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Report On
July 1993 Biomonitoring
for
Site 8 - Nitroglycerin Plant Office
Indian Head Division
Naval Surface Warfare Center
Indian Head, Maryland

Northern Division
Naval Facilities Engineering Command
Contract Number N62472-90-D-1298
Contract Task Order 0117

September 1993

Halliburton NUS
CORPORATION

R-09-93-10

REPORT ON
JULY 1993 BIOMONITORING
FOR
SITE 8 - NITROGLYCERIN PLANT OFFICE
INDIAN HEAD DIVISION, NAVAL SURFACE WARFARE CENTER
INDIAN HEAD, MARYLAND

COMPREHENSIVE LONG-TERM
ENVIRONMENTAL ACTION NAVY (CLEAN) CONTRACT

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Environmental Branch Code 18
Naval Facilities Engineering Command
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Submitted by:
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1.0 INTRODUCTION

The Northern Division of the Naval Facilities Engineering Command issued Contract Task Order Number 0117 (CTO 117) to Halliburton NUS Corporation (Halliburton NUS) in 1993 under the Comprehensive Long-Term Environmental Action Navy (CLEAN) Contract No. N62472-90-D-1298. CTO 117 is for quarterly biomonitoring at the Navy Installation Restoration Program Site 8 Nitroglycerin Plant Office (Installation Restoration Site 8), at the Indian Head Division, Naval Surface Warfare Center (NSWC) in Indian Head, Maryland. NSWC is part of the Chesapeake Division (CHESDIV) of the Naval Facilities Engineering Command. Under CTO 117, Halliburton NUS is performing eight rounds of quarterly biomonitoring from April 1993 until January 1995. The objective of the Biomonitoring Program is to assess the impact of mercury contamination in the biota of Site 8 and evaluate the potential ecological impacts of the Site 8 interim removal action.

Under a previous CTO (CTO 64), Halliburton NUS developed a Biomonitoring Program for Site 8 that was presented to CHESDIV in a site-specific Biomonitoring Plan (Halliburton NUS, 1992a). The plan outlined procedures for conducting quarterly biomonitoring at Site 8 through two distinct phases - Phases I and II. The program was designed so that it could be modified (particularly during Phase I) to achieve the overall objective of the Biomonitoring Program. Phase I was performed under CTO 64. During Phase I, which consisted of preliminary (U.S. Fish & Wildlife Service) sampling in July 1992 and two quarterly sampling events (October 1992 and January 1993), sample collection and analytical techniques were established and subsequently modified to better suit actual site conditions. Based on the results of Phase I, a revised (Revision 1) Biomonitoring Plan was prepared and issued in April 1993 (Halliburton NUS, 1993c). Phase II of the Biomonitoring Program is to be performed under CTO 117. Phase II was initiated in April 1993. While Phase II is expected to be completed in 1995, work will continue as long as CHESDIV deems necessary.

This report presents the results of the July 1993 biomonitoring, which was performed in accordance with an approved (revised) Biomonitoring Plan (Halliburton NUS, 1993c). This revised Biomonitoring Plan reflects modifications in the biomonitoring program that were made following Phase I sampling efforts. The Biomonitoring Plan currently in use is not expected to change substantively over the course of Phase II biomonitoring; however, changes in environmental variables (e.g., water levels, water quality, abundance of particular plant and animal species) or practical considerations may dictate the need for minor changes in sampling procedures and analytical methods.

1.1 BACKGROUND

For approximately 20 years, mercury was inadvertently released in small amounts from sink and floor drains in Building 766 of the Site 8 - Nitroglycerin Plant Office. The Building 766 sink and floor drains emptied into a storm drain system that discharged into a small (unnamed) stream that flows south and east for approximately 1/4 mile, enters a cattail marsh and pond, then empties into Mattawoman Creek. Previous investigations determined that sediments and surface waters of the stream, marsh, and pond contain elevated concentrations of mercury (ABB-ES, 1992a; ABB-ES, 1992b). The actual quantity of mercury that was released is unknown; however, it has been estimated that between 200 and 500 pounds of mercury were released to the environment at Site 8 (ABB-ES, 1992a).

In August 1992, Halliburton NUS began investigating the extent of mercury contamination in the soils, sediment, and surface water of Site 8 in accordance with an approved Abbreviated Field Sampling Plan (Halliburton NUS, 1992b). This investigation indicated that sediments in the upper section of the stream (near Building 766) were contaminated with mercury concentrations greater than 25 mg/kg (Halliburton NUS, 1993a). Mercury concentrations in the upper stream section ranged from non-detectable (lower than detection limits) to 671 mg/kg. Sediments in the marsh and pond had mercury concentrations ranging from non-detectable to 13.8 mg/kg. Background mercury concentrations (i.e., mercury levels in sediment and soil samples from the general vicinity of Site 8 but outside of the impacted stream corridor) ranged from non-detectable to 0.34 mg/kg.

The biomonitoring program developed by Halliburton NUS was designed to be carried out in the marsh/pond area of Site 8 only. Because the velocity of the stream is reduced as it widens and flows into the marsh and pond, the pond is a natural sediment trap, holding silt, detritus, and organic matter from upstream. Unlike the stream, which is subject to extreme fluctuations in temperature, flow, and turbidity, the marsh and pond support an abundant growth of aquatic vegetation as well as a variety of planktonic organisms, aquatic insects, fish, reptiles, amphibians, wading birds, and waterfowl (personal observation, P. R. Moore - Halliburton NUS). Thus the potential for contaminant (specifically mercury) exposure and bioaccumulation is considered to be higher in the marsh and pond than in the stream, and the biomonitoring effort focuses on this area.

1.2 SITE DESCRIPTION

The study site (Site 8 marsh/pond) lies within the main (or northern) NSWC area. The Site 8 marsh/pond discharges into Mattawoman Creek via a 6-foot-diameter culvert running under Noble Road. In addition, two

control sites were identified and designated for the biomonitoring program. Control Site 1 is a beaver pond on the Stump Neck Annex of NSWC, approximately 3 miles southeast of the study site and 1/2 mile northwest of Alexandria Church. Control Site 1 was designated a control site in October 1992. Control Site 2 is in Mattawoman Creek, approximately 3 miles east of the NSWC, just upstream of the Maryland Highway 225 Bridge. It was added prior to the January 1993 sampling round. The locations of Site 8 and Control Site 1 are shown on Figure 1-1.

Control Site 1 (beaver pond control site) is located on an unnamed tributary of the Chicamuxen Creek, the drainage to the south of Mattawoman Creek. This beaver pond was chosen as a control site because it offers security (access to the area is restricted and controlled by NSWC) and reasonably approximates the Site 8 pond in terms of water chemistry, water level, topography, and resident plants and animals. Control Site 2 (Mattawoman Creek control site) was selected because it appeared to offer better fish habitat than the beaver pond control site, and was in the same drainage basin as the Site 8 stream and pond. Both the Mattawoman and the Chicamuxen are tributaries of the Potomac River.

Because the beaver pond control site is approximately 2 miles upstream from Chicamuxen Creek and approximately 3 miles upstream from the Potomac River, it has not been contaminated by mercury from Site 8. Any pollutants (e.g., mercury) in its water, sediments, and biota are presumed to be from atmospheric or geologic sources rather than from Site 8. The Mattawoman Creek control site, which is approximately 4 miles upstream of the Site 8 outfall and 3 miles east of the NSWC boundary, is presumably unaffected by NSWC operations.

Until the summer of 1992, the Site 8 pond was 4 feet deep at its deepest point, the water level being maintained by a beaver dam lying just upstream of the culvert that drains the marsh/pond. The beaver dam was removed in the summer of 1992 and normal pool was lowered approximately 3 feet. During the October 1992 and January 1993 rounds of biomonitoring, the water level in the Site 8 pond was generally 1 to 2 feet deep. A weir was installed just upstream of the Noble Road culvert in April 1993, raising the water level in the pond by approximately 1 foot. Thus, permanent pool elevation will be intermediate between the high (pre-summer 1992) level maintained by the beaver dam and the extreme low level that existed in fall 1992 and winter 1993 after removal of the beaver dam.

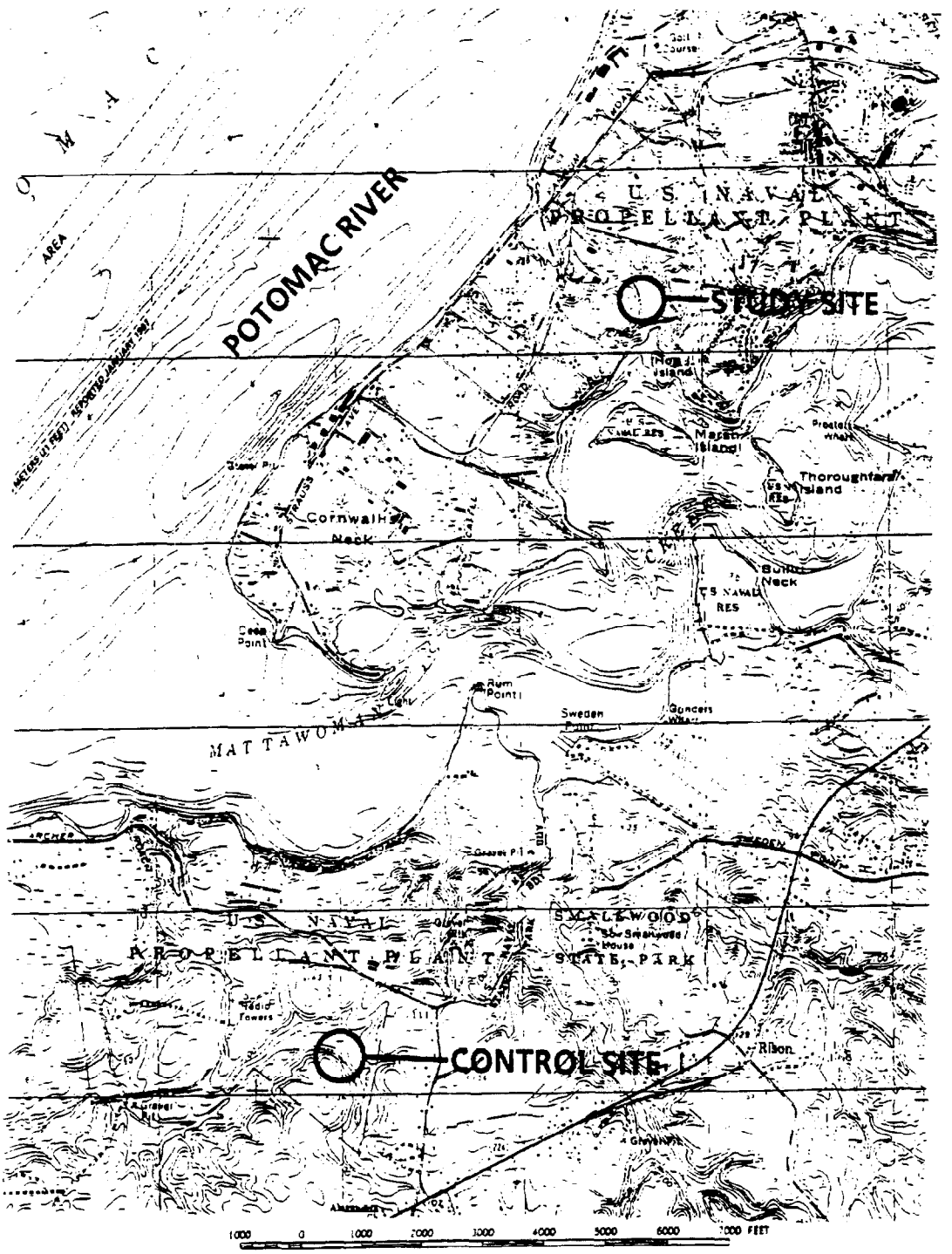

FIGURE 1-1
LOCATION MAP
SITE 8 AND CONTROL SITE 1
BIOMONITORING PROGRAM
INSTALLATION RESTORATION PROGRAM
SITE 8 - NITROGLYCERIN PLANT OFFICE

