

HERRING RIVER SURVEY

AUGUST 15-17

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INTRODUCTION

During the period of August 15-17, 1983 the Massachusetts Division of Water Pollution Control (MDWPC) conducted a water quality survey of the Herring River in Wellfleet. The survey was initiated at the request of personnel of the Cape Cod National Seashore. The primary purpose of this survey was to gather baseline data for the chemical and biological characterization of the Herring River system. An additional purpose was to determine the impacts of fluctuating pH levels on the resident macroinvertebrate and periphyton communities. A follow-up study will be undertaken when monitoring by Cape Cod National Seashore personnel reveals significant changes in pH from the baseline survey.

Water quality problems associated with fluctuating pH levels, specifically low pH - high acidity conditions, have been reported in the Herring River system and are thought to have contributed to an American eel (*Anguilla rostrata*) kill in 1980 (Portnoy, and Soukup, 1982). The area surveyed by the MDWPC was formerly a saltwater marsh that has been drastically altered by diking and ditch dredging for mosquito control purposes. Historically, salt marsh sediments were dredged and disposed of in spoils piles on the banks of the Herring River and tributaries. This practice exposes the sediments to intermittent drying and weathering. Sulfides contained in the exposed sediment deposits may react chemically with rain water to form weak solutions of sulfuric acid that leach through to the water table or run off directly to the Herring River or its tributaries thereby causing a reduction in pH.

A total of eight (8) sampling sites were established on the Herring River and tributaries. The sampling stations are described in Table 1 and presented on Figure 1. Station numbers designated by personnel of the National Seashore were retained in this study for consistency.

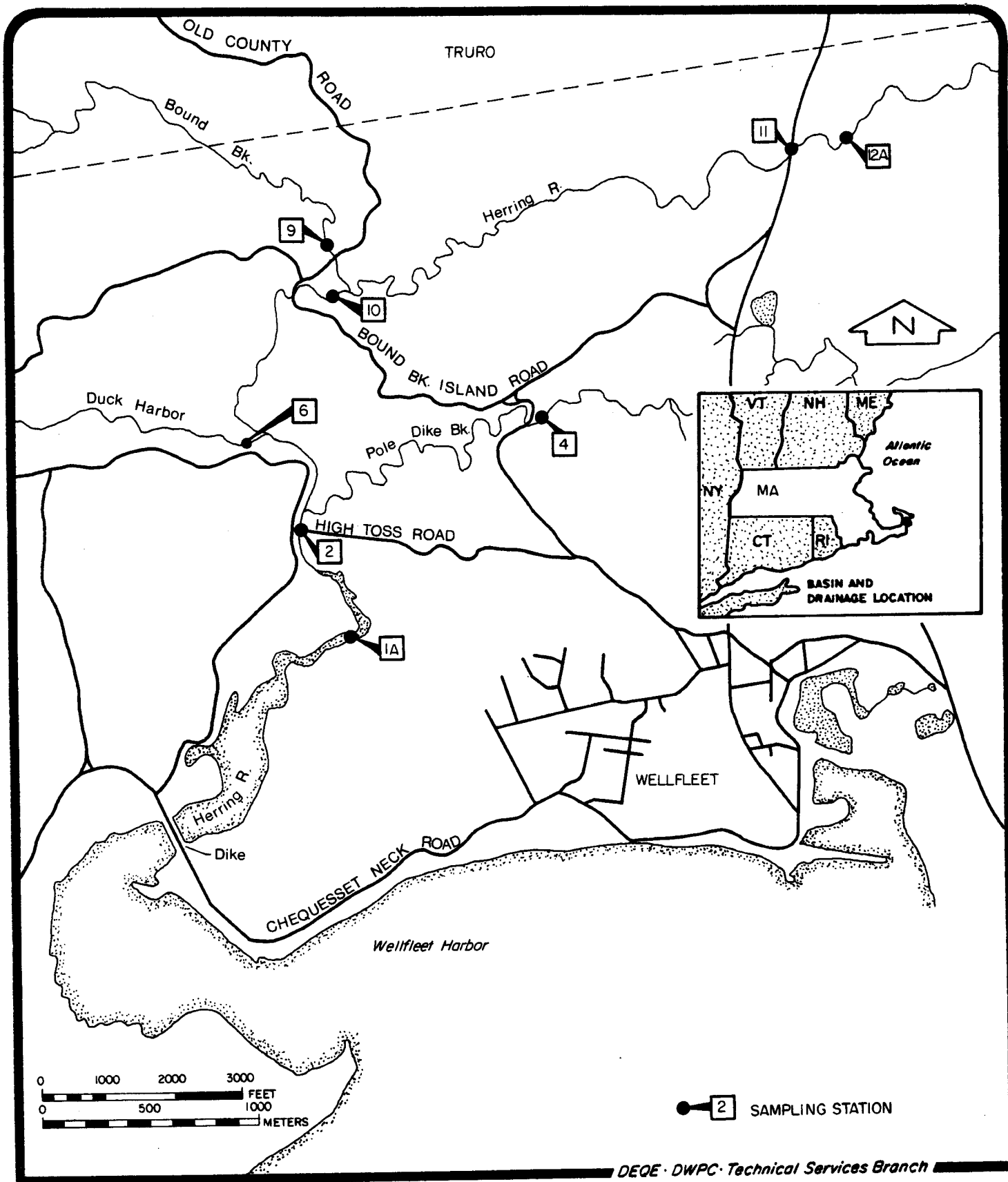
Temperature and dissolved oxygen determinations were performed on samples from each station. Physicochemical analyses at each site included: pH, total alkalinity, suspended solids, total solids, specific conductance, sulfate, total Kjeldahl-nitrogen, ammonia-nitrogen, nitrate-nitrogen, total phosphorus, chloride, and total and fecal coliform bacteria. Metals analyses included: aluminum, cadmium, chromium, copper, iron, lead, magnesium, manganese, nickel, selenium and zinc.

