U.S. FISH AND WILDLIFE SERVICE
MAINE FIELD OFFICE
SPECIAL PROJECT REPORT: FY97-MEFO-4-EC

SCREENING LEVEL CONTAMINANT SURVEY OF THE SUNKHAZE MEADOWS NATIONAL WILDLIFE REFUGE

MILFORD, MAINE

March 2000

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U.S. Fish and Wildlife Service
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EXECUTIVE SUMMARY

The 9,337-acre Sunkhaze Meadows National Wildlife Refuge is located in the Town of Milford, Maine. The refuge is bisected by Sunkhaze Stream, the area's major watercourse, and includes extensive tracts of regionally-unique peat bogs. The remainder of the refuge is comprised of spruce-fir and mixed hardwood forest and palustrine wetlands. Six brooks drain into the refuge and Sunkhaze Stream. The area surrounding the refuge is largely undeveloped timberland except for two old landfills that border the parcel. Along the refuge's southern boundary is the former Town of Milford Municipal Landfill. The town landfill operated between 1976 and 1992, receiving municipal solid waste. It was closed and capped in 1995. The Fort James Corporation operated a paper mill sludge landfill along the northern edge of the refuge between 1978 and 1996. The Fort James landfill was closed and capped in 1996. These landfills represented the greatest local, point-source contaminant threat to the refuge. Consequently, the sampling design for the screening survey was biased towards these areas.

In July 1993, three pairs of surface water and sediment samples were collected from locations along the refuge border and within the refuge from Baker Brook, Buzzy Brook and Sunkhaze Stream. Later in the same summer, chain pickerel and yellow perch were collected from two Sunkhaze Stream locations within the refuge, at the confluence of Baker Brook and at the confluence with Buzzy Brook. Water, sediment, and fish samples were analyzed for various contaminants including trace elements, organophosphate pesticides, organochlorine pesticides, polychlorinated biphenyls (PCBs), dioxins, and furans.

The purposes of this screening level survey were:

1) To determine baseline levels of environmental contaminants on Sunkhaze Meadows National Wildlife Refuge and,

2) To assess the impact of potential contaminant sources located adjacent to the refuge.

Analytical results from this screening-level contaminant survey are fairly encouraging. Excessive concentrations of organophosphate pesticides, organochlorine pesticides, dioxins, furans, and most trace elements are not found in most media. PCB concentrations in sediments from Baker Brook are elevated and may require additional investigation. Similarly, PCB levels in surface water from Baker Brook and Sunkhaze Stream are also elevated and will require resampling. Fish tissue samples from Sunkhaze Stream, however, did not exhibit elevated levels of PCBs. Chromium, copper, nickel, mercury, and zinc levels in Sunkhaze Stream fish tissue samples are elevated. Mercury contamination in fish is most likely related to atmospheric deposition, a common state-wide problem. The sources of chromium, copper, nickel, and zinc causing elevated fish tissue concentrations are not known.

Media-specific sampling results are summarized below:

Surface water - Six surface water samples were analyzed for trace elements, organochlorine pesticides, and PCBs.

- Nine trace elements were detected in surface water samples - aluminum, boron, barium, beryllium, cadmium, iron, magnesium, manganese, and strontium. Only aluminum was found at concentrations above the chronic exposure criterion of the Clean Water Act's Ambient Water Quality Criteria (AWQC). The aluminum level in surface water at Sunkhaze Meadows National Wildlife Refuge, however, is not unusual or highly elevated for northern Maine. The AWQC recognizes that many high quality waters in the United States may have aluminum levels above the chronic exposure criterion. Consequently, aluminum in surface water at the refuge should not be considered a significant risk to fish and wildlife.

- Organochlorine pesticides were not detected in any surface water samples.

- PCBs were detected in Baker Brook and Sunkhaze Stream surface water samples. The levels of total PCB detected in Baker Brook (max. 2.862 ppb) and Sunkhaze Stream (max. 2.965 ppb) surface water samples exceeded the chronic exposure criterion of the AWQC (0.014 ppb) by orders of magnitude. PCBs were not detected in Buzzy Brook surface water samples.

Sediment - Six sediment samples were analyzed for trace elements, organophosphate pesticides, organochlorines pesticides, PCBs, dioxins, and furans.

- Trace element concentrations in sediment were not elevated and, in most cases, were well below sediment effect guidelines.

- Organophosphate pesticides, such as carbaryl and carbofuran, were not detected in any sediment samples, the only medium analyzed for this suite of compounds.

- Several organochlorine pesticides were detected in sediments from Baker Brook. The levels were not highly elevated; most concentrations were at, or slightly above, the method detection limit.

- PCBs were detected in sediments from Baker Brook, Buzzy Brook, and Sunkhaze Stream. Total PCB concentrations in Baker Brook sediment samples (n = 2, 0.78 ppm, 0.15 ppm) exceeded the probable effect concentration (0.67 ppm) and threshold effect concentration (0.06 ppm). One Buzzy Brook sediment sample had a total PCB concentration (0.20 ppm) above the threshold effect concentration. Neither Sunkhaze Stream sediment sample exceeded the threshold effect concentration. The source of PCB contamination in Baker Brook is not known. The pattern of PCB congeners in sediment from upstream and refuge samples, however, suggests that the former Town of Milford Municipal Landfill is not the source of

PCBs in Baker Brook.

• A single detection of one dioxin compound, octachlorodibenzo-*p*-dioxin (OCDD), was found in a sediment sample from Sunkhaze Stream collected immediately upstream of the refuge. The concentration of 0.00000314 ppm, more easily expressed as 3.14 ppt (parts-per- trillion), was not highly elevated compared to sediment guidelines. Moreover, OCDD has a potency ten thousand times less than the most toxic dioxin compound - 2,3,7,8-TCDD. Furans were not detected in sediment samples.

Fish - Two composite samples of whole-body chain pickerel and two composites of whole-body yellow perch were analyzed for trace elements, organochlorine pesticides, and PCBs. Both pickerel samples were also analyzed for dioxins, and furans.

