1975

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INTERIM REPORT

An Assessment of Acute Impacts of the James River/ Windmill Point Habitat Development Site on the Macrobenthic Community

by

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October 1975

INTRODUCTION

In December, 1974 the Norfolk District and the Waterways Experiment Station (Dredged Material Research Program) of the U.S. Army Corps of Engineers began an experimental project to create an artificial marsh-island from dredge spoil produced by maintenance dredging of the James River below Hopewell, Virginia. Retaining dikes were constructed with sand dredged from a nearby shoal water site and muddy dredge spoil was eventually placed within the enclosure, located in shallow water adjacent to an old spoil island at Windmill Point. Just before construction of the dikes began, the Virginia Institute of Marine Science intensively sampled the benthos of the artificial island site and adjacent bottoms and the shallow sand "borrow" area. These samples were taken for the assessment of the impact of the dredging and construction activities on the benthic organisms of the region.

The Institute received a contract for the analysis of samples taken and resampling of the same sites on 30 June 1975. Resampling was completed by the end of July 1975. All samples from the November-December sampling and several from the July sampling have been completely analyzed.

The partially interpreted results of these field surveys are reported herein. Also included in the report is a general review of the benthic ecology of the tidal freshwater James River in which the habitat development site is located.

BENTHIC COMMUNITIES IN THE TIDAL FRESHWATER JAMES RIVER

Physical Setting

The tidal freshwater James River extends approximately 50 miles from the fall line at Richmond to the average position of measurable salinity at Swanns Point (Fig. 1). This reach can be divided into two major regions based on biota, geomorphology and physico-chemical criteria. The upper tidal freshwater James extends from the fall line down to Turkey Point, just above Hopewell. The lower tidal freshwater James extends from Turkey Point downriver to Swanns Point.

The upper portion of the river is narrow with large meanders and ox-bow lakes. The cross-sectional area of the river increases gradually downstream from Richmond. The lower region is wide with broad flats on either side of the channel. The cross-sectional area is much larger here than in the upper region.

An important ecological factor in the upper tidal freshwater region is the effect of waste disposal. Organic loading is extremely high from domestic and industrial outfalls. Coliform bacteria counts are higher than anywhere else in the James Basin, ranging from 10,000 to 1,000,000/

100 ml. Most of the organic and coliform load comes from Richmond which releases over 40,000 lbs. of BOD per day. Oxygen sags are a common occurrence during the summer in this region because of this heavy organic loading.

The lower tidal freshwater region is also affected by high organic loading, mostly from Hopewell's industrial plants. BOD averages 80,000 lbs/day but coliforms counts are lower than the upper region, ranging from 100 to 10,000/ 100 ml. Since the river has a much larger volume in this region it has greater assimilative ability and water quality improves greatly in the lower reaches of this region.

The tidal influence felt throughout the James below Richmond is an important feature of the environment. Currents generated by tides are much reduced from those found in the free-flowing James above Richmond. This allows the deposition of fine sediments brought down by the river, such that available benthic habitats are all muds or sands as opposed to the sands, gravels and boulders found in the lotic portion of the river. This severely restricts the composition of the biota since suitable substrates are not available for the diverse epifauna and crevice dwelling fauna of fast flowing fresh waters. Furthermore, tidal ebb and flow increases residence time of pollutants in this segment of the river. It typically takes an average of 7 days for a particle of water to traverse the 50 miles of the tidal freshwater zone. During floods this residence time may decrease to 3 days but under extreme low-flow conditions may increase to 17 days.

The exact position of the boundary between the lower tidal freshwater region and the oligohaline region is quite variable and diffuse. It depends on the magnitude of freshwater inflow into the James. The boundary typically shifts up or downriver several miles seasonally, but the salinity typically does not exceed 2‰ at Swanns Point.

Only during periods of drought will measurable salinity penetrate into this typically freshwater segment. This last occurred in the mid-1960's when the flow of the James at Richmond was 10 cfs, the lowest ever measured. Salinity intruded almost to Hopewell allowing for considerable overlap and replacement of the freshwater fauna by estuarine species.

During this drought the typical tubificid-chironomid community, characteristic of the lower tidal freshwater region, was probably displaced upriver as the salinity advanced upstream. The fauna 10 to 15 miles below Hopewell in the vicinity of Windmill Point must have been very much like that typical of the oligohaline region (usually found around Hog Island) and was probably dominated by the polychaete *Scolecolepides viridis*, the bivalve *Rangia cuneata* and estuarine species of the amphipod genus *Gammarus*. With the return of "normal" conditions the estuarine fauna retreated downriver except for *Rangia cuneata*, the adults of which have been able to survive there although no spawning or recruitment has since taken place in the freshwater zone, since salinities of near 5‰ are required for spawning and survival of larvae (Cain 1972). The Rangia populations, composed basically of one year class, have persisted below Jordan Point for about 10 years, but only few very large clams remain.

Freshwater Fauna

Another bivalve, the Asiatic clam, Corbicula manilensis, has also recently become established throughout the tidal freshwater James (Diaz 1974). Corbicula is an opportunistic freshwater species which, since its introduction in the late 1960's, has rapidly spread from its probable introduction point near Hopewell. In the fall of 1971 its range extended 5 miles above and 20 below Hopewell (down to mile 45). By the fall of 1972 it had extended its range to the fall line at Richmond and to 30 miles below Hopewell. During the summer of 1975 it was found below Swanns Point as far as Hog Point, well into the typically oligohaline zone.

The effect of the introduction of Corbicula on other benthos is difficult to determine. Corbicula which has a planktonic larval stage, has been able to rapidly colonize new territory whereas indigeneous freshwater bivalves have more limited powers of dispersal. It has high fecundity and is relatively tolerant of organic and chemical pollution. Dense sets have occurred in the fall, with densities over 5000 individuals/m^2 in some areas. By summer most of these recruits die but enough survive to dominate the benthic biomass in most areas of the tidal freshwater James.

Only two other freshwater bivalves are at all common in the tidal James River, the sphaeriid *Pisidium casertanum* and the unionid *Ellipito complanata*. *P. casertanum* is a very common nearetic species that is considered tolerant of and even favored by organic pollution (Fuller 1974). Only a few juvenile *E. complanata* have been taken in our surveys of the James. It is not known where the spawning stock resides. The most likely place would be on shallow sand bars.

The remains of large *E. complanata* populations are scattered throughout the entire tidal freshwater regions, with largest densities of shell in shallow sandy areas. The apparent great reduction in unionid populations in tidal freshwater James may be attributable to an increase in organic or toxic pollution as unionids are quite sensitive to pollutants (Fuller 1974).

In general the remaining indigeneous molluscan fauna of the tidal freshwater James is too sparse to be of much consequence. We have found very low densities and Koss et al. (1974) found that bivalves and gastropods comprised only 0.15% of the individuals collected in a survey of the upper tidal freshwater James.

The dominant and most diverse taxa in the tidal freshwater James are tubificid oligochaetes and dipteran insect larvae of the family Chironomidae. These two families are well represented in most lotic and limnetic waters and their species composition and density of individuals varies in relation to the degree of pollution (Brinkhurst & Cook 1974, Roback 1974). Other taxonomic groups which are important in the benthic communities of the tidal freshwater James are the oligochaete families Naididae and Enchytraceidae, Triclads, Hirudinea, Amphipoda, Ephemeroptera, Odonata, Trichoptera, Bryozoa, and various dipteran families.

Community Structure

The upper tidal freshwater region is characterized by low diversity and species richness (Koss et al. 1974, Diaz unpubl. data). The benthic fauna is most severely depressed just below Richmond, with a general recovery in both diversity and richness near Hopewell. The composition of the benthic community is rather uniform in this region. Before the introduction of *Corbicula*, the dominant organisms were the tubificids *Limnodrilus* spp., *Ilyodrilus templetoni*, and *Aulodrilus pigueti*, and the chironomids *Coelotanypus scapularis* and *Procladius* spp. The tubificids were numerically dominant but the chironomids were represented by more species.

Tubificids and chironomids have quite different life histories and modes of repopulation. Tubificids are aquatic throughout their lives and disperse only by crawling through the sediment. They are hermaphroditic but are incapable of self-fertilization, so they must find a mate and copulate. They do not lay large numbers of eggs but typically deposit one egg at a time in a cocoon (Brinkhurst & Jamieson 1971). However, they are able to produce cocoons rapidly as evidenced by the thick mats of worms that can develop in a short period (Wass, personal observation). Tubificid longevity is unknown.

Only the developmental stages of chironomids live in an aquatic environment; adults are flying insects. This gives the chironomids great powers of dispersal and is the main reason why chironomids are generally the first benthic forms to recolonize defaunated areas. Larvae of some species are motile and can crawl along the bottom or actively swim, but most are sedentary tube dwellers. Larval movement plays only a secondary role in dispersion and recruitment. The larvae are generally shortlived and it is the egg-laying of adult midges during warm seasons that maintains populations. During cold seasons there is little or no recruitment and larval development is typically arrested until warmer temperatures prevail allowing further development and metamorphosis.

Since the establishment of *Corbicula* in the upper tidal freshwater region, the community dominance has shifted and, during periods of peak larval settlement, *Corbicula* is the most numerous benthic animal present (Diaz unpubl. data), although most of the juveniles die by early summer.

Benthic productivity (as measured by wet weight biomass) of the upper tidal freshwater regions was low before the invasion of *Corbicula*; biomass was generally less than 6 g/m^2. Since the establishment of *Corbicula*, benthic biomass has increased slightly.

The lower tidal freshwater James is composed of two biological subsections. As the river approaches Hopewell the benthic communities become richer and dissolved oxygen levels increase. Species diversity and richness are again depressed in the vicinity of Hopewell and the composition of the communities is like that in the upper tidal freshwater segment. The dominants are again various *Limnodrilus* species, *Coelotanypus scapularis* and *Ilyodrilus templetoni*. The earliest quantitative sampling in this area (in the fall of 1971) showed *Corbicula* to be an established member of the community but not among the dominants. In 1971 the community was especially characterized by *Limnodrilus* spp. and *Coelotanypus scapularis* but by late 1972 *Limnodrilus* spp. and *Corbicula* dominated.