The presence and abundance of riparian and aquatic vascular vegetation were noted and recorded at each sampling site. Substrate descriptions were also recorded. Streamflow measurements were made at station nos. 2, 4, 9, 10, 11 and 12A. Phytoplankton, periphyton, and macroinvertebrate samples were transported to the MDWPC laboratory at Westborough for analysis. Chemical analyses were performed at the Lawrence Experiment Station.

In conjunction with the work performed by the MDWPC, a study was conducted by Kevin Sheehan, Kathleen Sellars, and Dr. Neil Ram of the Environmental Engineering Program, Department of Civil Engineering at the University of Massachusetts, Amherst. The investigators used a microtox toxicity testing system (Beckman Instruments, Inc.) to analyze samples of sediment obtained

TABLE 1
1983 HERRING RIVER BASIN SURVEY
WELLFLEET
DESCRIPTION AND LOCATION OF SAMPLE STATIONS

<u>STATION</u>	<u>DESCRIPTION AND LOCATION</u>
1A	Herring River approximately 1.0 mile upstream of the dike
2	Herring River at High Toss Road
4	Pole Dike Brook near Old County Road off of Bound Brook Island Road
6	Duck Harbor near confluence with Herring River
9	Bound Brook near confluence with Herring River
10	Herring River at railroad bridge near Bound Brook Road
11	Herring River at State Route 6
12A	Herring River approximately 0.4 mile upstream of State Route 6



HERRING RIVER

Figure 1

LOCATION OF SAMPLING STATIONS

from a spoils pile and the stream bottom at one site (sampling station 4). The study was funded by the Research and Demonstration Program of MDWPC. Results are on file at the MDWPC Technical Services Branch office in Westborough.

METHODOLOGY

Biological

Grab samples for phytoplankton examination were collected in the manner prescribed by the Maine Department of Environmental Protection (1974). This consists of holding clean, rinsed 1-quart sample bottles below the surface of the water until approximately one-half filled. These samples were kept on ice and transported to the MDWPC office at Westborough. Algal counts were made with a Whipple grid and a Sedgewick-Rafter counting chamber (Standard Methods for the Examination of Water and Wastewater, fifteenth edition, 1980, Washington, D.C.). A Swift compound microscope at 200 X power was used for the counts which were reported in cells/ml.

Periphyton samples were obtained by scraping various substrates such as logs, aquatic vascular plants and rocks. Between one and four samples were taken at each station depending upon the availability of natural substrates. These scrapes were placed in glass vials, filled with stream water and stored on ice for examination within twenty four hours.

Both phytoplankton and periphyton samples were identified with the aid of taxonomic keys by Smith (1950), Prescott (1954), and U.S. EPA (1982).

Macroinvertebrate samples were collected at station nos. 1A, 2, 4, 6, 9, 10, 11 and 12A (Figure 1). A D-frame 30 mesh net was used to scoop and sift fine sediments or catch animals dislodged from coarser substrates or vegetation. A Ponar grab-sampler was employed at stations 1A, 9, and 10 because the remote access to the station (1A) or the depth of the water precluded efficient, safe sampling with hip boots and D-net.

Attempts were made to gather representatives from each identifiable habitat at a given station. For instance, samples of the substrate material from the central part of the channel and the lateral margins, as well as emergent and submergent vegetation, were collected. These samples were sieved through a no. 30 mesh screen, the contents of the screen then transferred to the sample jars, and the jars filled with stream water. The sample jars were then placed on ice in a cooler for storage and transported to the MDWPC Westborough laboratory. The sample from station 1A was essentially free of extraneous debris and was easily sorted and preserved with 70% ethanol in the field. All other samples were sorted at the Westborough facility.

Specimens extracted from the samples were identified with the aid of the following keys: general--Pennak (1978); leeches--Klemm (1982); Oligochaeta--Hiltunen and Klemm (1980), Stimpson, et al. (1982), and Brinkhurst and Jamieson (1971); aquatic insects--Merritt and Cummins (1978); Ephemeroptera--Edmunds, et al. (1976); Odonata--Walker (1953); Trichoptera--Wiggins (1977); Coleoptera--Dillon and Dillon (1972, Volumes I and II); Diptera/Ceratopogonidae--Johannsen, et al. (1952); Diptera/Chironomidae--Simpson and Bode (1980); Pelecypoda--Burch (1972). Microscopic observations were made using a Bausch and Lomb 1-7X zoom stereo microscope and an Olympus CH phase contrast compound microscope.