• Compared to Maine, regional, and national studies; elevated levels of chromium, nickel, mercury, and zinc were detected in Sunkhaze Stream fish tissue. Chromium levels in Sunkhaze Stream chain pickerel and yellow perch are highly elevated compared to other data sets. Mercury levels in chain pickerel exceed statewide consumption advisory levels promulgated by the Maine Department of Environmental Protection. Copper and zinc levels in pickerel and perch are also elevated compared to national fish tissue studies, but the levels are not unusual for the New England region.

• Organochlorine pesticides were not commonly observed in the four fish samples. Dieldrin and DDE were found at low levels in a yellow perch composite sample collected from the Buzzy Brook/Sunkhaze Stream confluence.

• PCBs were found at low concentrations in three of four fish samples and undetected in the fourth sample.

• Dioxin and furan compounds were not detected in chain pickerel composite samples, the only fish samples analyzed for these organochlorine compounds. (Note: Due to budget limitations, yellow perch composite samples were not analyzed for dioxins and furans). The method detection limit for these fish samples was 1 pg/g or 1 part-per-trillion. This method detection limit at the time of sampling (circa 1995) is fairly high by current standards. Since the chain pickerel is the top-level fish predator in Sunkhaze Stream, we would not expect other sportfish species in the refuge to have higher levels of dioxin or furans. However, fish species with higher lipid content that are not sought by anglers, such as suckers, may contain detectable levels of dioxins and furans above the state background level of 0.40 pg/g (MEDEP 2000). These non-sportfish are frequently the prey for fish-eating birds (e.g., bald eagle, osprey). It is not known, therefore, if ecological receptors may be at risk from dioxin and furan contamination in fish from Sunkhaze Meadows NWR.

Conclusions

Based on limited surface water, sediment, and fish sampling, the Sunkhaze Meadows NWR does not appear to be significantly contaminated with the trace elements, organophosphate pesticides, organochlorines pesticides, dioxins and furans included in the analytical catalog.

PCB concentrations in Baker Brook sediment and surface water samples, however, are elevated. Similarly, Sunkhaze Stream surface water samples also contained high levels of PCBs.

Two landfills along the north and south borders of the Sunkhaze Meadows NWR do not appear to be significant local contaminant sources for the refuge. Although, malformed frogs have been collected down gradient from one landfill, the Fort James sludge landfill along the Stud Mill Road, the cause of the malformations is not known. Further investigation in the borrow pit ponds may be necessary to determine if contaminants are linked to malformations.

Recommendations

Follow-up work for the Sunkhaze Meadows National Wildlife Refuge should include:

- Collection of sediment samples and aquatic biota (fish and/or invertebrates) above beaver dams on Baker Brook. Sediment data suggest that PCBs may be accumulating in the brook. Additional sampling will define the nature and extent of PCB contamination in the brook. Collection and analysis (filtered and unfiltered) of surface water samples from Baker Brook and Sunkhaze Stream will be necessary to confirm PCB levels in water.

- Measurement of basic water quality parameters for 30-day periods during high (i.e., spring) and low flow (i.e., late summer) periods to develop better baseline data.

- Collection of surface water, sediment, and frog tissue samples from the borrow pit ponds along the Stud Mill Road. In 1997 and 1998, frog anatomical abnormalities were found in this location. A third survey conducted in 1999 did not find any abnormalities. However, the 1999 survey methodology was different and limited to one species, the northern leopard frog. While it is uncertain what role contaminants may play in frog malformations, analysis of media from the ponds for environmental contaminants, particularly pesticides, may be useful.

PREFACE

This report describes the results of a screening level survey to measure environmental contaminants in surface water, sediment, and fish at the Sunkhaze Meadows National Wildlife Refuge in Milford, Maine. Analytical work for this survey was completed under Patuxent Analytical Control Facility Catalog Number 5030031 - Purchase Orders No. 85830-3-4021 (trace elements), No. PACF-3-0109 (organophosphates), No. 85830-3-4023 (organochlorine pesticides and polychlorinated biphenyls), and No. 85830-3-4022 (dioxins and furans).

Questions, comments, and suggestions related to this report are encouraged. Written inquiries should refer to Report Number FY97-MEFO-4-EC and be directed to:

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Mike Curtis, Environmental Coordinator with the Fort James Corporation, and Lloyd Goodwin, Town of Milford Public Works Director generously provided background information and made available their files on the Fort James Landfill and Milford Municipal Landfill, respectively.

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Appendix C. ECDMS Analytical Report - **Organochlorine Pesticides and PCBs**, Geochemical & Environmental Research Group, Texas A&M, College Station, Texas.

Appendix D. ECDMS Analytical Report - **Dioxins and Furans**, Geochemical & Environmental Research Group, Texas A&M, College Station, Texas.

<u>Concentration units used in this report</u>

parts-per-million (ppm)	mg/l = milligrams-per-liter (surface water) mg/kg = milligrams-per-kilogram (sediment) µg/g = micrograms-per-gram (fish tissue)
parts-per-billion (ppb)	µg/l = micrograms-per-liter (surface water)
parts-per-trillion (ppt)	ng/kg = nanograms-per-kilogram (sediment) pg/g = picograms-per-gram (fish tissue)

ABBREVIATIONS and ACRONYMS

ac	acre
Al	aluminum
ATSDR	Agency for Toxic Substances and Disease Registry
AWQC	ambient water quality criteria
B	boron
Ba	barium
$BaCO_3$	witherite
$BaSO_4$	barite
BB	Baker Brook
Be	beryllium
α-BHC	hexachlorocyclohexane
γ-BHC	lindane
BZB	Buzzy Brook
CCC	Criteria Continuous Concentration
Cd	cadmium
CFR	Code of Federal Regulations
CGC	capillary gas chromatography
cm	centimeter
CMC	Criteria Maximum Concentration
Cr	chromium
Cu	copper
CVAA	cold vapor atomic absorption
DDD	dichlorodiphenyl-dichloroethane or [2,2-bis(*p*-chlorophenyl)-1,1-dichloroethane]
DDE	dichlorodiphenyl-dichloroethylene or [1,1-dichloro-2,2-bis(*p*-chlorophenyl)ethylene]
DDT	dichlorodiphenyl-trichloroethane or [1,1,1-trichloro-2,2-bis(*p*-chlorophenyl)ethane]
dw	dry-weight
EC	Environmental Contaminants
ECDMS	Environmental Contaminant Data Management System
EMAP	Environmental Monitoring and Assessment Program
EPA	Environmental Protection Agency
ER-L	Effect Range - Low
ER-M	Effect Range - Median
Fe	iron
FDA	Food and Drug Administration
ft	feet
g	gram

