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May 13, 1991
89C2634-9

Ms. Leslie Warner
E.I. du Pont de Nemours & Company Inc.
26th Street and Buffalo Avenue
Niagara Falls, New York 14302

Mr. James C. Brown
Olin Corporation
Lower River Road
Charleston, Tennessee 37310

Re: Evaluation of Gill Creek Sediments
on Aquatic Life

Dear Ms. Warner and Mr. Brown:

Woodward-Clyde Consultants is pleased to present this Evaluation of Gill Creek Sediments on Aquatic Life. This evaluation was prepared based on comments received from and discussions with Mr. David Mayak, Ph.D. of the New York State Division of Fish and Wildlife. This document is supplemental to the Risk Assessment for Remedial Options, Gill Creek Sediment Project (WCC, 1990).

Please contact us with any comments you may have.

Very truly yours,

George W Crowse
For Susan L. Mearns, Ph.D.
Assistant Project Scientist

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Lynn Rubisch Penniman, CPSS
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SLM/LRP/vbg/GC2

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EVALUATION OF GILL CREEK SEDIMENTS ON AQUATIC LIFE

Prepared for:

E.I. du Pont de Nemours & Company, Inc.
Niagara Falls, New York 14302

and

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Project No. 89C2634-9

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1.0
INTRODUCTION

Gill Creek is a small urban channelized stream which traverses chemical manufacturing plants owned by E.I. du Pont de Nemours and Company, Inc. (Du Pont) and Olin Corporation (Olin). Sediments in the section of Gill Creek bordering the two properties were remediated (in separate projects) by the companies in 1981.

In 1988 through 1990, additional investigations were undertaken by the companies to investigate sediment contamination downstream of the properties (within the confluence of Gill Creek and the Niagara River) and residual contamination from depositional sediments within the creek bordering the properties. These investigations have culminated in the Gill Creek Sediment Study (WCC, 1989), and the Risk Assessment for Remedial Options (WCC, 1990). The Risk Assessment recommended that two areas of the creek be targeted for remedial action. The largest of these areas is the area between the plant properties and the confluence with the Niagara River (referred to as Area 1). The second area (referred to as Area 3) is located between the two plant properties in a narrow strip near the Adams Avenue Bridge. Results of the Risk Assessment indicated that residual concentrations in the sediments located in the area of Gill Creek extending from Staub Road upstream to Buffalo Avenue (referred to as Area 2) and in the Niagara River downstream of Gill Creek (referred to as Area 4) do not appear to pose a threat to human health and the environment.

This document is supplemental to the Risk Assessment. It describes the environmental basis for WCC's recommendation concerning areas requiring remediation. Section 2.0 presents the project history (including previous remediation programs) and summarizes the results of investigations performed previously. Section 3.0 describes ecological conditions in Gill Creek and relates available biological and ecological information to the actual physical and chemical conditions within Gill Creek. It is focused on the previously remediated area (referred to as Area 2), since this area is not proposed for further remediation. Conclusions regarding the effects of the depositional sediments within Area 2 on aquatic life are included in Section 4.0. References are included in Section 5.0.

2.0
PROJECT DESCRIPTION AND HISTORY

This section presents background information concerning the Gill Creek Sediment Project and summarizes the data obtained from previous studies.

2.1 ENVIRONMENTAL SETTING

Gill Creek rises in a marshy area in the Town of Lewiston and flows south, approximately 7.5 miles to its confluence with the Niagara River. The Gill Creek watershed is approximately 14 square miles. Approximately 2 miles north of the confluence, Gill Creek is dammed to form Hyde Park Lake, which covers approximately 32 acres. North of Buffalo Avenue and below Hyde Park Lake, Gill Creek is typically 0.5 to 1.5 feet deep. The slope in this area is nearly flat at 0.0003 (i.e., 1,7 feet per mile). South of Buffalo Avenue, the creek traverses the Olin and Du Pont plants, flows beneath the Robert Moses Parkway (RMP) bridge and joins the Niagara River. Downstream of the Hyde Park Dam, flow in the creek is channelized.

Flow rates in Gill Creek are not regularly monitored. Therefore, sufficient data are not available for calculating a precise average flow rate. Based on WCC's measurements, a flow rate of approximately 2 cubic feet per second (cfs) appears to be representative of an average flow rate between the shorter term impacts of precipitation events. Since the mid-1960's, flow into Gill Creek has been augmented by the New York State Power Authority (NYPA) for recreational and aesthetic purposes associated with the impounded lake at Hyde Park.

Downstream of Adams Avenue, the Gill Creek flow is greatly augmented by non-contact cooling water discharges from Du Pont and Niachlor. The Niachlor outfall is located on the east bank of the creek, approximately 150 feet south of Adams Avenue. Non-contact cooling water discharges from the Niachlor Outfall at a rate of approximately 50 cfs. An additional 1 cfs of non-contact cooling water discharges at Du Pont outfall 006, located at the Du Pont Road crossing on the west bank of the creek. Flow velocities in Gill Creek are strongly influenced by the stage of the Niagara River.

The Niagara River Stage fluctuates approximately 1.5 feet over approximately a 24-hour period. These 1.5 foot "tides" are caused by the water diversion structures. To facilitate the hydroelectric diversion, NYPA partially obstructs the Niagara River by closing a gated structure (downstream of the Gill Creek confluence) each night and during the winter. This causes water levels to rise (when the diversion rate is high) through the night and fall during the day, and to remain relatively high during the winter.

As the Niagara River reaches its peak stage, flow in Gill Creek may temporarily reverse. During WCC's recent study, this reversal occurred for a maximum of one hour.

North of the Hyde Park dam, land use bordering Gill Creek is primarily designated as outdoor recreation, commercial and residential. Between the Hyde Park dam and Buffalo Avenue, the immediate vicinity of the stream banks are designated as outdoor recreation, bordered by industrial and residential users. South of Buffalo Avenue, Gill Creek traverses the Olin and Du Pont plants, where access is restricted.

2.2 1981 REMEDIATION PROJECTS

Shortly after the discovery of contaminated sediment in Gill Creek, Olin and Du Pont began implementing separate remediation programs. Data collected during this time frame are as follows:

1. September 1978 - Gill Creek sediment and water analysis (Du Pont)
2. November 1978 - Gill Creek sediment analysis for Du Pont (Recra Research)
3. June 1979 - Gill Creek sediment analysis for Du Pont (Recra Research)
4. 1981 - Sediment and water analyses during Du Pont creek remediation (Recra Research)
5. 1981 - Sediment analysis during Olin creek remediation

In the section of Gill Creek bordering Olin property, Olin excavated sediment to bedrock, and backfilled the area with compacted crushed stone. In the section of the creek bordering Du Pont property, Du Pont excavated sediment to a PCB clean-up level established at 50 ppm or less or to bedrock (whichever was encountered first). Du Pont replaced the excavation with compacted clay.