HALLIBURTON NUS
Environmental Corporation

Source: 7.5 Minute USGS Quad Indian Head, MD-VA 1966 Photo Revised 1978

1.3 OBJECTIVES

The primary objectives of the biomonitoring program are to assess the impact that mercury contamination at Site 8 has had on the biota of the Site 8 marsh/pond and to evaluate potential environmental impacts of any interim removal action. The October 1992 and January 1993 rounds of biomonitoring were intended to establish baseline conditions at Site 8 and provide information to refine and improve methods in subsequent phases of biomonitoring. The April 1993 round of biomonitoring was significant because it marked the first time that sampling was conducted in the Site 8 pond under normal (full-pool) conditions. The water level in the Site 8 pond remained at full pool during the July 1993 field sampling. Barring unforeseen problems with the newly-installed weir, the water level in the pond should remain relatively stable for the remainder of the study, and biological communities should, in time, reach an equilibrium.

2.0 SAMPLING LOCATIONS AND METHODS

The summer 1993 round of biomonitoring was conducted on July 15 and 16, 1993. Coastal Environmental Services, Inc. (CES), a subcontractor to Halliburton NUS, performed field sampling at six transects in the main area of the Site 8 marsh/pond (Transects 1, 2, 3, 4, 5, and 7) and at a location on the north side of Atkins Road Extension (Transect 10). The sampling locations are shown on Figure 2-1. As previously noted, a water control structure (weir and butterfly valve) was installed on April 23, 1993, raising the water level in the pond by 6 to 12 inches. This relatively small increase in depth resulted in an approximate doubling of the pond surface area (personal communication, B. Krinsky, Coastal Environmental Services, with P. Moore, Halliburton NUS, 1993).

At the time of the July 1993 biomonitoring, the configuration of the Site 8 pond was little changed from April. After the weir was installed in April, the Site 8 pond proper, which in previous sampling rounds encompassed only Transects 1 and 2, extended to include Transects 3, 4, 5, and 6. As before, the deepest part of the pond was the downstream-most portion, with depths at the dam of 2 to 3 feet. Transects 7 and 8, which remained streamlike at the time of the July biomonitoring, are expected to remain so in the future under normal circumstances (absent flooding). Transect 10, which was a freshwater marsh with standing water before the beaver dam was breached in 1992, continued to resemble a stream in July 1993.

The following ecological components were sampled in July 1993:

- Water Quality
- Periphyton
- Benthic Macroinvertebrates
- Fish

2.1 WATER QUALITY MEASUREMENTS

Water temperature, dissolved oxygen (DO), pH, and conductivity measurements were taken in the field with a Hydrolab Surveyor II only at a mid-depth because water was <1.0 meter deep at most transects. Salinity was measured with a portable S-C-T meter at the Site 8 pond and two control sites.

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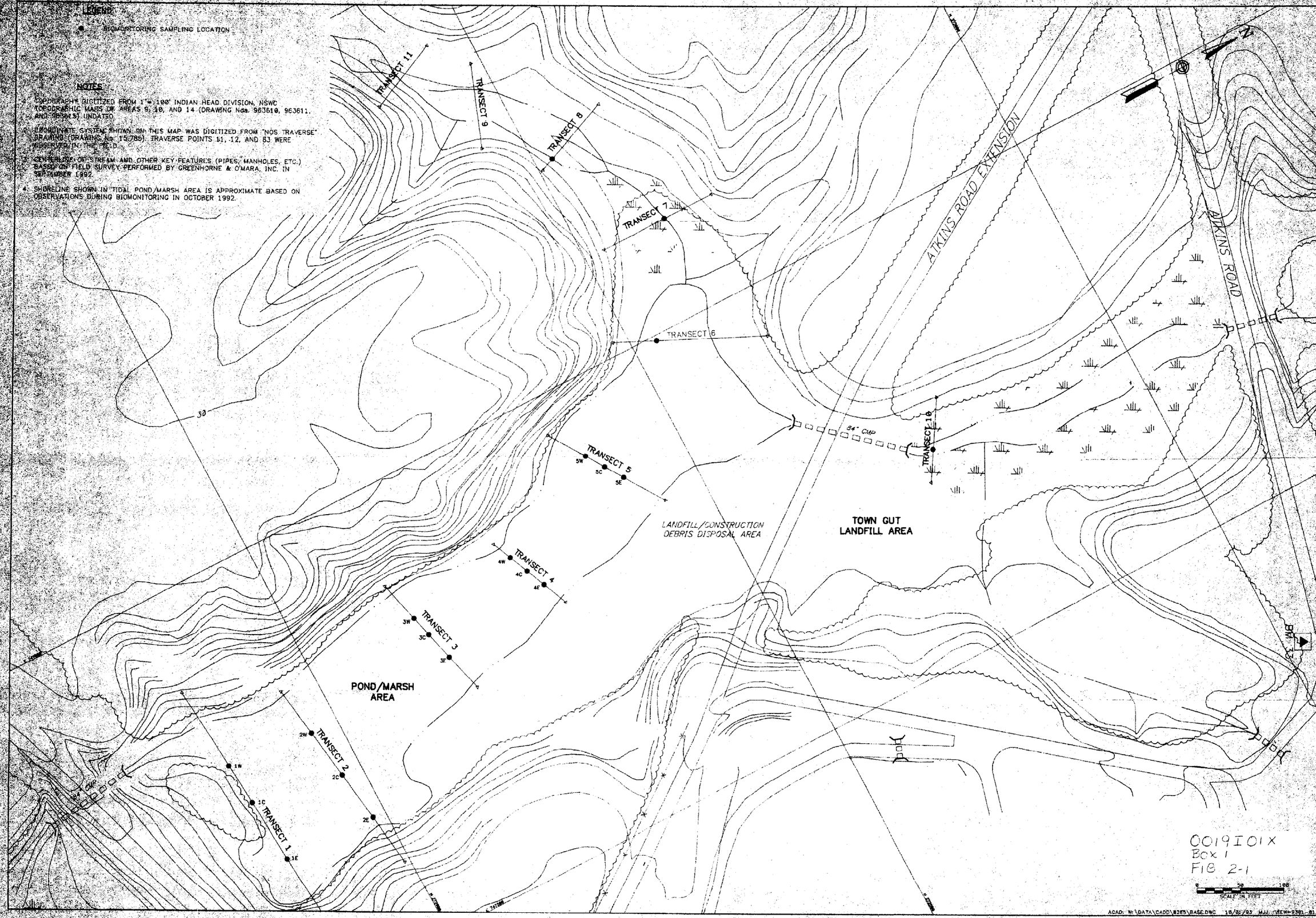
LEGEND

● BIOMONITORING SAMPLING LOCATION

NOTES

1. TOPOGRAPHY DIGITIZED FROM 1" = 100' INDIAN HEAD DIVISION, NSWC TOPOGRAPHIC MAPS OF AREAS 9, 10, AND 14 (DRAWING Nos. 963610, 963611, AND 963613) UNDATED.
2. COORDINATE SYSTEM SHOWN ON THIS MAP WAS DIGITIZED FROM "NOS TRAVERSE" DRAWING (DRAWING No. 15,785). TRAVERSE POINTS 11, 12, AND 83 WERE DESCRIBED IN THE FIELD.
3. CENTERLINE OF STREAM AND OTHER KEY FEATURES (PIPES, MANHOLES, ETC.) BASED ON FIELD SURVEY PERFORMED BY GREENHORNE & O'MARA, INC. IN SEPTEMBER 1992.
4. SHORELINE SHOWN IN TIDAL POND/MARSH AREA IS APPROXIMATE BASED ON OBSERVATIONS DURING BIOMONITORING IN OCTOBER 1992.



0019I01X
Box 1
FIG 2-1

ACAD: M:\DATA\CADD\8285\BASE.DWG 10/01/93 MJJ VIEW=0301-01

REV.	DESCRIPTION	PREP. BY	DATE	APPR'D

DEPARTMENT OF THE NAVY
WASHINGTON NAVY YARD
NAVAL FACILITIES ENGINEERING COMMAND
WASHINGTON, DC

CHESAPEAKE DIVISION

INDIAN HEAD DIVISION, NAVAL SURFACE WARFARE CENTER

SITE 8 – NITROCELLULOSE PLANT OFFICE
JULY 1993 – BIOMONITORING SAMPLING LOCATIONS

ISSUED: JULY 6, 1993

NOT FOR CONSTRUCTION

SEAL AREA

SAT TO | DATE
CODE I.D. NO. 80001
SCALE: AS SHOWN
SPEC. NO. 84 – NA
CONSTRN. CONTR. NO. NA
MANFAC DRAWING NO. NA
SHEET 1 OF 1
SIZE: D
DIS. SH. NO. FIGURE 2-1

2.2 PERIPHYTON SAMPLING

Periphyton was sampled with an artificial substrate device similar to that described in Standard Methods for Analysis of Water and Wastewater (APHA, 1985). This device employs glass slides in a frame supported by styrofoam floats. Two sets of periphyton samplers, each containing 8 slides (a total of 16 slides), were placed at each sampling location. After 14 days, the samplers were retrieved and transported to the laboratory for analysis.

Three randomly-selected slides from each array were analyzed for ash-free dry weight, three were analyzed for chlorophyll-a, and three were examined for species composition and abundance. One slide from each periphyton sampler was preserved and archived, in the event that additional analysis or verification of periphyton identification is required. Any remaining slides collected at a given sampling location were discarded.

2.3 BENTHIC MACROINVERTEBRATE SAMPLING

Benthic macroinvertebrates were sampled with a Petite Ponar grab sampler. Samples were sieved in the field, preserved, and transported to the laboratory for identification and enumeration. Standard methods described in APHA (1985) and Lind (1979) for collecting and counting benthic macroinvertebrates were employed.

