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INTRODUCTION

Davis et al. (1970) confirmed *Alosa* spawning in Pohick Creek, but did not cite the number of species nor their upstream extent. Presently, the USDA, Soil Conservation Service (SCS) is progressing with plans to construct an impoundment on Pohick Creek and on South Run, a tributary to the creek. In cooperation with the National Marine Fisheries Service, the SCS deemed that a new investigation of the use of Pohick Creek by anadromous species was warranted because more than a decade has passed since the study of Davis et al. (1970). The investigation was conducted by personnel of the Virginia Institute of Marine Science (VIMS).

The overall concern of the study was to determine if fish ladders are needed to permit upstream migration of spawning anadromous fishes beyond the sites of impoundment. Specific questions addressed were:

1. Do anadromous species presently utilize Pohick Creek?
2. If so, what species are present?
3. How far do the species migrate upstream?
4. What is the relative abundance of the species?
5. What effects will impoundments, with and without fish ladders, have on the anadromous fish resource?

METHODS

Four trips were made to Pohick Creek and the nearby surrounding area. The first, on 4 March 1981, was an inspection trip to determine sampling locations and gear selection. Subsequent sampling trips were conducted on 14-15 April, 30 April-1 May, and 14-15 May. The sampling periods were established after telephone interviews with personal contacts in the Fairfax County area indicated that dipnetting activity was high.

Sampling Locations

During the inspection trip a sampling site was chosen on Pohick Creek just below the confluence of the creek and South Run (Fig. 1). Tentative sampling sites were also selected at the planned impoundment areas and further upstream, in the event fish migrated above the junction of Pohick Creek and South Run. Additional sites were selected, one just below the junction of the creek and the outfall of the Lower Potomac Pollution Control Plant (hereafter, sewage treatment plant), and another at the crossing of Route 1 and the creek, in the event anadromous fish entered Pohick Creek but did not move upstream to the junction of the creek and South Run.

Three sites were also selected on Dogue Creek (Fig. 2) on the basis that these locations were frequented by sport fishermen who dipnetted river herring (alewife, *Alosa pseudoharengus*, and blueback herring, *A. aestivalis*). One purpose of establishing these sites was to make a relative comparison between dipnet catches in Dogue and Pohick creeks. Also, there has been a general decline in river herring abundance in the last decade (Loesch and Kriete 1976); therefore, with the additional sites in a different system, the failure to observe or capture *Alosa* in both creeks or their presence in only one creek would less likely be ascribed to sampling error (chance).

Gear and Sampling Procedures

Gill nets (7.6 cm stretched-mesh) were chosen to sample the Pohick site just below the junction of Pohick Creek and South Run. The stream in this area is approximately 10 m wide and varies in depth from about 15 to 91 cm. One gill net site was chosen just below the junction and another 91 m downstream. The nets were secured at the stream banks and the bottom lines weighted. The purpose of two nets was, in the event of spawning runs, to drop both nets at randomly selected times during a run to obtain a catch per unit effort (CPUE). If all fish moved upstream of the sampling area, then, additionally, an estimate of the size of the run would be made from the mean CPUE in conjunction with the duration of the run. All fish gilled and those between the nets, which were to be collected with an electric shocker and dipnets, were to be identified, counted, and returned to Pohick Creek upstream of the sampling area. Dipnets were also used in exploratory sampling (presence or absence of fish) at various sites in the streams when sport fishermen were not dipnetting or visual observations in the streams were not possible.

RESULTS

First Sampling Trip (14-15 April)

A gill net was set below the junction of Pohick Creek and South Run at approximately 1340 hours. A visual inspection was made of Pohick Creek, including South Run, until 1500 hours. No fish were caught or observed in this period. The gill net was left fishing, and the dipnetting sites on Dogue Creek were visited. At site A there was one fisherman who fished for 2 hours and had dipnetted eight male alewives. At site B there was also one fisherman who had dipnetted six male alewives in 2 hours. Two fishermen in 1 hour had one male alewife at site C. At 1800 hours the gill net in Pohick Creek was checked and visual observations were made until 1915 hours. No fish were caught or observed; the net was left to fish overnight. Sites A and C were revisited. At site A, three fishermen dipped an average of eight alewives in about 2 hours; a fourth fisherman who had been there at the first inspection now had 30 alewives, 20 males and 10 females.