2.3 POST-REMEDIATION INVESTIGATIONS

A substantial amount of environmental data have been collected at Gill Creek since the late 1970s. The data base is comprised of sediment and water analytical data, EP toxicity data, biomonitoring studies, sediment thickness data and benthic sampling and analysis. The individual investigations are listed below:

1. 1983 - Ministry of the Environment (MOE) biomonitoring data

2. October 1984 - Report of the Niagara River Toxics Committee, containing 1982 MOE biomonitoring data

3. November 1984 - Gill Creek bulk sediment and EP Toxicity analysis (City of Niagara Falls, ETC)

4. December 1984 - Gill Creek benthic sampling and analysis for Niachlor (Great Lakes Laboratories)

5. December 1987 - "Niagara River Area Sediments", sediment analysis and biomonitoring studies from NYSDEC sampling programs conducted in June and November 1986 and February 1987

6. March 1988 - Gill Creek bulk sediment and EP Toxicity analysis (City of Niagara Falls, Ecology and Environment)

7. April 1989 - Gill Creek Sediment Study (WCC)

8. August 1990 - Supplemental Field Investigation (WCC)

9. October 1990 - Additional Sediment Sampling at Adams Avenue (WCC)

10. October 1990 - Gill Creek discharge measurements and modeling (WCC)

Pertinent results from these studies are briefly summarized below. A more detailed summary is included in the Gill Creek Risk Assessment for Remedial Options.

2.3.1 Analytical Results from Sediment Sampling

In June and November 1986, as part of the NYSDEC Niagara River Implementation Sediment Studies, sediment samples were taken from the mouth of Gill Creek as well as nine other locations along the Niagara River. During the two-stage sampling program, four sediment core samples and two grab samaples were obtained from the Gill Creek mouth area. The cores were sectioned into one-inch intervals for analysis.

The main analytical program consisted of total volatile solids, priority pollutant metals, pesticide/PCBs (EPA method 8080), and chlorinated hydrocarbons (EPA Method 8120). Selected samples were also analyzed for polychlorinated dibenzofurans and dibenzo-p-dioxins (EPA method 8280). Analytical results from the sediment samples collected from the mouth of Gill Creek (the portion of Gill Creek receiving back wash from the Niagara River) indicated elevated levels of PCB-1248. Hexachlorobutadiene and mercury were also quantified at elevated levels.

These data suggested that sediments present near the confluence of Gill Creek and the Niagara River, downstream of the previously remediated area, were contaminated. This prompted Du Pont and Olin to conduct an extensive sediment sampling program. The results of the primary program are presented in the Gill Creek Sediment Study (WCC, 1989).

2.4 AQUATIC ORGANISMS INHABITING AREA 2 OF GILL CREEK

The benthic organisms identified as inhabiting Area 2 in Gill Creek live on or in (to an approximate depth of 2 meters) the sediments. These organisms include roundworms, aquatic earthworms, leaches, snails, crayfish, microscopic water fleas, freshwater shrimp and larval forms of aquatic insects. The benthic organisms collected in 1984 are representative of a diverse benthic community. The numbers of individuals within each taxonomic group were low. Examining the substrate composition and the substrate requirements of the benthic organisms identified will elucidate some physical parameters which may be influencing the numbers of individuals present in the community.

The fish species identified in Area 2 of Gill Creek are gizzard shad, golden shiner, white bass, white crappie, muskellunge, carp, common shiner, bluegill and pumpkinseed sunfish, brown bullhead and white sucker (WCC, 1989). The fish species identified probably are foraging for different prey items in Area 2 (e.g., gizzard shad, and golden shiners forage on zooplankton; muskellunge forages for fish; and brown bullhead, white sucker and carp ingest aquatic earthworms).

3.0 ECOLOGICAL CONDITIONS OF GILL CREEK

3.1 BENTHIC COMMUNITY OF AREA 2 IN GILL CREEK

A community refers to all the organisms in a prescribed area (Diamond and Case, 1986), and can be defined further as an assemblage of interacting plants and animals on a shared site (Freedman, 1989). The community can be refined further by restricting the concept by imposing spatial, trophic, taxonomic or life forms constraints on the community. A spatial constraint might include all the species in a single habitat (e.g., a pond) or in a particular stratum of the habitat (e.g., the sediments in the pond). A trophic classification includes all the species at one trophic level (e.g., all parasites, all nectar eaters). A taxonomic definition includes all species belonging to a higher taxonomic group (e.g., all fish). A life form differentiation refers to all species of the same life form (e.g., seaweeds, rain forest trees). Therefore a community is a set of species defined in various ways.

The community at Area 2 in Gill Creek will be defined in this report as encompassing both benthic organisms (bottom dwellers) and fish. The benthic organisms comprising this community in Area 2 of Gill Creek include the following:

- Aquatic flatworms identified to species (Phylum Platyhelminthes, Class Turbellaria, Order Tricladida, Family Planariidae, Dugesia tigrina);
- Aquatic roundworms identified to Phylum (Phylum Nematoda);
- Aquatic earthworms identified to Class (Phylum Annelida, Class Oligochaeta);
- Aquatic earthworms identified to Family (Phylum Annelida, Class Oligochaeta, Order Haplotaxida, Family Tubificidae);

- **Leeches** identified to species (Phylum Annelida, Class Hirudinea, Order Pharyngobdellida, Family Erpobdellidae, Nephelopsis obscura, and Dina spp.; Order Rhynchobdellida, Family Glossiphoniidae, Glossiphonia complanata);

- **Snails** identified to species (Phylum Mollusca, Class Gastropoda, Order Archaeogastropoda, Family Anyclidae, Ferrissia spp.; Order Mesogastropoda, Family Pleuroceridae, Goniobasis livescens; Order Basommatophora, Family Physidae Physa spp.; Class Pelecypoda, Order Heterodonta, Family Sphaeriidae, Sphaerium spp.);

- **Fresh**-water shrimp or scuds, or sideswimmers identified to species (Phylum Arthropoda, Class Crustacea, Order Amphipoda, Family Gammaridae, Gammarus fasciatus; Order Isopoda, Family Asellidae, Asellus spp.);

- **Water** fleas identified to Order (Phylum Arthropoda, Class Crustacea, Order Cladocera;

- **Water** fleas identified to species (Phylum Arthropoda, Class Crustacea, Order Copepoda, Family Cyclopidae, Cyclops spp.)

- **Crayfish** identified to Family (Phylum Arthropoda, Class Crustacea, Order Decapoda, Family Astacidae);

- **Aquatic** insect larvae identified to species (Phylum Arthropoda, Class Insecta, Order Trichoptera, Family Hydropsychidae, Hydropsyche betteni; Order Ephemeroptera, Family Baetiscidae, Baetisca spp.); and

- **Aquatic** insect larvae, midges, identified to Family (Phylum Arthropoda, Class Insecta, Order Diptera, Family Chironomidae).

