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A STUDY OF *ORCONECTES SHOUPI*, MILL CREEK BASIN, TENNESSEE, 1985

by

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Fourteen sites on Mill, Sevenmile, and Indian creeks in Davidson and Williamson Counties, Tenn., were surveyed for crayfish in July 1985. *Orconectes shoupi*, considered for listing as Endangered by the US Fish and Wildlife Service, numerically dominated at 8 of the 14 locations and comprised 78 percent of the crayfish community. The remaining 22 percent of the crayfish community consisted of two species, *O. minus* and *O. palacidus*. At sites where quantitative collections were made, *O. shoupi* densities ranged from 0.6/sq m to 11.9/sq m. *Orconectes shoupi* was numerically dominant at the majority of sites in Mill Creek, whereas the other two species of *Orconectes* were most common in Sevenmile Creek, a major tributary of Mill Creek. When *O. shoupi* dominated the community, it had a greater proportion of larger sized individuals than when it was subdominant to the other two species of *Orconectes*. Length-frequency analysis for this species indicated an early

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cohort (17 to 25 mm), a late cohort (maximum size 15 mm), and a group larger than 25 mm, which probably had overwintered from the previous year. *Orconectes shoupi* is a nocturnal, aggressive crayfish that is densest at sites with sufficient cover consisting of slab rock for large individuals or cobble or gravel for juveniles. Results of this survey indicated that, although this species has been reported only from well-oxygenated, sediment-free water, it is tolerant of suspended and settled sediment and eutrophic conditions.

PREFACE

The study described in this report was conducted at the request of the Environmental Resources Branch, US Army Engineer District, Nashville (ORN), by the US Army Engineer Waterways Experiment Station (WES). ORN will use the report as supporting documentation for an Environmental Impact Statement covering a proposed flood control project.

The principal investigators and authors of this paper were Dr. Andrew C. Miller, WES, and Mr. Paul D. Hartfield, Mississippi Museum of Natural Science. Assistance in design and conduct of the project was provided by Ms. Lizabeth Rhodes, ORN. In addition, Ms. Teresa Naimo, Tennessee Technological University; Mr. Frank Ferguson, Hinds Jr. College; Mr. Richard Biggins, US Fish and Wildlife Service; and Mr. Ken Conley, WES, helped in the field and/or laboratory. This work was accomplished under the general supervision of Dr. Thomas D. Wright, Chief, Aquatic Habitat Group; Dr. Conrad J. Kirby, Chief, Environmental Resources Division; and Dr. John Harrison, Chief, Environmental Laboratory. This report was edited by Ms. Lee T. Byrne of the WES Information Products Division.

COL Allen F. Grum, USA, was the previous Director of WES. COL Dwayne G. Lee, CE, is the present Commander and Director. Dr. Robert W. Whalin is Technical Director.

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CONTENTS

CONVERSION FACTORS, NON-SI TO SI (METRIC) UNITS OF MEASUREMENT

Non-SI units of measurement used in this report can be converted to SI (metric) units as follows:

Multiply	By	To Obtain
acres	4,046.873	square metres
feet	0.3048	metres
feet per mile	0.1893935	metres per kilometre
gallons (US liquid)	3.785412	cubic decimetres
inches	2.54	centimetres
miles (US statute)	1.609347	kilometres
square miles	2.589998	square kilometres

A STUDY OF *ORCONECTES SHOUPI*, MILL CREEK BASIN, TENNESSEE, 1985

PART I: INTRODUCTION

Background

1. *Orconectes shoupi* is currently known to inhabit only the Mill Creek Basin in Davidson and Williamson Counties, Tenn., which includes Mill and Sevenmile creeks and their tributary streams. It has never been a cosmopolitan species. Previous records also located it in Big Creek in Giles County and South Harpeth Creek and Richland Creek in Davidson County. This Nashville crayfish was first reported as *Cambarus propinkuus* and as *C. propinquus sanborni* by Fleming (1939) based on specimens collected from Mill Creek. Hobbs (1948) placed this species in the genus *Orconectes* and gave it the specific name *shoupi*.

2. Habitat information on this species is sparse. Recent studies by O'Bara, Korgi, and Stark* and by Bouchard (1984) have suggested that this species is dependent upon shallow flowing water in riffles or runs of small creeks. However, Hobbs (1974) listed it only from streams and did not provide any information on habitat preferences. The results of the recent status survey* for *O. shoupi* indicated that this species could qualify for protection under the Endangered Species Act of 1978, as amended (US Fish and Wildlife Service (USFWS) 1985). Because the range of the species is restricted and since Mill Creek lies within the greater Nashville metropolitan area, US Fish and Wildlife personnel are concerned that development pressures within the watershed can jeopardize the continued existence of *O. shoupi* (unpublished information from US Army Engineer District, Nashville (ORN), 1985).

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* C. J. O'Bara, A. J. Korgi, and G. J. Stark. 1985. "Status Survey of Nashville Crayfish, *Orconectes shoupi*," letter report submitted to the US Fish and Wildlife Service, Asheville, N. C., Tennessee Technological University, Cookeville, Tenn.

Purpose and Scope

3. The US Army Engineer District, Nashville (ORN), is preparing a feasibility study of flood protection for Mill and Sevenmile creeks (unpublished information from ORN, 1985). A number of alternatives to provide basin-wide protection have been considered; however, the following alternatives provide the most cost-effective solution:

a. Channel widening on Sevenmile Creek. Selective channel widening and riparian vegetation removal would be accomplished primarily on the right banks between River Mile (RM) 0.7 and 1.5. Widening would begin at .610 m (2 ft)* above present streambed and would provide a bottom channel width of 22.86 m (75 ft) during high water. At normal flow, water would be contained within the streambed.

b. Dry dam on Mill Creek. A dry-bed retention dam could be constructed below old Hickory Boulevard Crossing at RM 16.8. The top of the dam and streambed elevation would be 168 and 156 m (550 and 512 ft) mean sea level (msl), respectively; the length would be 304.8 m (1,000 ft). Total area of inundation would be approximately 275 ha (680 acres) during a 100-year flood event with a maximum retention time of 60 hr (Table 1). The length of the ponding area would be from RM 16.8 to approximately RM 21.0.

c. Dry Dam at Sevenmile Creek. This dry dam would be constructed at RM 3.7 and would inundate approximately 45.7 ha (113 acres) at full pool. The top elevation of the dam would be at 168 m (547 ft) msl and would extend down to the streambed at 158 m (519 ft) msl. Maximum retention time for a 100-year flood would be 48 hr (Table 1). The maximum flood pool would extend from RM 3.7 to 4.4. The temporary storage areas behind both dams would be permanently acquired by the local sponsor, Metro/Nashville. Although private development would be prohibited, the land could be leased for agricultural use.

4. The dry dams would function by temporarily retaining water during flood events. At least 95 percent of the time, water would flow unimpeded through culverts that would be at streambed elevation. While conventional dams cause sedimentation within the impoundment area, the design of these dams would allow more than 50 percent of the suspended sediment to flow through without being deposited. Point sources of sediment, usually from construction activities, are present in the Mill Creek Basin. However, watershed characteristics do not indicate that there is a significant source of sediment

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* A table of factors for converting non-SI units of measurement to SI (metric) units is presented on page 3.

or that heavy sedimentation would occur in the temporary ponding area. Of the amount that would be deposited, clay and silt would remain primarily in the overbank areas, and the heavier sand and gravel would be deposited in the channel. Much of the channel deposition would be temporary because, as with normal flood events, the sand and gravel would be transported downstream through the culverts during receding water or the next rise in flow.