The fishermen were interviewed during each inspection of the sites at Dogue Creek and questioned about dipnetting in Pohick Creek. The general concensus was that no experienced dipnetters attempted to fish Pohick Creek. They associated the absence of "herring" in Pohick Creek for the last several years with the presence and subsequent enlargement of the "sludge plant" (i.e., sewage treatment plant). Additionally, they indicated that we were sampling the end of a spawning wave, the previous night it was not uncommon for them to catch 3-4 herring in a dip.

The next morning at 0645 hours the gill net in Pohick Creek was checked and visual observations made. No fish were caught in the overnight set and none were observed in the creek.

Second Sampling Trip (30 April-1 May)

A gill net was set at 1415 hours below the junction of Pohick Creek and South Run. A visual inspection was conducted upstream and downstream of the net for about 1 hour. No fish were caught or observed. The gill net was left fishing. The three sites on Dogue Creek were then visited; no fishermen were present, and visual observations and dipnetting indicated an absence of river herring. Visual observations were then made in Pohick Creek just below the outfall of the sewage treatment plant, but no fish were sighted. The gill net in Pohick Creek was empty when checked again at 1730 hours. The three sites at Dogue Creek were each inspected twice between about 1750 to 1930 hours. There were no dipnetters, and no fish were sighted or dipped. The gill net in Pohick Creek was checked at 2100 hours; there were no fish in the net, and it was left set for the night. There were no fish in the net when it was inspected the next morning at 0700 hours.

Third Sampling Trip (14-15 May)

A gill net was set below the junction of Pohick Creek and South Run at 1400 hours, and visual observations of the stream were made for about 1 hour. No fish were caught or observed. Sites A and C on Dogue Creek were inspected. No dipnetters were present at either site, but hook-and-line fishermen were readily catching bluegills (species were not identified). Pohick Creek was then inspected at a site just below the sewage treatment plant outfall, and at 1645 hours the gill net was checked; there were no fish at either site. Dogue Creek was again visited. VIMS personnel dipnetted at site A for about 1 hour, but no fish were captured. At site C, two dipnetters had caught gizzard shad (Dorosoma cepedianum) but not river herring. At 1900 hours, the gill net in Pohick Creek was inspected; there were no fish in the net and it was left to fish overnight. The Dogue Creek sites were again inspected at about 2130-2200 hours. No fish were dipnetted. The following morning at 0630 hours the gill net in Pohick Creek was inspected; no fish were captured in the overnight set.

Mr. Robert Bendl (VIMS) took 14 water samples in the vicinity of the sewage treatment plant outfall for analysis of total chlorine residual between 1115-1500 hours on 15 May. He found concentrations ranging from 1 to 2 mg/l (Table 1), extremely high levels of chlorine residual, comparable to those found at the discharge end of the 30-minute contact tank of a properly managed sewage treatment plant. The values observed in the creek are similar to the monthly mean values for chlorine measured in the treated effluent before release to the creek as measured by sewage treatment plant personnel (Table 2). This suggests that the water in the creek consists predominantly of the treated sewage effluent.

DISCUSSION

The results of this investigation indicate that environmental conditions in Pohick Creek have been altered since the survey of Davis et al. (1970). Supporting evidences for this conclusion are: (1) the failure to detect alewives in Pohick Creek in extensive gill net sets or by visual observations in the first sampling period, while alewives were present in Dogue Creek; (2) the avoidance of Pohick Creek by dipnetters; (3) the failure to catch any species of fish in Pohick Creek, while resident species were present in Dogue Creek; and (4) the extremely high levels of total chlorine residual in Pohick Creek.

The suspected cause for the apparent absence of ichthyofauna in the surveyed area of Pohick Creek is the high chlorine levels in the sewage plant outfall.

The confirmation of Pohick Creek as an *Alosa* spawning ground by Davis et al. (1970) occurred in 1968 (adults) and 1969 (eggs and larvae) prior to the operation of the sewage plant in October, 1970. The plant, at that time, discharged 4.5 x 10^6 gallons per day (mgd), which increased to 11.7 mgd in 1971 (personal communication, Christy Briggs, State Water Control Board (SWCB)), and, at present, it is considerably higher (Table 2).