Samples for bacteriological analysis were collected in sterilized bottles held below the surface of the water. The samples were cooled and transported to the Lawrence Experiment Station for analysis (Standard Methods, 1980).

Aquatic vascular plants and riparian vegetation were identified and recorded in the field.

Physical and Hydrological

Water temperature was measured at each sample site with a hand-held Weksler model 12-18A pocket thermometer.

Dissolved oxygen samples were collected according to Welch (Limnological Methods, 1948). Determinations were made by Division personnel using the azide modification of the Winkler iodometric titration technique (Standard Methods, 1980).

The pH measurements were made in the field with an Instrumentation Lab Inc. portomatic 175 pH meter and Cole-Palmer electrode.

Streamflow determinations were made at a total of six sampling locations along the Herring River and selected tributaries. At four sites (station nos. 2, 4, 9, and 10) streamflow occurred through a partially filled culvert and, therefore, discharge was determined by calculating the volume of the culvert and measuring the time of travel through it with a float (Rantz, et al. 1982). At station nos. 11 and 12A stream velocity (v) was measured directly at approximately mid-depth with a propeller type current meter (Weather Measure Corp. No. F581-B) at several points across the stream. Flow (Q) was then calculated from $Q = Av$ where A is the cross-sectional area. Flow measurements at station 10 were taken approximately 500 feet downstream from the water quality station number 10.

Chemical

Grab water samples for chemical quality analysis were collected, either directly by hand below the surface of the water or with the aid of a plastic bucket, and transferred to clean rinsed glass bottles. Samples were cooled and transported to the Lawrence Experiment Station for analysis. Parametric coverage included: pH, total alkalinity, suspended solids, total solids, specific conductance, sulfate, total Kjeldahl-nitrogen, ammonia-nitrogen, nitrate-nitrogen, total phosphorus and chloride.

Samples for heavy metals analysis were collected in glass bottles that were preserved with concentrated nitric acid (to pH <2.0). They were also transported to the Lawrence Experiment Station for analysis.

Analytical methods used at the Lawrence Experiment Station are summarized in Table 2.

TABLE 2

ANALYTICAL METHODS USED AT LAWRENCE EXPERIMENT STATION

<u>PARAMETER</u>	<u>METHOD</u>	<u>REPORTED AS</u>
BOD	5-day oxygen depletion at 20°C	mg/l BOD
Dissolved Oxygen	Azide modification of Winkler method. 0.0375 N sodium thio-sulfate titrant, 300 ml sample	mg/l D.O.
pH	Electrometric, glass indicator, silver chloride reference	pH logarithmic Units
Turbidity	Nephelometric. Hach Turbidi-meter. Model 2100A	Nephelometric Turbidity Units
Total Alkalinity	0.02 N sulfuric acid potentiometric titration to pH 4.5, Orion Model 701, Digital pH meter	mg/l CaCO ₃
Suspended Solids	Filtration through standard glass fiber filter paper. Residue dried at 103-105°C. Gravimetric	mg/l S.S.
Total Solids	Evaporation to dryness at 103-105°C. Gravimetric	mg/l T.S.
Settleable Solids	Gravimetric settling using an Imhoff cone	ml/l sett. solids
Total Kjeldahl-Nitrogen	Acid digestion using Technical BD-40 Block Digester. Colorimetric analysis (reaction of ammonia, sodium salicylate, sodium nitroprusside, and sodium hypochlorite in buffered alkaline medium) using Technicon Auto Analyzer II	mg/l TKN
Ammonia-Nitrogen	Phenate method, automated. Colorimetric analysis using Technicon Auto Analyzer II	mg/l NH ₃ -N
Nitrate-Nitrogen	Hydrazine reduction method, automated. Colorimetric analysis using Technicon Auto Analyzer II	mg/l NO ₃ -N

TABLE 2 (CONTINUED)

<u>PARAMETER</u>	<u>METHOD</u>	<u>REPORTED AS</u>
Total Phosphate	Acid digestion using Technicon BD-40 Block Digester. Ascorbic acid reduction colorimetric method using Technicon Auto Analyzer II	mg/l P
Total Coliform	Membrane filter technique	Total coliforms/100 ml
Fecal Coliform	Membrane filter technique	Fecal coliforms/100 ml
COD	Dichromate reflux	mg/l COD
Conductivity	Wheatstone Bridge type meter. Yellow Springs Instrument conductivity bridge, Model 31	μmhos/cm
Color	Visual comparison of sample with known concentrations of colored solutions	Color Units
Chloride	Argentometric (titration with silver nitrate)	mg/l Cl
Silica	Colorimetric analysis (silicomolybdate reduction in acidic solution to "heteropoly blue" by aminonaphtholsulfonic acid) Technicon Auto Analyzer I	mg/l SiO ₂
Cadmium, copper, chromium, iron, lead, magnesium, manganese, nickel, zinc, hardness (Ca+Mg)	Atomic Absorption Spectrophotometry. Air-acetylene flame. Perkin-Elmer Model 403	mg/l
Aluminum, Tin	Atomic Absorption Spectrophotometry. Nitrous oxide-acetylene flame. Perkins-Elmer Model 403	mg/l
Hexavalent Chromium	Colorimetric using diphenylcarbazide. Klett-Summerson photoelectric colorimeter	mg/l Cr ⁺⁶

FIELD DATA RECORD

TABLE 3
1983 HERRING RIVER BASIN SURVEY
WELLFLEET
SUMMARY OF CLIMATIC CONDITIONS

Date:	August 15	August 16
Air Temperature (°C):	26.0	29.0
Wind Velocity (mph):	0-5	0-5
Percent Cloud Cover:	90-100	0-5
Precipitation (inches):*	0.33	0

* Rainfall measured at the National Park Service laboratory in North Truro, MA.