5. This report summarizes the results of a field survey and laboratory observations for the Nashville crayfish, *Orconectes shoupi*. Crayfish were collected from the Mill Creek Basin in Davidson and Williamson Counties in the Nashville metropolitan area. This study was conducted to obtain information on the habitat requirements and behavior of *O. shoupi*. Personnel of the ORN Planning Branch, Environmental Analysis Section, will use the results from this study to evaluate environmental effects of water resource development on Mill and Sevenmile creeks on *O. shoupi*.

PART II: STUDY AREA AND METHODS

Study Area

6. Mill Creek originates about 3.22 km (2 miles) south of Nolensville, Williamson County, Tennessee, flows north, and joins the Cumberland River at RM 194.4 in Nashville, Davidson County. Mill Creek Basin has a drainage of 2.59 sq km (108 square miles) and includes several tributaries; the most significant of these is Sevenmile Creek, which originates near the Davidson-Williamson county line. From there it flows north and east and then joins Mill Creek at RM 7.9. The Sevenmile Creek watershed encompasses 45.58 sq km (17.6 square miles).

7. The Mill Creek area consists of gently sloped plains with local relief ranging from 121.9 to 152 m (400 to 500 ft), although in upper sections the elevation exceeds 304.8 m (1,000 ft). The watershed is primarily in the central outer basin physiographic region of Tennessee with a small upstream sector in the central interior basin. The soils in the vicinity of Mill and Sevenmile creeks are in the Arrington-Lindell-Armour association. These range from undulating to rolling and from moderate to well-drained; most qualify as prime farmland soils. In the uplands adjacent to the floodplain, soils are of the Talbott-Rock-Outcrop association. These, which are not prime farmland soils, are undulating to hilly and are well-drained. They are characterized by limestone outcrops in inner parts of the Nashville Basin.*

8. The riverine habitat in Mill and Sevenmile creeks consists of pools, riffles, and flows over flat rock ledges usually littered with large- and small-sized slab rock, gravel, or cobble. Banks in the basin are 3 to 4.6 m (10 to 15 ft) high, and the main channel is from 24 to 30 m (80 to 100 ft) wide. The fishery of both creeks is characterized by species common to flowing shallow-water habitats. Commonly observed fishes include darters, small sunfishes, madtoms, suckers, and cyprinids such as stonerollers. In November 1981 at a site near the source of Mill Creek, small-sized bluegill, green and longear sunfish, and smallmouth bass were collected (unpublished

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* US Department of Agriculture. 1967. "Soil Survey, Laboratory Data, and Descriptions of Some Soils of Tennessee," in-house working document, Soil Conservation Service, Washington, DC.

information from ORN, 1985). Fish production is low in the basin because of reduced water levels during the summer and fall.

9. Along both creeks, there is usually a full canopy (70 to 90 percent coverage) of deciduous vegetation consisting of willow, cottonwood, sycamore, box elder, hackberry, maple, and oak. Common shrubs include Japanese honeysuckle, coralberry, spicebush, rose, and grapevines.

10. Water from Mill and Sevenmile creeks can be characterized as medium hard, with moderate levels of sulfate and low chloride levels. (See Table 2 for selected water chemistry at Mill Creek.) Dissolved oxygen levels vary, depending upon the time of day; however, values are usually near saturation. Nutrients are moderate except immediately below point-source discharges.

11. Mill Creek has been characterized as carrying a high sediment load;* however, investigations above the damsites on both Mill and Sevenmile creeks did not reveal high levels of sediment or indicate that erosion was a problem (unpublished information from ORN, 1985). However, because of expanding urbanization, frequent construction actions in the watershed can cause localized sediment deposition.

12. There has been considerable development on Mill Creek near Antioch (Figure 1, RM 12.0-13.0). (See Appendix B, Table B6, for habitat description for Site 3, which was at RM 12.5). In this river reach, there are numerous pipelines and bridge crossings in addition to urban development. In 1982, the city of Nashville cleared and snagged sections of Mill Creek between RM 1.64 and 13.5.

13. Sedimentation from local construction, chemical spills from transportation accidents, and dissolved oxygen depletion are problems that have historically contributed to degradation of water quality in Mill Creek.** There have been fish kills in Mill Creek Basin that ranged from moderate to severe. However, water quality conditions in the basin have recently improved. Sewage outfalls were eliminated in 1977 when the Mill Creek interceptor sewer was extended to collect sewage and to transport it to the Nashville central plant. Replacement of deteriorating sewer lines at RM 11.9, 12.4, 12.5, 12.9, 13.5, and 13.8, while producing temporary construction

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* O'Bara, Korgi, and Stark, op. cit.

** Tennessee Conservation League. 1980. "Environmental Inventory Mill Creek, Cumberland River Basin, Davidson and Williamson Counties, Tennessee," unpublished report.

impacts, will further improve water quality. Legislation that will also affect conditions in the basin includes the Tennessee Water Quality Control Act of 1977, under the National Pollutant Discharge Elimination System. Currently, point-source discharges are located at RM 24.0, 10.4, and 7.8. Land use in the Mill Creek Basin consists of residential (6,151.25 ha (15,200 acres), 21.5 percent), commercial/industrial (667.73 ha (1,650 acres), 2.3 percent), community services (607.03 ha (1,500 acres), 2.1 percent), and other (21,193.47 ha (52,370 acres), 74.1 percent). This latter category includes transportation, communications, utility services, mining, agricultural and forest lands, rights-of-way for streets and railroads, and vacant land. Based upon the population projections (1.3 percent annual increase rate) and historical growth, residential land in the Mill Creek area is anticipated to increase by approximately 75 percent between 1980 and 2030 (unpublished information from ORN, 1985).

Study Methods

14. Sample sites were chosen to document conditions along Mill and Sevenmile creeks since both creeks may be affected by proposed water resource development. Fourteen sites were surveyed for crayfish, nine on Mill Creek, one above the mouth of Indian Creek, and four on Sevenmile Creek (Figure 1 and Table 3). At each site, one to seven separate (replicate) collections for crayfish were made. The survey, which was conducted on 11 July (Sites 6 and 7) and 22-23 July 1985, consisted of 41 collections for crayfish.

15. At each of the 14 locations, information on stream conditions such as habitat type, presence of instream cover and aquatic vegetation, evidence of human activity and recent sedimentation, and substrate and flow characteristics was recorded (see Appendices A and B). After general information was recorded, specific sites were identified, and the downstream portion was blocked with a 6.10-m (20-ft) minnow seine. Two individuals then moved rapidly toward the net while kicking and otherwise disturbing the substrate. This process was repeated up to four times before the net was retrieved and brought to shore, and the crayfish were transferred to 18.94-ℓ (5-gal) buckets.