2.4 FISH SAMPLING

2.4.1 Fish Surveys

No systematic fish surveys were conducted at the three study sites in April or July 1993. Previous (Phase I) surveys (Halliburton NUS, 1993a; Halliburton NUS, 1993b) indicated that fish species diversity and abundance were very low at all sites and that electrofishing samples revealed little about community structure. In October 1992, for example, two species, *Gambusia* sp. (presumably *holbrooki*) and *Fundulus heteroclitus*, comprised approximately 90 percent of more than 300 fish collected at the Site 8 pond (Coastal Environmental Services, 1992; Halliburton NUS, 1993a). No fish were collected in the beaver pond control site in October 1992. Although the fish surveys have been abandoned, a species list and notes on occurrence will be maintained for each sampling location, based on fish collections made for mercury analysis. This will provide a crude measure of species richness and abundance.

2.4.2 Fish Sampling for Mercury Residues

A mix of fish sampling techniques was employed in July in an effort to collect enough fish for a thorough analysis of mercury levels in tissue. Minnow traps baited with cottonseed cake were set at the Site 8 study site and control sites, left overnight, and retrieved the following day. Baited trap nets were also deployed at the Site 8 pond, left overnight, and retrieved the following morning. Trap nets were set perpendicular to shore just below the water surface in 1 to 3 feet of water. The trap nets were of conventional design with a leader and two wings directing fish to the baited "heart" of the net. A 100-foot-long monofilament gill net was fished overnight at the beaver pond control site. Electrofishing was not employed at any of the three sites because it was ineffective in previous sampling attempts.

In previous rounds of biomonitoring, an inability to collect target species [i.e., large-mouth bass (*Micropterus salmoides*), brown bullhead (*Ameiurus nebulosus*), and the mosquitofish (*Gambusia* sp.)] necessitated the use of surrogates [e.g., bluegill (*Lepomis macrochirus*) for large-mouth bass, creek chubsucker (*Erimyzon oblongus*) for brown bullhead] in mercury analyses (Halliburton NUS, 1993b; Halliburton NUS, 1993d). These target species (and their surrogates) were chosen because they represent three distinct trophic levels: top-of-the-food-chain predator, bottom-feeding omnivore, and surface-feeding insectivore.

In July, it was necessary to use bluegill and warmouth (*Lepomis gulosus*) in lieu of large-mouth bass for "top-of-the-food-chain predator" at Site 8. Redfin pickerel (*Esox americanus*) was the only predator species captured at the beaver pond control site in July. Several brown bullhead were captured at Site 8 in July, but a creek chubsucker was the only "bottom-feeding omnivore" collected from the beaver pond control site. No fish were collected in the Mattawoman Creek minnow traps, thus no fish were available for comparison of mercury levels in tissues. All fish collected were placed on ice and shipped to Gascoyne Laboratories, Incorporated, for mercury residue analysis.

3.0 BIOMONITORING RESULTS AND DISCUSSION

3.1 WATER QUALITY

Water quality data are presented in Table 3-1. Water temperatures in the Site 8 pond (Transects 1, 4, and 7) ranged from 29.2 to 31.1°C on July 15, 1993. Water temperatures were lower at the Mattawoman Creek control site (26.0°C) and Transect 10 (26.3°C). Water temperature at the beaver pond control site was 24.3°C on the afternoon of July 15. DO concentrations ranged from 5.0 to 15.5 mg/L at three Site 8 transects, levels adequate to support a variety of aquatic life. The DO concentration at Transect 10, located in a tributary stream flowing into the head of the Site 8 pond (north of the Adkins Road Extension), was 1.3 mg/L. DO concentrations measured at the Mattawoman Creek and beaver pond control sites were 2.2 and 0.8 mg/L, respectively, the lowest levels observed over the course of this study. Measurements of pH ranged from 6.8 to 8.9 at Site 8 (Transects 1, 4, and 7) and were slightly lower at both control sites (5.7 and 6.5).

EPA (1986) recommends that 7-day mean dissolved oxygen levels be maintained at 6.0 mg/L for the eggs and larvae of most warm water fish species. The suggested instantaneous minimum DO for both cold water and warm water fish species is 5.0 mg/L. DO is a critical water quality parameter in most circumstances because it defines available fish and invertebrate habitat. When oxygen is abundant, aquatic organisms are better able to withstand a variety of stresses, ranging from high water temperatures to chemical pollution to disease. When oxygen is limited, as was the case with the two control stations and Transect 10 in July, all the aforementioned stresses are exacerbated. The Site 8 pond, however, appears to provide adequate DO levels for fish and invertebrates, even in summer when DO levels are normally lowest in small ponds.

Because fish have been captured regularly at both control sites over the course of this study (October 1992 through July 1993), the low DO levels seen in July 1993 at these sites must be transient or localized. There are obviously refuges in the vicinity of both stations that provide enough oxygen for fish to survive periods of high temperatures and low oxygen levels. In the case of Mattawoman Creek, fish may enter small, shaded tributary streams with cooler

TABLE 3-1

WATER QUALITY DATA - JULY 15, 1993
INDIAN HEAD DIVISION, NAVAL SURFACE WARFARE CENTER
INDIAN HEAD, MARYLAND

Station	DO (mg/L)	Temp (°C)	pH	Cond (μmhos)	Salinity (ppt)
Transect 1	15.5	31.1	8.9	399.0	0
Transect 4	8.9	29.9	7.7	331.0	0
Transect 7	5.0	29.2	6.8	331.0	0
Transect 10	1.3	26.3	6.8	348.0	0
Beaver Pond (Control Site 1)	0.8	24.3	5.7	77.0	0
Mattawoman Creek (Control Site 2)	2.2	26.0	6.5	177.0	0

water temperatures, or move downstream into the Potomac. In the beaver pond control site, there are almost certainly areas with DO concentration higher than 0.8 mg/L, either in the headwaters of the pond where the tributary enters, or in the vicinity of cool submarine seeps or springs.

In previous quarterly rounds of biomonitoring, water samples were taken from the Site 8 pond and the two control sites for measurements of Total Organic Carbon (TOC) and Total Hardness (as $CaCO_3$).

3.2 PERIPHYTON

In July 1993, periphyton (or "attached" algae) collected from Transect 1 of the Site 8 pond were 78.0 percent Bacillariophyta (diatoms) and 18.0 percent Chlorophyta (green algae) (Tables A-1, A-2, and A-3 of Appendix A). *Navicula* was the most common genus in samples, making up 43.9 percent of diatoms and 34.3 percent of all algae collected at this transect. At least nine other diatom genera were collected, none in large numbers. *Synedra*, the most abundant diatom by far in April samples (80.6 percent of algae collected) was present in small numbers in July (2.3 percent of total). This indicates that *Synedra* numbers peak with spring blooms and diminish thereafter.

Four genera of Chlorophyta (green algae) were present in July 1993 samples from Transect 1, with *Ulothrix* most common. No green algae were collected from Transect 1 in April. On the other hand, no Cyanophyta (blue-green algae) were found at Transect 1 in July 1993, while high densities of the blue-green *Oscillatoria* were present in April. Palmer (1975) lists *Oscillatoria* as the second-most pollution tolerant genus of algae, after *Euglena*.

Small numbers of Pyrrophyta (dinoflagellate) and Cryptophyta (another flagellate form) were present for the first time in July samples. *Peridinium*, the dinoflagellate collected, is a widely-distributed genus and the genus most closely associated with freshwater (Prescott, 1970). Rhodomonas the cryptophyta, is typically found in freshwater streams (Prescott, 1970). The phylum Euglenophyta was represented by two genera, *Phacus* and *Trachelmonas*, in July. *Phacus* was collected for the first time in July. The distinctively-shaped *Trachelmonas,* collected in January and July, is a component of both the plankton and the periphyton communities, but is generally uncommon in both (Whitford and Schumacher, 1973).

The periphyton of Transect 2, which in April 1993 were 98.7 percent diatoms, were again dominated by diatoms in July (85.7 percent of algal cells collected). *Navicula* and *Cyclotella* were the two most abundant diatom genera in July, making up 40.4 percent and 23.4 percent of diatoms, respectively. *Navicula* is

diatom genera in July, making up 40.4 percent and 23.4 percent of diatoms, respectively. *Navicula* is number 7 on the EPA list (in Palmer, 1975) of the 22 most pollution-tolerant genera of algae, and *Cyclotella* is number 15 (number 1 being the most pollution tolerant and characteristic of a polluted environment).

Total diatom density (mean density per sample) at Transect 2 decreased from 147,828 cells/cm^2 in April to 246.3 cells/cm^2 in July 1993. A single genus, *Synedra*, showed a density of 128,815 cells/cm^2 in April. Some reduction in densities was to be expected, because diatoms typically bloom in the late spring or early summer in the eastern U.S. (Cole, 1975). But the dramatic decrease observed between April and July appears to be the result of a sampling anomaly.

CES personnel involved with processing the July periphyton samples saw evidence of macroinvertebrate grazing on the periphyton colonizing the glass slides, of the artificial substrate (Coastal Environmental Services, 1993b). The APHA (1985) manual suggests that 2 weeks is the "optimum" sampling period for periphyton during the summer, because "...exposures of less than 2 weeks may result in very sparse collections, and exposures of more than 2 weeks may result in loss of (periphyton) due to sloughing." The APHA notes further that macroinvertebrate grazing "may occur" within 7 to 14 days, and, if so, recommends that exposure times (sampling intervals) be reduced to 7 to 10 days. Because the Indian Head biomonitoring program is designed to detect gross, rather than subtle or statistically-significant changes in periphyton community structure, it will not be necessary to fine tune the periphyton exposure times to this degree.

The periphyton community of Transect 3 was dominated by diatoms (92.2 percent of total) in July, but densities were extremely low. Mean diatom density was only 180 cells/cm^2 at this transect. The most abundant diatom genus, *Navicula*, had only 81.7 cells/cm^2. The periphyton community at Transect 3 in April was also diatom dominated (94.7 percent of total), but diatom densities were several orders of magnitude higher: 22,184 cells/cm^2 for *Synedra*, 10,909 cells/cm^2 for *Navicula*, and 6,141 cells/cm^2 for *Melosira*. Some the marked decrease from April to July in periphyton densities is due to normal seasonal variation, but the effect of macroinvertebrate grazing cannot be discounted.

Diatoms were the most abundant periphyton group in July samples from Transect 4 (71.9 percent of total), but green algae also made up a significant proportion of the total (24.5 percent). Although 4 genera of green algae were collected, only one (*Ulothrix*) was present in significant numbers (112.7 cells/cm^2). *Navicula* and *Cyclotella* were the most common highest diatom (20.8 and 14.6 percent of total algae), and *Ulothrix* the most common green algae (18.7 percent of total algae).

April periphyton samples from Transect 4 were dominated by two diatom genera, *Synedra* (68.7 percent of total) and *Navicula* (18.3 percent of total). Small numbers of green algae (*Ulothrix*) and blue-green algae (*Oscillatoria*) were also present in April. Total periphyton density at Transect 4 was much higher in April 1993 (114,638 cells/cm^2) than July (602.3 cells/cm^2) or January (4,741 cells/cm^2). As noted before, there was evidence of macroinvertebrate grazing on algae attached to periphytometer slides in July.