TABLE 4
1983 HERRING RIVER BASIN SURVEY
WELLFLEET
SUBSTRATE DESCRIPTION AND PREDOMINANT PERIPHYTON

<u>STATION</u>	<u>SUBSTRATE DESCRIPTION AND ESTIMATED % AREAL COVER</u>	<u>PREDOMINANT PERIPHYTON</u>
1A	70% sand; 30% muck	<u>Cladophora</u> sp., unidentified diatoms
2	10% sand; 80% detritus; 10% muck	<u>Fragilaria</u> sp., river fungus
4	30% detritus; 70% muck; trace of sand	<u>Spirogyra</u> sp.
6	10% sand; 10% detritus; 80% muck	<u>Gyrosigma</u> sp., <u>Mougeotia</u> sp.
9	25% detritus; 75% muck	periphyton not found
10	30% detritus; 70% muck	<u>Spirogyra</u> sp.
11	20% sand; 80% muck	<u>Spirogyra</u> , sp., <u>Microspora</u> sp.
12A	65% sand; 25% detritus; 10% muck	<u>Oscillatoria</u> sp., unidentified crustose

TABLE 5
1983 HERRING RIVER BASIN SURVEY
WELLFLEET

STATION	OBSERVED RIPARIAN VEGETATION	OBSERVED AQUATIC VASCULAR PLANT TYPES
1A	Cat-tail Reed Bulrush <u>Hibiscus palustris</u> (marsh mallow)	Pondweed <u>Lemna minor</u> (duckweed)
2	<u>Pinus rigida</u> (pitch pine) Cat-tail Bur-reed Bulrush <u>Saponaria officinalis</u> (bounding-bet) <u>Spiraea alba</u> (meadowsweet) Blackberry Locust <u>Echinocystis lobata</u> (wild cucumber)	Various grasses <u>Lemna minor</u> (duckweed)
4	Various ferns Various grasses Bulrush Cherry	Pondweed Various grasses <u>Lemna minor</u> (duckweed)
6	Various grasses Beech <u>Spiraea alba</u> (meadow sweet) Blackberry Cherry <u>Echinocystis lobata</u> (wild cucumber)	Pondweed Various grasses
9	Various grasses Bulrush <u>Iris</u> sp.	No submerged or emergent aquatic vascular plants found in-stream
10	<u>Pinus rigida</u> (pitch pine) Cat-tail Various grasses Bulrush <u>Quercus ilicifolia</u> (scrub oak) <u>Spiraea alba</u> (meadow sweet) Cherry Poison ivy Night shade	Pondweed <u>Lemna minor</u> (duckweed)

TABLE 5 (CONTINUED)