The organisms identified above form the benthic community of Area 2 in Gill Creek. The factors that control or influence why these particular benthic organisms form the community are presented below. The regional species association that constitutes a subset of all the species that could be found inhabiting the sediments in Area 2 of Gill Creek is influenced by these factors. Basically the causes of limited membership in a community are typically within the following three categories:

- Lack of traits that would permit a species to function under the physical conditions of the environment;

- Limitations on dispersal (or movement away from the environment in question); and

- Interactions among species (e.g., competitive interactions resulting in only one species of a group of similar species flourishing in the environment).

The physical conditions are often used to determine the pool of eligible species that may inhabit a given environment. Eligible species considered as having the potential to inhabit Area 2 of Gill Creek should be capable of surviving in an aquatic habitat which receives frequent (although random in occurrence) anthropogenic perturbations (disturbances originating from human activities). Typical physical conditions of an environment include:

- Seasonal climatic patterns of temperature, rainfall, light and wind;

- Altitude;

- Soil texture;

- Water salinity and depth; and

- Availability of inorganic and organic nutrients.

Limitations on dispersal and interactions among species, typically act interdependently. Dispersal and competition often interact and influence the species inhabiting a community. Typically the species (of two competitive species) that arrives first in the community excludes the other species. Dispersal and predation interact and influence foraging strategies as does predation and competition.

3.2 THE BIOLOGY OF THE BENTHIC ORGANISMS AT AREA 2 IN GILL CREEK

The benthic organisms identified in Area 2 of Gill Creek are roundworms, flatworms, aquatic earthworms, leeches, snails, crayfish, microscopic water fleas, and freshwater shrimp, and larval forms of aquatic insects.

3.2.1 Roundworms (Phylum Nematoda)

Almost any collection of sand, mud, debris, or vegetation from the bottom or margin of a pond, lake, brook, or river will be found to contain small roundworms, sometimes in great abundance (Pennak, 1978). Roundworms are either parasitic or free-living. The parasitic roundworms live off of other organisms. The free-living forms have various feeding habits.

Some free-living roundworms feed only on dead plant material, others feed on only dead animal material, others are detritus feeders, ingesting both dead plant and animal matter. Some species of roundworms are herbivores, eating living plants, others are predaceous and carnivorous (ingesting animal prey). Typical prey animals are other nematodes, aquatic earthworms, water fleas and freshwater shrimp.

Nematodes are perhaps the most highly adaptable from ecological and physiological standpoints (Pennak, 1978). The same species may be found from the tropics to the subarctic, from warm springs to cold lakes, and inhabiting many different types of substrates. Most species are confined to the upper most five centimeters of substrate in natural freshwater habitats (Pennak, 1978). Populations of roundworms can be maintained in habitats with low concentrations of dissolved oxygen (between 2 to 10 percent saturation), but are capable of withstanding anaerobic conditions only for one to several weeks.

3.2.2 Flatworms (Phylum Platyhelminthes)

Most of the species of flatworms are parasitic, and/or marine or terrestrial inhabitants. The freshwater forms are found everywhere, usually on or in close association with substrates.

Flatworms ingest living or dead or crushed animal, or plant matter (Pennak, 1978). Typically they ingest small living invertebrates (e.g., microscopic water fleas, or freshwater shrimp). Cannibalism has been observed in habitats supporting too many flatworms.

Flatworms are found inhabiting springs, spring brooks, ditches, marshes, pools, ponds, lakes and caves. Most species are photonegative and hide under objects during the day. Flatworms thrive in any kind substrate where there is an appropriate food supply. There is often a correlation between standing and running waters and size of the individuals. Large, sedentary individuals are typically found in standing or still waters. Some species are capable of surviving in habitats with only a trace of dissolved oxygen, others survive in habitats where dissolved oxygen concentrations range form 5 percent to 40 percent saturation. A few species are restricted to habitats where the dissolved oxygen is 70 percent saturation or greater.

3.2.3 Aquatic earthworms (Phylum Annelida)

The majority of aquatic earthworms occur in the mud, debris and substrate of stagnant pools and ponds in streams and lakes everywhere (Pennak, 1978). The shallow zones typically at a depth of one meter are preferred habitats, although species do occur in the deepest parts of lakes.

The majority of aquatic earthworms ingest substrate (similar to terrestrial earthworms) and digest the organic matter present in the substrate. The ingestion of the organic matter can occur at a depth of 2 to 3 centimeters below the water-substrate interface. Typically the food consists of filamentous algae, diatoms or plant and animal detritus (Pennak, 1978). One species is carnivorous and preys on insect larvae and other aquatic earthworms.

Aquatic earthworms occupy a niche similar to that occupied by terrestrial earthworms. They feed on the bottom and mix the substrate as effectively as terrestrial earthworms mix garden soil. Temperature, although usually not a limiting factor, can determine the relative abundance of aquatic earthworms. The species of aquatic earthworms belonging to the Family Tubificidae are the dominant forms encountered at depths greater than one meter. The most concentrated populations of Tubificidae are found in streams or rivers that are polluted with sewage. Most of the species can survive in habitats with a low dissolved oxygen concentration. The survival of aquatic earthworms in habitats with low dissolved oxygen concentrations is influenced by temperature. High temperatures and low dissolved oxygen typically are not conducive to maintaining populations.

3.2.4 Leeches (Phylum Annelida)

Leeches are predominantly a freshwater organism found in ponds, marshes, lakes and slow flowing streams (Pennak, 1978). The size of leeches can vary from five millimeters to 45 centimeters.

Leeches are parasitic, typified by those species with suckers as mouth parts, scavengers, feeding on dead animal matter, and carnivorous, feeding on snails, insects, aquatic earthworms and other small animals.

Habitats preferred by leeches include warm, protected shallows where there is little wave action and where plants, stones and debris are available for concealment. Leeches are primarily nocturnal and hide under debris during the day. Typically species are found in water at depths of 2 meters and they require substrates to which they can adhere. Consequently, leeches are uncommon on mud or clay bottoms.

3.2.5 Snails (Phylum Mollusca)

Snails are found in almost every type of freshwater habitat, from small ponds and streams to large lakes and rivers. Only the coldest alpine lakes, grossly polluted waters and saline inland waters are without snail populations. Snails are typically found on the substrate in waters ranging in depth from 10 centimeters to 2 meters.

The majority of freshwater snails are vegetarians, feeding on algae. Dead plant material is ingested in addition to dead animal matter by some species. Snails are typically considered good scavengers, and utilize their sticky mucous trail as a method of obtaining food.

One of the most important physical parameters influencing the survival of snails is the amount of dissolved salts in the water, specifically calcium carbonate (the essential material for shell construction). Therefore, it is generally true that soft waters contain few species and individuals, and hard waters contain many species and individuals. Hydrogen-ion concentration is closely associated with (and partly determined by) the carbon dioxide content of the water. Lakes low in carbonates are typically acidic (pH less than 7.0), those high in carbonates are typically alkaline. The majority of species occur under alkaline conditions (pH greater than 7.0). Dissolved oxygen content of the water is another limiting factor for snails. Most species require a high dissolved oxygen concentration. Therefore, severely polluted rivers and lakes that usually become oxygen deficient are devoid of snails. Snails are typically found in the shallow waters (depth approximately 3 meters), and are influenced by temperature. Extremely cold (i.e., freezing temperatures) and temperatures exceeding 30 degrees Centigrade will limit the abundance of snails.