GERG	Geochemical and Environmental Group
GFAA	graphite furnace atomic absorption
GPS	global positioning system
ha	hectare
HCB	hexachlorobenzene
Hg	mercury
HNO_3	nitric acid
HRGC	high resolution gas chromatography
HRMS	high resolution mass spectrometry
ICP	inductively coupled plasma emission
IJC	International Joint Commission
kg	kilogram
km	kilometer
l	liter
LEL	Lowest Effect Level
m	meter
MCL	Maximum Contaminant Limit
MEDEP	Maine Department of Environmental Protection
MEFO	Maine Field Office
Mg	magnesium
mg	milligram
mi	mile
ml	milliliter
Mn	manganese
MW	monitoring well
µg	microgram
µS	micro-Siemens
NCBP	National Contaminant Biomonitoring Program
NEL	No Effect Level
ng	nanogram
Ni	nickel
NWR	National Wildlife Refuge
OC	organochlorine
OCDD	octochlorodibenzo-*p*-dioxin
OP	organophosphate
PACF	Patuxent Analytical Control Facility
Pb	lead
PCB	polychlorinated biphenyl
PEC	Probable Effect Concentration
pg	picogram
ppm	parts-per-million

ppb	parts-per-billion
ppt	parts-per-trillion
REMAP	Regional Environmental Monitoring and Assessment Program
RTI	Research Triangle Institute
SD	standard deviation
SEL	Severe Effect Level
Sr	strontium
SS	Sunkhaze Stream
TCDD	2,3,7,8-tetrachlorodibenzo-*p*-dioxin
TEC	Threshold Effect Concentration
TOC	total organic carbon
USDOI	United States Department of Interior
USFWS	United States Fish and Wildlife Service
V	vanadium
WPA	Waterfowl Production Area
ww	wet-weight
Zn	zinc

1. INTRODUCTION

The 3,778 ha (9,337 ac) Sunkhaze Meadows National Wildlife Refuge (NWR) is located in the Town of Milford, Penobscot County, approximately 24 km (15 mi) north of Bangor in east-central Maine. The Sunkhaze Meadows NWR is comprised of the namesake unit in Milford, and satellite units in Unity, Benton, and Troy (Carlton Pond WPA). The Milford Unit of Sunkhaze Meadows NWR (hereafter referred to as the refuge or Sunkhaze Meadows NWR), where this contaminant screening survey was conducted, was established as a unit of the U.S. Fish and Wildlife Refuge System in 1988.

The primary land feature of Sunkhaze Meadows NWR is bog or peatland. Sunkhaze Meadows and Spencer Meadows (Figure 1) are large northern peat bogs that form the bulk of the refuge land area, approximately 1,820 ha (4,500 ac). Watercourses are the other major physiographic feature of the refuge. The refuge is bisected by Sunkhaze Stream, which is a tributary of the Penobscot River. Six watercourses are tributaries of Sunkhaze Stream within the refuge. Buzzy Brook and Little Buzzy Brook flow into Sunkhaze Stream from the west; Little Birch Stream, Birch Stream, and Johnson Brook enter from the east; and Baker Brook flows in from the south. These waterways and wetlands of the Sunkhaze Meadows National Wildlife Refuge are important staging areas for migrating waterfowl. The wetlands and uplands of the refuge collectively provide breeding habitat for over 110 bird species. Sunkhaze Meadows NWR is located in a relatively undeveloped portion of Penobscot County. The area surrounding the refuge is largely undeveloped timberland. There are, however, potential contaminant sources near the refuge - roads and landfills.

1.1 Roads - Two roads form more than half of the refuge boundaries. The northern and northeastern edges of the boundary are bordered by the Stud Mill Road. The southeastern border is formed by the County Road. The Stud Mill Road and County Road are unpaved roads that are typical of northern and eastern Maine. The Stud Mill Road is a privately-owned logging road, while the County Road is maintained by the Town of Milford. Vehicle traffic along these roadways is fairly constant throughout the year. Occasionally, illegal dumping of solid and liquid waste likely occurs along these roadways. Debris and refuse have been observed along the roadways on an infrequent basis. Numerous roadside ditches, bridges, and culverts along the Stud Mill Road and County Road are potential pathways for vehicle-related or illegally-disposed contaminants into the watercourses of Sunkhaze Meadows NWR.

1.2 Landfills - There are two landfills near the refuge (Figure 2). The Fort James (formerly James River) Corporation's sludge landfill along the Stud Mill Road and the Town of Milford Municipal Landfill along the County Road are located immediately adjacent to the Sunkhaze Meadows NWR boundaries and two brooks.