As in the previous 3 quarters of biomonitoring, the four Site 8 transects contained a diverse assemblage of periphyton in July 1993 that was dominated numerically by diatoms. Eleven diatom genera, 9 green algae genera, 2 euglonoid genera, 1 cryptophyte (*Rhodomonas*) 1 blue-green genus (*Stichosiphon*), and one dinoflagellate (*Peridinium*), were present in July samples. Many of the diatom genera present (e.g., *Nitzschia*, *Synedra*, *Gomphonema*, and *Cyclotella*) are used as bioindicators of eutrophication or pollution in aquatic ecosystems (Palmer, 1975; APHA, 1985). *Navicula*, the most abundant diatom in 9 of 12 Site 8 samples, is listed by Palmer as a pollution-tolerant genus. However, the APHA (1985) lists *Navicula* as a genus associated with clean water. Given this genus's widespread distribution in freshwater, brackish water, and marine environments, and the large number (more than 50) of *Navicula* species that occur worldwide, it would be necessary to determine which specie(s) of Navicula occur(s) at Site 8 before drawing any conclusions about its value as a bioindicator. Identifying periphyton to this level is beyond the scope of this investigation.

The Mattawoman Creek control site was reasonably diverse (9 diatom genera, 3 green algae genera, 2 blue-green algae genera, 1 dinoflagellate, and 1 euglenoid genus) in July, but total algal density (mean density per sample) was very low, 267.7 cells/cm^2 versus 5,786 cells/cm^2 in April. This compares to a total algal density in July of 374.8 cells/cm^2 in the Site 8 pond. Of the 3 locations, the Stump Neck pond had the highest algal density (1,010.7 cells/cm^2).

As noted in the April Biomonitoring Report (Halliburton NUS, 1993d), the rate at which periphyton are produced and colonize substrates--such as the periphytometer employed in this study--is generally higher in ponds and lakes. Thus one would have expected periphyton densities at Site 8 to be much higher than those at Mattawoman Creek and beaver pond control sites. This was the case in April, 1993 (Halliburton NUS, 1993d), but was not true in July. As noted, this may have been the result of macroinvertebrates grazing on periphyton attached to the artificial substrate.

In April 1993, diatoms and green algae comprised 63.8 percent and 24.4 percent of periphyton in the Mattawoman Creek control site samples. In July, however, 51.9 percent of algae were diatoms and 41.6 percent were green algae. There appeared to be a slight shift from diatoms to green algae, with greens

relatively more abundant in July and more diverse (3 genera versus 2 in April). Diatoms and green algae comprised 94.9 percent and 0.3 percent of Site 8 periphyton in April 1993. In July, by contrast, 78.9 percent of attached algae at Site 8 were diatoms and 16.5 percent were green algae, again signaling a shift from diatoms to greens in summer. More striking was the increase in diversity of green algae at Site 8 from April to July. Two genera of green algae were identified from Site 8 samples in April (plus one unidentified group), while nine genera of green algae were collected in July.

The beaver pond control site in Stump Neck was the least diverse of the three sites in April, with only five taxa present, all diatoms. *Navicula* (58.9 percent of total) and *Synedra* (27.9 percent of total) were the most abundant genera. Total periphyton density was also lowest at the Stump Neck pond in April. It was pointed out at that time (Halliburton NUS, 1993d) that the Stump Neck beaver pond lies in forested watershed, has stained, acidic water, and appears to have low biological productivity. The same report noted that the beaver pond control site has only been in existence for a few years, and should become more productive as canopy opens up (beavers continue to fell trees around the pond), allowing more sunlight to reach the surface of the pond, and additional nutrients are released by submerged soils and decomposing plant material.

There was a marked increase in diversity in July at the beaver pond control site, with 8 diatom genera, 7 green algae genera, a blue-green genus (*Stichosiphon*), and a dinoflagellate (*Peridinium*) genus present in samples. Total periphyton density at Stump Neck was 1,010.7 cells/cm^2, the highest of the three study sites.

The spring-to-summer shift from a diatom-dominated periphyton community to a diatom-green algae community observed at Site 8 and Mattawoman Creek control site held true for the beaver pond control site. All periphyton in April samples from beaver pond were diatoms. In July, by contrast, 65.4 percent of periphyton were diatoms and 28.7 percent were green algae. Blue-green algae made up 3.5 percent of July samples from the beaver pond. The increase in densities and diversity observed at beaver pond control site may be the result of rapid periphyton community development in a young, biologically-dynamic body of water. The fact that periphyton densities at beaver pond control site were high relative to the other two sites may be the result of lower rates of grazing by macroinvertebrates, cooler water temperatures more conducive to algal growth (24.3°C at the beaver pond compared to 26.0°C at Mattawoman Creek and 29.2-31.1°C at Site 8), or some other undetermined factor.

3.3 BENTHIC MACROINVERTEBRATES

The Site 8 pond, with its rooted aquatic vegetation (in shallows and around pond margins) and soft, gently-sloping bottom (consisting of silt, muck, and organic detritus) is typical of tidally-influenced freshwater ponds in the Potomac River estuary (Maryland DNR, 1981). At the time of the April 1993 macrobenthos sampling and again in July, the bottom substrate was characterized as unconsolidated silt and mud (Coastal Environmental Services, 1993a; Coastal Environmental Services, 1993b). Table 3-2 lists densities and relative proportions of macroinvertebrates found in benthic sediments from Site 8 and the two control sites in 1993.

In April 1993, macroinvertebrate densities were low in benthos collections from all sites. At every transect, densities were lower in April 1993 than January. Densities at six Site 8 transects ranged from 114 organisms/m^2 at Transect 3 to 1283 organisms/m^2 at Transect 5. In January 1993, macroinvertebrate densities ranged from 790 organisms/m^2 at Transect 2 to 4,846 organisms/m^2 at Transect 6, which is no longer sampled for benthos. Densities were low again in July, ranging from 38 to 316 organisms/m^2 at five Site 8 transects.

Diversity was also very low in April at all Site 8 transects and the two control sites: none of the transects sampled contained more than four taxa. Density was even lower in July: none of the transects contained more than 3 taxa. Diversity is used in this report in its loosest sense--in strict terms, the number of taxa observed at a given location is a measure of "richness." April collections from the Site 8 pond (Transects 1, 2, 3, 4, 5, and 7) were made up largely of oligochaetes and chironomids, with oligochaetes making up from 50.0 to 96.3 percent of animals collected from a given transect. This was the same pattern seen in July: virtually all macroinvertebrate collected were either oligochaete or chironomids.

In January 1993, by contrast, 14 macroinvertebrate taxa were collected from Transect 1 (deepest water near dam) alone, with Oligochaeta the most common group (48.2 percent of total). Excluding Transect 1 (which was sampled more intensively than other stations), diversity in January 1993 was highest (nine taxa) at Transect 2. All of the other Site 8 transects showed low diversity in January 1993, with only four to six taxa present. In October 1992, by contrast, three Site 8 transects contained nine or more taxa (Halliburton NUS, 1993a).

The most common organism in Site 8 collections in January, April, and July 1993 was the annelid worm Oligochaeta. Aquatic oligochaetes are burrowing detritivores, well suited for silt and mud substrates. Most of the aquatic species are able to tolerate low DO concentrations (Pennak, 1978). Oligochaete species are

TABLE 3-2

BENTHIC MACROINVERTEBRATES
DENSITY (NO./M²) AND RELATIVE ABUNDANCE (%) OF BENTHIC MACROINVERTEBRATES
INDIAN HEAD DIVISION, NAVAL SURFACE WARFARE CENTER

Taxon	TRANSECT 1			TRANSECT 2			TRANSECT 3			TRANSECT 4			TRANSECT 5		
	Jan 93	Apr 93	Jul 93	Jan 93	Apr 93	Jul 93	Jan 93	Apr 93	Jul 93	Jan 93	Apr 93	Jul 93	Jan 93	Apr 93	Jul 93
Hymanella sp.															
Nematoda															
Oligochaeta	878(48.2)	95(68.3)	38(100)	615(77.8)	273(86.4)	48(76.2)	962(93.4)	57(50.0)	306(96.8)	1000(86.0)	345(85.8)	278(100)	3058(85.5)	1235(96.3)	316(100)
Banchiura sp.		13(9.4)			38(12.0)	5(7.9)		38(33.3)	10(3.2)					10(<1.0)	
Polychaeta	19(1.0)			24(3.0)											
Hirudinea							10(1.0)						77(2.2)		
Asellus sp.	98(5.4)			15(1.9)											
Gammarus sp.	493(27.1)			10(1.3)						29(2.5)					
Ephemerella sp.	26(1.4)														
Gomphus sp.	42(2.3)			5(0.6)			10(1.0)			19(1.6)					
Calopteryx sp.	6(0.3)														
Hemiptera															
Notonecta undulata	3(0.2)			10(1.3)											
Sialis sp.															
Trichoptera															
Dysticidae	6(0.3)														
Diptera (adult)															
Diptera (larvae)		6(4.3)		5(0.6)				19(16.7)					19(0.4)	19(1.5)	
Culex sp.															
Chironomidae	228(12.5)	25(18.0)		101(12.8)	5(1.6)	10(15.9)	48(4.7)			96(8.3)	57(14.2)		77(2.2)		
Helisoma sp.	6(0.3)														
Gyraulus sp.	3(0.2)														
Physa sp.														19(1.5)	
Physella sp.	6(0.3)														
Unionidae															
Sphaerium sp.	6.0(0.3)			5(0.6)						19(1.6)			347(9.7)		
Totals	1820	139	38	790	316	63	1030	114	316	1163	402	278	3578	1283	316

*No collections made at this station in January 1993.
**No collections made at this station in April 1993.

TABLE 3-2
BENTHIC MACROINVERTEBRATES
DENSITY (NO./M²) AND RELATIVE ABUNDANCE (%) OF BENTHIC MACROINVERTEBRATES
INDIAN HEAD DIVISION, NAVAL SURFACE WARFARE CENTER
PAGE TWO

Taxon	TRANSECT 7			TRANSECT 10			BEAVER POND CONTROL SITE (CONTROL SITE 1)			MATTAWOMAN CREEK CONTROL (CONTROL SITE 2)		
	Jan 93*	Apr 93	Jul 93	Jan 93	Apr 93	Jul 93	Jan 93*	Apr 93	Jul 93	Jan 93*	Apr 93	Jul 93
Hymanella sp.												
Planariidae									19(1.9)			
Nematoda												
Oligochaeta		96(83.5)	134(100)	3178(84.0)	431(91.9)	468(97.9)		326(84.9)	832(82.0)		10(3.0)	192(50.0)
Branchiura sp.												
Polychaeta												
Hirudinea												
Asellus sp.												
Gammarus sp.												10(2.6)
Ephemerella sp.												
Gomphus sp.												
Calopteryx sp.												
Hemiptera												
Notonecta undulata												
Sialis sp.												10(2.6)
Trichoptera												
Dysticidae												
Diptera (adult)												
Diptera (larvae)								10(2.6)				
Culex sp.												
Chironomidae								19(4.9)	163(16.1)		326(97.0)	172(44.8)
Helisoma sp.								29(7.6)				
Gyraulus sp.												
Physa sp.		19(16.5)			38(8.1)							
Physella sp.				39(1.0)								
Unionidae												
Corbicula sp.				19(0.5)								
Pisidium sp.				506(13.4)								
Sphaerium sp.				41(1.0)		10(2.1)						
Totals	0	115	134	3783	469	478	0	384	1014	0	336	384

*No collections made at this station in January 1993.

variable in their ability to withstand environmental stresses. Several genera are very stress-resistant (e.g., *Tubifex* and *Limnodrilus*) and may develop tremendous populations in the absence of other aquatic organisms which have been destroyed by pollution. It is not true of all species in these genera, however. Nor is it true of all genera in the family Tubificidae (Whitley, 1982).