3.2.6 Water fleas, Freshwater shrimp, Scuds, Sideswimmers (Phylum Arthropoda, Order Cladocera, Order Copepoda, Order Amphipoda)

These animals are microscopic in size (between 0.2 and 3.0 millimeters in length). These animals occur in nearly all types of freshwater habitats (Pennak, 1978). The water fleas are filter feeders, ingesting algae, microscopic animals, and organic detritus (including bacteria). Animals within the Order Copepoda ingest plankton and prey by scraping the bottom substrate. The freshwater shrimp (or scuds or sideswimmers) ingest all kinds of plant and animal matter (including freshly killed animals, and organic debris).

The water fleas are abundant in freshwater, except for rapid flowing streams, and brooks, and grossly polluted waters. Typically water fleas are found in open waters and they migrate vertically in the water column (drifting upwards at dusk, and downwards at dawn). Water fleas are found inhabiting waters with very low dissolved oxygen concentrations, variable calcium concentrations, and varying pH (6.5 to 8.5). Members of the Order Copepoda are found in open water and along the shallow vegetated edges. Coexistence between two species in the same genus typically is influenced by vertical, seasonal and food particle size preferences (Pennak, 1978). Copepods are influenced by temperature and are tolerant of low dissolved oxygen concentrations. The freshwater shrimp (or scuds, or sideswimmers) are common in unpolluted waters, such as springs, spring brooks, streams, pools, ponds and lakes. These animals require an abundance of dissolved oxygen (greater than 7 percent saturation), react negatively to light (hide during daylight hours), and are tolerant of cold temperatures.

3.2.7 Crayfish (Phylum Arthropoda)

Crayfish are typical inhabitants of running waters, shallows of lakes, ponds, sloughs, swamps, underground waters and wet meadows.

Generally, crayfish are omnivores but seldom predators. They ingest all types of aquatic vegetation, and scavenge for food. Adult crayfish generally hide under debris or stones during the day and forage during the night. Crayfish prefer shallower waters, seldom found at depths greater than one meter. Most species tolerate normal but wide ranges in temperature, hydrogen-ion concentrations and carbon dioxide concentrations.

3.2.8 Aquatic Insect Larvae (Phylum Arthropoda; genera Hydropsyche, and Baetisca; Family Chironomidae)

The genus Hydropsyche represents an animal in the caddis fly group of insects. Adult caddis flies are small to medium moth-like insects found near streams, ponds and lakes between May and September (Pennak, 1978). The larvae form hollow cylindrical cases out of debris (e.g., sand grains, gravel, leaves, bark and twigs) and hide in these cases at the bottom of shallow ponds or streams. The genus Baetisca represents an animal in the mayfly group of insects. Adult mayflies are found near freshwater bodies where the larval forms are located. Mayfly nymphs or larval forms occur in all types of freshwater, wherever there is an abundance of dissolved oxygen (greater than 5 parts per million). The Family Chironomidae represents midges. Adult midges occur in swarms near bodies of water and near lights at night. Chironomid larvae occur everywhere in aquatic vegetation and on the bottoms of all types of freshwater habitats.

Caddis fly larvae are considered omnivores. The members of Hydropsyche are classified as net filter feeders. The larvae construct fine nets that strain particulate matter from the water. The larvae may ingest the entire net and contents, or may clean the net periodically. Mayfly nymphs are opportunistic feeders. They are primarily herbivores, although many species ingest detritus and living animals. Chironomid larvae are herbivores and feed on algae, aquatic plants and organic detritus. Some members of this family construct tubes of organic detritus, algae, small grains of sand and silt. The mud inhabiting species are filter feeders.

Caddis fly larvae are found in shallow freshwater habitats where there is an adequate supply of oxygen. They occur on all types of substrates (rock, gravel, sand, debris, mud, and vegetation). The larvae that build nets (e.g., Hydropsyche) are restricted to rapid flowing waters. Mayfly nymphs are most characteristic of shallow waters. Species occur in specific habitats (e.g., some species occur only in vegetation, others only on mud, debris, gravel or rock bottoms, and some are found only under rocks) further defined by water velocity. Chironomid larvae typically are found in sluggish streams, ponds and lakes, sometimes at great depths. Chironomids are tolerant of very low dissolved oxygen concentrations.

3.3 PHYSICAL AND CHEMICAL PARAMETERS OF AREA 2 IN GILL CREEK

Substrate was removed in 1981 from the reach of Gill Creek between Staub Road and Buffalo Avenue (referred to as Area 2). Crushed rock was emplaced on the substrate between Adams Avenue and Buffalo Avenue (approximate length of 600 feet). Compacted clay was emplaced on the substrate from Staub Road to Adams Avenue (approximately 900 feet in length).

3.3.1 Organic Matter and Composition of Sediments

The percent of organic matter in depositional sediments at Area 2 in Gill Creek were calculated for the 1984 report (Spotila, 1984). Substrate collected from the area near

Buffalo Avenue contained an average of 21 percent organic matter. Substrate collected from the area nearest Staub Road contained an average of 13 percent organic matter. Substrate collected from in between Staub Road and Buffalo Avenue contained an average of six percent organic matter (Spotila, 1984).

The depositional sediment from Area 2 in Gill Creek was further characterized by percent composition of water, solids, and grain-size distribution (Spotila, 1984). The substrate collected nearest Buffalo Avenue was composed of 40.32 percent water and 59.68 percent solids. The solid material was comprised of particulates, 37.70 percent of the solid material was comprised of particles greater than 4.760 millimeters (mm) in size, and 49.40 percent of the solid material was comprised of particles less than 0.045 mm. The depositional sediment near Staub Road was composed of 57.59 percent water and 42.41 percent solid material. Sixty-two percent of this solid material was comprised of particles less than 0.045 mm. The intermediate reaches of Area 2 in Gill Creek (inbetween Staub Road and Buffalo Avenue) were comprised of approximately 25 percent water and 75 percent solid material. Between 23 and 58 percent of the solid material was comprised of particulates less than 0.045 mm.

The concentration of organic matter in the depositional sediment at Area 2 in Gill Creek was greatest near Buffalo Avenue and near Staub Road. The portion of Area 2 in Gill Creek near Staub Road probably is influenced by the backwash from the Niagara River. The portion of Area 2 in Gill Creek near Buffalo Avenue probably is influenced by allochthonous input (organic matter entering the creek, e.g., leaves from trees) potentially from the drainage of Hyde Park Lake, and by upstream sediments.