1.2.1 Fort James Landfill - The 11 ha (27 ac) Fort James Corporation landfill is located approximately 1,100 m (3,600 ft.) east of Buzzy Brook along the refuge's northern boundary. The landfill was closed on December 1, 1996 (MEDEP File #S-04285-WN-A-N). Between 1979 and 1996, the landfill received sludge from paper mill operations, woody debris, lime, tire chips, and miscellaneous material. The landfill cover is comprised of soil, borrow, grit, and sand. Twenty-one groundwater wells surround the landfill. A pair of monitoring wells, MW #202 A & B, are located on refuge land (N 45° 01' 22"/W -068° 33' 21"). Groundwater is sampled and analyzed from all wells three times per year for calcium, hardness, iron, magnesium, manganese, sodium, chemical oxygen demand, chloride, nitrogen (total kjeldahl as N), nitrogen-ammonia, phosphorus, dissolved solids, sulfate, tannin/lignin, total organic carbon, and turbidity. Monitoring well analytical reports are distributed to the Maine Department of Environmental Protection and the refuge. The potential for overland transport of contaminants from the James River landfill appears remote. No established surface water drainages appear to exist between Buzzy Brook and the landfill. There are borrow pit ponds, however, within 260 m (850 ft.) of the landfill. The groundwater direction is towards the borrow pit ponds and two monitoring wells are located between the ponds and landfill (MW #105A&B - N 45° 01' 24.85"/W -068° 33' 09.39"; MW #104B - N 45° 01' 25.40"/W -068° 33' 00.52"). In 1997 and 1998, malformed frogs, including a pickerel frog (*Rana palustris*) with four hind limbs, were found in the borrow pit ponds. The occurrence of limb malformations in frogs is currently being intensively studied throughout North America.

1.2.2 Milford Municipal Landfill - The 2 ha (5 ac) Milford Municipal Landfill is located approximately 300 m (980 ft.) east of Baker Brook along the southern boundary of the refuge. The Milford Landfill was closed in 1995 (MEDEP File #S-05298-WO-A-N or Solid Waste File #03135). The landfill received municipal solid waste, demolition debris, white goods, tires and household waste from 1976 through 1993. The landfill is capped with an impermeable clay cover and a vegetative cover. Visual inspections by USFWS personnel in late February 1999 (an unusual period of minimal snow cover) did not indicate any sloughing, erosion, or breakouts on the cap. Groundwater monitoring wells are located at the SW corner (MW#3; N 44° 56'34"/W -068° 33' 31"), SE section near the entrance (MW#4, N 44° 56’34”/W -068° 33’ 28”), and midway along the NE edge of the landfill (MW#2, N 44° 56' 39"/W -068° 33' 29"). There are no monitoring wells associated with this landfill on refuge property. The three existing wells are monitored biannually for State Closure Indicator Parameters: hardness, chloride, chemical oxygen demand, iron, manganese, sodium, and sulfate (CES, Inc. 1998). The potential for overland transport of contaminants from the landfill appears remote. No established surface water drainages exist between Baker Brook and the northwest corner of the landfill. The floodplain of Baker Brook, however, is within 260 m (850 feet) of the landfill and it is likely that groundwater underlying the landfill discharges to the brook.

2. STUDY PURPOSES

The purposes of this study were:

- To determine background levels of environmental contaminants in the fish, surface water, and sediment of Sunkhaze Meadows NWR, and

- To assess the potential impact of possible contaminant sources (e.g., illegal dumping, vehicular traffic, or landfills) on the fish and wildlife resources of the refuge.

3. STUDY AREA

The 3,778 ha (9,337 ac) Milford Unit of the Sunkhaze Meadows National Wildlife Refuge encompasses nearly 8 km (5 mi) of Sunkhaze Stream and another 19 km (12 mi) of tributary streams including Buzzy Brook, Little Buzzy Brook, Johnson Brook, Birch Stream, Little Birch Stream, and Baker Brook. The streams of the refuge that pass through the open areas of Sunkhaze Meadows and Spencer Meadows support fish species such as smallmouth bass (*Micropterus dolomieu*) and chain pickerel (*Esox niger*), while the smaller tributaries passing through forested or shrubby areas provide habitat for coldwater fish species like brook trout (*Salvelinus fontinalis*) and cusk (*Lota lota*; Rupp 1955, Smithwood and McKeon 1999).

Sunkhaze Meadows NWR is within the USGS Lower Penobscot hydrologic unit #01020005. The waters of the refuge tend to be soft (specific conductance 28-43 µS/cm; USFWS, unpublished data) and highly colored (82-260 Platinum-Cobalt Units; UMaine-Water Research Institute, unpublished data). Although a bog habitat, the waters of the refuge do not appear to be highly acidic. In August 1997, pH values measured by the USFWS Office of Fishery Assistance during fish sampling ranged from 6.05 to 7.0 (Smithwood and McKeon 1999). In May 1999, pH values in 5 refuge streams ranged from 6.73 to 7.67 (UMaine-Water Research Institute, unpublished data).

The refuge screening level contaminant survey was conducted on three waterways, Baker Brook, Buzzy Brook, and Sunkhaze Stream. Baker Brook and Buzzy Brook were selected because they may be the principal receiving waters for landfill contaminants. Sunkhaze Stream was included in the survey because it is the major waterway on the refuge.

3.1 Baker Brook - Baker Brook is a meandering 10 km (6 mi) stream that originates in the Town of Bradley near Maine Public Reserve Land (Number 26 Swamp). Baker Brook flows from south to north for 4 km (2.5 mi) within refuge boundaries, to its confluence with Sunkhaze Stream. At the County Road bridge, the brook is bordered by scrub-shrub vegetation dominated by speckled alder (*Alnus rugosa*). Within the refuge, the brook courses through sedge tussocks and small, narrow stands of red maple (*Acer rubrum*). A vegetation transect established west of Baker Brook in 1996 (Famous and Famous 1997) includes the following species: spatterdock (*Nuphar variegatum*), pickerel weed (*Pontederia cordata*), uptight sedge (*Carex stricta*), sweet gale (*Myrica gale*), large cranberry (*Vaccinium macrocarpon*), sphagnum (*Sphagnum* spp.), sheep laurel (*Kalmia angustifolia*), leatherleaf (*Chamaedaphne calyculata*), and black spruce (*Picea mariana*).

3.2 Buzzy Brook - Buzzy Brook begins in the Town of Greenbush. It receives drainage from Whitney Brook, and over the course of 6 km (4 mi), drains southerly into Sunkhaze Stream. At the Stud Mill Road crossing, the brook is bordered by red spruce (*Picea rubens*)/balsam fir (*Abies balsamea*) stands beside sedge meadow, alder, and aspen (*Populus tremuloides*) stands. Immediately after the road crossing, the brook enters a broader, 0.25 km expanse of meadow, bog and heath. Plants identified (Famous and Famous 1997) within the brook and this expanse include pondweed (*Potamogeton natans*), arrow head (*Sagittaria latifolia*), uptight sedge, smartweed (*Persicaria amphibium*), marsh fern (*Thelypteris palustris*), sweet gale, large cranberry, sphagnum (*Sphagnum* spp.), sheep laurel, leatherleaf, rhodora (*Rhododendron canadense*), withe-rod (*Viburnum cassinoides*), and black spruce. Small, narrow bands of red maple are located along the eastern edge of the brook at the confluence with Sunkhaze Stream.