Downstream from Hopewell the pollution load is assimilated and diversity again increases to the highest levels for the entire tidal freshwater James River. The pre-Corbicula dominants in this lower tidal freshwater area were Limnodrilus spp., Coelotanypus scapularis and Rangia cuneata. Among the sub-dominant species were Ilyodrilus templetoni, the chaoborid midge Chaoborus punctipennis and the ephemeropteran Hexagenia mingo. When Corbicula invaded this segment it did not become as abundant as upriver, suggesting that the Limnodrilus-Coelotanypus-Rangia community was more resistant to the invasion by Corbicula than the communities in the upper tidal freshwater areas. As mentioned earlier Rangia is fast dying out and whether or not Corbicula will replace it as a dominant species remains to be seen.

Again, the abundance of Limnodrilus spp. in the upper lower tidal freshwater region suggests poor water quality, but in the lower part of this segment Limnodrilus is no longer the overwhelming dominant as it is upriver. The proportion of mature to immature worms and the ratio of Limnodrilus to other species decreases greatly. Here Limnodrilus is a member of a complex community rather than a monoculture of an "indicator" species.

In the upper half of this section, the benthic biomass is of the same order of magnitude as the upper tidal freshwater region (generally less than 9 g/m^2). In the lower half, biomass can range from 2 to 3000 g/m^2, indicating both a patchy distribution of _Rangia_ and higher productivity.

The distribution of benthic communities of the tidal freshwater James reflects the location of pollution sources along the river. Unfortunately, no historical data exist that would indicate the condition of the James before heavy industrialization and urbanization of Richmond and Hopewell. Tidal conditions and the deposition of fine sediments are natural factors which have remained important to benthic organisms in the James. Thus, fauna of the tidal freshwater James was never like that in the relatively unpolluted Piedmont section above Richmond; rather it was probably very much like the lower tidal freshwater James with 100 species or more represented. The fauna of the Piedmont section has upwards of 200 species representing about 100 families (Kirk 1974). The tubificids are only a minor part of the fauna and are not as diverse as in the tidal freshwater James. The chironomids on the other hand are much more diverse in the Piedmont James with over 40 taxa represented compared to 25 found in the tidal sections.

RESULTS OF PREOPERATIONAL SAMPLING (NOVEMBER 1974)

Samples were obtained from 51 stations (Fig. 2). Forty stations were aligned in four transects of 10 stations each extending from the south shore across the habitat development site to the edge of the channel. Three control stations (41, 42, and 43) were located on the spoil shoal but away from the immediate vicinity of the development site. Eight stations (designated by letters A through H) were positioned in and adjacent to the upstream borrow pit site. Two 0.05 m^2 Ponar grab samples were taken at each station and after removing a small sediment sample, their contents were sieved through a 0.5 mm screen, preserved with buffered formalin, and stained with a vital stain (phloxine B). Later, the samples were microscopically examined and the animals present sorted into major taxonomic groups and placed in ethanol.

From the 102 grab samples taken, 20,857 individuals representing 32 recognizable taxa were recovered (Table 1). These represent 5 phyla, 13 families, 26 genera, and 31 species. Additional species will undoubtedly be reported once taxonomic confirmations are completed. The family Tubificidae is numerically dominant with 15,296 individuals, 73.3% of the total specimens collected, followed by Corbiculidae, 4253 (20.4%) and Chironomidae, 807 (3.9%). The other 10 families had 501 individuals (2.4% of the fauna).

The family Chironomidae had the most species, with at least 10, and probably more present. The family Tubificidae had 9 species present (not including immature Limnodrilus) and the remaining 11 families had only one species each (Table 2). Four genera (Limnodrilus, Corbicula, Ilyodrilus, and Coelotanypus) composed 95% of the total individuals. Of these, Limnodrilus and Corbicula were mainly represented by immature individuals comprising 84% of the total individuals collected, whereas adults composed only 2.77% and 0.24% of the total, respectively.

The distributions of species in the four dominant genera, Limnodrilus, Corbicula, Ilyodrilus and Coelotanypus, are shown in Figs. 3-10. Small Corbicula manilensis (<10 mm, length) are treated separately from those larger, for it was felt that while the larger clams were a persistent component of the community, smaller clams were ephemeral and their overwhelming densities would obscure the distribution pattern of adults. Small Corbicula were abundant throughout the area but were more abundant at the shallower sites around the spoil island and along the mainland shore. Larger Corbicula were widely distributed, except at the channel edge; populations were most dense along the shore.

Immature Limnodrilus were abundant throughout the Windmill Point area but were less abundant along the shore than in the muddy sediments offshore. Adult L. hoffmeisteri had a similar pattern of distribution, whereas adult L.

cervix were only present on the shoal bank. Adult *L. profundicola* occurred much less frequently and was most abundant in deeper bottoms. *Ilyodrilus templetoni* was widely distributed but rare along the shore. The most abundant chironomid, *Coelotanypus scapularis* was widely distributed with no readily apparent pattern of abundance.

Shannon's formula (Pielou 1975) was used to calculate species diversity with and without the small *Corbicula* and *Limnodrilus* spp. immatures (Figs. 11 and 12). These two groups were much more numerous than any other and this shows the impact of their dominance on informational diversity. Diversity at the borrow pit and upriver stations is shown in Table 3. Species diversity is a complex concept which reflects several aspects of community structure and a detailed analysis of these components of diversity and interpretations which may be assigned to them will be included in the final report.

SELECTED RESULTS OF POSTOPERATIONAL SAMPLING (JULY 1975)

Collections from 6 sites were examined to see if any impact of the dredging and habitat creation could be detected from a precursory comparison of the two sampling periods. The sites chosen were stations 11, 24, and 40 at the habitat creation site and A, B, and D at the borrow pit site. An additional sample (II) was taken from the interior of the island near previously sampled station 17. These preliminary results are given in Tables 4 and 5. The Chironomidae are not listed by species from these seven sites pending the results of Dr. S. W. Roback's identifications.

The numerical dominants during the July sampling at these selected sites were, as in November, juvenile *Corbicula manilensis*, *Limnodrilus* spp. immatures and chironomids. This brief examination of the July data does not allow a quantitative evaluation of the impact of the dredging, island construction and spoil disposal, but it is apparent that the assemblages found in the vicinity of the habitat creation project and the borrow pit were not drastically different from those found in November, before the project began. Although differences in the density of some dominant species and species diversity (Table 6) for specific sites were observed between the two sampling periods, it will NOT be possible to deduce any meaningful trends until more of the July samples are analyzed.

The greater abundance of the mayfly larvae, *Hexagenia mingo*, in July than in November is notable and probably reflects seasonality. Otherwise other abundant species were about equally represented during the two sampling periods. Two taxa, an unidentified ostracod and the trichopteran *Oecetis*, were collected in July but not in November. Several other species taken in November have not yet turned up in the July samples, but most undoubtedly will once all samples are analyzed.

The sample taken from the intertidal mud within the spoil containment dikes, heavily vegetated with pickerel weed (Pontederia cordata) and arrowhead (Sagittaria latifolia) indicated dense populations of Limnodrilus spp. and chironomids (Table 7). Corbicula and Hexagenia were not present but the oligochaete Branchiura sowerbyi was more abundant there than elsewhere.

The samples taken in the sand borrow pit contained an assemblage similar to that on deeper bottoms and did not contain some forms, e.g. triclads, sphaeriids and unionids which were found on the surrounding shallow sand bottoms.

DISCUSSION

The benthic fauna of the freshwater tidal James River is extremely eurytopic with respect to sediment type and other environmental characteristics. It is dominated by eurytopic and opportunistic invertebrates, principally tubificids, Corbicula manilensis and chironomids. Only a few, generally less abundant species have truly restrictive habitat preferences (e.g. enchytraeid oligochaetes are only found in nearshore sands and the tubificid Peloscolex multisetosus is only found in channel muds). Furthermore, life history characteristics of these dominant species suggest that they can rapidly repopulate defaunated bottoms. The ubiquity and resilience of the fauna makes assessment of impact of man's activities difficult.

Acute effects on the benthos were certainly felt in the area of the artificial marsh island development and in the area dredged for dike material fill. The areal of extent of this impact beyond the immediate confines of the island and borrow pit is unknown. Within the island site an average of 4,500 macrobenthic animals/m^2 were destroyed, 85% of which were immature Limnodrilus and Corbicula. In the dike fill borrow site, approximately 1,700 individuals/m^2 were destroyed, 97% of which were immature Limnodrilus and Corbicula.

Before the sites were resampled, 8 months had elapsed, allowing time for substantial recovery of the populations of the opportunistic dominant species. Dense populations of Limnodrilus and chironomid larvae had even established in the interior of the marsh island. Post operational sampling was conducted too late to assess acute impacts in the vicinity of the habitat development or borrow pit, but it appears that any acute impacts were short lived, except in the borrow pit itself where the habitat has been substantially modified. The impacts of the borrow pit may be of long term importance. The pit is 20 feet deep in places and has no open connection with deep water. It might be a site of deposition of ooze and depleted dissolved oxygen.

Although analysis of the remaining July samples will allow a more complete analysis of impact, certain uncertainties in assessment will undoubtedly remain due to the delay and infrequency in sampling and poorly known seasonality of the fauna. To further understand the extent and duration of impact we recommend resampling a small number of selected stations at least again in November 1975 and preferably also during the spring and summer of 1976.

Table 1. Site species matrix of individual abundance for Nov.-Dec. 1974 benthic sampling at the James River Windmill Point habitat development site. (Values are sum of two .05 m^2 Ponar grabs).

Species	1	2	3	4	5	6	7	8	9	10
Tricladida							2			
Bivalvia										
Corbicula manilensis (large)			2		4	1	1	2		
Corbicula manilensis (small)	690	23	10	12	78	116	78	258	8	4
Sphaeriidae		1								
Unionidae			3							
Ectoprocta										
Urnatella gracilis										
Annelida										
Naididae										
Aulodrilus pigueti	39		1							
Branchiura sowerbyi					2		1			
Ilyodrilus templetoni		57	13	21	18	11	7		25	30
Limnodrilus spp. (imm.)	62	303	263	343	278	379	185	343	280	336
L. cervix					4	10		1		
L. hoffmeisteri		6	10	1	6	9	2	2	4	35
L. profundicola					12	2	1	2		1
Peloscolex multisetosus										4
Potamothrix vejdovskyi					2					
Enchytraeidae	4									
Tubificidae (cap. setae)										
Illinobdella moorei			1							
Amphipoda										
Gammarus fasciatus								1		
Insecta										
Hexagenia mingo			4	4	2		1			
Chaoborus punctipennis										
Chironomus spp.				1		1				
Chironomus ? sp.										
Coelotanypus scapularis		50	11	6			5	1	14	30
Cryptochironomus spp.	3			1		1	2	2	1	
Stenochironomus sp.								2		
Stictochironomus sp.	5									
Pentaneura spp.			5				1			
Polypedilum sp.	7									
Procladius spp.		7	2	4						5
Cladotanytarsus spp.										
Total Numbers	810	447	326	393	410	533	286	614	332	454

Table 1. Site species matrix of individual abundance for Nov.-Dec. 1974 benthic sampling at the James River Windmill Point habitat development site. (Values are sum of two .05 m^2 Ponar grabs).