Chlorine toxicity to fish is well documented (e.g., Alderson 1972; Brungs 1973; Grothe and Eaton 1975; Jolley 1976; Jolley et al. 1978; Jolley et al. 1980; Middaugh et al. 1977; Roberts et al. 1975). Avoidance responses to chlorine have also been described. Tsai (1970), as a result of his investigation of changes in fish populations and migration in Little Patuxent River, Maryland, suggested that chlorinated sewage wastes may block upstream spawning migrations of the white perch (Morone americana), a semi-anadromous species. Meldrim et al. (1974) reported that white perch (140-160 mm TL) exhibited avoidance responses to chlorine concentrations as low as 0.02 mg/l. Sprague and Drury (1969) reported that rainbow trout (Salmo gairdneri) avoided water with a total chlorine concentration of only 0.001 mg/l (orthotolidine method). In addition to determining the toxic effects of total residual chlorination to early life stages of the anadromous striped bass (Morone saxatilis), Middaugh et al. (1977) also reported avoidance behavior. In tests conducted at 1.0-3.0 ppt salinity and 18$\pm$ 1C, 24-day-old striped bass larvae showed reproducible avoidance responses to total residual chlorination concentrations of 0.79-0.82 mg/l and 0.29-0.32 mg/l; at concentrations of 0.16-0.18 mg/l, no avoidance was indicated. Other determinations of fish avoidance to chlorine have been published (e.g., Fava and Tsai 1976; Cherry et al. 1977a; Cherry et al. 1977b; Meldrim and Fava 1977).

Chlorine avoidance and toxicity studies with fish have focused on the early life stages, the most critical (sensitive) periods in development. Also, there are often economic restraints from the standpoint of experimental design in the use of large specimens. Thus, threshold concentrations of chlorine for stream avoidance by the adult anadromous species of present concern are unknown. It is reasonable to assume, however, that the high total residual chlorine concentrations in Pohick Creek on 15 May, 1981 would have elicited avoidance responses by river herring, and have had a highly toxic effect upon the resident species.

Facilities are presently being constructed in the plant for breakpoint chlorination (because of a nitrogen concern) and dechlorination (personal communication, Christy Briggs, SWCB). Dechlorination would eliminate any chlorine concerns in Pohick Creek. At present, however, the SWCB is re-evaluating nitrogen limits, and the eventual employment of the breakpoint chlorination and dechlorination systems is dependent on the SWCB decision.

Obviously, the question of how far anadromous fish migrate upstream in Pohick Creek and South Run cannot be answered. The streams are too small to accommodate American shad (A. sapidissima) or striped bass spawning runs. However, based on my experiences with river herring in the states of Connecticut and Virginia, in conjunction with visible evaluations of the physical and hydrological features of Pohick Creek and South Run, I believe both species would proceed upstream beyond the impoundment sites. The required migratory distance is not excessive; from the mouth of the Potomac River to the impoundment sites is approximately 160 km. Davis and Cheek (1966) reported that river herring in the past spawned as far as 217 km upstream from the mouth of the Cape Fear River, North Carolina. Davis et al. (1970) sampled about 12 km downstream from the proposed Pohick Creek impoundment site; therefore, the additional distance is actually very small. In Connecticut waters, Loesch and Lund (1977) concluded that blueback herring upstream distribution was not a function of distance, but rather a function of seeking desirable spawning sites, and proper hydrological conditions permitting access to such sites.

I believe river herring would again utilize Pohick Creek for spawning if the chlorine in the stream were eliminated or its concentration greatly reduced. The availability of stock for restoration is attested to by the presence of alewives in Dogue Creek and an active commercial fishery for river herring in the Potomac River. Impoundments on Pohick Creek and South Run would reduce the availability of spawning grounds, but to what extent is unknown. If the chlorine problem is rectified, upstream passage facilities for anadromous fishes should be included in impoundment construction. The construction of passage facilities would not be warranted if high chlorine levels in Pohick Creek persist and are acceptable (in a regulatory sense) to a degree that is toxic to early life stages of Alosa or results in stream avoidance.

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Table 1. Total chlorine residual in 14 samples collected in Pohick Creek in the vicinity of the Lower Potomac Water Pollution Control Plant on 15 May 1981.

Station	No. of samples	Distance from outfall (m)	Cl_2 residual (mg/l) Mean	Min.	Max.
A	2	0	1.4	1.4	1.4
B	3	22.9	1.5	1.2	2.0
C	3	50.3	1.3	1.0	1.8
D	3	83.8	1.9	1.6	2.2
E	1	129.5	(1.2)		
F	1	152.4	(1.0)		
G	1	10.7[a]	(0)		

[a]Station G was located upstream of the outfall, all other distances were downstream.

Table 2. Data summary of the chlorine residual in the discharge of the Lower Potomac Water Pollution Control Plant, January 1980-April 1981.