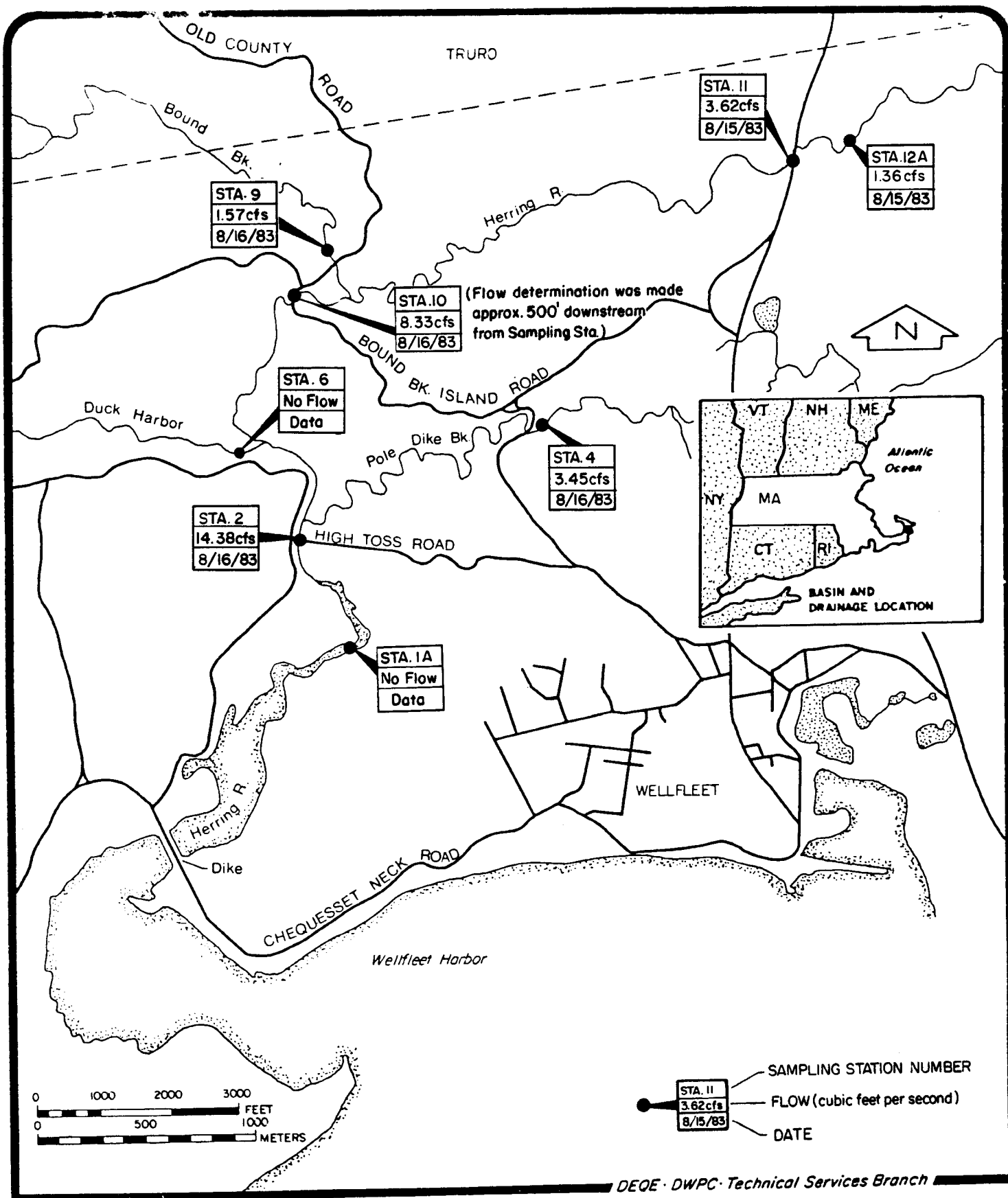
<u>STATION</u>	<u>OBSERVED RIPARIAN VEGETATION</u>	<u>OBSERVED AQUATIC VASCULAR PLANT TYPE</u>
11	<u>Pinus rigida</u> (pitch pine) Cat-tail Bur-reed Poison ivy Maple Golden rod <u>Iris sp.</u>	Pondweed Arrowhead Various grasses Water willow Bladderwort
12	Various ferns Area wooded, trees not described	No aquatic vascular plants found

TABLE 6
1983 HERRING RIVER BASIN SURVEY
WELLFLEET

TIME - TEMPERATURE - FIELD pH - DISSOLVED OXYGEN

DATES OF COLLECTION: 16 August 1983; those with *15 August 1983

<u>STATION</u>	<u>TIME (hr)</u>	<u>WATER TEMPERATURE (°C)</u>	<u>FIELD pH MEASUREMENT (Standard Units)</u>	<u>DISSOLVED OXYGEN (mg/l)</u>	<u>PERCENT D.O. SATURATION</u>
1A	1530	20	5.7	4.8	53
2	1600	19	5.9	5.8	63
4	1145	15	5.7	3.1	31
6	1630	19	6.2	4.3	46
9	0915	16	4.1	1.6-top	16
10	1015	16	5.7	1.4-bottom 4.4	45
11*	1740	16	6.1	6.1	62
12A*	1615	18	6.5	6.6	70



HERRING RIVER

Figure 2

SAMPLING STATION FLOW MEASUREMENTS

WATER QUALITY AND PHYTOPLANKTON DATA

*data from
mid-summer period at
sulfate removal (reduction)
(Note: abnormally high pH, low SD4)*

TABLE 7
1983 HERRING RIVER BASIN SURVEY

WELLFLEET

WATER QUALITY DATA (mg/l)

August 17, 1983

STATIONS:	1A	2	4	6	9	10	11	12A
<u>PARAMETER</u>								
pH (Standard Units)	6.1	6.1	6.0	6.9	4.1	6.0	6.6	6.6
Total Alkalinity	7.0	8.0	8.0	24	--	7.0	9.0	7.0
Acidity	--	--	--	--	5.0	--	--	--
Suspended Solids	12	12	4.5	15	31	7.0	0.0	0.0
Total Solids	430	220	180	330	230	140	78	58
Specific Conductance (umhos/cm)	675	311	217	476	346	205	145	130
Sulfate	30	25	20	39	34	17	6.0	5.5
Total Kjeldahl-Nitrogen	1.9	1.4	1.3	2.8	2.9	1.4	0.51	0.71
Ammonia-Nitrogen	0.29	0.35	0.16	0.98	1.4	0.32	0.03	0.02
Nitrate-Nitrogen	0.1	0.7	0.4	0.2	0.2	0.1	0.0	0.0
Total Phosphorus	0.18	0.17	0.23	0.51	0.19	0.12	0.07	0.06
Chloride	185	80	50	115	70	120	35	30
Total Coliform/100 ml	1500	700	3000	2000	400	800	240	480
Fecal Coliform/100 ml	100	10	20	10	5	10	10	5

TABLE 8
1983 HERRING RIVER BASIN SURVEY

WELLFLEET

METALS DATA (mg/l)