16. All crayfish were identified, their sex determined, reproductive condition noted, and total cephalothorax length (to the nearest millimetre)

recorded. After measurements were taken, the crayfish were returned to the river. Areal dimensions of sample sites were measured, and average depth was calculated from nine measures of depth (three transects with water depth recorded at center and equal distances between center and opposing banks).

17. Approximately 100 *O. shoupi* from Sites 6 and 7 were packed in an ice chest, kept cool with containerized ice, and returned by air to Vicksburg, Miss., on 11 July 1985. At the Waterways Experiment Station (WES), they were separated into twin 1.22- to 2.44-m (4- by 8-ft) Plexiglas chambers, one with circulating water and one with no current. These individuals were used for observations on behavior with respect to time of day, crowding, absence of cover, introduction of sediments, and water velocity. On 3 September, 25 *O. shoupi* were used for a field experiment on the effects of deep water on behavior and mortality.

PART III: RESULTS AND DISCUSSION

Field Studies

18. Forty-one collections of crayfish were made at 14 sites by personnel from the WES during July in Mill Creek Basin (Figure 1, Table 3). Of the 1,159 crayfish collected and identified, 78 percent were *Orconectes shoupi*, and 22 percent consisted of *O. minus* and *O. palacidus*. In addition, approximately five individuals in the genus *Cambarus* were collected.

19. *Orconectes shoupi* numerically dominated the crayfish community at all but one site on Mill Creek; the other two species of *Orconectes* were most abundant at Sevenmile Creek. The species that numerically dominated always had a greater number of large individuals (cephalothorax length greater than 25 mm) than the subdominant species (Figures 2 and 3). When *O. shoupi* was most dominant, a greater number of large-sized individuals were present than when it was subdominant. Densities of *O. shoupi* ranged from 0.6 to 11.9 individuals/sq m, cephalothorax length ranged from 4.0 mm to 43.0 mm and averaged 18.3 mm (Table 4). There were no significant differences in size between male and female *O. shoupi* (Table 5).

20. *Orconectes shoupi* collected in early July at Sites 6 (RM 14.7) and 7 (RM 16.4) exhibited a trimodal distribution (Figure 4). At this time, a late cohort of juveniles had reached a maximum size of 15 mm, while an earlier cohort had achieved a length of 17 to 25 mm. All individuals greater than 25 mm were hatched last year and probably will not overwinter. In Illinois, Van Deventer (1937) determined that cephalothorax length for *Cambarus* (or *Orconectes) propinquus* increased by about 2.48 mm/molt and averaged 10 molts/season. Crayfish that survived the winter molted once or twice in the spring and then died at a maximum size of 35 to 40 mm. Polymodal length-frequency distributions were common at the end of the season because the population consisted of many individuals that molted at slightly different times.

21. Estimated densities for *O. shoupi* ranged from 0.6/sq m at Site 14 (RM 5.2) in Sevenmile Creek to 11.9/sq m at Site 6 (RM 14.7) in Mill Creek (Table 4). The undescribed species ranged from 0.1 sq m at Site 3 (RM 12.5) on Mill Creek (although none were taken at Site 6, RM 14.7 on Mill Creek) to 4.9/sq m at Site 12, RM 1.5, on Sevenmile Creek. Actual densities were dependent upon availability and size of instream cover. For example, Site 6

(RM 14.7) on Mill Creek was characterized by flat slab rock and cobble over bedrock. At Site 7 (RM 16.4), which was approximately 2 km downriver, the substrate consisted of gravel and cobble. *O. Shoupi* was dominant at both sites (100 and 96 percent, respectively), although densities were 5.3/sq m at Site 6 and 11.9/sq m at Site 7. The gravel-cobble substrate at Site 7 provided good cover for juveniles; at this site there were a larger number of smaller sized individuals (average cephalothorax length was 15.8 mm) than at Site 6, where the average length of *O. shoupi* was 19.5 mm (Figure 2).

Laboratory Observations

22. Live *O. shoupi* were shipped to WES, acclimated to laboratory temperatures, and introduced into a pair of 1.2- by 2.4-m Plexiglas tanks, one with no current and the other with water flowing at a rate of 15 to 60 cm/sec. Immediately after introduction, the crayfish were disoriented and did not move. However, within 60 min, approximately two-thirds had found shelter under flat rocks in both tanks. At first, the crayfish sought shelter under the nearest rocks with no regard to crowding, but after 24 hr, they were evenly dispersed throughout the tanks.

23. Individuals in the current moved more quickly toward shelter than did those in slack water. The most aggressive crayfish moved into high velocity areas and excluded subdominant crayfish. Under extreme crowding, *O. shoupi* were agitated and moved about continuously challenging others, and only the largest were able to maintain positions under flat rocks.

24. When light diminished, animals that were under rocks began to move about and forage. Activity was greatest from sunset to midnight. During this time, crayfish moved in and out of rock shelters and enlarged their burrows. By daylight, all activity ceased, and they returned to their burrows. In laboratory conditions, this species was noted to be highly photosensitive and to avoid light.

25. Under field conditions, *O. shoupi* have not been collected in deep water such as the backwater of the Cumberland River (RM 0.0 to 0.9). However, sampling for crayfish in deep water is difficult, and results can be inconclusive. In an experiment conducted at WES, a group of *O. shoupi* was experimentally exposed to deep water to mimic some effects of dry dam operation. *Orconectes shoupi* were acclimated to Mississippi River water and placed four

to a cage made from wire screen; then three cages were lowered to a depth of approximately 15 m at a site in the Mississippi River near Vicksburg. A control group was left at the surface in 1 m of water. At the end of 1 hr, no mortality or unusual behavior was observed. It appears that in Mill Creek distribution of *O. shoupi* is independent of pressure effects.

Habitat Requirements

26. *Orconectes shoupi* were tolerant of a wide range of environmental conditions and were collected in all habitats surveyed in Mill Creek. They were found in riffles and runs with gravel and cobble substrate and in pools with 10 cm of settled sediment. At Site 7 (RM 16.4), 175 *O. shoupi* (5.3/sq m) were collected in a riffle with cobble over bedrock. At Site 3 (RM 12.5), where 266 *O. shoupi* (5.7/sq m) were collected, the water was turbid, oil was visible, and about 1 cm of sediment covered the substrate. In general, sites sampled in the upper reaches of Mill Creek were relatively free of sediment deposition, whereas many of the sites within urbanized areas had varying amounts of deposited solids from construction (see Appendix A). Both adults and juveniles were found at sites where there was heavy sedimentation. At some of the sites where sediment had blanketed the gravel or bedrock, crayfish had excavated shallow burrows in the recently deposited material. *Orconectes shoupi* were also found in small pools where flow was intermittent (Sites 9 and 10 on Mill Creek). At four of the nine sites on Mill Creek where *O. shoupi* were collected, from 21 to 17 cm of sediment had recently been deposited. At one site, juveniles (cephalothorax length 4 mm) were collected; at a site with 17 cm of sediment, 60 *O. shoupi* (5.3/sq m) were found.