Year	Month	MGD[a]	Cl_2 residual (mg/l)		
			Mean	Min.	Max.
1980	Jan.	19.2	2.3	0	4.0
	Feb.	17.4	2.3	0.6	4.0
	Mar.	18.2	2.3	0.1	3.6
	Apr.	19.2	2.0	0	3.1
	May	18.9	2.0	0	2.8
	June	17.1	2.1	0.8	3.5
	July	16.6	1.7	0	3.7
	Aug.	16.9	2.1	0.6	3.6
	Sept.	17.4	2.1	1.0	3.5
	Oct.	18.0	2.0	1.3	3.3
	Nov.	17.8	1.9	0.6	4.0
	Dec.	17.6	2.0	0.4	2.9
1981	Jan.	18.1	1.9	1.2	2.8
	Feb.	18.7		(No data)	
	Mar.	21.2	2.0	0.9	2.9
	Apr.	21.8	1.9	1.2	2.6

Data source: State Water Control Board, Alexandria, VA.

[a]Millions of gallons per day.

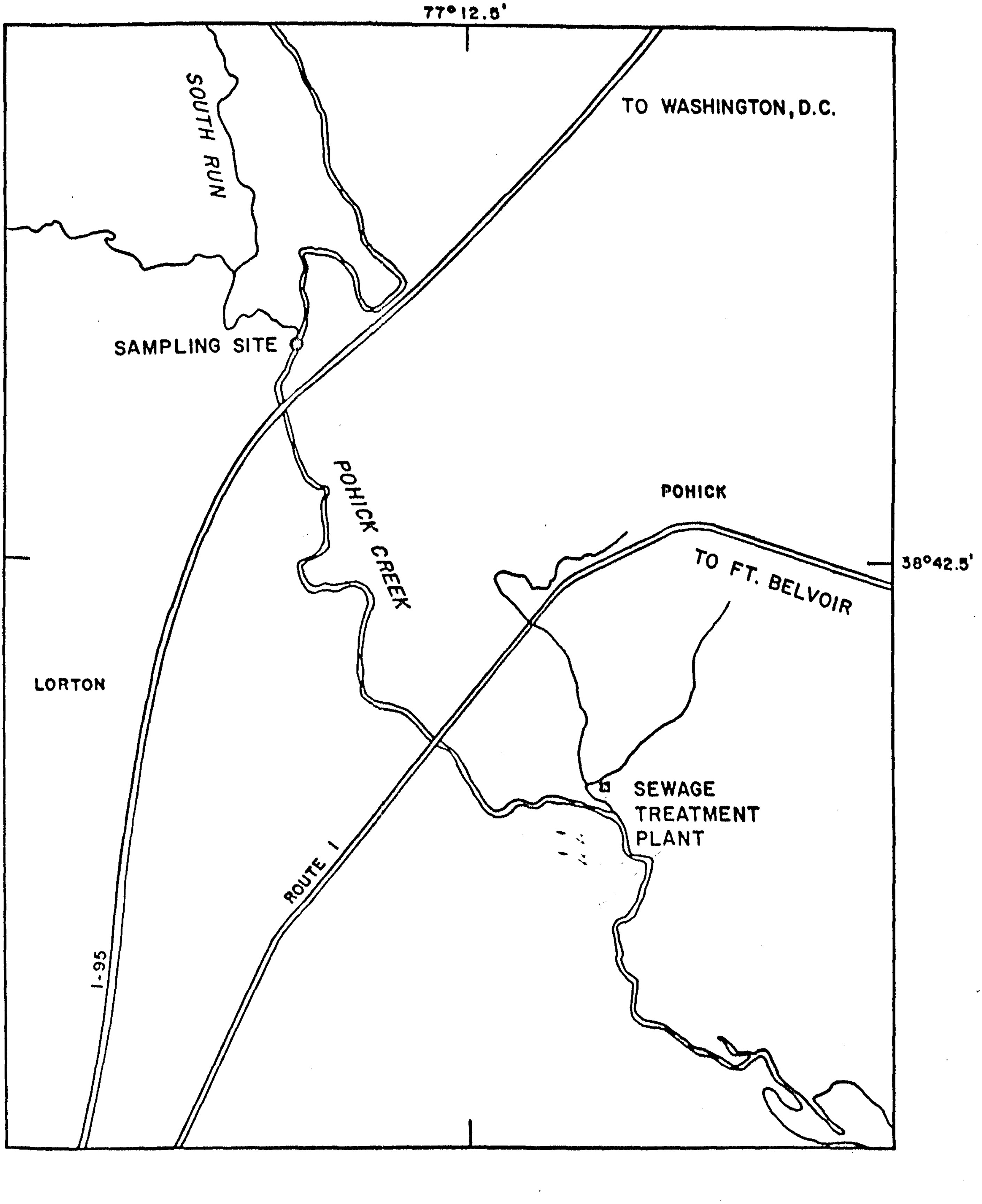

Figure 1. Location of the Pohick Creek and South Run sampling site.