3.3 Sunkhaze Stream - Sunkhaze Stream is approximately 22 km (13 mi) in length. It begins in Township 32 MD and flows southerly then westerly through Sunkhaze Meadows NWR before draining into the Penobscot River. The Sunkhaze Stream reach on refuge land is approximately 13 km (8 mi). Indian Brook, Wiley Brook, and Halfway Brook contribute flow to Sunkhaze Stream before the stream enters the refuge. Above the Stud Mill Road bridge, Sunkhaze Stream is typical of many Maine streams; narrow (3 m or 10 ft.), braided, and densely bordered by alder. On the refuge, the riparian characteristics of Sunkhaze Stream are considerably different from its headwaters. The stream widens considerably (average width 30 m (100 ft.)) as it flows through the 0.25 to 0.50 km wide sedge-dominated expanses of Sunkhaze Meadows and Spencer Meadows.

4. METHODS

4.1 Surface Water, Sediment, and Fish Collections - Surface water and sediment samples were collected for contaminant analysis on 29 and 30 July 1993. Fish samples were collected on 11 August 1993. Sixteen samples were submitted to the USFWS Patuxent Analytical Control Facility (PACF) for contaminant analyses - 6 sediment, 6 water, and 4 fish.

Surface water was collected in 1 L Cubitainers™. Cubitainers were rinsed three times with ambient water at each site prior to sample collection. The Cubitainer was submerged approximately 36 cm below the water surface, opened, and filled. Each water sample was preserved with HNO_3 at a pH of 2. Surface water was collected at Baker Brook before the brook entered the refuge, and in the interior of the refuge down gradient of the former Milford Municipal Landfill. In Buzzy Brook, water samples were collected near the refuge boundary north of the Stud Mill Road and in the interior of the refuge at the confluence of Buzzy Brook and Sunkhaze Stream. Two samples were collected from Sunkhaze Stream. One sample was collected on the northeast side of the Stud Mill Road before the stream enters the refuge, and another at the boundary east of the power lines before the stream leaves the refuge.

Surficial sediments were collected with an Ekman dredge or stainless steel spoon at six locations: two each from Sunkhaze Stream, Buzzy Brook, and Baker Brook (Figure 1). At each location, several grabs of sediment were placed in a stainless steel bucket, homogenized, and placed in chemical-clean 500 ml I-Chem™ jars. Sediments were collected at the same locations as surface water with one exception. The sediment sample for Buzzy Brook near the refuge boundary (BZB1) had to be collected south of the Stud Mill Road, while the water sample was taken on the north side. Sediment in Buzzy Brook immediately north of the Stud Mill Road lacked fines and organic matter, so a sample was taken on the south side of the road.

Fish were collected with experimental gill nets or by angling at two Sunkhaze Stream locations - at the confluence with Baker Brook and at the confluence with Buzzy Brook (Figure 1). The maximum total length in centimeters and the total weight to the nearest gram were recorded for each fish (Table 2). Whole-body samples of chain pickerel (*Esox niger*) and yellow perch (*Perca flavescens*) were wrapped in aluminum foil (dull side towards the sample), labeled, and placed in plastic freezer bags. Fish samples were placed in ice-filled coolers and transported to freezers for storage at -20^{o} C within hours of collection. Individual fish were arranged into composites by species. Following catalog approval, all water, sediment, and fish samples were shipped via overnight carrier to the analytical laboratories.

The geographic coordinates of sampling locations are listed in Table 2. Some coordinates for collection locations were determined in the field with a Trimble GPS unit. The GPS unit was not available for fish sampling and for surface water and sediment collections in the interior of the refuge. Collection coordinates for these locations were estimated from electronic mapping packages (e.g., TopoScout™). Consequently, the interior refuge coordinates listed in Table 2 should only be considered approximations.

4.1.1 Sample Coding. The same basic prefix codes were used to identify sampling locations: BB for Baker Brook, BZB for Buzzy Brook, and SS for Sunkhaze Stream (see box below). Slightly different sample codes, however, are included in the laboratory analytical reports. Minor additions were made to the location codes to differentiate media samples. For example, for water samples the letter "A" was added to the location code (i.e., SS1A). For sediment samples, the abbreviation "SED" was added to the location code (i.e., SSSED1). In the fish code, "F1" was added to the location code to signify a chain pickerel sample (i.e., BZB2F1), while "F2" was used to identify the yellow perch sample (i.e., BZB2F2). Fish were collected at the confluence of Sunkhaze Stream and Baker Brook or Buzzy Brook, so the collection locations for these samples are not quite the same as the Baker Brook or Buzzy Brook surface water and sediments samples.

Location Sample Codes and Descriptions

Code	Description of Location
SS1	Sunkhaze Stream, upstream of the Stud Mill Road bridge
SS2	Sunkhaze Stream, as the stream exits the refuge at the power lines
BB1	Baker Brook, upstream of the County Road bridge
BB2	Baker Brook, in the interior of the refuge
BZB1	Buzzy Brook, at the intersection with the Stud Mill Road
BZB2	Buzzy Brook in the interior of the refuge immediately above the confluence with Sunkhaze Stream

4.2 Laboratory Analytical Methods - Surface water, sediment, and fish samples from Sunkhaze Meadows NWR were analyzed for five suites of environmental contaminants by the USFWS Patuxent Analytical Control Facility and its contract laboratories. Due to limited funding, not all media samples from Sunkhaze Meadows NWR were subjected to the same contaminant analyses. The contaminant scans included 19 trace elements, 6 organophosphates, 22 organochlorine pesticides, 75 polychlorinated biphenyl congeners, and 17 dioxin and furan compounds (Table 3). In addition to contaminants, lipid content was measured in fish tissue, and Total Organic Carbon and particle size were determined in all sediment samples.