The proportion of solid material that is greater than 4.760 mm in size (37.7 percent) in the depositional sediments collected near Staub Road, supports the finding that the Niagara River is influencing the lower reach of Area 2 in Gill Creek. This assertion is supported further when the percentage of solid material composed of particles greater than 4.760 mm in Area 2 is examined along the length of Area 2. The data indicates that the portion of solid material composed of particles greater than 4.760 mm in size decreases downstream of Buffalo Avenue until Staub Road when the portion of solid material composed of particles greater than 4.760 mm increases. It is highly unlikely that the solid material in the substrate (the depositional sediments) near Staub Road composed of large particulates originated upstream. It is very likely that the depositional sediments near Staub Road were deposited by the backwash of the Niagara River.

3.3.2 Composition of Sediments and Benthic Organisms

The benthic organisms identified as inhabiting Area 2 in Gill Creek live on or in (to an approximate depth of 2 meters) the sediments. The benthic organisms collected in 1984 are representative of a diverse benthic community. The numbers of individuals within each taxonomic group were low. However, this does not necessarily mean that Area 2 has a low productivity of benthic organisms. Examining the substrate composition and the substrate requirements of the benthic organisms identified will elucidate some physical parameters which may be influencing the numbers of individuals present in the community.

Flatworms, leeches, water fleas, freshwater shrimp, scuds, sideswimmers, copepods, and crayfish all require some type of debris in which to hide. Making an assumption that the percent organic matter in sediments is roughly equivalent to the amount of debris available, and that particulates greater than 4.760 mm in size are the minimum sized particulates these animals can use as cover, only limited portions of Area 2 in Gill Creek would have suitable habitat for these animals. The limited portions of Area 2 are near Staub Road and near Buffalo Avenue. The sediments in Area 2 near Staub Road contained an average of 21 percent organic matter and approximately 38 percent of the solids were composed of particulates greater than 4.760 mm. The sediments in Area 2 near Buffalo Avenue contained an average of 13 percent organic matter and approximately 20 percent of the solids were composed of particulates greater than 4.760 mm. Therefore, if the number of suitable habitats are limited, the number of individuals the habitat can support also is limited.

Leeches also require substrates to which they can adhere (e.g., rocky substrates); consequently, they are uncommon on clay substrates (i.e., the portion of Area 2 adjacent to the Du Pont property to which a clay cap was emplaced). Snails require alkaline waters with high concentrations of calcium carbonate, the species of aquatic larvae identified (Hydropsyche betteni and Baetisca spp.), caddis flies and mayflies, require rapidly flowing waters. These limitations on the physical environment probably act as constraints on the numbers of individuals of these species the habitat (substrate) can support in this section of Area 2.

Roundworms and aquatic earthworms are ubiquitous in aquatic environments. The feeding habits of roundworms (detritus feeders, herbivores or carnivores) and aquatic earthworms (substrate feeders) are ideal for these species to exploit all available aquatic habitats. If the physical conditions of the environment preclude many individuals of species capable of living in the environment from doing so, those species that are not constrained by the physical conditions will be represented by large numbers (or high density biomass) of individuals. Therefore, because the benthic community in Area 2 of Gill Creek is composed of (relatively) large numbers of aquatic earthworms and roundworms (relative to the other benthic organisms) it is assumed these worms have found a suitable habitat with little or no competition from other benthic organisms.

3.4 PCBs, BENTHIC ORGANISMS, AND FISH IN AREA 2 OF GILL CREEK

Polychlorinated Biphenyl congeners (PCBs) are ubiquitous in the environment (Colombo et al., 1990; Thomas, 1983; Whittle and Fitzsimons, 1983) and long term trends indicate PCB residues in aquatic life are decreasing (Suns et al., 1983). PCBs were documented in sediments from Area 2 in Gill Creek prior to the remediation in 1981 (WCC, 1989; WCC, 1990). Since the remediation (removal of contaminated sediments and capping of sediments left in place) PCBs in the depositional substrate have been documented. Deposition of sediments has been documented on the capped substrate near Staub Road and also near Buffalo Avenue. The depositional sediments near Staub Road are originating from the Niagara River, the depositional sediments near Buffalo Avenue are originating from sediments upstream.

3.4.1 PCBs and Biota

The terms bioconcentration, bioaccumulation and biomagnification are used frequently in the literature to describe uptake of compounds by animals. Bioconcentration can be defined as the chemical residue obtained directly from the water via gill or epithelial tissues (Brungs and Mount, 1978). Bioaccumulation is a broader term that refers to residues obtained from both food and water (Macek et al., 1979). Biomagnification, therefore, is the total process of bioaccumulation by which tissue residues of toxic substances increase as material passes up through two or more trophic levels (Biddinger and Gloss, 1984).

References in the literature both support and disprove biomagnification of PCBs in aquatic food chains (Crossland et al., 1986; Duursma, 1989; Kim et al., 1989; Oliver and Niimi, 1988; Sarkaa, 1979; Scavia and Robertson, 1990; Schneider, 1982; Spehar et al., 1980). The literature is in agreement on the following characteristics of PCBs.

- PCBs do adsorb onto particulate matter in sediments (Dunnivant, 1989; Formica, 1988).
- PCBs do adhere to sediments containing high concentrations of organic matter (Limburg, 1984).
- PCBs have a low water solubility and vapor pressure and are not easily degraded by physical, chemical or biological processes (Crossland et al., 1986).
- Because of their strong hydrophobic (water hating) and lipophilic (fat loving) character, these compounds are mainly associated with colloids, suspended particulate matter and sediments, and lipid tissue of organisms (Colombo et al., 1990).
- The lower chlorinated forms of PCBs are volatilized more readily than the higher chlorinated forms (Schmitt et al., 1981; Schmitt et al., 1985).
- Desorption from sediments into the water-sediment interface occurs and is influenced by temperature (the process increases in the summer when the water temperature increases) (Apicella, 1984).
- Desorption from sediments is influenced by bioturbation (stirring and mixing of the sediments by benthic organisms) (Larsson, 1985).
- Desorption from sediments is influenced by flow rates of the water, the slower the flow the greater amounts of PCBs are released from the sediments into the water-sediment interface (Apicella, 1984).

- Transport of PCBs from the water-sediment interface into sediments occurs by assimilation and excretion by biota, adsorption by particles and the sedimentation of particulate and detrital matter (Hiriazumi et al., 1979; Choi and Chen, 1976; Chiou et al., 1977).

The fate and distribution of PCBs among biota and sediments is controlled by the physical and chemical properties of PCBs (i.e., vapor pressure, octanol-water partition coefficient, and water solubility).

Oligochaete worms (aquatic earthworms) and the uptake and excretion processes of organochlorine compounds have been investigated (Markwell et al., 1989; Oliver, 1987). Benthic aquatic organisms living in contaminated habitats accumulate organochlorine compounds (e.g., PCBs). Uptake of these contaminants has been documented in freshwater mussels (Kauss and Hamdy, 1985), oligochaete worms (Oliver, 1984), Chironomidae (Larsson, 1984), crustaceans (Sanders and Chandler, 1972), and caddis fly larvae (Bush et al., 1985). Because these animals comprise a significant proportion of the diets of fishes and predatory invertebrates, benthic invertebrates are considered an important transfer route between contaminated sediments and higher trophic levels (Kovats and Ciborowski, 1989).

