studied in closed-pond systems in California, Missouri, and Texas as whole-ond applications. This study determined dissipation rates of triclopyr and its major metabolites, TCP (3,5,6-trichloropyridinol) and TMP (3,5,6-trichloro-methoxypyridine) in water, sediment, and finfish. Two ponds at each site containing a healthy biological community were treated at 2.5 mg/L triclopyr. Water and sediment samples were collected through 12-week posttreatment, and nontarget animals were collected through 4-week posttreatment.

Dissipation rates for triclopyr, TCP, and TMP were similar at each of the study sites, despite differences in weather, water quality, biotic community, light transmission, and geographic location. Half-lives of triclopyr in water ranged from

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5.9 to 7.5 days, while TCP ranged from 4.0 to 10.0 days, and TMP ranged from 4.0 to 7.7 days. Levels of triclopyr and TCP declined in sediments at half-lives ranging from 2.8 to 4.6 days and 3.8 to 13.3 days, respectively. Levels of TMP in sediment were below limits of detection. Triclpyr and TCP cleared from fish in relation to concentrations found in the water column. TMP levels in fish were generally an order of magnitude higher than levels of triclpyr and TCP, particularly in the viscera portion of the animals.

No adverse effects on water quality or on the nontarget biotic community were found following triclopyr applications. Results of this study were similar to those of triclopyr dissipation studies conducted in reservoirs, lakes, and riverine systems in Georgia, Florida, Minnesota, and Washington. Therefore, the degradation and dissipation of triclopyr and its metabolites are similar in representative systems throughout the continental United States.