Species	11	12	13	14	15	16	17	18	19	20
Tricladida		2								
Bivalvia										
Corbicula manilensis (large)		2	2	2		2	2	1	3	
Corbicula manilensis (small)	173	14	7	33	146	71	114	160	18	19
Sphaeriidae										
Unionidae					2	4			1	
Ectoprocta										
Urnatella gracilis										
Annelida										
Naididae						1				
Aulodrilus pigueti										
Branchiura sowerbyi					5					
Ilyodrilus templetoni	3	18	25	8	49	3	14	6	5	15
Limnodrilus spp. (imm.)	11	100	432	204	602	170	237	176	357	255
L. cervix					4	3	11	3		
L. hoffmeisteri		1		5	12	18	15	28	5	21
L. profundicola						1	1	3		10
Peloscolex multisetosus					1				1	2
Potamothrix vejdovskyi										
Enchytraeidae	1						2			
Tubificidae (cap. setae)										
Illinobdella moorei			1					1		
Amphipoda										
Gammarus fasciatus					1					1
Insecta										
Hexagenia mingo			3	5	6			3	1	
Chaoborus punctipennis										
Chironomus spp.				1			2			
Chironomus ? sp.										
Coelotanypus scapularis		9	11	5	4		1		5	11
Cryptochironomus spp.	1		3	2	1	1		1	1	
Stenochironomus sp.										
Stictochironomus sp.	1									
Pentaneura spp.			2		3			1		
Polypedilum sp.										
Procladius spp.			2	5				1	2	4
Cladotanytarsus spp.										
Total Numbers	190	147	489	278	836	275	399	385	407	346

Table 1. Site species matrix of individual abundance for Nov.-Dec. 1974 benthic sampling at the James River Windmill Point habitat development site. (Values are sum of two .05 m^2 Ponar grabs).

Species	21	22	23	24	25	26	27	28	29	30
Tricladida								2	1	3
Bivalvia										
<u>Corbicula</u> <u>manilensis</u> (large)				4	2		1		2	
<u>Corbicula</u> <u>manilensis</u> (small)	546	19	25	12	7	23	77	48	22	40
Sphaeriidae									1	
Unionidae									1	
Ectoprocta										
<u>Urnatella</u> <u>gracilis</u>										
Annelida										
Naididae					1			1		
<u>Aulodrilus</u> <u>pigueti</u>										
<u>Branchiura</u> <u>sowerbyi</u>										
<u>Ilyodrilus</u> <u>templetoni</u>		17	16		5	23	14	19	61	65
<u>Limnodrilus</u> spp. (imm.)	131	165	398	140	187	217	320	427	460	482
<u>L.</u> <u>cervix</u>				4	9	3	3			
<u>L.</u> <u>hoffmeisteri</u>		1		4	11	5	4	14	1	45
<u>L.</u> <u>profundicola</u>					1			1		
<u>Peloscolex</u> <u>multisetosus</u>									3	12
<u>Potamothrix</u> <u>vejdovskyi</u>										
Enchytraeidae	3									
Tubificidae (cap. setae)										
<u>Illinobdella</u> <u>moorei</u>									1	
Amphipoda										
<u>Gammarus</u> <u>fasciatus</u>										1
Insecta										
<u>Hexagenia</u> <u>mingo</u>			10	4	9	2	9	16	1	
<u>Chaoborus</u> <u>punctipennis</u>										
<u>Chironomus</u> spp.				2	1					
<u>Chironomus</u> ? sp.			3							1
<u>Coelotanypus</u> <u>scapularis</u>	1	42	3	4	3	10		8	7	23
<u>Cryptochironomus</u> spp.	9	3		2	1	2	4	2	3	2
<u>Stenochironomus</u> sp.	3				2			1	1	
<u>Stictochironomus</u> sp.	1								1	
<u>Pentaneura</u> spp.		1	5	2	9	3	5	10		
<u>Polypedilum</u> sp.										
<u>Procladius</u> spp.	1	2	1	2	2	1	4	3	5	4
<u>Cladotanytarsus</u> spp.										1
Total Numbers	697	254	461	180	250	289	448	564	597	708

Table 1. Site species matrix of individual abundance for Nov.-Dec. 1974 benthic sampling at the James River Windmill Point habitat development site. (Values are sum of two .05 m^2 Ponar grabs).

Species	31	32	33	34	35	36	37	38	39	40
Tricladida	1	1							1	
Bivalvia										
Corbicula manilensis (large)		2		1	1	4	2		2	
Corbicula manilensis (small)	594	10	7	15	6	25	8	6	36	20
Sphaeriidae										
Unionidae									1	
Ectoprocta										
Urnatella gracilis										
Annelida										
Naididae		1								
Aulodrilus pigueti							3	4		
Branchiura sowerbyi										
Ilyodrilus templetoni		46	18	27	77	55	44	43	97	84
Limnodrilus spp. (imm.)	73	205	80	218	233	609	318	381	609	415
L. cervix						3				
L. hoffmeisteri		4				16		15	20	29
L. profundicola			2			5			8	11
Peloscolex multisetosus		4			1		1	3	7	20
Potamothrix vejdovskyi										
Enchytraeidae	10									
Tubificidae (cap. setae)										
Illinobdella moorei										
Amphipoda										
Gammarus fasciatus		1								
Insecta										
Hexagenia mingo						3		3	9	
Chaoborus punctipennis										
Chironomus spp.										
Chironomus ? sp.		1							1	
Coelotanypus scapularis		25	3	17	23	15	10	24	22	26
Cryptochironomus spp.	2	3				2	2	1	3	
Stenochironomus sp.					1		1			
Stictochironomus sp.										
Pentaneura spp.						3			3	
Polypedilum sp.										
Procladius spp.		5	1	2		3	3	3	10	8
Cladotanytarsus spp.										1
Total Numbers	692	321	111	280	342	752	392	495	855	691

Table 1. Site species matrix of individual abundance for Nov.-Dec. 1974 benthic sampling at the James River Windmill Point habitat development site. (Values are sum of two .05 m^2 Ponar grabs).

Species	41	42	43	A	B	C	D	E	F	G	H
Tricladida											
Bivalvia											
Corbicula manilensis (large)	1					1	1				
Corbicula manilensis (small)	21	6	12	38	113	96	39	63	140	28	68
Sphaeriidae											
Unionidae	1			10		3					
Ectoprocta											
Urnatella gracilis	1										
Annelida											
Naididae											
Aulodrilus pigueti		1									
Branchiura sowerbyi				3				1			
Ilyodrilus templetoni	47	103	33	1	1	2	1				
Limnodrilus spp. (imm.)	675	470	285	142	66	70	30	70	88	37	36
L. cervix	1										
L. hoffmeisteri	11	34	8	12	1	4		2	6	4	4
L. profundicola		11		3							
Peloscolex multisetosus	3		8								
Potamothrix vejdovskyi											
Enchytraeidae											
Tubificidae (cap. setae)										3	1
Illinobdella moorei											
Amphipoda											
Gammarus fasciatus					3	2					
Insecta											
Hexagenia mingo	1			4							
Chaoborus punctipennis			1								
Chironomus spp.		1		3							
Chironomus ? sp.						1	1				
Coelotanypus scapularis	45	12	20	2	1						
Cryptochironomus spp.	5	3	1	1	2			1	2		
Stenochironomus sp.	1				1					3	
Stictochironomus sp.											
Pentaneura spp.		1		1							
Polypedilum sp.											
Procladius spp.	5	1	3								
Cladotanytarsus spp.											
Total Numbers	863	644	396	221	188	180	72	137	236	75	109

Table 2. Proportion and numerical importance of each benthic species at the James River/Windmill Pt. habitat creation site (November-December 1974).

Species	% of total	Number of individuals
Limnodrilus spp. immature	64.02	13,353
Corbicula manilensis (small)	20.14	4,202
Ilyodrilus templetoni	5.88	1,227
Coelotanypus scapularis	2.44	509
Limnodrilus hoffmeisteri	2.13	445
Procladius spp.	0.48	101
Hexagenia mingo	0.48	100
Limnodrilus profundicola	0.36	76
Cryptochironomus spp.	0.35	73
Peloscolex multisetosus	0.33	70
Limnodrilus cervix	0.28	59
Pentaneura spp.	0.26	55
Corbicula manilensis (large)	0.24	51
Aulodrilus pigueti	0.23	48
Unionidae	0.12	26
Enchytraeidae	0.10	20
Stictochironomus sp.	0.09	18
Stenochironomus sp.	0.08	17
Chironomus spp.	0.08	16
Triclad	0.06	14
Branchiura sowerbyi	0.06	12
Gammarus fasciatus	0.05	11
Chironomus ? sp.	0.04	8
Polypedilum sp.	0.03	7
Naididae	0.02	4
Tubificids with capillary setae	0.02	4
Illinobdella moorei	0.02	4
Sphaeriidae	0.01	2
Cladotanytarsus	0.01	2
Potamothrix vejdovskyi	0.01	2
Chaoborus punctipennis	0.00	1
Urnatella gracilis	0.00	1

Table 3. Species diversity at borrow pit and upstream impact assessment stations for the James River habitat creation project.

Site	H' (bits/indiv.) (*Corbicula* and *Limnodrilus* immature excluded)	H' (bits/indiv.) Total assemblage
Borrow Pit		
A	2.91	1.84
B	2.42	1.30
C	2.61	1.50
D	1.58	1.26
E	1.50	1.10
F	0.81	1.17
G	1.43	2.08
H	0.72	1.19
Impact Assessment Sites		
42	1.75	1.36
43	2.37	1.59

Table 4. Species from selected July 1975 sites. (Values are sum of two 0.05 m^2 Ponar grabs).