27. The proposed dry dams on Mill and Sevenmile creeks would influence a specific reach of each water body. These ponding areas would include approximately 6 km on Mill Creek and about 1 km on Sevenmile Creek. The effects of the dry dams would increase inundation time at each flood event (Table 1). During a 100-year flood event, increased time would range from 10 to 60 hr in Mill Creek and from 5 to 48 hr in Sevenmile Creek. Although *O. shoupi* has a restricted range, it is not dependent on flowing water with no sedimentation for continued existence. In an earlier description of this species, Hobbs (1974) reported only that it inhabited streams; there was no mention of a dependence on nonturbid flowing waters. Based upon the results

of this survey, it appears that *O. shoupi* will be able to tolerate the effects of dry dam operation on Mill and Sevenmile creeks.

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Table 1

Physical Data on Proposed Dry-Bed Retention Dams on Mill Creek and Sevenmile Creek, Tennessee*

Project	Flood Frequency, yr	Discharge, cfs		Elevation, ft		Flood Duration or Retention Time, hr		Project	
		Natural	Project	Natural	Project	Natural	Project	Capacity acre-ft	Area of Inundation acres
Mill Creek	2	6,600	2,200	522.4	536.9	0	29	1,420	205
	10	13,150	3,350	525.4	544.4	4	47	3,730	440
	50	21,450	6,150	527.5	548.5	8	56	5,930	630
	100	25,200	7,600	528.4	550.0	10	60	6,890	680
	500	37,350	21,450	530.9	552.5	16	66	8,810	765
Sevenmile Creek	2	1,500	500	524.2	531.6	0	15	140	29
	10	3,500	700	528.0	538.1	3	29	440	60
	50	5,950	800	529.5	544.8	3	44	960	98
	100	7,150	1,100	529.8	546.8	5	48	1,160	113
	500	11,000	4,600	530.8	548.2	10	56	1,320	125

* Unpublished information from ORN, 1985.

Table 2

Water Chemistry Data for Mill Creek, 3-4 November 1981*

Parameter	Mill Creek, River Mile - Measurement*			
	16	9	6	4
Temperature, °C	16.1	20.0	17.6	16.4
Dissolved oxygen, mg/ℓ	7.0	13.5	9.8	10.4
Hardness, $CaCO_3$ mg/ℓ	262.0	270.0	274.0	260.0
Alkalinity, $CaCO_3$ mg/ℓ	228.0	204.0	212.0	206.0
Conductance, µhos/cm^2	530.0	590.0	570.0	550.0
pH	7.8	8.1	7.9	7.4
Turbidity, FTU	3.5	2.3	2.0	1.6
Chloride, mg/ℓ	27.3	37.2	25.3	25.3
Sulfate, mg/ℓ	21.8	49.9	50.2	48.5
Total solids, mg/ℓ	334.0	374.0	358.0	344.0
Suspended solids, mg/ℓ	4.0	4.0	2.0	2.0
Dissolved solids, mg/ℓ	330.0	370.0	356.0	342.0

* Unpublished information from ORN, 1985.

Table 3

Sites Surveyed on Mill and Sevenmile Creeks, Tennessee

Stream	Description	Site No.	River Mile
Mill	Damsite	1	16.8
	Near mouth of Indian Creek	2	17.2
	Antioch Pike	3	12.5
	Elm Pike	4	3.1
	Antioch	5	13.5
	Bell Road	6	14.7
	Pettus Road	7	16.4
	Culbertson Road	8	18.8
	Sunset Road	9	24.1
Indian	Mouth of Indian Creek	10	0.2
Sevenmile	Paragon Mills Road	11	1.0
	Welch Road	12	1.5
	Damsite	13	3.7
	Old Hickory Boulevard	14	5.2

Table 4

Summary Information for *Orconectes shoupi* Collected at 14 Sites in the Mill Creek Basin, Tennessee, July 1985

Stream	Site No.	*O. shoupi* Collected	*O. shoupi* per sq m	Average Length,*	Community Percentage
Mill Creek	1	35	2.2	15.6	45
	2	123	6.5	17.4	90
	3	266	5.7	21.0	97
	4	29	6.9	13.8	62
	5	60	5.3	20.1	92
	6	80	11.9	19.5	100
	7	175	5.3	15.8	96
	8	20	-	16.7	87
	9	31	-	16.7	91
Indian Creek	10	23	-	16.5	96
Sevenmile Creek	11	10	0.9	17.6	27
	12	29	2.2	16.5	31
	13	21	0.9	19.9	29
	14	2	0.6	22.0	40

* Cephalothorax Length (mm)

Min	Max	Average
4.0	43.0	18.3

Table 5

Summary Statistics for Cephalothorax Length for *Orconectes Shoupi* Collected from Mill and Sevenmile Creeks, Tennessee, July 1985

Treatment	No.	Mean ± Standard Error	T Value	Probability
Females	463	18.18 ± 0.30	-0.75	NS*
Males	442	18.47 ± 0.25		

* NS = No significant difference at the 0.05 level.