4.2.1. Trace Elements - The trace element scan performed by Research Triangle Institute (RTI) included the following elements: aluminum, arsenic, boron, barium, beryllium, cadmium, chromium, copper, iron, mercury, magnesium, manganese, molybdenum, nickel, lead, selenium, strontium, vanadium, and zinc. Inductively coupled plasma emission (ICP), graphite furnace atomic absorption (GFAA), and cold vapor atomic absorption (CVAA) analytical methods used by RTI are described on pages 25 through 28 of Appendix A. Surface water, sediment, and fish were analyzed for trace elements.

4.2.2. Organophosphate Pesticides - The organophosphate scan performed by the USFWS Patuxent Analytical Control Facility included the following compounds: aldicarb, carbaryl, carbofuran, methiocarb, and methomyl. The gas chromatography analytical methods used by PACF are described on page 10 of Appendix B. Sediment was the only medium analyzed for organophosphates.

4.2.3. Organochlorine Pesticides - The organochlorine pesticide scan performed by the Geochemical and Environmental Group of Texas A&M included the following compounds: aldrin, dieldrin, endrin, *alpha* BHC (hexachlorocyclohexane), *beta* BHC, *delta* BHC, *gamma* BHC (lindane), *alpha* chlordane, *cis*- nonachlor, *gamma* chlordane, *trans*-nonachlor, oxychlordane, HCB (hexachlorobenzene), heptachlor,heptachlor epoxide, mirex, *o*,*p*'-DDD (dichlorodiphenyl-dichloroethane), *o*,*p*'-DDE (dichlorodiphenyl- dichloroethylene), *o*,*p*'-DDT (dichlorodiphenyl-trichloroethane), *p*,*p*'-DDD, *p*,*p*'-DDE, and *p*,*p*'- DDT. The capillary gas chromatography (CGC) analytical methods used by GERG for organochlorine pesticides and PCBs are described on pages 76 through 79 of Appendix C. Surface water, sediment, and fish were analyzed for organochlorine pesticides.

4.2.4. Polychlorinated Biphenyls - The polychlorinated biphenyl (PCB) scan performed by the Geochemical and Environmental Group of Texas A&M included total PCBs (GPCB) and 75 congeners (see Table 3 for the congener list). The capillary gas chromatography (CGC) analytical methods used by GERG for PCBs and organochlorine pesticides are described on pages 76 through 79 of Appendix C. Surface water, sediment, and fish were analyzed for polychlorinated biphenyls.

4.2.5. Dioxins and Furans - The dioxin and furan scan performed by the Geochemical and Environmental Group (GERG) of Texas A&M included the following compounds:

1,2,3,4,6,7,8-heptachlorodibenzo-*p*-dioxin (HpCDD);
1,2,3,4,6,7,8-heptachlorodibenzo-*p*-furan (HpCDF);
1,2,3,4,7,8,9-heptachlorodibenzo-*p*-furan (HpCDF);

1,2,3,4,7,8-hexachlorodibenzo-*p*-dioxin (HxCDD);
1,2,3,4,7,8-hexachlorodibenzo-*p*-furan (HxCDF);
1,2,3,6,7,8-hexachlorodibenzo-*p*-dioxin (HxCDD);
1,2,3,6,7,8-hexachlorodibenzo-*p*-furan (HxCDF);
1,2,3,7,8,9-hexachlorodibenzo-*p*-dioxin (HxCDD);
1,2,3,7,8,9-hexachlorodibenzo-*p*-furan (HxCDF);
1,2,3,7,8-pentachlordibenzo-*p*-dioxin (PeCDD);
1,2,3,7,8-pentachlorodibenzo-*p*-furan (PeCDF);
2,3,4,6,7,8-hexachlorodibenzo-*p*-furan (HxCDF);
2,3,4,7,8-pentachlorodibenzo-*p*-furan (PeCDF);
2,3,7,8-tetrachlorodibenzo-*p*-dioxin (TCDD);
2,3,7,8-tetrachlorodibenzo-*p*-furan
TCDF); octachlorodibenzo-*p*-dioxin
(OCDD); and octachlorodibenzo-*p*-furan
(OCDF).

The high-resolution gas chromatography/high-resolution mass spectrometry (HRGC/HRMS) analytical methods used by GERG for dioxins and furans are described on pages 12 and 13 of Appendix D. One sediment sample from Sunkhaze Stream (SS1) and two chain pickerel tissue samples (BB2F1 and BZB2F1) were the only samples analyzed for these compounds.

4.2.6. TOC & Particle Size - Total organic carbon and particle size in sediment samples were also measured by Research Triangle Institute. The methods are described on pages 27 and 28 of Appendix A.

5. ANALYTICAL RESULTS

Analytical results for surface water, sediment, and fish are summarized below. Total PCBs (ΣPCBs) are expressed in this report as the sum of concentrations from congener-specific analyses. Total PCBs were also reported in the routine organochlorine (OC) scan, but the resolution in that analyses is much less sensitive than the congener-specific scan. ΣPCB values from the OC scan were not used in this report. When compared, the ΣPCB values from the OC scan and the congener-specific scan often do not match, particularly in media that routinely have very low concentrations of the contaminant such as surface water. The ΣPCB concentration derived from the sum of PCB congeners is likely the most accurate representation of ΣPCBs in the sample.

5.1 SURFACE WATER

Surface water results are summarized in Table 4 (trace elements), Table 5 (organochlorine pesticides and total PCBs), and Table 6 (PCB congeners). Although the laboratory results are reported in the appendices in mg/l (milligrams-per-liter = parts-per-million), we converted to µg/l (micrograms-per-liter = parts-per-billion) in the text of this report and its tables. The use of µg/l is often more appropriate in presentations of water sampling results, since it is the concentration unit frequently used in ambient water quality criteria.