	11	24	40	A	B	D	II
Triclads			1	2		9	
Bivalves							
Corbicula manilensis (large)		1	1				
Corbicula manilensis (small)	350	10	13	18	10	259	
Sphaeriidae				6		1	
Unionidae				2		6	
Annelids							
Branchiura sowerbyi			1	4	3	1	4
Ilyodrilus templetoni		2	22		1	3	13
Limnodrilus spp. immature	6	19	156	107	27	175	536
L. cervix							7
L. hoffmeisteri		7	12	14	1	13	10
Peloscolex multisetosus			6			1	
Tubificids (cap. setae)	6					3	
Illinobdella moorei						1	
Amphipods							
Gammarus fasciatus				1			
Ostracods				1			
Insects							
Oecetis sp.				1			
Hexagenia mingo				52			
Chaoborus punctipennis				1			
Chironomidae	3	8	24	65	37	19	50
Totals	365	47	235	274	79	491	630

Table 5. Proportion and numerical importance of each benthic species at the James River/Windmill Pt. habitat creation site (from selected sites, July 1975).

Species	% of total	Number of individuals
Corbicula manilensis (small)	45.11	673
Limnodrilus spp. (immature)	32.84	490
Chironomidae	10.56	156
Hexagenia mingo	3.48	52
Limnodrilus hoffmeisteri	3.15	47
Ilyodrilus templetoni	1.88	28
Tricladida	0.80	12
Branchiura sowerbyi	0.60	9
Tubificidae with capillary setae	0.60	9
Unionidae	0.54	8
Sphaeriidae	0.47	7
Peloscolex multisetosus	0.47	7
Corbicula manilensis	0.13	2
Illnobdella moorei	0.07	1
Gammarus fasciatus	0.07	1
Ostracoda	0.07	1
Oecetis spp.	0.07	1
Chaoborus punctipennis	0.07	1

Table 6. Species diversity at selected July 1975 sites. Total benthic assemblage used in computation.

Site	H' (bits/indiv.)
~~II~~ 11	0.30
24	2.16
40	1.73
A	2.38
B	1.76
D	1.68
II	0.81

Table 7. Proportion and numerical importance of benthic species from the interior of the created island.

Species	% of fauna	Number of individuals
Limnodrilus spp. immature	86.45	536
Chironomidae	8.06	50
Ilyodrilus templetoni	2.10	13
Limnodrilus hoffmeisteri	1.61	10
Limnodrilus cervix	1.13	7
Branchiura sowerbyi	0.64	4

Literature Cited

Brinkhurst, R. D. and D. G. Cook. 1974. Aquatic earthworms (Annelida: Oligochaeta), p. 143-156. In: C. W. Hart and S. L. H. Fuller. (Eds.). Pollution Ecology of Freshwater Invertebrates. Academic Press, New York.

Brinkhurst, R. O. and B. G. M. Jamieson. 1971. Aquatic Oligochaeta of the World. Univ. of Toronto Press, Toronto. 860 p.

Cain, T. D. 1972. The reproductive cycle and larval tolerances of *Rangia cuneata* in the James River, Virginia. Dissertation of the University of Virginia, 121 p.

Diaz, R. J. 1974. Asiatic clam, *Corbicula manilensis* (Philippi), in the tidal James River, Virginia. Chesapeake Sci. 15:118-120.

Fuller, S. L. H. 1974. Clams and mussels (Mollusca: Bivalvia), p. 215-257. In: C. W. Hart and S. L. H. Fuller. (Eds.). Pollution Ecology of Freshwater Invertebrates. Academic Press, New York.

Kirk, W. L. 1974. Macroinvertebrates, p. 141-419. In: Virginia Institute for Scientific Research, Richmond, Virginia, The Effects of Thermal Loading by the Bremo Power Station on a Piedmont Section of the James River, Vol. I. Final Report for Virginia Electric and Power Company.

Koss, R. W., L. D. Jensen, and R. D. Jones. 1974. Benthic Invertebrates, p. 121-142. In: L. D. Jensen (Ed.), Environmental responses to thermal discharges from the Chesterfield Station, James River, Virginia. Cooling Water Studies for Electric Power Research Institute, Research Project RP-49.

Pielou, E. C. 1975. Ecological Diversity. Wiley-Interscience, New York. 196 p.

Roback, S. S. 1974. Insects (Arthropoda: Insecta), p. 314-376. In: C. W. Hart and S. L. H. Fuller (Eds.). Pollution Ecology of Freshwater Invertebrates. Academic Press, New York.