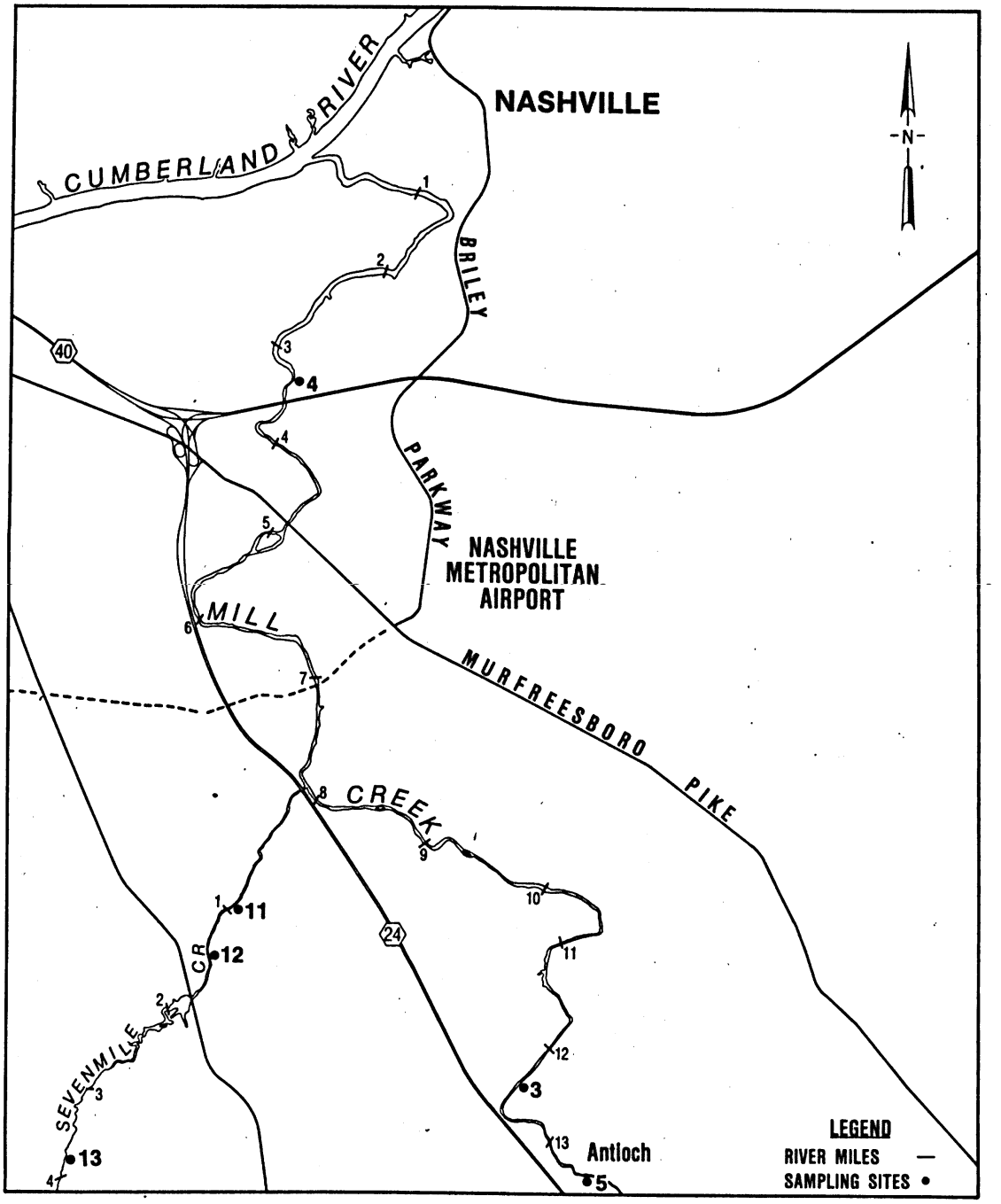

Figure 1. Sites on Mill and Sevenmile creeks, Davidson and Williamson Counties, Tennessee, surveyed for crayfish, July 1985 (Continued)

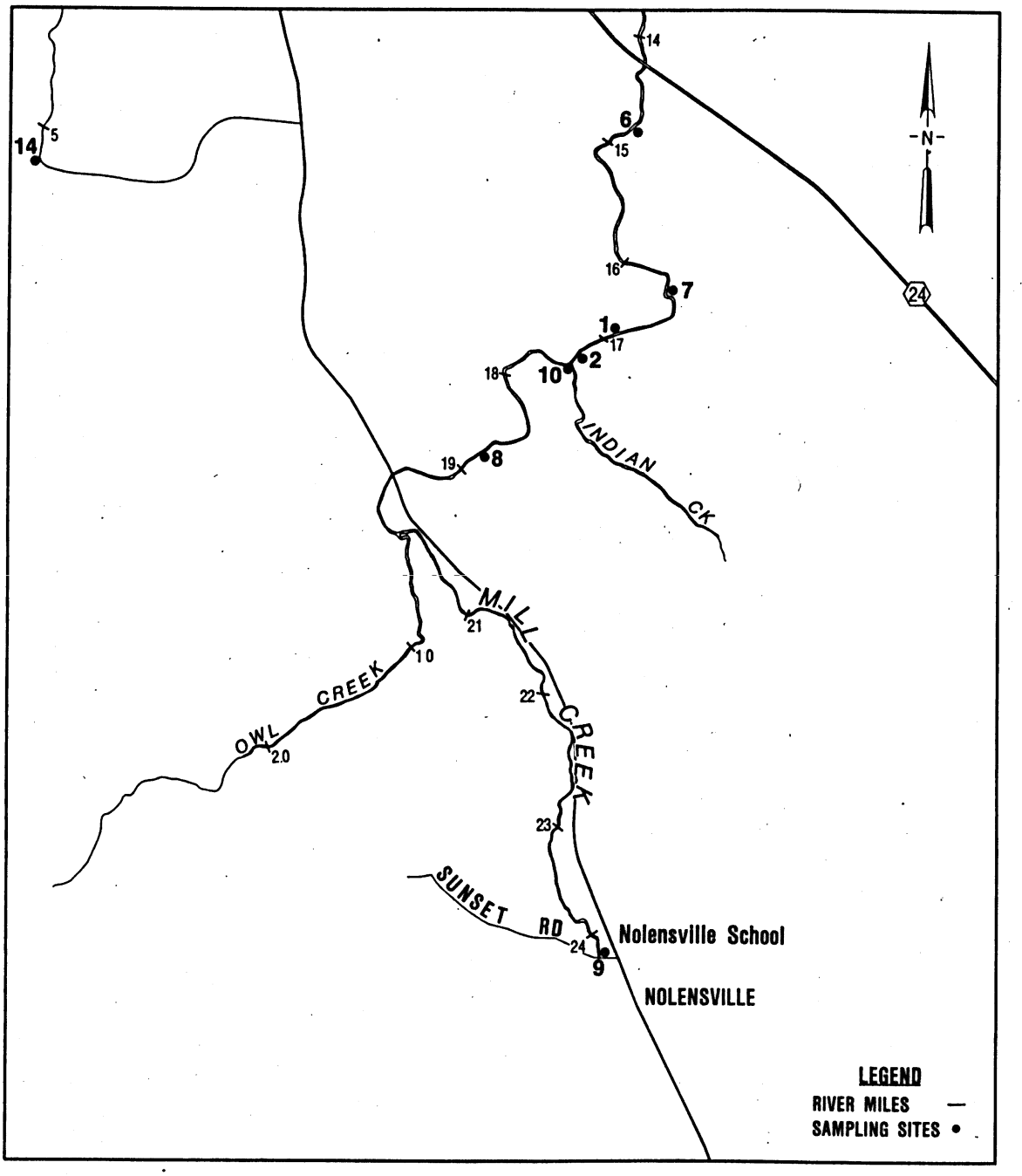

Figure 1. (Concluded)