Bottom-dwelling larvae of aquatic invertebrates tend to accumulate organochlorine compounds in proportion to the amounts present in the surrounding sediments, although specific attributes of the organisms, type of sediment and the chemical properties of the contaminants influence uptake (Larsson, 1984; Reynoldson, 1987). The uptake of PCBs by benthic organisms is influenced by the fat content of the organism (PCBs are lipophilic) and by the available concentrations of PCBs in the water-sediment interface (Shaw and Connell, 1987).

The flux of PCBs from the depositional sediments to the water column (including the aqueous and suspended sediment phase at the water/sediment interface) was estimated for Area 2 of Gill Creek. The portion of Area 2 adjacent to the Olin property has a rate of 2.3 micrograms per second (μg/s). The portion of Area 2 adjacent to the Du Pont property has a rate of 28.9 micrograms per second (μg/s). The estimated concentration of PCBs resulting from the depositional sediments in Area 2 (based on the flow rates presented in the Risk Assessment, WCC, 1990) is 0.022 micrograms per liter (μg/L). The level of PCBs should not pose any acute toxicological effects on the aquatic organisms inhabiting Area 2.

3.4.2 PCBs and Benthic Organisms in Area 2 of Gill Creek

Removal of the source of depositional sediments containing PCBs from Area 2 in Gill Creek (near Staub Road, and upstream of Buffalo Avenue) will remove the potential for the benthic organisms to assimilate PCBs. The caps (both crushed rock and clay) currently in place are prohibiting and will continue to prohibit the interaction of the sediments containing PCBs (left in place since the 1981 remediation) with water at the water-sediment interface. Therefore, because the desorption of PCBs from sediments underneath the cap is necessary to affect the benthic organisms inhabiting Area 2, prohibiting the interaction between water and sediment, and prohibiting bioturbation by aquatic earthworms will ensure that the PCBs in the sediments beneath the caps remains adhered to those sediments.

3.4.3 PCBs and Fish in Area 2 of Gill Creek

The effects of PCBs on fish have been documented in the literature (Colombo et al., 1990; Crossland et al., 1986; Kim et al., 1989; Schmitt et al., 1981; Schmitt et al., 1983; Spehar et al., 1980; Suns et al., 1983; Walker, 1976). PCBs tend to accumulate in the fatty tissues of fish (Colombo et al., 1990; Crossland et al., 1986; Spehar et al., 1980). Consequently, during reproduction (when the fatty reserves are used to produce gonads and the eggs and sperm are expelled from their bodies) the levels of PCBs remaining in their bodies decrease (Spehar et al., 1980).

Residues of PCB concentrations in fish have been correlated with weight and size of the fish (Spehar et al., 1980). The assertion has been made that PCBs have acute and chronic effects as well as subtle effects on the growth, reproduction and behavior of fish (Walker, 1976). However, it also has been documented that PCBs do not have an effect on the early survival of fish (Spehar et al., 1980). Additionally, the effects of PCBs on the liver and kidneys of fish have been documented as expected because those are the organs responsible for removing toxins from the blood (Kim et al., 1989).

The uptake of PCBs by fish probably is from both ingestion of prey and from water passing over the gills. Therefore, by removing the source of PCBs in the depositional sediments at Area 2 of Gill Creek (near Staub Road and upstream near Buffalo Avenue), the uptake of PCBs by fish in Gill Creek will be reduced.

3.5 BIOMASS ESTIMATES

3.5.1 Benthic Organism Biomass Estimate and Annual Productivity in Area 2 of Gill Creek

The biomass of particular benthic organisms and their annual productivity was estimated in Area 2 of Gill Creek. Calculations were based on data collected on December 5, 1984 (Spotila, 1984). Concern has been focused on the depositional sediments (which contain PCBs) near Staub Road and Buffalo Avenue. The estimated biomass of benthos was used to estimate the impact of the benthic invertebrates on the local fishery (i.e., the size of the fish population that could be supported by ingestion of the available benthic organisms in Area 2 of Gill Creek).

The approach used in quantitating stream productivity involved the following steps:

- The population density (number of organisms per square foot [organisms/ft^2]) was calculated for each group of benthic invertebrates found in Area 2 of Gill Creek sediments identified during the 1984 study.

- The biomass (milligrams per square foot [mg/ft^2]) for each group of these organisms was calculated.

- The annual turnover (i.e., the number of complete population replacements per year) for each group of benthic organisms was estimated.

- The annual productivity (mg/ft^2/year) was calculated for each group of benthic organisms using the formula:

Annual productivity = Biomass x Annual Turnover

- The overall annual productivity was calculated by summing the values for all benthic invertebrate groups.
- The fish population which could be supported by ingestion of benthic invertebrates was estimated, using food and biomass conversion factors reported in the literature for various species of fish.

A number of uncertainties are associated with each of these steps. Conservative values have been estimated when specific information (i.e., body weight, generation times, etc.) was not available to ensure productivity was not underestimated. The assumptions used in the calculations are discussed below.

3.5.1.1 Population Density

Gill Creek was divided into two distinct regions for the purpose of estimating stream productivity. The two regions were divided on the basis of the capping materials used during remediation in 1981. One region (adjacent to the Olin property) has crushed rock as a substrate base and the second region (adjacent to the Du Pont property) has clay as a substrate base. Sediment samples were collected in order to identify benthic organisms from one location adjacent to the Olin property and three locations adjacent to the Du Pont property. Benthic organisms were collected with a ponar dredge. The area of substrate sampled by the ponar dredge is assumed to be 1-square-foot. The population densities of particular benthic organisms collected in Area 2 of Gill Creek are presented in Table 1. Closely related species have been grouped together when appropriate.

3.5.1.2 Biomass

Wet weights of individual benthic organisms collected from Area 2 in Gill Creek are presented in Table 2. Values for oligochaetes, hirudineans, gastropods, trichopterans, ephemeropterans, and dipterans are derived from Wetzel (1975; Table 16-27). Mean animal wet weight data were not available for the remaining groups of benthic organisms. For those benthos for which data were not available, conservative wet weight values (based on animal size) were assigned. Biomass (mg/ft^2) was calculated for individual groups of benthic organisms and all groups combined, as total biomass (Table 3).