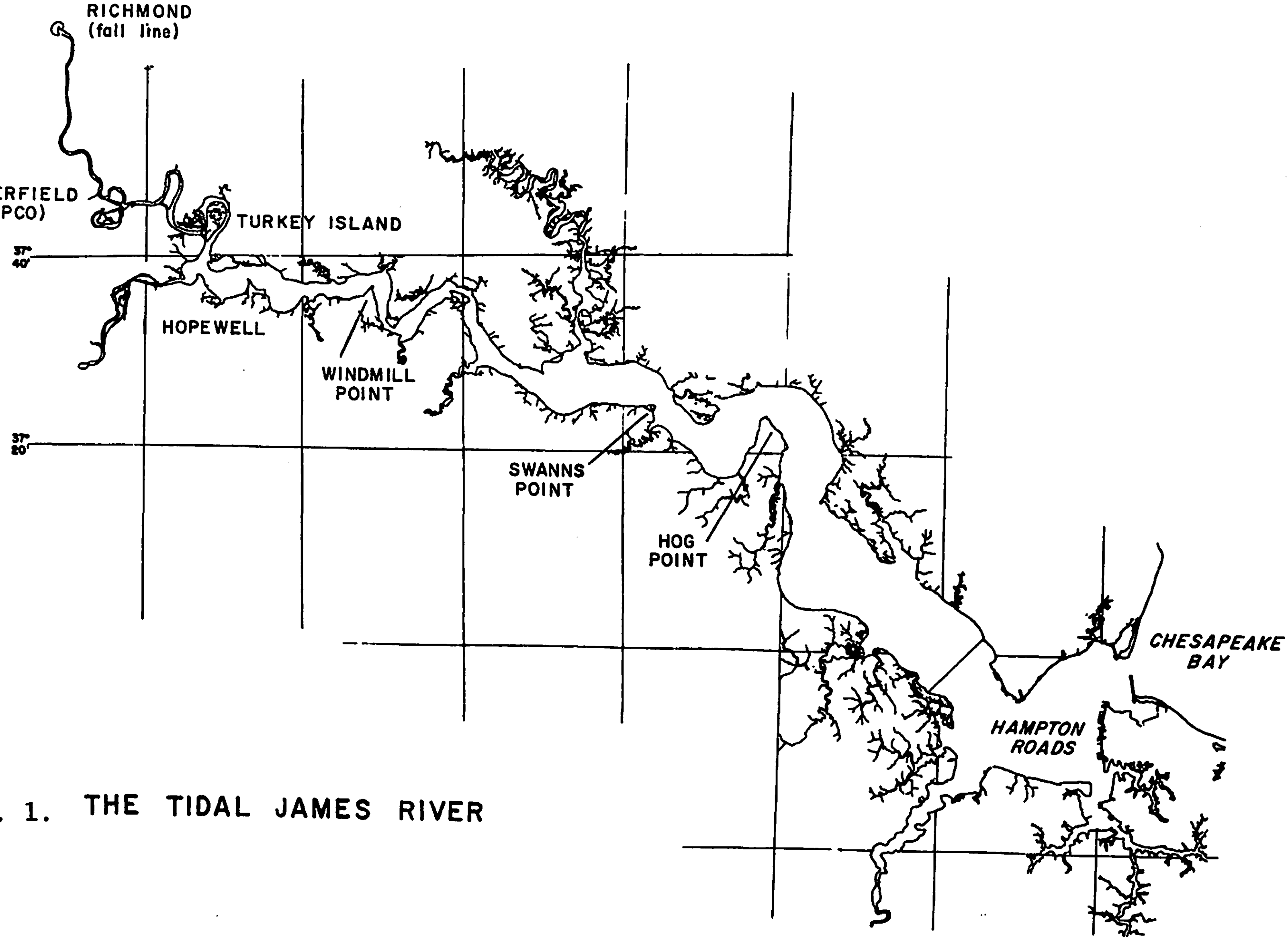

Fig. 1. THE TIDAL JAMES RIVER

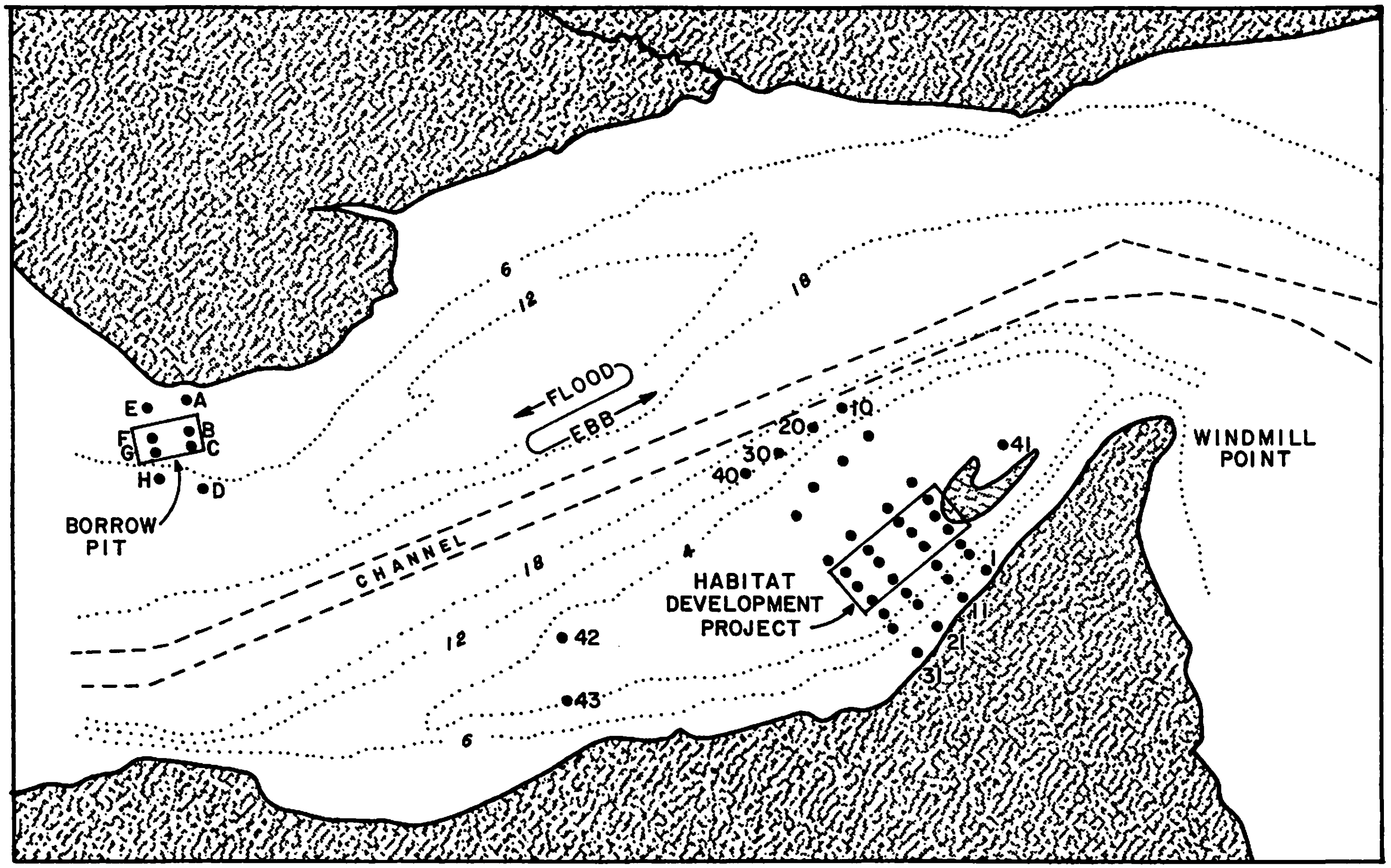

Fig. 2. Benthic sampling locations for the James River Windmill Point habitat development project.

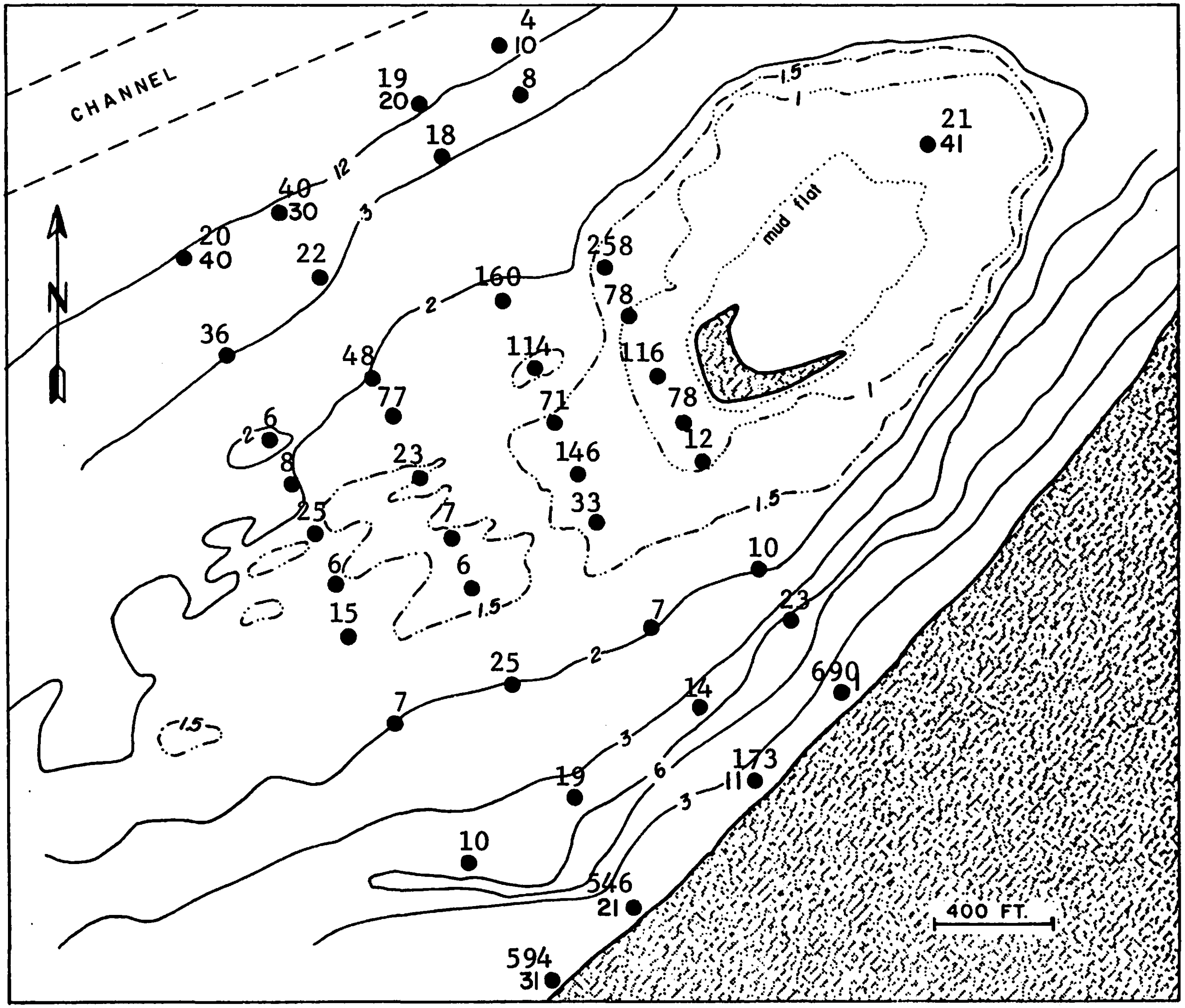

Fig. 3. Distribution of Corbicula manilensis (<10 mm) in the area of the habitat development site, James River. (Values are sum of two .05 m^2 Ponar grabs).

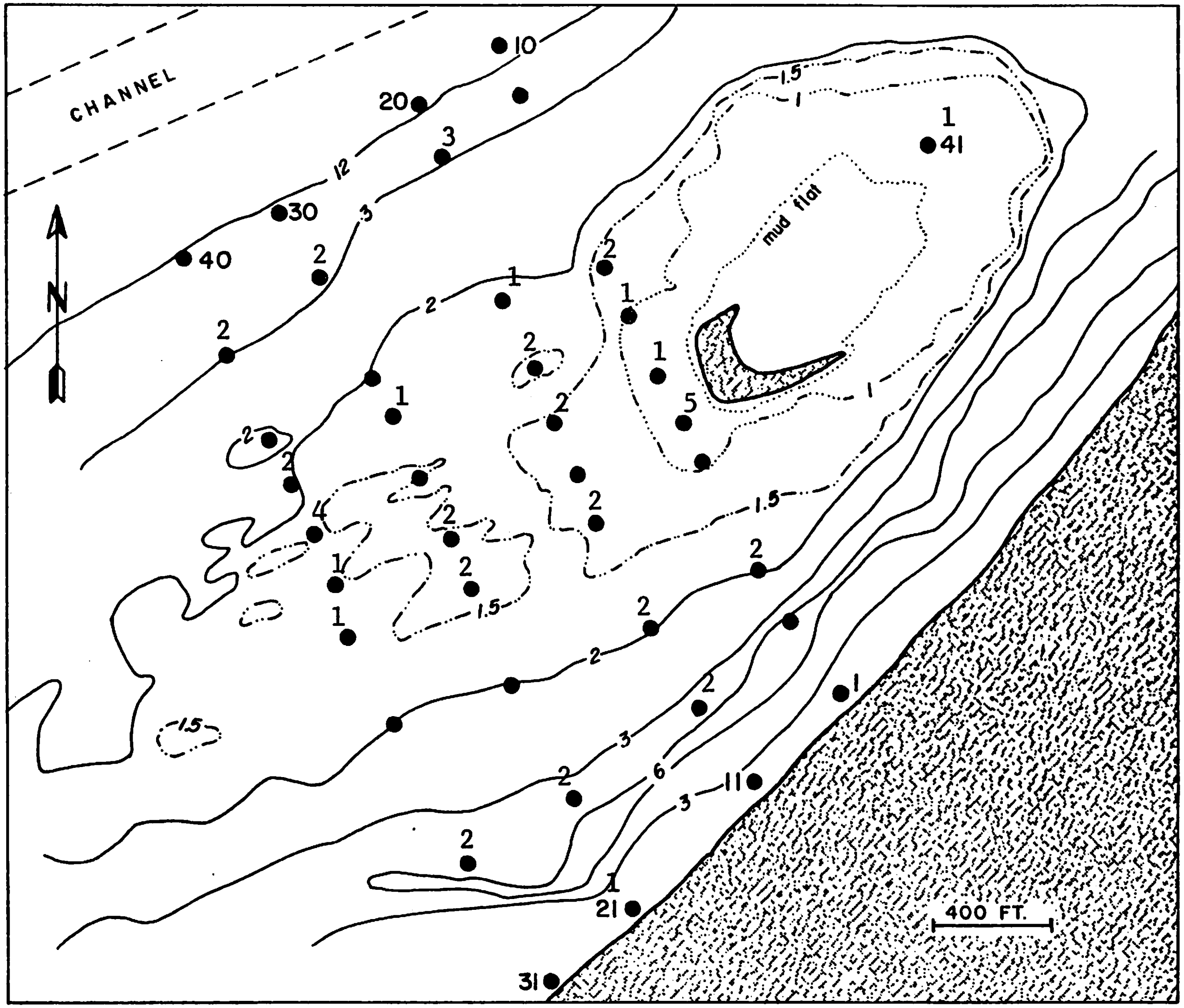

Fig. 4. Distribution of Corbicula manilensis (>10 mm) in the area of the habitat development site, James River. (Values are sum of two .05 m^2 Ponar grabs).