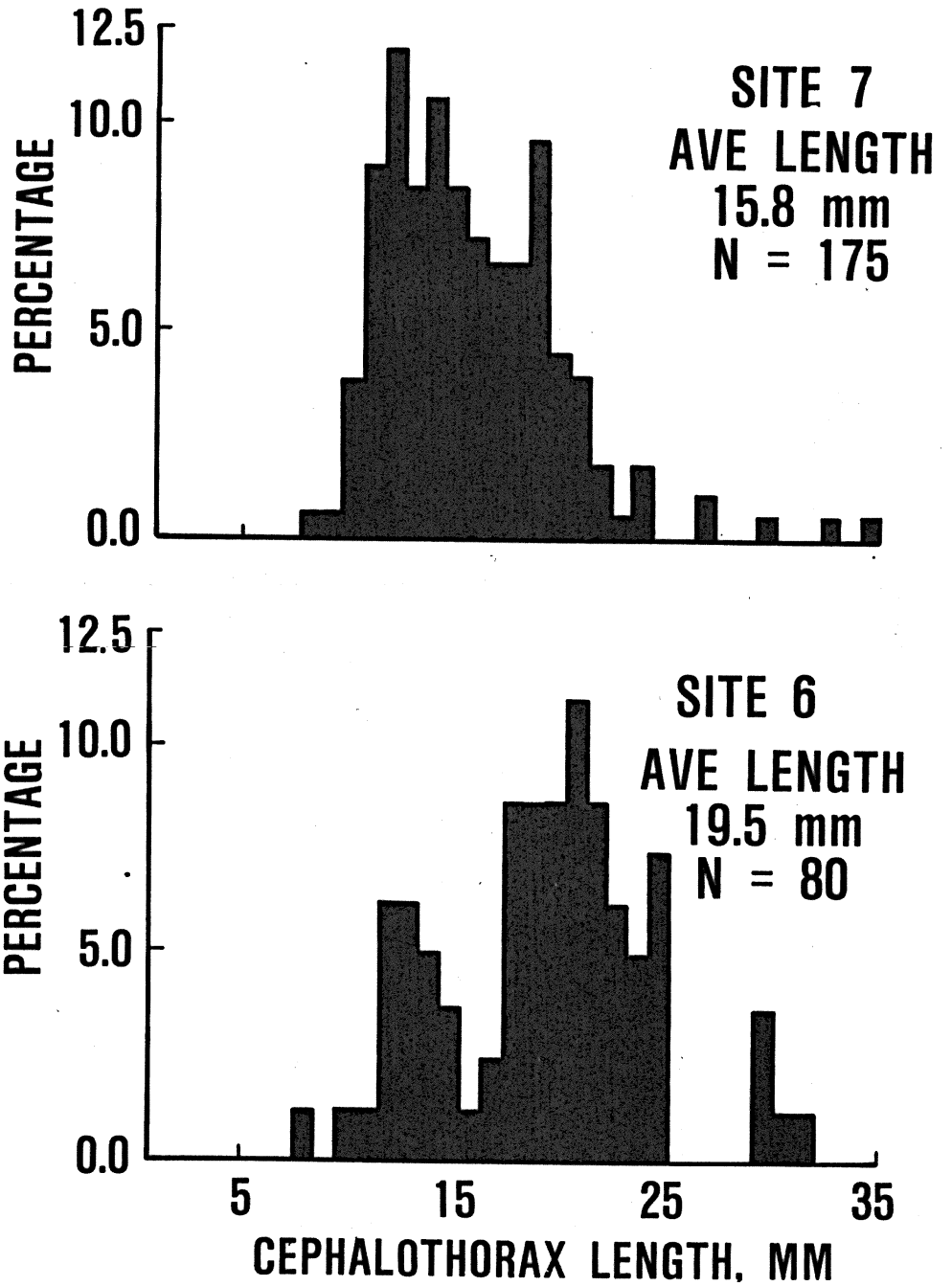

Figure 2. Length-frequency histograms for *O. shoupi*, Mill Creek Basin, Tennessee, July 1985

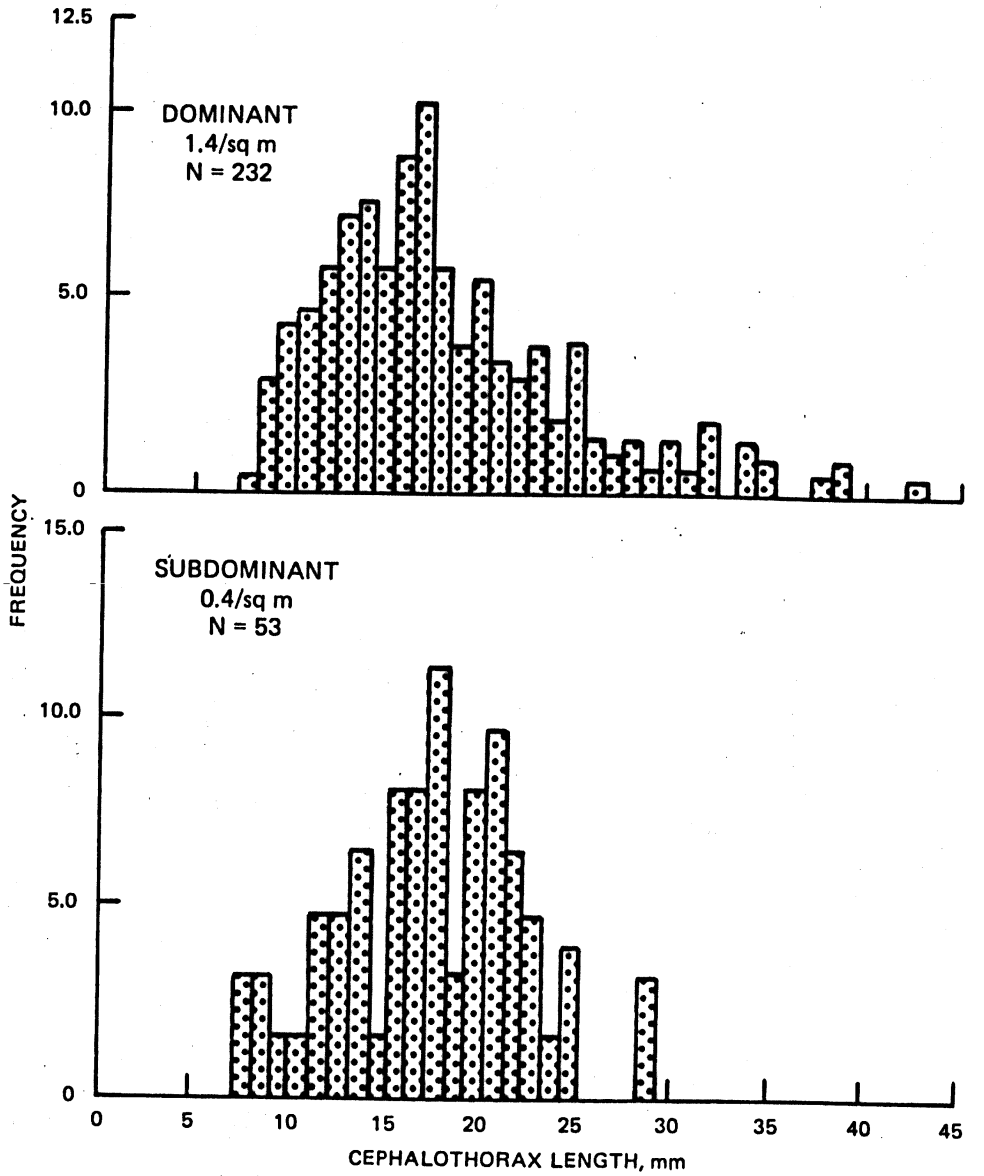

Figure 3. Length-frequency histograms for two species of *Orconectes*, Mill Creek Basin, Tennessee, July 1985