Two odonate (dragonfly larvae) genera, *Gomphus* and *Calopteryx,* were collected from the Site 8 pond in January 1993. No dragonfly larvae were collected in April or July. The Odonata are regarded as indicators of reasonably-good water quality, but can tolerate extremes of certain chemical parameters, such as chlorides and sulfates (Roback, 1974). *Gomphus*, a silt and mud-burrowing genus, was collected from four transects in January, while *Calopteryx*, a "climbing" predator often found in submerged weed beds, was collected from Transect 1 only. Pennak (1978) notes that dragonfly larvae are typically found in the bottoms of ponds, marshes, and sluggish streams, but are rare in polluted waters.

The mayfly *Ephemerella*, a detritivorous genus typically found in unpolluted waters and notably intolerant of organic pollution (EPA, 1990) was collected at Transect 1 in January, but was not collected in April or July. It should be noted that this genus, although associated with clean water, is ubiquitous in a wide range of habitats (there are some 80 species of *Ephemerella*) and some species are tolerant of low-oxygen conditions (Pennak, 1978). It would be unwise to draw any inferences about habitat quality on the basis of this genus's presence.

The megalopteran (alderfly larvae) *Sialis*, a sediment-dwelling predator that feeds on insect larvae, annelid worms, and crustaceans, was collected in 1992 (Halliburton NUS, 1993a), but has not bee collected in 1993. Roback (1974) identifies *Sialis* as one of the few pollution tolerant genera of Megaloptera. However, this is based on the genus's ability to withstand extremes of pH and high concentrations of several ions (e.g., sulfate and chloride), not a tolerance of low oxygen levels. *Sialis* requires DO concentrations of at least 5.0 mg/L, according to the same reference.

The marked decrease in densities and diversity at all Site 8 transects in April was attributed to: (1) unusually-heavy rains in the spring in the Indian Head area, and (2) installation of a weir-water control structure in the pond (Halliburton NUS, 1993d). Heavy spring rains and flooding probably resulted in flushing of the drainage basin, with many macroinvertebrates (excluding certain burrowing forms, like oligochaetes) being driven downstream. The benthos of Site 8 is particularly vulnerable to displacement because there are few habitat-forming structures (stumps, logs, boulders, pilings) in the pond that provide refuge from the current. Also, the substrate is mostly loose, unconsolidated material that is easily disturbed,

resuspended, and transported downstream. There apparently was not enough time between the flushing of the system and the late-April sampling for recolonization to occur.

The installation of a weir/water control structure in the Site 8 pond may have also contributed to the low numbers and diversities observed. A cofferdam was put in place on April 19 and the area behind the cofferdam was subsequently drained (J. Bossart, Indian Head Naval Ordnance Station, personal communication with P. Moore, Halliburton NUS). A permanent weir was installed on April 23. The pond level, which had been unusually high as a result of torrential spring rains, fell to the level of the weir after it was installed. The degree to which these activities resulted in displacement or disturbance of macroinvertebrates is unknown, but some displacement of macroinvertebrates may well have occurred.

The two control sites, neither of which was sampled in January 1993, were characterized by low densities and low diversity in April. The Mattawoman Creek control site sample was 97 percent chironomids, while the beaver pond control site was composed of only four groups--oligochaetes (85% of total), dipteran larvae, chironomids, and the pulmonate gastropod (snail) *Helisoma*. In July 1993, the Mattawoman Creek control site sample contained roughly equal densities of oligochaetes (50.1 percent) and chironomids (44.9 percent), with small numbers of *Gammarus* and the megalopteran *Sialis*. Beaver pond control site benthos samples in July contained only 3 taxa-oligochaetes, chironomids and flatworms (planariidas).

Based on the results of April and July sampling, the macroinvertebrate benthofauna of the Site 8 pond can only be described as depauperate, with low densities of benthic organisms and low taxa richness (or "diversity"). It is unknown whether these low densities are an indication of slow (post-flooding and weir installation) recolonization, or a long-term change in benthic community structure caused by changes in the composition of the bottom substrate of the pond.

Very few comprehensive studies of benthos in tidal freshwater have been conducted (see review in Odum et al., 1984). Diaz and Boesch (1977) and VIMS (1978) investigated effects of development on benthos in the James River, Virginia, a river similar to the Potomac in terms of discharge and drainage area (van der Leeden, 1990), and, one presumes, trophic state, nutrient loads, water temperature regimes, and biota, given their geographical proximity and the similarity of the two watersheds.

Both investigations (Diaz and Boesch, 1977; VIMS, 1978) revealed that the benthos of the James River and adjacent freshwater marshes were dominated numerically by tubificid oligochaetes and larval chironomids, and both suggested that the asiatic clam *Corbicula* was the most important component of benthic biomass. Members of the order Diptera (which includes flies, mosquitoes, and midges) are the only insect larvae

found in significant numbers in the fresh-to-brackish waters of the Potomac estuary, which includes Mattawoman Creek and environs (Maryland DNR, 1981). Thus, the numerical dominance of oligochaetes and chironomids and the low diversity of aquatic insect larvae at Site 8 tidal pond is not surprising, and is not necessarily indicative of a macroinvertebrate community that has been diminished by deteriorating water quality. *Corbicula* have been found in small numbers at Transect 10, the transect which lies in a tributary of the Site 8 pond, but the substrate of the pond does not appear to be firm enough or stable enough to support large numbers of these clams.

Diaz and Boesch (1977) suggested that the low species richness and simple community structure generally found in tidal freshwater marshes and ponds result from the homogeneity of the habitat, and in particular featureless sand or mud substrates. Many aquatic insect larvae (e.g., many caddisfly, mayfly, and stonefly genera) are closely associated with debris, leaf litter, gravel, crevices in rocks, and roots, leaves, and stems of aquatic plants. Diverse communities of aquatic insects are typically found in areas providing a diversity of habitats (or "niches") with acceptable temperature and oxygen regimes and abundant food.

3.4 FISH DIVERSITY

As noted earlier in Section 2.4.1, plans to conduct systematic fish population surveys were abandoned as a result of the low species diversity and general scarcity of fish observed in July (U.S. Fish & Wildlife Service) and October 1992 samples. However, species captured in the course of collecting fish for mercury analyses are noted, logged, and compiled in site-specific species lists. Table 3-3 lists fish species collected to date from the Site 8 pond and the two control sites.

Species diversity (as indicated by number of species captured) is highest at the Site 8 pond, with eight species collected to date. All species collected are common species of tidal freshwater creeks and ponds of the mid-Atlantic coast (Odum et al., 1984; Lee et al., 1980). *Gambusia* and *Fundulus* appear to be the most abundant species in the Site 8 pond and its tributaries. Other species have been common (e.g., bluegill, *Lepomis macrochirus*) to uncommon (e.g., large-mouth bass, *Micropterus salmoides*) in Site 8 collections. Until July 1993, only a few individuals representing a single species, the eastern mudminnow, *Umbra pygmaea*, had been collected in the Stump Neck beaver pond. In July, two new species, *Erimyzon oblongus* and *Esox americanus* were captured. Three species have been collected at Mattawoman Creek since it was added as a control site in January 1993, but none has been present in large numbers. It was hoped that the Mattawoman Creek control site would produce more fish in the spring, because many species known to be present downstream in the Potomac estuary either move upstream into tributaries like the Mattawoman to spawn or move into shallow water to spawn, making them more vulnerable to capture.

TABLE 3-3

FISH COLLECTED FROM SITE 8 AND CONTROL SITES
INDIAN HEAD DIVISION, NAVAL SURFACE WARFARE CENTER
INDIAN HEAD, MARYLAND

SPECIES	SITE 8					BEAVER POND (CONTROL SITE 1)				MATTAWOMAN CREEK (CONTROL SITE 2)			
	7-92	10-92	1-93	4-93	7-93	10-92	1-93	4-93	7-93	10-92	1-93	4-93	7-93
Notropis sp.												●	
Erimyzon oblongus			●						●		●		
Esox americanus									●				
Ameiurus nebulosus	●	●			●								
Umbra pygmaea							●	●					
Fundulus heteroclitus	●	●	●	●									
Gambusia sp.	●	●	●										
Lepomis gibbosus		●											
Lepomis gulosus					●								
Lepomis macrochirus	●		●	●	●								
Micropterus salmoides	●												
Morone americana												●	

But the presence of fishermen in the area of the Mattawoman Creek control site during April 1993 sampling ruled out electrofishing, and very few fish were captured in seines and minnow traps. Attempts to collect fish in Mattawoman Creek in July 1993 were unsuccessful.

The installation of a weir-water control structure at the Site 8 pond, which was discussed in Section 1.2, is expected to reduce fish species diversity over time. The weir will prevent fish (and invertebrates) from moving into the Site 8 pond from Mattawoman Creek. All recruitment of biota will be from upstream, or from the pond itself. It is unclear whether this will result in marked changes in invertebrate communities, but it appears likely that the fish community will change over time, with a fishery developing that is less diverse and more typical of a freshwater stream/pond than an estuary.

In the absence of recruitment from downstream, at least one species--the mummichog, *Fundulus heteroclitus*--is expected to decrease in relative abundance. A review of published life history accounts of this species suggests that the mummichog is able to reproduce and maintain population levels in freshwater impoundments under certain circumstances, but is more likely to flourish in brackish tidal waters (Scott and Crossman, 1973; Lee et al., 1980). It is unknown what effect the installation of the weir and the isolation of the pond will have on *Gambusia*, bluegill, and brown bullhead. Bluegill and brown bullhead are freshwater species. *Gambusia* sp. (presumably *holbrooki*) is an adaptable euryhaline species that fares equally well in fresh or brackish water, lakes, ponds, backwaters of rivers, and drainage ditches (Lee et al., 1980).

3.5 ANALYSIS OF MERCURY IN TISSUE OF AQUATIC ORGANISMS

As previously noted, fish samples were shipped on ice to Gascoyne Laboratories, Inc., for analysis. EPA Method 7471 (analytical detection limit = 0.01 mg/kg) was used to determine the concentration of total inorganic mercury present in each sample. Analyses were performed on homogenized whole body samples, rather than on fillets. The rationale for using whole body samples was the assumption that small prey species such as *Fundulus* and *Gambusia*, which have made up the majority of fish collected from Site 8 and both control stations, are almost always eaten whole by predatory fish, piscivorous birds, and piscivorous mammals. The number and total weight of fish comprising each sample and the concentration of total mercury present in each sample are summarized in Table 3-4.