5.1.1 Trace Elements in Surface Water - Aluminum, boron, barium, beryllium, cadmium, iron magnesium, manganese, and strontium were detected in surface water. Arsenic, chromium, copper, mercury, molybdenum, nickel, lead, selenium, vanadium, and zinc were not detected. Aluminum was found in all six surface water samples. Concentrations of Al were highest in samples collected from the refuge interior locations of Buzzy Brook (130.8 µg/l @ BZB2) and Baker Brook (121.4 µg/l @ BB2). Boron was only detected in Baker Brook at the refuge boundary inlet (7.4 µg/l @ BB1) and in Sunkhaze Stream as it leaves the refuge (9.7 µg/l @ SS2). Barium concentrations were similar in the Sunkhaze Stream as it enters and leaves Sunkhaze Meadows NWR (3.2 and 3.5 µg/l). In Buzzy Brook, the Ba concentration was nearly twice as high outside of the refuge (5.2 µg/l @ BZB1) as inside the refuge (2.9 µg/l @ BZB2). Beryllium was detected in half the samples, one from each watercourse. Beryllium levels were 0.5 µg/l, 0.6 µg/l, and 0.7 µg/l in Buzzy Brook (BZB1), Baker Brook (BB1), and Sunkhaze Stream (SS2), respectively. Cadmium was detected in one sample from Baker Brook (BB1) and in one from Sunkhaze Stream (SS2), both at 0.6 µg/l. Iron levels were generally higher at collection locations along the periphery of the refuge. Levels of Fe ranged from 844.2 µg/l to 306.9 µg/l. **Magnesium** was also detected in all six water samples (range: 1,930.0 µg/l - 599.2 µg/l), as was **manganese** (range: 98.6 µg/l - 18.8 µg/l) and **strontium** (range: 46.9 µg/l - 17.5 µg/l).

5.1.2. Organochlorine Pesticides in Surface Water - OC pesticides were not detected in Sunkhaze Meadows NWR surface water samples.

5.1.3 Total PCBs and PCB Congeners in Surface Water - Total PCB concentrations were highest in surface water samples from Sunkhaze Stream, upstream from the Stud Mill Road bridge before the stream enters the refuge (SS1, 2.96 **:** g/l), and in Baker Brook inside the refuge (BB2, 2.86 µg/l). Based on congener-specific analytical results, PCBs were not detected in Buzzy Brook surface water samples.

Only one PCB congener, actually a co-elute (PCB #60/56), was detected in the upstream Baker Brook sample (BB1 @ 0.19 µg/l) and the Sunkhaze Stream sample as it leaves the refuge (SS2 @ 0.14 µg/l). In two other samples, many more PCB congeners were detected. In the refuge Baker Brook sample (BB2) and the Sunkhaze Stream sample as it enters the refuge (SS1), 13 and 8 PCB congeners were identified, respectively. The only non-*ortho* congener detected was PCB #15 (0.11 µg/l @ SS1). The di-*ortho* congener, PCB #138, was found in SS1 (0.26 µg/l) and BB2 (0.18 µg/l), while PCB #170 was only found at BB2 (0.31 µg/l).

5.2 SEDIMENTS

Sediments samples were analyzed for trace elements (Table 7), organochlorine pesticides and GPCBs (Table 8), PCB congeners (Table 9), organophosphate pesticides, dioxins, and furans, particle size, and Total Organic Carbon. Sediment results are expressed as dry weight (DW) concentrations. Except for dioxin, all concentrations are expressed in mg/kg (milligrams-per-kilogram = parts-per- million). Dioxins in sediment are expressed in ng/kg (nanogram-per-kilogram = parts-per-trillion).

5.2.1 Trace Elements in Sediment - Of the 19 trace elements included in the scan of 6 sediment samples, only boron (B) and mercury (Hg) were not detected in all samples.

Aluminum (Al) - Aluminum concentrations within the six sediment samples ranged from 4201 mg/kg to 9167 mg/kg, with the highest concentrations occurring in sediment samples collected from the interior of the refuge (BB2) and at the Sunkhaze Stream refuge outlet (SS2).

Arsenic (As) - Arsenic was not detected in Baker Brook sediments along the refuge perimeter, but the refuge interior sample (BB2) from this brook had a concentration of 1.24 mg/kg. The As concentration in Buzzy Brook sediments was twice as high within the refuge (BZB2 @ 1.80 mg/kg) as the location at the Stud Mill Road perimeter (BZB1 @ 0.86 mg/kg) where the brook enters the refuge. In Sunkhaze Stream sediments, As concentrations were similar at both sampling locations. Where the stream enters the refuge at the Stud Mill Road bridge, the As concentration was 0.95 mg/kg, while at SS2 where Sunkhaze Stream leaves the refuge the concentration was 1.09 mg/kg.

Barium (Ba) - In Baker and Buzzy Brooks, Ba concentrations were higher within the refuge (BB2 @ 30.50 mg/kg; BZB2 @ 30.92 mg/kg) than where the brooks enter the property (BB1 @ 27.04 mg/kg; BZB1 @ 20.31 mg/kg). The Ba level in Sunkhaze Stream sediments was slightly higher at the inlet to the refuge (SS1 @ 34.36 mg/kg) than at the outflow (SS2 @ 30.38 mg/kg).

Beryllium (Be) - The highest Be concentration was detected in the sediment sample from Buzzy Brook (BZB1 @ 0.73 mg/kg) near the Stud Mill Road. Concentrations, in decreasing order, in other sediment samples were 0.69 mg/kg (SS2), 0.50 mg/kg (BB1), 0.49 mg/kg (SS1), 0.47 mg/kg (BZB2) and 0.37 mg/kg (BB2).

Cadmium (Cd) - Cadmium was detected in 5 of the 6 sediment samples. The element was not detected in the refuge location of Baker Brook (BB2). In the upstream Baker Brook sample (BB1 @ 0.77 mg/kg), the up gradient Buzzy Brook sample (BZB1 @ 0.83 mg/kg), and the outflow of Sunkhaze Stream (SS2 @ 0.73 mg/kg), Cd concentrations in sediment were similar. Lower Cd concentrations were detected in Buzzy Brook, within the refuge (BZB2 @ 0.31 mg/kg), and in Sunkhaze Stream as it enters the refuge (SS1 @ 0.29 mg/kg).