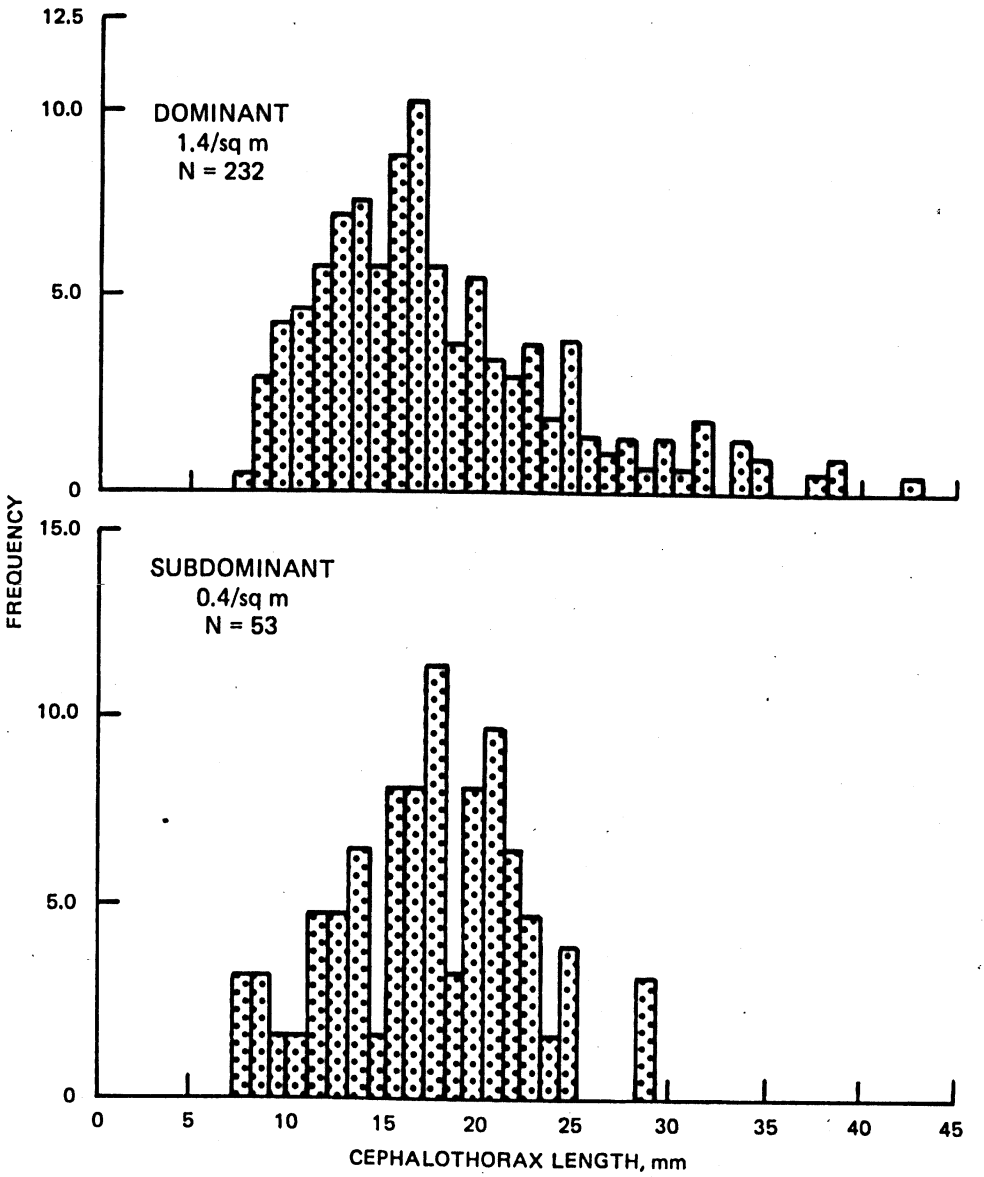

Figure 4. Length-frequency histograms for *Orconectes shoupi* collected from Sites 6 and 7, Mill Creek, Tennessee, 11 July 1985

APPENDIX A: SITES SURVEYED

Site 1: Mill Creek at dam site. An old low-head dam at this location formed a long pool above the dam with water approximately 0.61 m (2 ft) deep at the time of the survey. Below the dam, flow was moderate. Water was very turbid; a heavy sediment load was coming from a small creek that entered the upstream end of the pool. The stream ran next to a dairy barn, which probably accounted for the low dissolved oxygen (DO) levels (5.0 mg/ℓ). Water temperature was 26.5° C. At this site, terrestrial vegetation formed a canopy covering from 75 to 100 percent of the stream.

Site 2: Mill Creek at mouth of Indian Creek. At this site, there was moderate flow, and short pools were connected by riffles and runs. The water was clear, and a vegetative canopy covered about 75 to 100 percent of the stream. The DO content was 8.0 mg/ℓ, and water temperature was 27° C.

Site 3: Mill Creek at Antioch Pike. The channel was 21.9 m (72 ft) wide, and the water was shallow and very turbid (DO was 6.0 mg/ℓ). Sediments thickly blanketed pools, slab rocks, and gravel. There was a thin layer (less than 2.0 cm) of sediment in the riffles. Construction and recent fill were noted on the west bank above the bridge and along the east bank below the bridge. Garages, shops, parking lots, and roads were common along this reach of river. Canopy coverage ranged from 0 to 50 percent.

Site 4: Mill Creek above Elm Pike. At this location, the channel was wide, although constricted at riffles, and water velocity was moderate to high. The water was turbid, and sediment had settled in the pools; however, riffles and runs were clear of sediment. Canopy coverage was from 50 to 75 percent. Water willow (*Justica americana*) was noted along both banks. The DO concentration was 7.0 mg/ℓ.

Site 5: Mill Creek at Antioch. At this location, the water velocity was slow, and the habitat consisted of short riffles and long pools. There were filamentous algae growing in the pools. The water was not turbid, although there were 2- to 17-cm thick deposits of sediment in slack water areas. A plume of sediment came down the stream at 0810 hours; within 10 min, the water became very turbid and remained so while crayfish were being collected. There were construction activities upstream and downstream of this location. Canopy coverage ranged from 75 to 100 percent. The DO was 8 mg/ℓ, and water temperature was 24.0° C.

Site 6: Mill Creek at Bell Road. A small riffle downstream of the bridge was surveyed. The water was shallow and clear with little evidence of recent sedimentation.

Site 7: Mill Creek at Pettus Road. A bedrock run with scattered cobble and slab rock upriver of the bridge was sampled. The water was clear with no evidence of sediment deposition.

Site 8: Mill Creek at Culbertson Road. At this location, the creek was wide and shallow, and there was very little flow. The habitat consisted of long shallow pools connected by short riffles. There was a heavy growth of filamentous algae in the pools. The water was clear, and the DO measured 8.0 mg/ℓ; water temperature was 24.0° C. The canopy coverage ranged from 75 to 100 percent.

Site 9: Mill Creek at Sunset Road. There was very little current at this site, and the pools were connected by short riffles. Filamentous algae were abundant in the stream, and there was no vegetation canopy. Lands around the stream were heavily farmed. The DO concentration was 16.0 mg/ℓ, and water temperature was 30.5° C.

Site 10: Mouth of Indian Creek. Only a qualitative sample was taken at this location. There was little flow, and short shallow pools were connected by narrow riffles. Algae were common in the pools. Canopy coverage was approximately 25 percent. DO concentration was 2.2 mg/ℓ, and water temperature was 27° C.

Site 11: Sevenmile Creek at Paragon Mills Road. At this location, flow was good, although the channel was narrow. The habitat consisted of small pools connected by riffles and runs. There was evidence of recent sedimentation in the pools. Canopy coverage was 100 percent. The water was clear, and DO measured 8.0 mg/ℓ; the water temperature was 27.0° C.

Site 12: Sevenmile Creek at Welch Road. Near this site, a subdivision was on the east bank, and a shopping center was on the west bank of the creek. The channel was narrow with good flow and consisted of shallow pools connected by long runs and riffles. The water was clear.