In previous quarterly reports (Halliburton NUS, 1993b; Halliburton NUS, 1993d), it was suggested that the limited data did not exhibit any particular trends with respect to mercury concentrations in tissue. For example, the data failed to demonstrate a marked difference in the concentrations of mercury measured in different fish species collected at a particular site (e.g., Site 8). Because mercury exhibits a tendency to

TABLE 3-4

MERCURY CONCENTRATIONS IN FISH TISSUE
(FISH COLLECTED JULY 15-16, 1993)
INDIAN HEAD DIVISION, NAVAL SURFACE WARFARE CENTER
INDIAN HEAD, MARYLAND

FISH SPECIES	SITE 8			MATTAWOMAN CREEK (CONTROL SITE 1)			BEAVER POND (CONTROL SITE 2)		
	No. Fish Analyzed	Total Weight (grams)	mg Hg/kg	No. Fish Analyzed	Total Weight (grams)	mg Hg/kg	No. Fish Analyzed	Total Weight (grams)	mg Hg/kg
Erimyzon oblongus	0	N/A	N/A	0	N/A	N/A	1	15.6	0.09
Ameiurus nebulosus	2	60.0	0.05	0	N/A	N/A	0	N/A	N/A
Esox americanus	0	N/A	N/A	0	N/A	N/A	1	34.0	0.21
Lepomis gulosus	1	58.7	0.23	0	N/A	N/A	0	N/A	N/A
Lepomis macrochirus	2	141.7	0.09	0	N/A	N/A	0	N/A	N/A

biomagnify (increase in concentration at higher levels of a food chain), detection of higher concentrations of mercury in bluegill (a mid-food chain organism that eats insects and small fish) than in *Gambusia* or *Fundulus* (both omnivores that eat zooplankton, insects, and some plant material) was anticipated. No such pattern was observed in 1992 fish samples or in samples collected in the first two quarters of 1993. And, as noted in previous quarterly reports, the analytical detection limit of 0.01 mg Hg/kg made it difficult to determine if the low levels (0.02 to 0.15 mg/kg) of mercury present in all species were significantly different.

The tissue concentrations of mercury measured in the samples of Site 8 bluegill collected in January, April, and July 1993 (0.02, 0.06, and 0.09 mg Hg/kg, respectively) are similar to concentrations reported by the USFWS for this area between 1987 and 1991 (USFWS, 1991). As noted in these USFWS reports, the levels of mercury reported for Indian Head bluegill are similar to those reported for bluegill collected from other locations in Maryland and the United States. The combined bluegill data (1987-1993) suggest that the levels of mercury available to these organisms have remained relatively constant over the last six years, and that mercury tissue levels in bluegill have remained within the range reported for this species from other Maryland locations.

Eisler (1987) suggested that fish tissue levels of 0.1 mg/kg mercury (wet weight) be used as a guideline for the protection of piscivorous birds (e.g., the common merganser, *Mergus merganser*), and recommended that 1.1 mg/kg mercury serve as a guidance level for the intake of fish by piscivorous mammals (e.g., the river otter, *Lutra canadensis*).

In the first three rounds of biomonitoring (October 1992, January 1993, and April 1993), the concentrations of mercury present in fish samples from Site 8 and the two control sites were almost always below these suggested guidance levels, indicating that piscivorous birds and mammals that feed in these areas are not at risk (Halliburton NUS, 1993b; Halliburton NUS, 1993d). Prior to July, only one sample (*Gambusia* in January 1993) exceeded the 0.1 mg Hg/kg guidance level. Unfortunately, because attempts to capture *Gambusia* were unsuccessful at both control sites in January, it was impossible to determine whether this slight increase in mercury body burden in Site 8 *Gambusia* was significant, whether it was a function of habitat preference (using areas with higher concentrations of mercury in sediments or emerging insects) or some other confounding factor. No *Gambusia* were collected in April or July 1993. Table 3-5 shows trends in mercury concentration of fish since October 1992.

In July 1993, however, two samples (warmouth from Site 8 and redfin pickerel from the beaver pond control site) showed mercury levels higher than 0.2 mg/kg. These slightly-elevated mercury concentrations are not surprising, given the food habits of these species. Warmouth have a more piscivorous diet than most

TABLE 3-5

TRENDS IN MERCURY CONCENTRATIONS, SITE 8 AND CONTROL SITES
OCTOBER 1992 - JULY 1993
INDIAN HEAD DIVISION, NAVAL SURFACE WARFARE CENTER
INDIAN HEAD, MARYLAND

Location	Organism	Mercury Concentrations (mg Hg/kg)			
		October 1992	January 1993	April 1993	July 1993
Site 8 Pond	*Gambusia* (Mosquitofish)	0.06	0.15	--	--
	Creek chubsucker	--	0.03	--	--
	Bluegill	0.02	0.02	0.06	0.09
	Brown bullhead	0.04	--	--	0.05
	Warmouth	--	--	--	0.23
	Crayfish	--	--	--	0.07
	Frog	--	--	0.03	--
Beaver Pond (Control Site 1)	Eastern mudminnow	--	--	0.07	--
	Creek chubsucker	--	0.03	--	0.09
	Redfin pickerel	--	--	--	0.21
Mattawoman Creek (Control Site 2)	*Notropis* (Shiner) family	--	--	0.04	--
	White perch	--	--	0.02	--

Lepomids (or "sunfish"), which is generally attributed to the species' large, bass-like mouth (Carlander, 1977). Redfin pickerel are also carnivores--eating insects, crayfish, and fish--but are increasingly piscivorous as they attain larger sizes (Carlander, 1969; Lee et al., 1980). Piscivorous species such as the warmouth and redfin pickerel that feed high in the food chain tend to bioaccumulate mercury (Sorensen, 1991).

It should be pointed out that both samples with mercury concentrations higher than previously observed consisted of a single fish. The pitfalls of drawing inferences from a single observations are obvious. Mercury is notorious for accumulating in fish muscle and viscera at radically different rates, even within a population. This variability in rate of mercury accumulation has been attributed to genetic differences between fish, differences in sex and maturity, size-related differences, and the presence or absence of pesticides, organic wastes, and other chemical agents (Sorensen, 1991). Moreover, the fact that one sample with an elevated mercury level was from Site 8 and the other was from the uncontaminated Stump Neck control site suggests that these slightly elevated concentrations are caused by the tendency of carnivorous fish species to bioaccumulate mercury (whether the source be industrial, atmospheric, or geologic) rather than the presence of high levels of mercury in the water, sediment, and biota of either pond.

In the absence of more complete data (i.e., more fish samples from Site 8 and both control sites), it is difficult to draw any conclusions from the fish toxicology studies. Halliburton NUS will continue to employ a variety of conventional (e.g., nets, traps, and electrofishing equipment) and unconventional (e.g., trotlines) fish collecting techniques and step up the sampling intensity (to the extent practicable) in an effort to produce more data from representative and important fish species.

Supplemental samples of frogs collected in April 1993 and crayfish collected in July 1993 contained 0.03 and 0.07 mg Hg/kg, respectively. As noted previously, Eisler (1987) suggests that for the protection of sensitive species of birds and mammals that "regularly consume fish and other aquatic organisms," that total mercury concentrations in the prey items should not exceed 0.1 mg/kg wet weight for birds and 1.1 mg/kg for mammals. Thus the mercury concentrations measured in crayfish and frogs are not indicative of a serious mercury contamination problem lower in the food chain.

4.0 CONCLUSIONS AND RECOMMENDATIONS

4.1 CONCLUSIONS

Phase I findings suggested that the Site 8 marsh/pond system has a relatively simple community structure, and data from April and July 1993, the first two rounds of Phase II, support this assertion. The periphyton community was dominated by diatoms and green algae in October 1992 and July 1993, and by diatoms in January and April 1993. Periphyton, which are short-lived and very prolific, often show these kinds of pronounced seasonal shifts in community structure. The Site 8 benthic macroinvertebrate community is composed largely of herbivores that feed on attached algae and detritivores (such as oligochaetes) that feed on organic detritus. The two most abundant fish species (*Fundulus heteroclitus* and *Gambusia* sp.) in 1992 collections from the Site 8 pond are omnivores that feed on plant matter, larval and adult insects, and small fish. In 1993, no fish species have been abundant, but bluegill and brown bullhead have been collected on several occasions. Fish species diversity and abundance are low at Site 8. Concentrations of mercury in fish tissue from Site 8 over the course of this investigation have revealed no clear differences between species or areas. Mercury levels in fish samples collected in the first three quarters of biomonitoring were below those suggested as a guideline for protection of sensitive piscivorous birds (0.1 mg/kg) and piscivorous mammals (1.1 mg/kg) in all cases but one, a *Gambusia* sample from the Site 8 pond in January 1993. In July 1993, a warmouth from the Site 8 pond and a redfin pickerel from the beaver pond control site contained 0.23 and 0.21 mg/kg of mercury, respectively. All indications are that birds and mammals that feed on Site 8 fish and invertebrates are not at risk, however.

None of these data should be regarded as conclusive, as they are based on small sample sizes. Future biomonitoring will reveal more about community structure and will yield more definitive information about levels of mercury in Site 8 biota.

4.2 RECOMMENDATIONS

Despite a number of practical and logistical problems caused by low water levels, Phase I biomonitoring was useful in that it provided data to establish baseline conditions at the study site. Based on the results of the Phase I biomonitoring, a number of refinements were implemented. These refinements included: (1) reducing the number of replicate benthos samples taken at the study site, (2) re-evaluating fish sampling

methods employed, (3) omitting quantitative studies of fish abundance (catch-per-unit-effort) and diversity, and (4) adding an additional control site (Mattawoman Creek) in hopes of collecting more fish for analysis of mercury levels in tissues.

Numerous researchers have commented on the tendency of benthic macroinvertebrates to be patchily, rather than uniformly distributed (Cummins, 1975; Wetzel, 1975). Given this patchiness and the large number of samples that would be required to discern statistically significant differences between sampling events (based on the variability observed in Phase I), the number of benthos samples collected quarterly has been reduced, and data have been assessed qualitatively rather than statistically (as originally planned).

As noted earlier, fish population surveys were abandoned during Phase I. The fish community of Site 8 in July and October 1992 was dominated by two species, *Gambusia* sp. and *Fundulus heteroclitus*, both of which are small, schooling species. As a result, fish sampling may produce several hundred fish in a very short time (if a large school is encountered) or no fish over a longer time period. Moreover, factors totally unrelated to NSWC operations, such as rainfall, may well determine electrofishing success. For these reasons Halliburton NUS (1993b) recommended that fish be collected for mercury analyses only during Phase II, and that additional effort go into collecting adequate numbers of fish from the three targeted groups (i.e., large-mouth bass, brown bullhead, and *Gambusia*). Based on two Phase I and two Phase II fish collections, it will often be necessary to use substitute test species (e.g., bluegill for large-mouth bass, *Fundulus* for *Gambusia*).