3.5.1.3 Annual Turnover

The productivity of individual benthic organism groups is highly dependent on their population turnover rates. The annual turnover for each group of benthos is presented in Table 3. These turnover values are estimates based on reported generation times, growth rates and time required to reach maturity. A turnover rate of 1X was developed for tricopterans and ephemeropterans based on an annual reproductive cycle (Wetzel, 1975). Dipterans (chironomids, in particular) have one to two reproductive cycles per year, and a turnover rate of 2X was assumed for this group. Oligochaetes have a slow growth rate (requiring one to four years to reach maturity) and frequently undergo extended periods of metabolic inactivity during periods of environmental stress. The turnover rate for oligochaetes was assumed to be 1X. Aquatic nematodes average three generations per year (or a turnover rate of 3X). Hirudineans average two generations per year and gastropods average two generations per year (or a turnover rate of 2X). Isopods have an average generation time of eight to 12 months, a conservative turnover rate of 2X was estimated for isopods. The turnover rate of 1X was used for pelecypods because of the long incubation and growth periods these organisms have prior to reaching maturity. Amphipods have a rapid turnover rate, reaching maturity after 33 to 98 days (growth rate is temperature-dependent). A conservative turnover value of 8X was assumed (based on an assumption of six months of growth during warm weather only). Information concerning the generation times for cladocerans, Dugesia or Cyclops, was not readily available; therefore, a conservative value (8X) was assumed for the turnover value of these three benthic organisms.

3.5.1.4 Annual Productivity of Benthic Organisms

The annual productivity for each group of benthic organisms is presented in Table 3. The three major contributors to the annual productivity of benthic organisms in Area 2 in Gill Creek were predicted to be oligochaetes, pelecypods, and dipterans. The total annual productivity was estimated to range from 1.3 gm/ft^2/year (portion of Area 2 adjacent to the Du Pont property) to 4.0 gm/ft^2/year (portion of Area 2 adjacent to the Olin property).

Using a conversion factor of one square meter equals 10.76 square feet (1 m^2 = 10.76 ft^2), the annual biomass of benthic organisms in Area 2 of Gill Creek is:

- 13.99 grams (gm)/meter squared (m^2)/year (yr) for the portion of Area 2 adjacent to the Du Pont property; and
- 43.04 gm/m^2/yr for the portion of Area 2 adjacent to the Olin property.

3.5.2 Annual Fish Productivity

Table 4 presents the maximal fish productivity which potentially could be supported by the benthic organisms biomass in Area 2 of Gill Creek. Values are presented for two groups of fish:

- **Carp** with a low food conversion efficiency (1.9%); and
- **Perch** with a relatively high conversion efficiency (19.5%).

Most other species common to the area, including white sucker and brown bullhead catfish, are assumed to have food conversion efficiencies intermediate to these two values. The maximum productivity for fish in Area 2 of Gill Creek was predicted to be 0.8 gm/ft^2/year (calculated using the perch efficiency factor) for the portion of Area 2 adjacent to the Olin property.

Using a conversion factor of one square meter = 10.76 square feet, and converting milligrams into grams, the annual biomass of carp, brown bullhead, and white suckers in Area 2 of Gill Creek was estimated from the conversion efficiencies in the literature. These three species of fish were selected because they are typical benthic feeders. The conversion efficiencies in the literature were specifically for carp and perch. The assumption was made that the conversion efficiencies for white suckers and brown bullheads would be less than the conversion efficiency for perch. However, using the perch efficiency value for brown bullheads and white suckers is the most conservative estimate. Therefore, the conversion efficiency value (obtained from the literature) for perch was used for brown bullheads and white suckers.

The annual biomass of carp estimated for Area 2 of Gill Creek is:

- 0.86 $gm/m^2/yr$ at the portion of Area 2 adjacent to the Olin property; and
- 0.269 $gm/m^2/yr$ at the portion of Area 2 adjacent to the Du Pont property.

The annual biomass of brown bullhead and white sucker estimated (based on the perch efficiency factor) for Area 2 of Gill Creek is:

- 8.46 $gm/m^2/yr$ at the portion of Area 2 adjacent to the Olin property; and
- 2.74 $gm/m^2/yr$ at the portion of Area 2 adjacent to the Du Pont property.

The fishery capable of being supported by the benthic organisms in Area 2 of Gill Creek is a very small resource. Typical small stream fishery resources range from 27.67 to 101.80 $gm/m^2/yr$ (Hackney, 1978).

3.6 FISH FORAGING STRATEGIES

The feeding habits of fish are influenced by the composition of the community (coexisting species), the availability of preferred prey items, and the ability of the fish to switch foraging strategies.

Most fish species will ingest a variety of prey. The major constraint on foraging tactics employed by fish is the size of their gape (or mouth). A foraging fish will ingest prey items it is physiologically capable of ingesting (physically capable of inserting in its mouth) even though it may have specific morphological features which aid the fish in ingesting specific prey items.

Coexisting species of fish usually are capable of ingesting the same or similar items. However, coexisting fish typically will not ingest the same prey; one species will ingest prey item A and one fish will ingest prey item B. Coexisting species may partition (divide) the habitat vertically (within the water column) or horizontally (shallow edges or deep open water) or they may partition the habitat diurnally (one species forages during the day, the other at night). Coexisting fish species, by employing a partitioning strategy, are avoiding direct competition. Another partitioning strategy is the optimal foraging strategy.

The optimal foraging strategy entails that a predator focus on a search image of the prey when the prey organism is extremely abundant. Therefore, the predator expends the least amount of energy for the greatest amount of energy return. As the prey organism declines in abundance the predator needs to switch foraging strategies and develop a different search image to retain the optimal benefits of a foraging strategy.

The principal prey organisms in Area 2 of Gill Creek are aquatic earthworms, aquatic insect larvae, and snails. However, the abundance of the benthic organisms is not great. Therefore, it is doubtful that the fish species documented in Area 2 of Gill Creek would forage principally in this area. It would be expected that the fish in Area 2 would be more opportunistic feeders, faced with the low abundance of prey items.

3.7 OPTIMAL HABITATS OF FISH

The fish species identified in Area 2 of Gill Creek are gizzard shad, golden shiner, white bass, white crappie, muskellunge, carp, common shiner, bluegill and pumpkinseed sunfish, brown bullhead and white sucker (WCC, 1989). The fish species identified probably are foraging for different prey items in Area 2.

The gizzard shad, and golden shiner will forage for the water fleas, copepods and freshwater shrimp. The white bass, large white crappie and muskellunge will forage on other fish and crayfish. Carp, common shiner, bluegill and pumpkinseed sunfish will forage on aquatic plants, water fleas, copepods, freshwater shrimp, snails, chironomids, aquatic insect larvae, roundworms, flatworms, and aquatic earthworms. The brown bullhead and white sucker will forage primarily for the aquatic earthworms. However, because the abundance of prey in Area 2 of Gill Creek is low (so the fish are not receiving a good return on the energy expended searching for prey) these fish can and will forage in other areas of Gill Creek and in the Niagara River.

4.0 CONCLUSIONS AND SUMMARY

The benthic organisms and species of fish inhabiting Area 2 of Gill Creek are not adversely affected by the concentrations of PCBs that remain in the sediments after the remediation in 1981, because of the caps (either crushed rock or clay) emplaced on top of these sediments. In order for the PCBs to desorb from these sediments, the sediments need to come into contact with the water-sediment interface. The caps prevent the desorption of the PCBs from the sediments, prevent any interaction between water and the sediments, and prevent bioturbation of the sediments.