August 17, 1983

SAMPLE STATION:	1A	2	4	6	9	10	11	12A
<u>PARAMETER</u>								
Aluminum	0.33	<0.10	0.33	0.53	0.80	0.17	<0.10	<0.10
Cadmium	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Chromium	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Copper	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Iron	3.0	2.8	4.2	8.0	5.2	2.3	0.70	0.45 *
Lead	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Magnesium	11	5.5	3.6	10	4.7	3.4	2.5	2.3
Manganese	0.10	0.07	0.11	0.05	0.08	0.09	0.20	0.01
Nickel	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Selenium	0.004	0.000	0.000	0.003	0.000	0.003	0.003	0.000
Zinc	0.00	0.00	0.00	0.00	0.01	0.00	0.01	0.00

TABLE 9
1983 HERRING RIVER BASIN SURVEY
WELLFLEET
PHYTOPLANKTON DATA (cells/ml)

DATE:	August 16, 1983						August 15, 1983	
STATION:	<u>1A</u>	<u>2</u>	<u>4</u>	<u>6</u>	<u>9</u>	<u>10</u>	<u>11</u>	<u>12A</u>
Bacillariophyceae								
<u>Cocconeis</u> sp.	--	--	--	111	--	--	--	--
<u>Cyclotella</u> sp.	--	--	--	278	--	--	14	--
<u>Eunotia</u> sp.	--	--	--	111	--	--	--	--
<u>Fragilaria</u> sp.	--	--	--	334	--	14	--	--
<u>Gyrosigma</u> sp.	--	--	--	111	--	--	--	--
<u>Melosira</u> sp.	--	28	--	--	--	--	14	--
<u>Meridion</u> sp.	--	--	--	56	--	--	--	--
<u>Navicula</u> sp.	--	14	--	612	--	--	--	--
<u>Nitzschia</u> sp.	14	--	--	278	--	--	--	--
<u>Pinnularia</u> sp.	--	--	--	--	14	--	--	--
<u>Stauroneis</u> sp.	--	--	--	57	--	--	--	--
<u>Synedra</u> sp.	--	--	--	222	--	--	--	--
<u>Tabellaria</u> sp.	--	28	--	--	--	--	--	--
SUBTOTAL	14	70	--	2170	14	14	28	--
Chrysophyceae								
<u>Dinobryon</u> sp.	--	--	--	--	--	--	--	14
SUBTOTAL	--	--	--	--	--	--	--	14
Chlorophyceae								
<u>Ankistrodesmus</u> sp.	--	--	--	--	--	--	--	56
<u>Chlamydomonas</u> sp.	14	--	14	--	42	--	--	14
<u>Haematococcus</u> sp.	--	--	14	--	--	--	--	--
<u>Oocystis</u> sp.	--	--	--	56	--	--	--	--
<u>Tetraedron</u> sp.	--	--	--	--	--	--	--	14
<u>Ulothrix</u> sp.	--	--	--	--	--	--	28	--

TABLE 9 (CONTINUED)

STATION:	August 16, 1983						August 15, 1983	
	<u>1A</u>	<u>2</u>	<u>4</u>	<u>6</u>	<u>9</u>	<u>10</u>	<u>11</u>	<u>12A</u>
Unidentified								
Filamentous sp.	--	--	--	--	83	--	--	--
Unidentified								
Flagellate 1	--	56	--	334	--	--	--	--
Unidentified								
Flagellate 2	--	14	--	--	--	--	--	--
SUBTOTAL	14	70	28	390	125	--	28	84
Cryptophyceae								
<u>Cryptochrysis</u> sp.	--	--	--	--	42	42	--	--
<u>Cryptomonas</u> sp.	14	--	--	--	--	--	--	--
SUBTOTAL	14	--	--	--	42	42	--	--
Cyanophyceae								
<u>Anabaena</u> sp.	--	--	--	--	--	--	--	14
<u>Anacystis</u> sp.	--	--	--	--	--	--	--	--
<u>Anacystis cyanea</u>	--	14	--	--	28	--	--	97
SUBTOTAL	--	14	--	--	28	--	--	111
Dinophyceae								
<u>Gymnodinium</u> sp.	--	--	--	--	--	--	--	28
Unidentified	--	--	--	111	--	--	--	--
SUBTOTAL	--	--	--	111	--	--	--	28
Euglenophyceae								
<u>Trachelomonas</u> sp.	--	--	--	167	--	--	--	--
SUBTOTAL	--	--	--	167	--	--	--	--
GRAND TOTAL	42	154	28	2838	209	56	56	237

MACROINVERTEBRATE ANALYSIS

The list of organisms identified for this study appears in Appendix A. Where possible, organisms were identified to species level. Most identifications, however, were to generic or family level while some organisms were keyed only to order or class. The taxonomic level attained depended on the condition and maturity of the specimens and the utility of available keys.

While the sampling effort was not quantitative, the results are useful for characterizing the Herring River with respect to its resident macroinvertebrate community. In addition to Appendix A, Table 10 shows, respectively: the total number of organisms collected from each station; the richness, or number of different taxa present, the number of arthropods from each organic enrichment tolerance category (cf. Hilsenhoff, 1982) occurring in each sample; the total number of arthropods; and a non-quantitative value based on the number of arthropods present and their respective tolerance values. N_i = the number of individuals in each category, N_a = tolerance value, and N = the total number of indexed arthropods (Hilsenhoff, 1982). It is important to note that the level of sampling effort at each site was comparable and that macroinvertebrates were present at each station. However, the total number of organisms and the number of taxa (i.e., richness) differed between stations. For example, 112 organisms representing 19 taxa were encountered at Station 11 while only six individuals from three taxa were found at Station 6 (Duck Harbor).