Halliburton NUS recommended in a previous Biomonitoring Report (Halliburton NUS, 1993d) that taxa such as Trichoptera and Unionidae be classified at least to the genus level (species level when practicable), and that certain other genera (e.g., the mayfly *Ephemerella*) be identified to species. More specific recommendations regarding the appropriate level of macroinvertebrate identification were part of the revised Biomonitoring Plan (Halliburton NUS, 1993c). These new standards were employed in identifying benthic macroinvertebrates collected in July, and will be used in future biomonitoring. This should provide more information about the true diversity of the systems and, more importantly, allow a more detailed examination of pollution-tolerant and pollution-intolerant genera and species. As is, it is difficult to draw any conclusions about the relative pollution tolerance of the groups that are represented. Identification to the species level is essential for evaluations of the pollution sensitivity of many benthic organisms.

For the second consecutive sampling period, benthic macroinvertebrate abundance and diversity were very low. Since the unconsolidated mud and silt bottom of the Site 8 pond provides poor attachment sites (or habitat) for benthic macroinvertebrates, artificial substrate samplers (of the Hester-Dendy type) will be

employed in the future to complement the grab sampling device (petite ponar) used in the first four quarters of biomonitoring. The APHA (1985) notes that artificial substrate samplers are useful because they minimize the effect of physical variables (such as substrate type) and are particularly effective collectors of larval aquatic insects and crustaceans, groups that may have been underrepresented in Site 8 samples.

Halliburton NUS and subcontractor Coastal Environmental Services will utilize a combination of passive and active fish collection methods including minnow traps, trap or fyke nets, gill nets, electrofishing and seining to collect fish at the study and two control sites. The sampling objective is to collect more fish representing the target species (or acceptable surrogates), thus producing more meaningful and accurate measurements of mercury levels.

The water level in the Site 8 pond was low during Phase I biomonitoring. In spite of the logistical problems that this caused, solid baseline information was obtained and a number of sampling refinements were made. Normal water levels were present in April 1993 and July 1993. The entire pond can now be sampled effectively, and it is hoped that over time a more complete picture of the pond ecosystem and its plant and animal communities will emerge.

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APPENDIX A

PERIPHYTON SAMPLING RESULTS, JULY 1993

TABLE A-1

TRANSECT 1W
PERIPHYTON SAMPLING RESULTS
SITE 8 - NITROGLYCERIN PLANT OFFICE
INDIAN HEAD DIVISION, NAVAL SURFACE WARFARE CENTER
INDIAN HEAD, MARYLAND

July 1993

Taxon	Density (cells/cm^2)	Relative Abundance (%)	Weight (mg/m^2)	Relative Weight (%)
BACILLARIOPHYTA				
Cymbella	37		0.15	
Cyclotella	100		0.04	
Gomphonema	37		0.05	
Melosira	62		0.09	
Navicula	62		0.10	
Synedra	12		0.06	
Other diatoms	12		0.01	
CHLOROPHYTA				
Bulbochaete	37		0.69	
Cosmarium	12		0.59	
PYRROPHYTA				
Peridinium	12		0.06	
EUGLENOPHYTA				
Phacus	12		0.16	
TOTALS	395		2.00	
BACILLARIOPHYTA	322	81.5	0.50	25.0
CHLOROPHYTA	49	12.4	1.28	64.0
PYRROPHYTA	12	3.0	0.06	3.0
EUGLENOPHYTA	12	3.0	0.16	8.0

TABLE A-2

TRANSECT 1C
PERIPHYTON SAMPLING RESULTS
SITE 8 - NITROGLYCERIN PLANT OFFICE
INDIAN HEAD DIVISION, NAVAL SURFACE WARFARE CENTER
INDIAN HEAD, MARYLAND

July 1993

Taxon	Density (cells/cm^2)	Relative Abundance (%)	Weight (mg/m^2)	Relative Weight (%)
BACILLARIOPHYTA				
Cyclotella	62		0.03	
Cymbella	25		0.10	
Melosira	37		0.05	
Navicula	249		0.42	
Pinnularia	25		0.39	
Stephanodiscus	12		0.10	
Surirella	12		<0.01	
Synedra	12		0.06	
Other diatoms	50		0.03	
CHLOROPHYTA				
Ulothrix	50		0.29	
PYRROPHYTA				
Peridinium	12		0.06	
EUGLENOPHYTA				
Trachelomonas	12		0.16	
TOTALS	558		1.69	
BACILLARIOPHYTA	484	86.7	1.18	69.8
CHLOROPHYTA	50	9.0	0.29	17.2
PYRROPHYTA	12	2.2	0.06	3.6
EUGLENOPHYTA	12	2.2	0.16	9.5

TABLE A-3

TRANSECT 1E
PERIPHYTON SAMPLING RESULTS
SITE 8 - NITROGLYCERIN PLANT OFFICE
INDIAN HEAD DIVISION, NAVAL SURFACE WARFARE CENTER
INDIAN HEAD, MARYLAND

July 1993

Taxon	Density (cells/cm^2)	Relative Abundance (%)	Weight (mg/m^2)	Relative Weight (%)
BACILLARIOPHYTA				
Cymbella	15		0.06	
Cyclotella	20		0.01	
Gyrosigma	5		0.02	
Melosira	5		0.01	
Navicula	115		0.19	
Synedra	5		0.02	
CHLOROPHYTA				
Cosmarium	5		0.24	
Scenedesmus	5		0.03	
Ulothrix	115		0.67	
TOTALS	290		1.25	
BACILLARIOPHYTA	165	56.9	0.31	24.8
CHLOROPHYTA	125	43.1	0.94	75.2

TABLE A-4

TRANSECT 2W
PERIPHYTON SAMPLING RESULTS
SITE 8 - NITROGLYCERIN PLANT OFFICE
INDIAN HEAD DIVISION, NAVAL SURFACE WARFARE CENTER
INDIAN HEAD, MARYLAND

July 1993

Taxon	Density (cells/cm²)	Relative Abundance (%)	Weight (mg/m²)	Relative Weight (%)
BACILLARIOPHYTA				
Cymbella	5		0.02	
Cyclotella	30		0.01	
Melosira	5		0.01	
Navicula	95		0.16	
Surirella	5		<0.01	
Other diatoms	10		0.01	
CHLOROPHYTA				
Mougeotia	25		0.46	
Scenedesmus	5		0.03	
Schroederia	5		<0.01	
Spirogyra	10		0.18	
CRYPTOPHYTA				
Rhodomonas	10		0.01	
CYANOPHYTA				
Stichosiphon	30		0.01	
EUGLENOPHYTA				
Phacus	5		0.06	
TOTALS	240		0.96	
BACILLARIOPHYTA	150	62.5	0.21	21.9
CHLOROPHYTA	45	18.8	0.67	69.8
CRYTOPHYTA	10	4.2	0.01	1.0
CYANOPHYTA	30	12.5	0.01	1.0
EUGLENOPHYTA	5	2.0	0.06	6.3

TABLE A-5

TRANSECT 2C
PERIPHYTON SAMPLING RESULTS
SITE 8 - NITROGLYCERIN PLANT OFFICE
INDIAN HEAD DIVISION, NAVAL SURFACE WARFARE CENTER
INDIAN HEAD, MARYLAND

July 1993

Taxon	Density (cells/cm^2)	Relative Abundance (%)	Weight (mg/m^2)	Relative Weight (%)
BACILLARIOPHYTA				
Cymbella	91		0.38	
Cyclotella	68		0.03	
Frustulia	11		<0.01	
Gomphonema	11		0.01	
Melosira	11		0.02	
Navicula	148		0.25	
Nitzschia	11		0.02	
Surirella	11		<0.01	
Synedra	34		0.16	
Other diatoms	23		0.01	
CHLOROPHYTA				
Chlamydomonas	11		<0.01	
Scenedesmus	11		0.08	
EUGLENOPHYTA				
Trachelmonas	11		0.15	
TOTALS	452		1.11	
BACILLARIOPHYTA	419	92.7	0.88	79.3
CHLOROPHYTA	22	4.9	0.08	7.2
EUGLENOPHYTA	11	2.4	0.15	13.5

TABLE A-6

TRANSECT 2E
PERIPHYTON SAMPLING RESULTS
SITE 8 - NITROGLYCERIN PLANT OFFICE
INDIAN HEAD DIVISION, NAVAL SURFACE WARFARE CENTER
INDIAN HEAD, MARYLAND

July 1993

Taxon	Density (cells/cm^2)	Relative Abundance (%)	Weight (mg/m^2)	Relative Weight (%)
BACILLARIOPHYTA				
Cymbella	10		0.04	
Cyclotella	75		0.03	
Frustulia	5		<0.01	
Navicula	55		0.09	
Pinnularia	10		0.16	
Surirella	5		<0.01	
Synedra	5		0.02	
Other diatoms	5		<0.01	
TOTALS	170		0.34	
BACILLARIOPHYTA	170	100.0	0.34	100.0

TABLE A-7

TRANSECT 3W
PERIPHYTON SAMPLING RESULTS
SITE 8 - NITROGLYCERIN PLANT OFFICE
INDIAN HEAD DIVISION, NAVAL SURFACE WARFARE CENTER
INDIAN HEAD, MARYLAND

July 1993

Taxon	Density (cells/cm^2)	Relative Abundance (%)	Weight (mg/m^2)	Relative Weight (%)
BACILLARIOPHYTA				
Cymbella	15		0.06	
Cyclotella	45		0.02	
Melosira	15		0.02	
Navicula	120		0.20	
Pinnularia	30		0.47	
Surirella	15		<0.01	
Synedra	30		0.14	
TOTALS	270		0.91	
BACILLARIOPHYTA	270	100.0	0.91	100.0

TABLE A-8

TRANSECT 3C
PERIPHYTON SAMPLING RESULTS
SITE 8 - NITROGLYCERIN PLANT OFFICE
INDIAN HEAD DIVISION, NAVAL SURFACE WARFARE CENTER
INDIAN HEAD, MARYLAND

July 1993

Taxon	Density (cells/cm²)	Relative Abundance (%)	Weight (mg/m²)	Relative Weight (%)
BACILLARIOPHYTA				
Cymbella	16		0.07	
Cyclotella	32		0.01	
Frustulia	11		<0.01	
Navicula	70		0.12	
Surirella	11		<0.01	
Synedra	5		0.03	
CHLOROPHYTA				
Chlorella	5		<0.01	
CYANOPHYTA				
Stichosiphon	16		<0.01	
PYRROPHYTA				
Peridinium	5		0.03	
EUGLENOPHYTA				
Trachelmonas	5		0.07	
TOTALS	176		0.33	
BACILLARIOPHYTA	145	82.4	0.23	69.7
CHLOROPHYTA	5	2.8	<0.01	0
CYANOPHYTA	16	9.1	<0.01	0
PYRROPHYTA	5	2.8	0.03	9.1
EUGLENOPHYTA	5	2.8	0.07	21.2

TABLE A-9

TRANSECT 3E
PERIPHYTON SAMPLING RESULTS
SITE 8 - NITROGLYCERIN PLANT OFFICE
INDIAN HEAD DIVISION, NAVAL SURFACE WARFARE CENTER
INDIAN HEAD, MARYLAND