Removal of the depositional sediments originating from the Niagara River (via back wash from the Niagara River into Gill Creek) from Area 2 of Gill Creek (near Staub Road) will remove the source of PCBs to which the benthic organisms and fish currently are exposed.

The benthic organism community inhabiting Area 2 of Gill Creek is diverse. However, the total estimated biomass of the benthic organisms is not sufficient to sustain a productive fishery resource. The benthos inhabiting Area 2 are constrained by the available habitat.

Several of the benthic organisms (leeches, flatworms, water fleas [cladocerans], freshwater shrimp, scuds, sideswimmers [amphipods], copepods [Cyclops], and crayfish) require substrate with debris that affords hiding locations from predators. Snails and the aquatic insect larvae are affected by water quality parameters such as temperature and dissolved oxygen concentrations, which are influenced by water flow. The aquatic roundworms and earthworms are ubiquitous in aquatic habitats, provided they have a source of food. Area 2 of Gill Creek is a shallow (average depth is approximately 1.5 feet), slow flowing body of water. The substrate of Area 2 has crushed rock emplaced along approximately 600 feet and compacted clay emplaced along approximately 900 feet downstream of the crushed rock. Depositional sediments on top of the caps in Area 2 are dispersed randomly, and the depth of the depositional sediments is approximately one-quarter inch. Food for the benthic organisms is limited to those areas where depositional sediments are located and is constrained by the depth and organic content of the sediments. Therefore, the physical habitat of Area 2 is not conducive to supporting large populations of the benthic organisms collected.

The fishery resource that Area 2 of Gill Creek can support is low. The fish species that primarily ingest benthic organisms (white sucker, brown bullhead, and carp) will forage in other locations within Gill Creek and in the Niagara River to find enough food to sustain them. Those species (white crappie, bluegill, muskellunge, gizzard shad, golden shiner, common shiner, pumpkinseed sunfish, and white bass) that do not forage primarily on benthic organisms will forage in other locations within Gill Creek and in the Niagara River due to the paucity of prey available to them in Area 2.

The fishery resource in Area 2 is poor probably due to the following:

- Physical parameters of Area 2 are not conducive to sustaining a viable fisheries. The depth of water is shallow, which influences the dissolved oxygen concentration and water temperature (important parameters for benthic organisms and fish).

- Physical attributes of substrate in Area 2 are not conducive to sustaining a biomass of benthic organisms capable of sustaining a fishery resource.

In summary, the effects of the PCBs in the depositional sediments in Area 2 on aquatic life probably do not warrant removal of these sediments. Removal of sediments from Area 1 will remove the source of PCBs to which the benthic organisms and fish are currently exposed.

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Tables

TABLE 1

POPULATION DENSITY OF BENTHIC ORGANISMS COLLECTED IN AREA 2 OF GILL CREEK
DECEMBER 5, 1984
(Units given as number of organisms per square foot.)

Benthic Group[1]	Olin Site	Upper DuPont Site	Mid DuPont Site	Lower DuPont Site	Mean Dupont Sites[2]
Dugesia	0	0	0.4	0.1	0.2
Nematoda	0	0.6	1.8	0	0.8
Oligochaeta	338	80.5	80.9	224	128
Hirudinea	0.7	0	0.5	1.1	0.5
Gastropoda	0.6	0.1	0.4	0.4	0.3
Pelecypoda	0.9	0.3	0.3	0.6	0.4
Amphipoda	3.3	0.4	0.3	0.1	0.3
Isopoda	0.4	0	0	0	0
Cladocera	1.1	0	0	0.4	0.1
Cyclops	0	0	0.3	0	0.1
Trichoptera	0.3	0	0	0	0
Ephemeroptera	0	0	0.1	0	0.1
Diptera	40.9	3.1	0.9	0.1	1.4

Notes:
1 Closely related species have been grouped together when appropriate.
2 DuPont and Olin stream sections treated separately, based on differences in substrate capping materials (Olin has crushed rock, DuPont has compacted clay).

TABLE 2

ESTIMATED MEAN WET WEIGHT (BIOMASS) PER INDIVIDUAL ANIMAL
(Units of measure are milligrams [mg].)

Benthic Group	Mean Biomass/Organism[1]	Biomass/Organism Value Used to Estimate Productivity
Dugesia	NA	10 mg[2]
Nematoda	NA	10 mg[2]
Oligochaeta	1.7-6.0 mg	6.0 mg
Hirudinea	6-23 mg	23 mg
Gastropoda	3.3-33 mg	33 mg
Pelecypoda	NA	1,000 mg[2]
Amphipoda	NA	10 mg[2]
Isopoda	NA	10 mg[2]
Cladocera	NA	5 mg[2]
Cyclops	NA	5 mg[2]
Trichoptera	1.6-13 mg	13 mg
Ephemeroptera	1.1-7.3 mg	7.3 mg
Diptera	1.5-8.7 mg[3]	8.7 mg

Notes:
1 Mean values (individual animal wet weight) derived from Table 16-27, in Wetzel, R.G. 1975.
2 Body weight data not available. Value is a conservative estimate, based on animal size.
3 Values based on chironomid data.
NA = Not available.

TABLE 3

BENTHIC BIOMASS AND ANNUAL BENTHIC PRODUCTIVITY IN AREA 2 OF GILL CREEK

(Units of measure are milligrams per square foot [mg/ft^2] and milligrams per square foot per year [$mg/ft^2/yr$].)

	December Biomass (mg/ft^2)			Annual Productivity ($mg/ft^2/yr$)[1]	
Benthic Group	**Olin Site**	**DuPont Site**	**Annual Turnover**	**Olin Site**	**DuPont Site**
Dugesia	0	2.0	X8	0	16.0
Nematoda	0	8.0	X3	0	24.0
Oligochaeta	2,028	768	X1	2,028	768
Hirudinea	16.1	11.5	X2	32.2	23.0
Gastropoda	19.8	9.9	X2	39.6	19.8
Pelecypoda	900	400	X1	900	400
Amphipoda	33	3.0	X8	264	24
Isopoda	4.0	0	X2	8	0
Cladocera	5.5	0.5	X8	44	4
Cyclops	0	0.5	X8	0	4
Trichoptera	3.9	0	X1	3.9	0
Ephemeroptera	0	0.7	X1	0	0.7
Diptera	356	12.2	X2	712	24.4
TOTAL (all groups)	**3,366**	**1,216**		**4,032**	**1,308**

Notes: [1] Annual productivity calculated using the equation:

Annual Productivity = Biomass X Annual Turnover

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TABLE 4

FISH PRODUCTIVITY (mg/ft^2/year) IN AREA 2 OF GILL CREEK
(Values based on conversion of benthic biomass to vertebrate [fish] biomass, assuming high and low conversion efficiencies.)[1]

	Olin Site	DuPont Site
Carp	76.6	24.9
Perch	786	255

Notes: [1] Carp reported to utilize 1.9% of ingested food for growth and reproduction. Perch are reported to utilize 19.5% of ingested food for this purpose. Source: Wetzel, 1975.