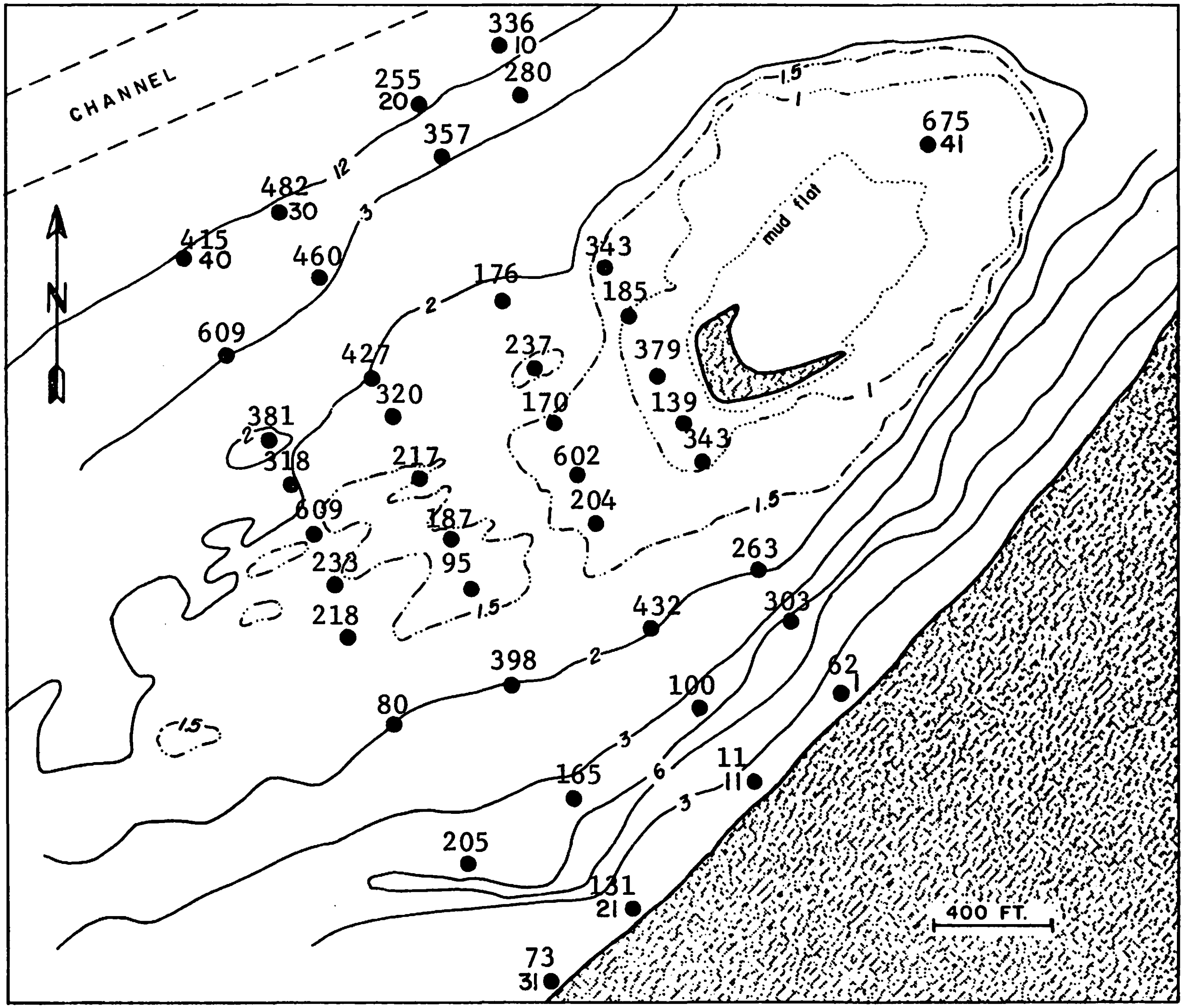

Fig. 5. Distribution of Limnodrilus spp. immature in the area of the habitat development site, James River. (Values are sum of two .05 m^2 Ponar grabs).

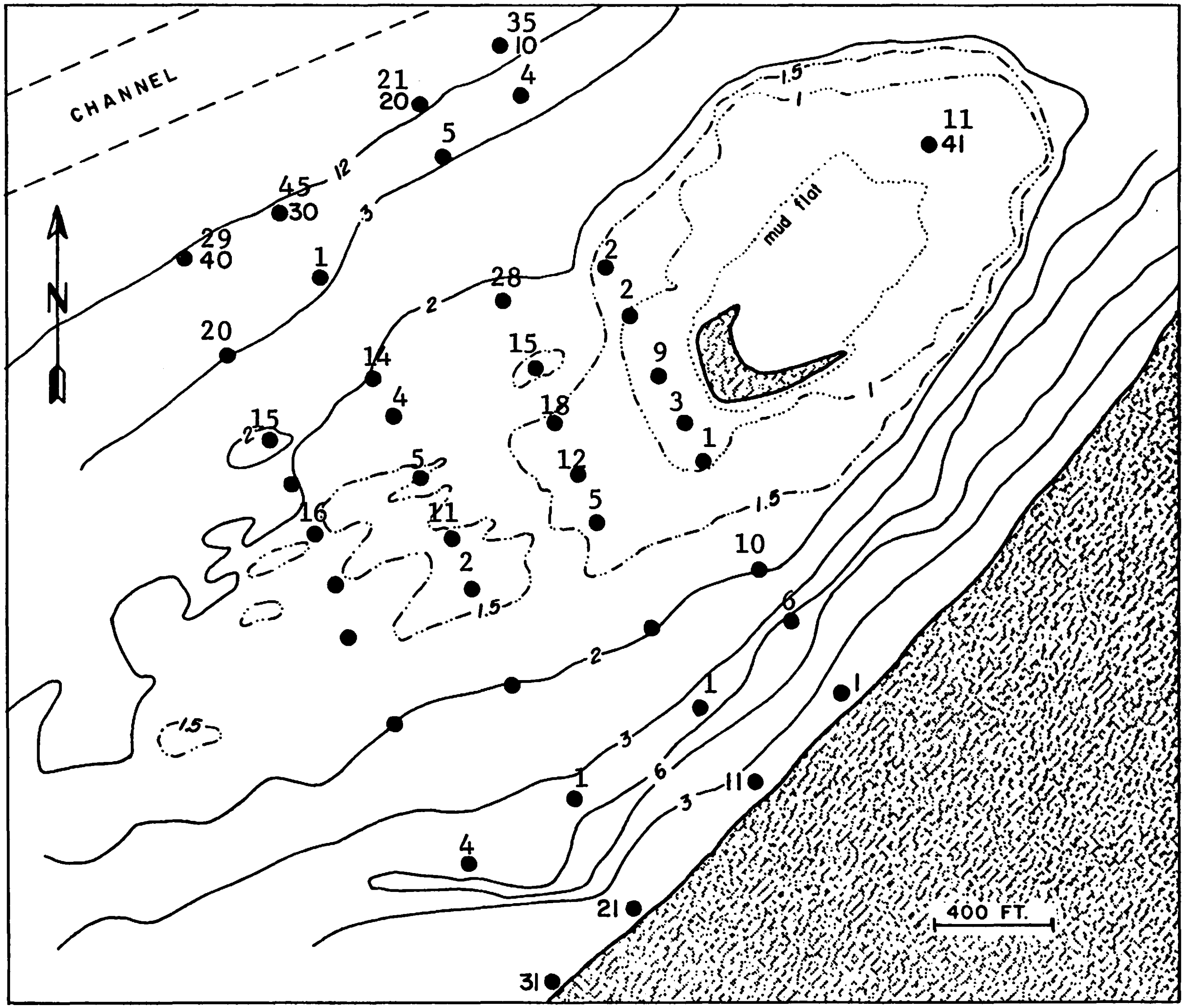

Fig. 6. Distribution of Limnodrilus hoffmeisteri in the area of the habitat development site, James River. (Values are sum of two .05 m^2 Ponar grabs).

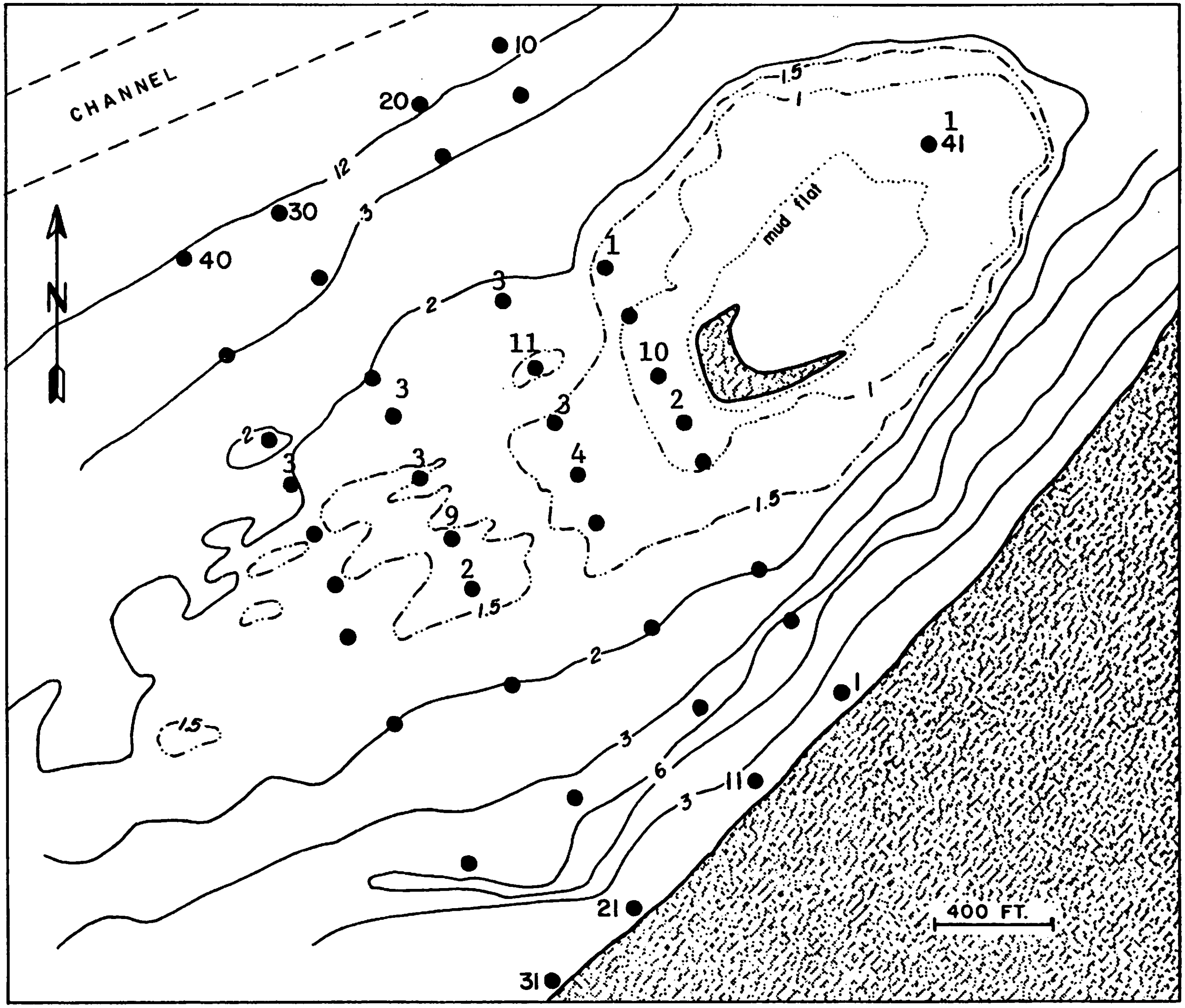

Fig. 7. Distribution of <u>Limnodrilus cervix</u> in the area of the habitat development site, James River. (Values are sum of two .05 m^2 Ponar grabs).