July 1993

Taxon	Density (cells/cm^2)	Relative Abundance (%)	Weight (mg/m^2)	Relative Weight (%)
BACILLARIOPHYTA				
Cymbella	10		0.04	
Cyclotella	20		0.01	
Gyrosigma	5		0.02	
Navicula	55		0.09	
Pinnularia	5		0.08	
Surirella	10		<0.01	
Synedra	5		0.02	
Other Diatoms	15		0.01	
CHLOROPHYTA				
Chlorella	5		<0.01	
CRYPTOPHYTA				
Rhodomonas	5		0.01	
PYRROPHYTA				
Peridinium	5		0.03	
TOTALS	140		0.31	
BACILLARIOPHYTA	125	89.3	0.27	87.1
CHLOROPHYTA	5	3.6	<0.01	0
CRYPTOPHYTA	5	3.6	0.01	3.2
PYRROPHYTA	5	3.6	0.03	9.7

TABLE A-10

TRANSECT 4W
PERIPHYTON SAMPLING RESULTS
SITE 8 - NITROGLYCERIN PLANT OFFICE
INDIAN HEAD DIVISION, NAVAL SURFACE WARFARE CENTER
INDIAN HEAD, MARYLAND

July 1993

Taxon	Density (cells/cm²)	Relative Abundance (%)	Weight (mg/m²)	Relative Weight (%)
BACILLARIOPHYTA				
Cyclotella	31		0.01	
Gomphonema	21		0.03	
Melosira	10		0.01	
Navicula	165		0.28	
Surirella	21		0.01	
Synedra	21		0.10	
Other diatoms	134		0.08	
CHLOROPHYTA				
Chlamydomonas	10		<0.01	
Scenedesmus	21		0.14	
Ulothrix	82		0.48	
EUGLENOPHYTA				
Trachelmonas	10		0.13	
TOTALS	526		1.27	
BACILLARIOPHYTA	403	76.6	0.52	40.9
CHLOROPHYTA	113	21.5	0.62	48.8
EUGLENOPHYTA	10	1.9	0.13	10.2

TABLE A-11

TRANSECT 4C
PERIPHYTON SAMPLING RESULTS
SITE 8 - NITROGLYCERIN PLANT OFFICE
INDIAN HEAD DIVISION, NAVAL SURFACE WARFARE CENTER
INDIAN HEAD, MARYLAND

July 1993

Taxon	Density (cells/cm^2)	Relative Abundance (%)	Weight (mg/m^2)	Relative Weight (%)
BACILLARIOPHYTA				
Cymbella	15		0.06	
Cyclotella	120		0.05	
Gyrosigma	30		0.10	
Melosira	15		0.02	
Navicula	135		0.23	
Surirella	45		0.01	
Other diatoms	90		0.05	
CHLOROPHYTA				
Ulothrix	194		1.13	
CRYPTOPHYTA				
Rhodomonas	30		0.04	
TOTALS	674		1.69	
BACILLARIOPHYTA	450	66.8	0.52	30.8
CHLOROPHYTA	194	28.8	1.13	66.9
CRYPTOPHYTA	30	4.5	0.04	2.4

TABLE A-12

TRANSECT 4E
PERIPHYTON SAMPLING RESULTS
SITE 8 - NITROGLYCERIN PLANT OFFICE
INDIAN HEAD DIVISION, NAVAL SURFACE WARFARE CENTER
INDIAN HEAD, MARYLAND

July 1993

Taxon	Density (cells/cm²)	Relative Abundance (%)	Weight (mg/m²)	Relative Weight (%)
BACILLARIOPHYTA				
Cyclotella	112		0.05	
Cymbella	37		0.16	
Frustulia	12		<0.01	
Gomphonema	12		0.02	
Navicula	75		0.13	
Pinnularia	12		0.20	
Synedra	62		0.30	
Other diatoms	125		0.08	
CHLOROPHYTA				
Chlamydomonas	12		<0.01	
Scenedesmus	12		0.08	
Spirogyra	50		0.93	
Ulothrix	62		0.36	
PYRROPHYTA				
Peridinium	12		0.06	
EUGLENOPHYTA				
Trachelmonas	12		0.16	
TOTALS	607		2.53	
BACILLARIOPHYTA	447	73.6	0.94	37.2
CHLOROPHYTA	136	22.4	1.37	54.2
PYRROPHYTA	12	2.0	0.06	2.4
EUGLENOPHYTA	12	2.0	0.16	6.3

TABLE A-13

CONTROL SITE 1
TRANSECT BEAVER POND W
PERIPHYTON SAMPLING RESULTS
SITE 8 - NITROGLYCERIN PLANT OFFICE
INDIAN HEAD DIVISION, NAVAL SURFACE WARFARE CENTER
INDIAN HEAD, MARYLAND

July 1993

Taxon	Density (cells/cm²)	Relative Abundance (%)	Weight (mg/m²)	Relative Weight (%)
BACILLARIOPHYTA				
Cyclotella	36		0.02	
Gomphonema	71		0.09	
Navicula	516		0.87	
Pinnularia	18		0.28	
Synedra	142		0.69	
Other diatoms	605		0.37	
CHLOROPHYTA				
Chlamydomonas	18		0.01	
Mougeotia	89		1.65	
Scenedesmus	18		0.12	
Ulothrix	374		2.18	
Spirogyra	89		1.65	
PYRROPHYYTA				
Peridinium	36		0.18	
TOTALS	2012		8.11	
BACILLARIOPHYTA	1388	69.0	2.32	28.6
CHLOROPHYTA	588	29.2	5.61	69.2
PYRROPHYTA	36	1.8	0.18	2.2

TABLE A-14

CONTROL SITE 1
TRANSECT BEAVER POND C
PERIPHYTON SAMPLING RESULTS
SITE 8 - NITROGLYCERIN PLANT OFFICE
INDIAN HEAD DIVISION, NAVAL SURFACE WARFARE CENTER
INDIAN HEAD, MARYLAND

July 1993

Taxon	Density (cells/cm²)	Relative Abundance (%)	Weight (mg/m²)	Relative Weight (%)
BACILLARIOPHYTA				
Gomphonema	18		0.02	
Navicula	251		0.42	
Stephanodiscus	6		0.05	
Synedra	72		0.35	
CHLOROPHYTA				
Chlorella	30		0.01	
Mougeotia	30		0.55	
Oocystis	90		0.03	
Ulothrix	119		0.70	
CYANOPHYTA				
Stichosiphon	107		0.02	
PYRROPHYTA				
Peridinium	12		0.06	
TOTALS	735		2.21	
BACILLARIOPHYTA	347	47.2	0.84	38.0
CHLOROPHYTA	269	36.6	1.29	58.4
CYANOPHYTA	107	14.6	0.02	0.9
PYRROPHYTA	12	1.6	0.06	2.7

TABLE A-15

CONTROL SITE 1
TRANSECT BEAVER POND E
PERIPHYTON SAMPLING RESULTS
SITE 8 - NITROGLYCERIN PLANT OFFICE
INDIAN HEAD DIVISION, NAVAL SURFACE WARFARE CENTER
INDIAN HEAD, MARYLAND

July 1993

Taxon	Density (cells/cm²)	Relative Abundance (%)	Weight (mg/m²)	Relative Weight (%)
BACILLARIOPHYTA				
Cymbella	25		0.10	
Frustulia	12		<0.01	
Gomphonema	12		0.02	
Navicula	125		0.21	
Synedra	37		0.18	
Other diatoms	37		0.02	
CHLOROPHYTA				
Mougeotia	12		0.23	
PYRROPHYTA				
Peridinium	25		0.13	
TOTALS	285		0.89	
BACILLARIOPHYTA	248	87.0	0.53	59.6
CHLOROPHYTA	12	4.2	0.23	25.8
PYRROPHYTA	25	8.8	0.13	14.6

TABLE A-16

CONTROL SITE 2
TRANSECT MATTAWOMAN CREEK W
PERIPHYTON SAMPLING RESULTS
SITE 8 - NITROGLYCERIN PLANT OFFICE
INDIAN HEAD DIVISION, NAVAL SURFACE WARFARE CENTER
INDIAN HEAD, MARYLAND

July 1993

Taxon	Density (cells/cm²)	Relative Abundance (%)	Weight (mg/m²)	Relative Weight (%)
BACILLARIOPHYTA				
Cymbella	5		0.02	
Cyclotella	25		0.01	
Melosira	5		0.01	
Navicula	60		0.10	
Synedra	5		0.02	
Other diatoms	15		0.01	
CHLOROPHYTA				
Cosmarium	5		0.24	
Ulothrix	194		1.13	
CYANOPHYTA				
Stichosiphon	20		<0.01	
TOTALS	334		1.54	
BACILLARIOPHYTA	115	34.4	0.17	11.0
CHLOROPHYTA	199	59.6	1.37	89.0
CYANOPHYTA	20	6.0	<0.01	0

TABLE A-17

CONTROL SITE 2
TRANSECT MATTAWOMAN CREEK C
PERIPHYTON SAMPLING RESULTS
SITE 8 - NITROGLYCERIN PLANT OFFICE
INDIAN HEAD DIVISION, NAVAL SURFACE WARFARE CENTER
INDIAN HEAD, MARYLAND

July 1993

Taxon	Density (cells/cm²)	Relative Abundance (%)	Weight (mg/m²)	Relative Weight (%)
BACILLARIOPHYTA				
Cymbella	5		0.02	
Frustulia	5		<0.01	
Navicula	50		0.08	
Pinnularia	5		0.08	
Surirella	10		<0.01	
Synedra	15		0.07	
CHLOROPHYTA				
Bulbochaete	5		0.09	
Ulothrix	30		0.17	
CYANOPHYTA				
Synechococcus	15		<0.01	
PYRROPHYTA				
Peridinium	5		0.03	
TOTALS	145		0.54	
BACILLARIOPHYTA	90	62.1	0.25	46.3
CHLOROPHYTA	35	24.1	0.26	48.1
CYANOPHYTA	15	10.3	<0.01	0
PYRROPHYTA	5	3.4	0.03	5.6

TABLE A-18

CONTROL SITE 2
TRANSECT MATTAWOMAN CREEK
PERIPHYTON SAMPLING RESULTS
SITE 8 - NITROGLYCERIN PLANT OFFICE
INDIAN HEAD DIVISION, NAVAL SURFACE WARFARE CENTER
INDIAN HEAD, MARYLAND

July 1993

Taxon	Density (cells/cm²)	Relative Abundance (%)	Weight (mg/m²)	Relative Weight (%)
BACILLARIOPHYTA				
Cymbella	25		0.10	
Cyclotella	75		0.03	
Melosira	25		0.04	
Navicula	37		0.06	
Synedra	25		0.12	
Other diatoms	25		0.02	
CHLOROPHYTA				
Ulothrix	100		0.58	
EUGLENOPHYTA				
Phacus	12		0.16	
TOTALS	324		1.11	
BACILLARIOPHYTA	212	65.4	0.37	33.3
CHLOROPHYTA	100	30.9	0.58	52.3
EUGLENOPHYTA	12	3.7	0.16	14.4