Relative tolerances of the arthropods to organic pollution were examined (cf. Hilsenhoff, 1982). It appears that all the stations sampled are significantly and comparably enriched with organic matter. The number of individuals versus tolerance to organic enrichment is summarized in Table 10 using a scale of zero to five, where zero is very intolerant and five is very tolerant. Because of the similar occurrence of tolerant organisms at all sites this qualitative (as used here) comparison is sufficient to raise suspicion of the presence of a toxic or other stress effect accounting for the low number of taxa at Stations 6 and 1A and the paucity of individuals at Station 6.

Further detailed comparisons between the sampling stations based on disparities in the number of taxa or the total number of organisms are not justified. The presence or absence of macroinvertebrate taxa at a given site are influenced by many variables including suitable habitat, hydrology, and water quality. A detailed analysis of the macroinvertebrate communities would have to account for these variables, not the least of which is the influence of substrate. The 52 individuals from the single taxon found at Station 1A, for example, is probably a reflection of the increased proportion of sand among the substrates. Future examinations of the macroinvertebrates in this system should be carefully designed to provide quantitative data that will more precisely compare stations and isolate physical and chemical parameters that influence observed differences. Furthermore, results of a more intensive sampling program may serve to indicate whether the results encountered at Stations 1A and 6 were the result of true environmental stress or merely an artifact of the sampling approach used for this study.

TABLE 10
1983 HERRING RIVER BASIN SURVEY
WELLFLEET

SUMMARY OF MACROINVERTEBRATE SAMPLING RESULTS

STATION	TOTAL NUMBER OF ORGANISMS	RICHNESS	ORGANIC ENRICHMENT TOLERANCE VALUES**						INDEXED ARTHROPODS (N)	$\Sigma N_i N_a$ N
			0	1	2	3	4	5		
12A	62	13	--	--	2	4	27	--	33	3.76
11	112	19	--	--	4	6	52	--	62	3.77
10	>100	11	--	--	1	12	35	--	48	3.71
9	75	11	--	--	1	5	7	7	20	4.00
6	6	3	--	--	--	2	--	3	5	4.20
4	24	10	--	--	2	3	16	--	21	3.67
2	92	21	--	--	3	15	21	1	40	3.50
1A*	52	1	--	--	--	--	--	--	52	--

* The tolerance value for the one taxon encountered at Station 1A, Gammarus sp., is in question and was not included in the numerical analysis.

** Zero is very intolerant and five is very tolerant.

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APPENDIX A

APPENDIX A
1983 HERRING RIVER BASIN SURVEY
WELLFLEET
LIST OF MACROINVERTEBRATES

STATION	WATER BODY	ORGANISMS	TALLY
1A	Herring River	Arthropoda Crustacea Amphipoda Gammaridae <u>Gammarus</u> sp.	52
2	Herring River	Annelida Oligochaeta unid. sp. Lumbriculidae Naididae Tubificidae IMWOCC* <u>Limnodrilus hoffmeisteri</u> Hirudinea Erpobdellidae Arthropoda Crustacea Isopoda <u>Asellus communis</u> Insecta Ephemeroptera Baetidae <u>Callibaetis</u> sp. Odonata Coenagrionidae Hemiptera Notonectidae <u>Notonecta</u> sp. Corixidae Coleoptera Haliplidae <u>Haliphus immaculicolis</u> Dytiscidae <u>Laccophilus</u> sp. Gyrinidae <u>Gyrinus</u> sp.	1 1 1 6 5 6 18 2 11 2 7 16 4 3

* Immature without capilliform chaetae

APPENDIX A (CONTINUED)

STATION	WATER BODY	ORGANISMS	TALLY
2 (Cont'd)	Herring River	Diptera	
		Chironomidae	
		Tanypodinae	
		<u>Procladius</u> sp.	1
		Orthocladiinae	
		<u>Psectrocladius</u> sp.	3
		Chironominae	
		<u>Chironomus</u> sp.	1
		<u>Cryptochironomus</u> sp.	1
		<u>Phaenopsectra</u> <u>flavipes</u>	1
		<u>Tribelos</u> sp. (prob.)	1
		<u>Tanytarsini</u> sp.	1
4	Pole Dike Brook	Arthropoda	
		Crustacea	
		Isopoda	
		Asellidae	
		<u>Asellus</u> <u>communis</u>	12
		Amphipoda	
		Talitridae	
		<u>Hyalella</u> <u>azteca</u>	2
		Insecta	
		Coleoptera	
		Gyrinidae	
		<u>Dineutus</u> sp.	1
		Hydrophilidae	
		<u>Helochaeres</u>	
		or <u>Enochrus</u> sp.	1
		Diptera	
		Chironomidae	
		Tanypodinae	
		<u>Thienemannimyia</u> group	2
		<u>Pentaneura</u> sp.	1
		<u>Procladius</u> sp.	1
		Chironominae	
		<u>Phaenopsectra</u> <u>flavipes</u>	1
		<u>Tribelos</u> sp.	1
		Mollusca	
		Pelecypoda	
		<u>Pisidium</u> sp.	2