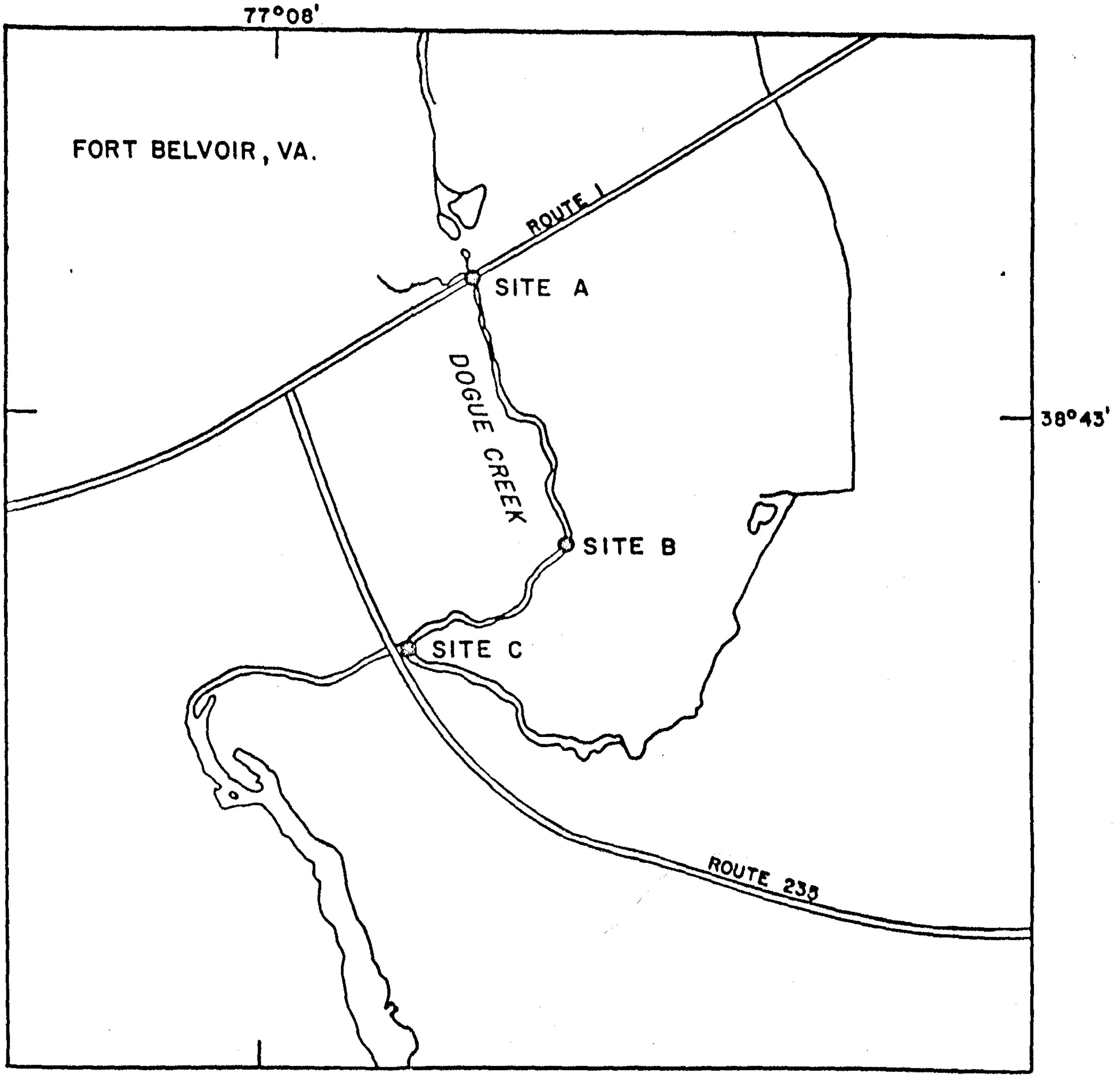

Figure 2. Location of the Dogue Creek sampling sites.