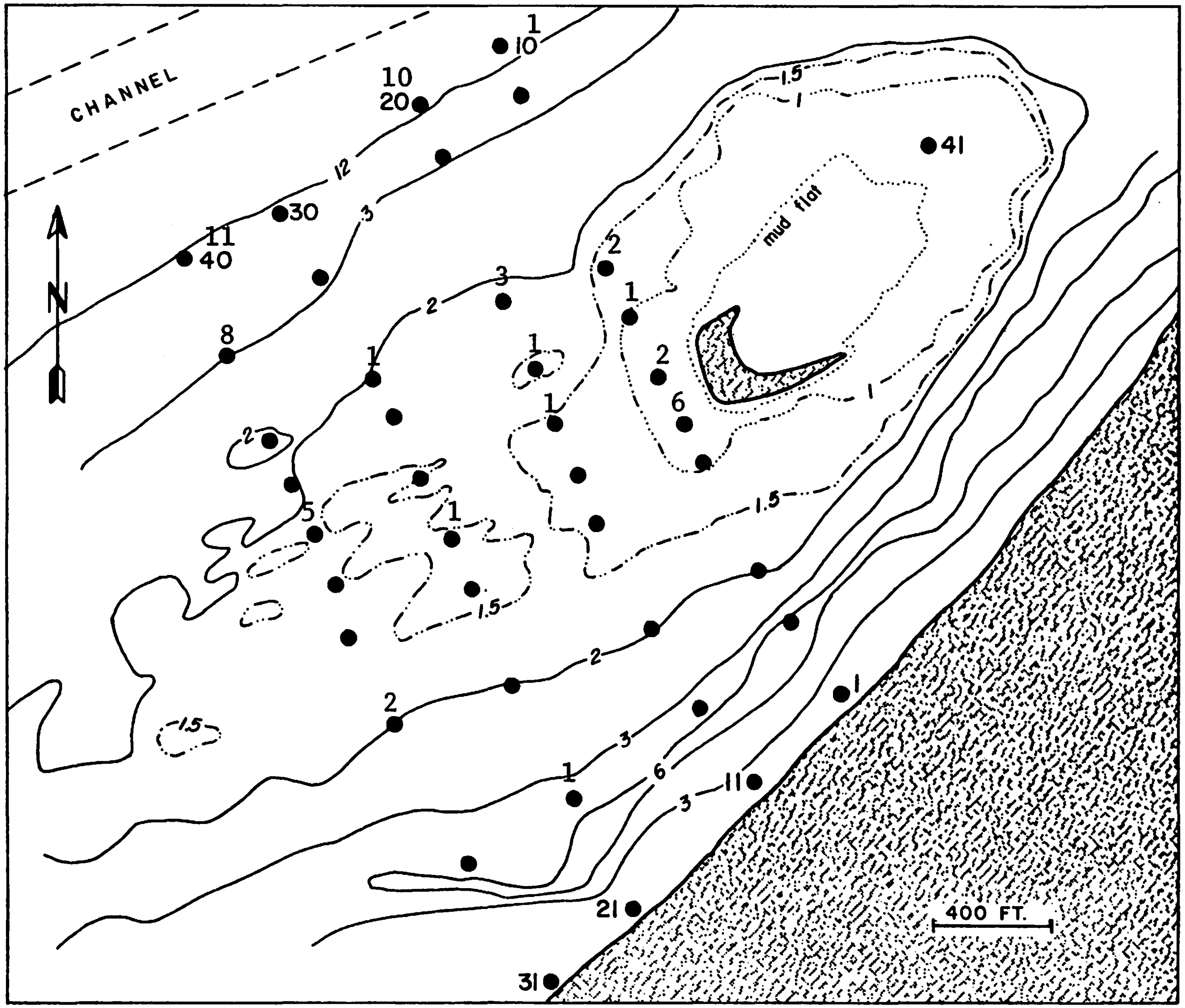

Fig. 8. Distribution of Limnodrilus profundicola in the area of the habitat development site, James River. (Values are sum of two .05 m^2 Ponar grabs).

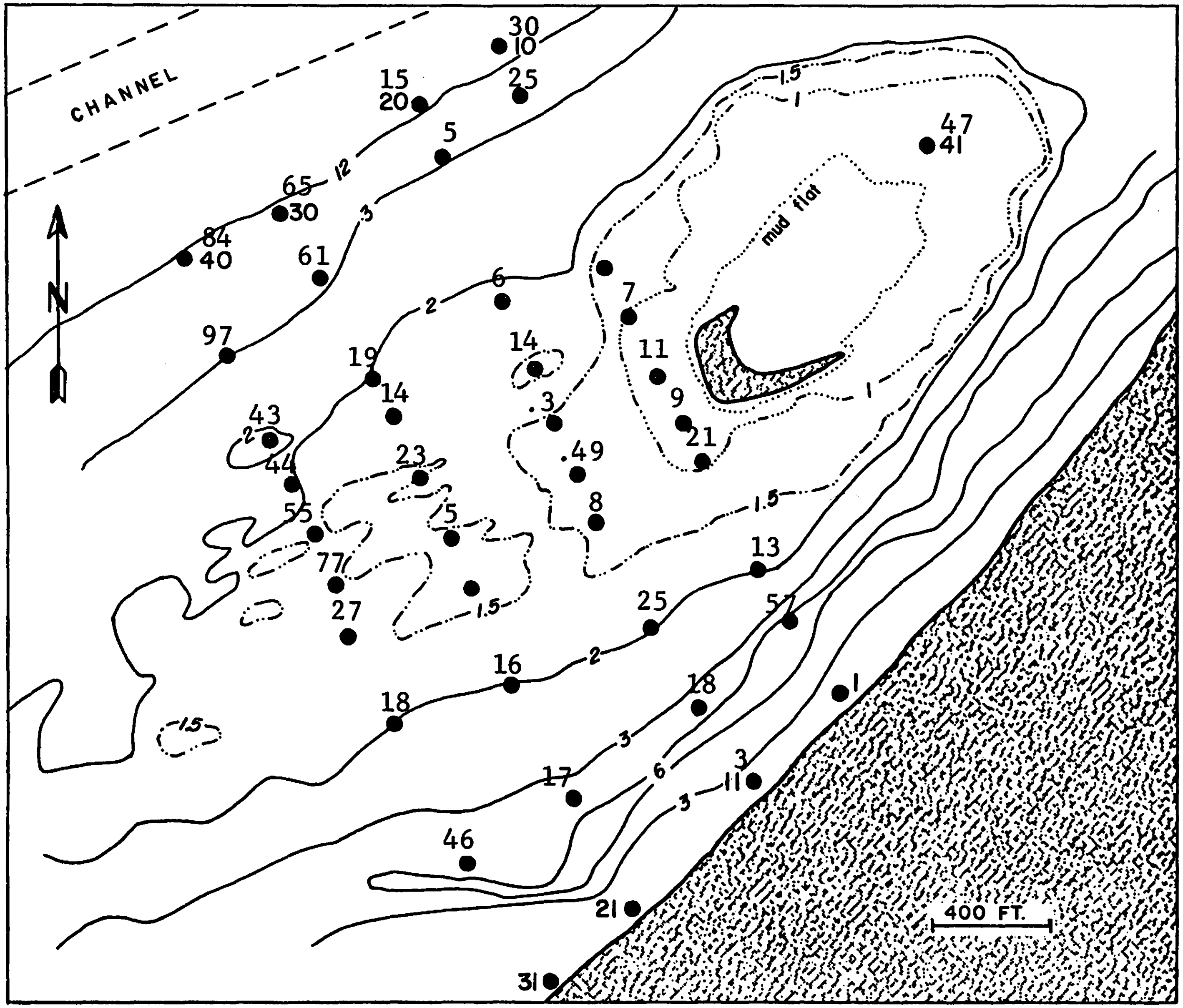

Fig. 9. Distribution of Ilyodrilus templetoni in the area of the habitat development site, James River. (Values are sum of two .05 m^2 Ponar grabs).