Site 13: Sevenmile Creek at damsite. At this location, there was a long reach with a bedrock-gravel-cobble riffle. The canopy covered from 0 to 25 percent of the stream. The water was clear and shallow, but became deep in the upper sections where there were long pools connected by riffles and runs. Sediment was noted in the pools. Seventy-five to one hundred percent of the

stream was covered by vegetative cover. DO level measured 10.0 mg/ℓ, and water temperature was 26° C.

Site 14: Sevenmile Creek at Old Hickory Boulevard. At this reach, the stream was very narrow and consisted of long narrow pools connected by short riffles with little current. Along both banks were construction and recent fill.

APPENDIX B: HABITAT INFORMATION

This appendix contains habitat information on sites surveyed for crayfish, Mill Creek Basin, Davidson and Williamson Counties, Tenn., during July 1985.

Table B1

Habitat Data from Site 1, Mill Creek, 23 July 1985

Sample No.	Area sq m	Depth, cm Avg	Depth, cm Max	Water Clarity	Sedimentation	Habitat	Substrate	Current	DO,* mg/ℓ
					Site 1				
1	6.9	7.6	12.7	Turbid	Heavy	Riffle	Gravel	Moderate	5.0
2	8.7	7.1	7.6	Turbid	Heavy	Riffle	Gravel	Moderate	6.0
					Site 2				
1	9.3	10.4	19.7	Turbid	Little	Riffle	Gravel/bedrock	Rapid	-
2	2.6	29.2	ND**	Turbid	Little	Riffle	Gravel/bedrock	Rapid	-
3	1.8	14.0	ND	Clear	High	Pool	Rock/bedrock	None	-
4	5.3	22.9	ND	Clear	High	Pool	Gravel/bedrock	None	-

* DO = dissolved oxygen.
** ND = not determined.

Table B2

Habitat Data from Site 3, Mill Creek, 23 July 1985

Sample No.	Area sq m	Depth, cm Avg	Depth, cm Max	Water Clarity	Sedimentation	Habitat	Substrate	Current	DO,* mg/ℓ
					Site 3				
1	1.8	20.3	ND	Turbid	Light	Riffle	Gravel/cobble	Slow	-
2	5.9	15.2	ND	Turbid	Heavy	Riffle	Gravel/cobble	Slow	-
3	9.6	10.4	14.0	Turbid	Heavy	Riffle	Gravel/cobble	Slow	-
4	9.4	12.2	16.5	Turbid	Heavy	Riffle	Gravel/cobble	Slow	-
5	8.4	16.5	27.9	Turbid	Heavy	Riffle	Gravel bedrock	Fast	-
6	4.7	12.7	ND	Turbid	Heavy	Pool	Gravel/bedrock	None	-
7	6.9	16.2	22.9	Turbid	Heavy	Pool	Bedrock	None	-
					Site 4				
1	4.2	7.9	12.7	Turbid	Little	Riffle	Gravel/bedrock	Moderate	7.0

* DO = dissolved oxygen.
** ND = not determined.

Table B3

Habitat Data from Site 5, Mill Creek, 24 July 1985

Sample No.	Area sq m	Depth, cm Avg	Depth, cm Max	Water Clarity	Sedimentation	Habitat	Substrate	Current	DO,* mg/ℓ
					Site 5				
1	8.3	7.6	10.2	Clear	Little	Riffle	Rock/bedrock	Slow	-
2	1.8	17.8	ND**	Clear	Heavy (7")	Pool	Bedrock	Little	-
3	1.2	5.2	ND	Clear	Heavy (2")	Pool	Bedrock	Little	-

* DO = dissolved oxygen.

** ND = not determined.

Table B4

Habitat Data from Site 6, Mill Creek, 11 July 1985

Sample No.	Area sq m	Depth, cm Avg	Depth, cm Max	Water Clarity	Sedimentation	Habitat	Substrate	Current	DO,* mg/ℓ
					Site 6				
1	6.7	10.3	12.7	Clear	Little	Riffle	Cobble/gravel	Rapid	-
					Site 7				
1	32.7	10.7	14.0	Clear	None	Riffle	Cobble/bedrock	Rapid	-

* DO = dissolved oxygen.

Table B5

Habitat Data from Site 8, Mill Creek, 24 July 1985

Sample No.	Area sq m	Depth, cm Avg	Depth, cm Max	Water Clarity	Sedimentation	Habitat	Substrate	Current	DO,* mg/ℓ
					Site 8				
1	8.7	4.6	11.4	Clear	Little	Riffle	Gravel/cobble	Moderate	9.0
2	14.9	20.3	ND**	Clear	Little	Riffle	Bedrock/algae	Moderate	-
3	ND	ND	ND	Clear	Little	Pool	Bedrock	Moderate	-
4	1.5	3.8	ND	Clear	Little	Riffle	Cobble	Moderate	-
					Site 9				
1	-	-	-	Clear	None	Riffle	Bedrock	Moderate	16.0
2	1.1	-	-	Clear	None	Pool	Bedrock/gravel	Moderate	-
3	1.5	10.2	-	Clear	None	Pool	Bedrock/gravel	None	-

* DO = dissolved oxygen.

** ND = not determined.

Table B6

Habitat Data from Site 10, Indian Creek, 24 July 1985

Sample No.	Area sq m	Depth, cm Avg	Depth, cm Max	Water Clarity	Sedimentation	Habitat	Substrate	Current	DO,* mg/ℓ
					Site 10				
1	ND**	ND	ND	Clear	Little	Pool	Gravel/algae	None	-
2	ND	ND	ND	Clear	Little	Pool	Gravel/algae	None	-
					Site 11				
1	4.7	19.0	-	Clear	Little	Riffle	Bedrock/gravel	Moderate	8.0
2	6.1	5.8	12.7	Clear	Little	Riffle	Bedrock/gravel	Moderate	-
					Site 12				
1	10.4	5.3	7.6	Clear	Little	Riffle	Cobble/gravel	Moderate	-
2	2.6	11.4	-	Clear	Little	Riffle	Cobble/gravel	Moderate	-

* DO = dissolved oxygen.

ND = not determined.

Table B7

Habitat Data from Site 13, Sevenmile Creek, 24 July 1985

Sample No.	Area sq m	Depth, cm Avg	Depth, cm Max	Water Clarity	Sedimentation	Habitat	Substrate	Current	DO,* mg/ℓ
					Site 13				
1	3.0	10.2	ND**	Clear	None	Riffle	Gravel/bedrock	Moderate	10.0
2	3.3	7.6	ND	Clear	None	Riffle	Gravel/bedrock	Moderate	-
3	4.5	6.3	ND	Clear	None	Riffle	Gravel/bedrock	Moderate	-
4	ND	-	ND	Clear	Little	Pool	Gravel/silt	None	-
5	ND	-	ND	Clear	Little	Riffle	Silt/bedrock	Little	-
6	ND	-	ND	Clear	Little	Pool	Gravel/bedrock	None	-
7	4.6	17.8	ND	Clear	Little	Riffle	Sand/gravel	Moderate	-
					Site 14				
1	1.7	11.4	ND	Clear	None	Pool	Sand/gravel	None	-
2	ND	ND	ND	Clear	Little	Pool	Cobble/bedrock	None	-

* DO = dissolved oxygen.

** ND = not determined.