APPENDIX A (CONTINUED)

STATION	WATER BODY	ORGANISMS	TALLY
6	Duck Harbor	Annelida	
		Oligochaeta	
		<u>Limnodrilus hoffmeisteri</u>	1
		Arthropoda	
		Insecta	
		Diptera	
		Chironomidae	
		Tanypodinae	
		<u>Psectrotanypus</u> sp.	2
		Chironominae	
		<u>Chironomus</u> sp.	3
9	Bound Brook	Annelida	
		Oligochaeta	
		Tubificidae IMWOCC	3
		IMWCC*	3
		Naididae	13
		<u>Nais variabilis</u>	10
		<u>Pristina osborni</u>	1
		Arthropoda	
		Crustacea	
		Isopoda	
		Asellidae	
		<u>Asellus communis</u>	7
		Insecta	
		Coleoptera	
		Dytiscidae	
		<u>Hygrotus/Hydroporus</u> sp.	25
		Trichoptera	
		Phryganeidae	1
		Diptera	
		Chironomidae	
		Tanypodinae	
		<u>Psectrotanypus</u> sp.	4
		Chironominae	
		<u>Chironomus</u> sp.	7
		<u>Polypedilum</u> sp.	1

* Immature with capilliform chaetae

APPENDIX A (CONTINUED)

STATION	WATER BODY	ORGANISM	TALLY
10	Herring River	Annelida	
		Oligochaeta	
		Tubificidae	
		<u>Limnodrilus</u> sp. and	numerous
		IMWOCC	
		Arthropoda	
		Crustacea	
		Copepoda	3
		Ostracoda	1
		Isopoda	
		Asellidae	
		<u>Asellus communis</u>	32
		Amphipoda	
		Talitridae	
		<u>Hyaella azteca</u>	1
		Insecta	
		Coleoptera	
		Gyrinidae	
		<u>Dineutus</u> sp.	1
		Diptera	
		Ceratopogonidae	
		<u>Palpomyia/Bezzia/</u>	11
		<u>Johannsenomyia</u> sp.	
		Chironomidae	
		Orthoclaudiinae	
		<u>Cricotopus sylvestris</u>	1
		group	
		Chironominae	
		<u>Dicrotendipes</u> sp.	1
		<u>Paratanytarsus</u> sp.	1
		Arachnida	
		Hydracarina	4
11	Herring River	Annelida	
		Oligochaeta	
		Naididae	
		Unidentified sp.	1
		<u>Stylaria lacustris</u>	5
		<u>Stylaria fossularis</u>	1
		Arthropoda	
		Crustacea	
		Isopoda	
		Asellidae	
		<u>Asellus communis</u>	39
		Amphipoda	
		Talitridae	
		<u>Hyaella azteca</u>	10

APPENDIX A (CONTINUED)

STATION	WATER BODY	ORGANISMS	TALLY
11 (Cont'd)	Herring River	Insecta	
		Ephemeroptera	
		Baetidae	1
		Odonata	
		Lestidae	
		<u>Lestes disjunctus</u>	1
		Coenagrionidae	
		Unidentified sp.	1
		<u>Ischnura/Anomalagrion</u> sp.	1
		Coleoptera	
		Haliplidae	
		<u>Halipus</u> spp.	2
		Gyrinidae	
		<u>Dineutus</u> sp.	1
		Diptera	
		Chironomidae	
		Tanypodinae	
		<u>Thienemannimyia</u> group	1
		Orthoclaadiinae	
		<u>Cricotopus bicinctus</u>	2
		<u>Psectrocladius</u> sp.	3
		<u>Orthocladus</u> sp. (prob.)	3
		Mollusca	
		Gastropoda	
		Planorbidae	
		<u>Helisoma anceps</u>	3
		<u>Planorbula armigera</u>	3
		Hydrobiidae	
		<u>Amnicola limosa</u>	10
		Pelecypoda	
		Pisidiidae	
		<u>Musculium partumeium</u>	24
12A	Herring River	Platyhelminthes	
		Turbellaria	
		<u>Dugesia</u> sp.	1
		Annelida	
		Hirudinea	
		Unidentified sp.	1
		Arthropoda	
		Crustacea	
		Isopoda	
		<u>Asellus communis</u>	20
		Amphipoda	
		Talitridae	
		<u>Hyalella azteca</u>	7

APPENDIX A (CONTINUED)

STATION	WATER BODY	ORGANISMS	TALLY
12A (Cont'd)	Herring River	Insecta	
		Odonata	
		Coenagrionidae	1
		Hemiptera	
		Corixidae	18
		Gerridae	
		Gerris sp.	2
		Trepobates sp.	4
		Coleoptera	
		Gyrinidae	
		Gyrinus sp.	2
		Trichoptera	
		Limnephilidae	
		Limnephilus sp.	1
		Diptera	
		Chironomidae	
		Tanypodinae	
		Thienemannimyia group	3
		Orthocladinae	
		Corynoneura sp.	1
		Mollusca	
		Gastropoda	
		Unidentified sp.	1