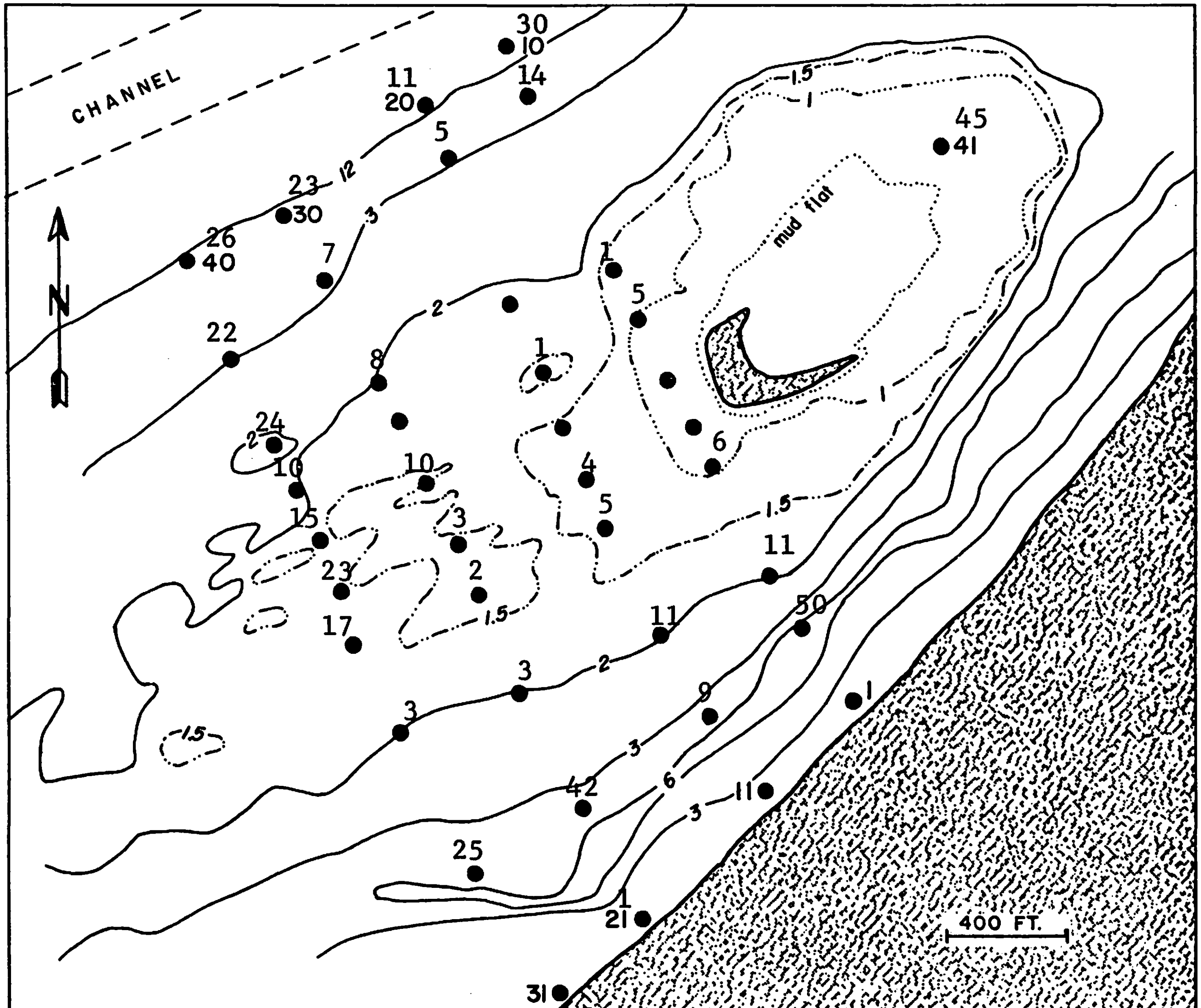

Fig. 10. Distribution of Coelotanypus scapularis in the area of the habitat development site, James River. (Values are sum of two .05 m^2 Ponar grabs).

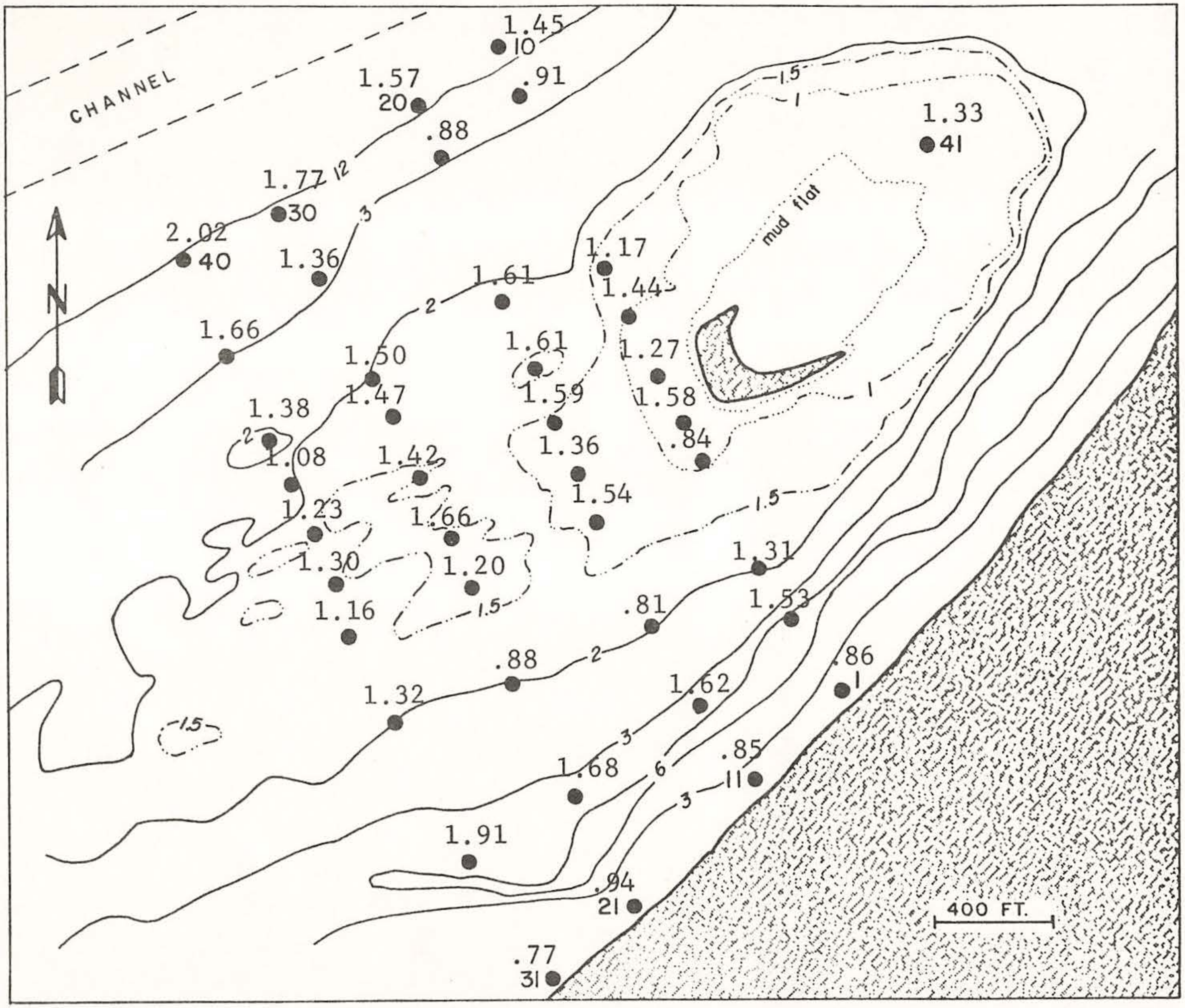

Fig. 11. Species diversity (H') at the benthic sites for the James River Windmill Point habitat development project.

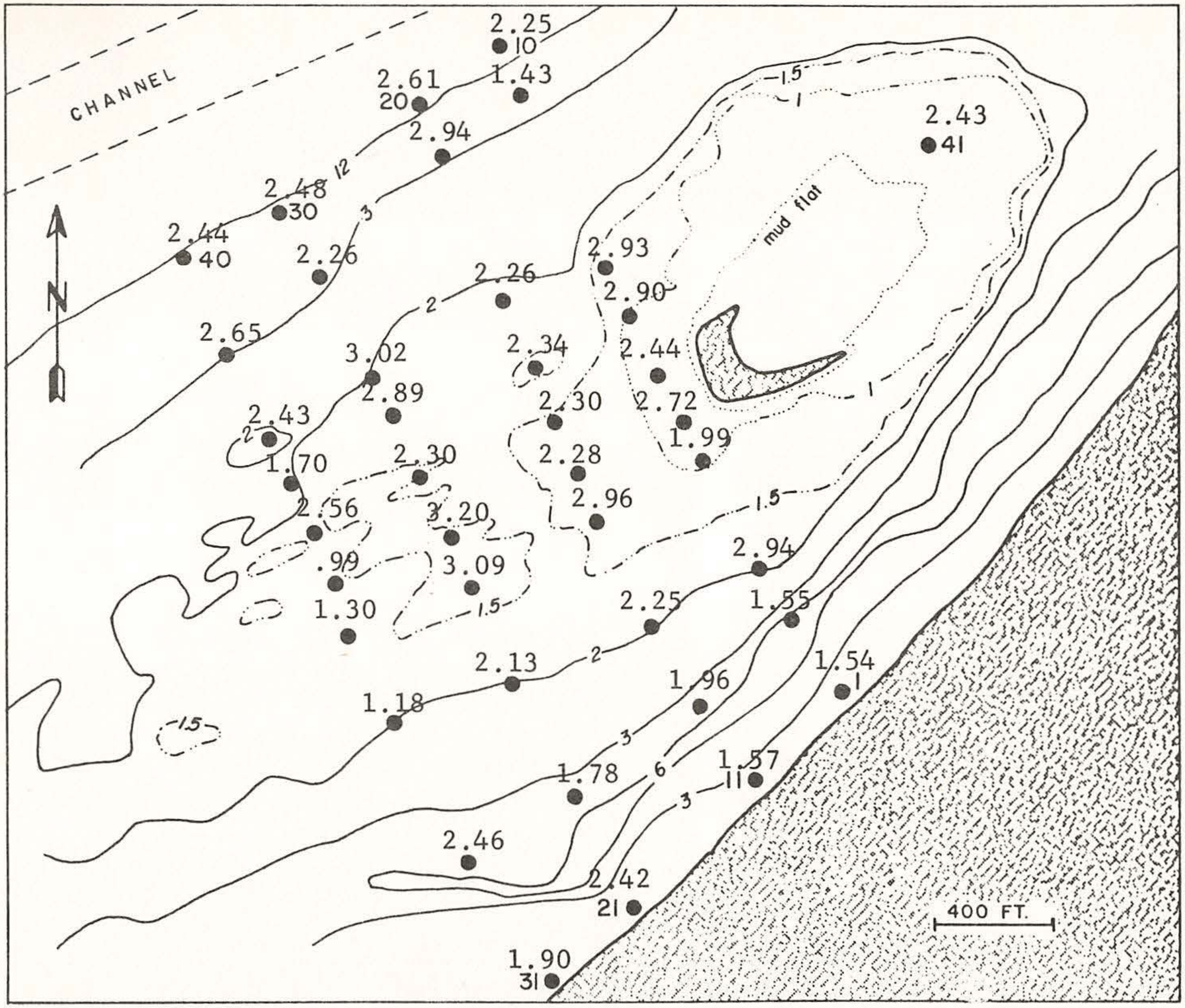

Fig. 12. Species diversity, calculated without small Corbicula manilensis (<10 mm) and Limnodrilus spp. immature, at the benthic sites for the James River Windmill Point habitat development project.