Chromium (Cr) - Three sediment samples had similar Cr concentrations in the 30+ mg/kg range. Chromium in this range was found in both Baker Brook samples (BB1 @ 30.15 mg/kg, BB2 @ 34.39 mg/kg) and in the refuge Buzzy Brook sample (BZB2 @ 30.26 mg/kg). The remaining 3 sediment samples had considerably less Cr. In Sunkhaze Stream the Cr concentrations were 17.32 mg/kg (SS2) and 13.27 mg/kg (SS1), while in the up gradient Buzzy Brook sample the level was 7.52 mg/kg (BZB1).

Copper (Cu) - Copper was detected in two sediment samples, both from locations within the refuge. In Baker Brook (BB2) the Cu concentration was 17.53 mg/kg, while in Buzzy Brook (BZB2) the level was 7.06 mg/kg.

Iron (Fe) - Iron concentrations in sediment were higher on the refuge than in samples collected up gradient of the refuge perimeter. In Baker Brook, the refuge sample (BB2 @ 12,750 mg/kg) was more than twice as high in Fe as the off-refuge, up gradient sample (BB1 @ 5,950 mg/kg). In Buzzy Brook, Fe was more than three times higher outside of the refuge (3,153 mg/kg @ BZB1) than inside (11,260 @ BZB2). In Sunkhaze Stream, the Fe concentration in the up gradient sediment sample

(SS1@ 6,667 mg/kg) was nearly one-third less than the refuge sample (SS2 @ 9,354 mg/kg). Expressed as percentages of sediment, by weight, the most common presentation of Fe data, the levels were 0.59% @ BB1, 1.27% @ BB2, 0.32% @ BZB1, 1.13% @ BZB2, 0.67% @ SS1, and 0.94% @ SS2.

Magnesium (Mg) - Manganese concentrations in sediment ranged from 875 mg/kg to 2,966 mg/kg. Sediment samples collected in stream reaches up gradient of the refuge had consistently lower Mg concentrations than samples taken on the refuge. The Mg concentrations in sediment by watercourse were: Baker Brook 2,966 mg/kg (BB2) and 1,679 mg/kg (BB1), Buzzy Brook 2,646 mg/kg (BZB2) and 875 mg/kg (BZB1), Sunkhaze Stream 2,321 mg/kg (SS2) and 1,635 mg/kg (SS1).

Manganese (Mn) - Similar to Mg in sediment, Mn concentrations ranged widely from 75.27 mg/kg to 303.6 mg/kg. In Baker Brook and Buzzy Brook, the refuge locations (BB2 @ 290.6 mg/kg, BZB2 @ 303.6 mg/kg) had higher Mn concentrations than the up gradient collection locations (BB1 @ 149.7 mg/kg, BZB1 @ 75.27 mg/kg). In Sunkhaze Stream, the sample above the refuge (SS1) had a Mn concentration of 258.5 mg/kg, while the sample at the refuge outlet (SS2) had a level of 181.1 mg/kg.

Molybdenum (Mo) - Molybdenum was detected in only one of the six sediments samples. In the Sunkhaze Stream sediment sample before the stream exits the refuge (SS2), the Mo concentration was 5.16 mg/kg.

Nickel (Ni) - Nickel in sediment was detected in higher concentrations on the refuge than in up gradient areas. The highest concentrations were detected in the refuge samples from Baker Brook (16.59 mg/kg @ BB2), Buzzy Brook (15.46 mg/kg @ BZB2), and Sunkhaze Stream (13.54 mg/kg @ SS2). In the up gradient areas, the concentrations were 11.83 mg/kg (BB1), 9.56 mg/kg (SS1), and 7.35 mg/kg (BZB2).

Lead (Pb) - Lead concentrations were similar in the two Baker Brook sediment samples (13.58 mg/kg @ BB1, 13.61 mg/kg @ BB2). In Buzzy Brook and Sunkhaze Stream, sediments from up gradient areas (BZB1 @ 10.49 mg/kg, SS1 @ 9.00 mg/kg) had lower Pb concentrations than samples collected within the refuge (BZB2 @ 16.00 mg/kg, SS2 @ 15.25 mg/kg).

Selenium (Se) - Selenium was only detected in two sediment samples, both from locations outside of the refuge. In the upstream Baker Brook sediment sample (BB1), the Se concentration was 0.50 mg/kg, while in the upstream Sunkhaze Stream sample (SS1) the level was identical (0.50 mg/kg).

Strontium (Sr) - Strontium in sediment ranged from a low of 8.53 mg/kg (SS1) to a high of 16.24 mg/kg (BB1). On the refuge, strontium levels in sediment samples from the Baker Brook (BB2 @ 13.83 mg/kg) and Sunkhaze Stream (SS2 @ 13.35 mg/kg) were similar. In Buzzy Brook, the Sr concentrations were 10.99 mg/kg (BZB1) and 14.54 mg/kg (BZB2).

Vanadium (V) - Vanadium was consistently found in higher concentrations on the refuge than in up gradient sediment samples. The up gradient Baker Brook (BB1), Buzzy Brook (BZB1), and Sunkhaze Stream (SS1) vanadium concentrations were 9.43 mg/kg, 5.45 mg/kg, and 7.70 mg/kg, respectively. On the refuge, the sediment vanadium levels in each drainage were 13.15 mg/kg (BB2), 12.61 mg/kg (BZB2), and 11.36 mg/kg (SS2).

Zinc (Zn) - Zinc, like vanadium, was found in higher concentrations in sediments taken within the refuge than in up gradient areas. In Sunkhaze Stream, the difference in zinc concentrations between upgradient and refuge samples was less than the other two drainages within the survey. The Zn level in Sunkhaze Stream sediment above the Stud Mill Road bridge (SS1) was 33.04 mg/kg, while the concentration at the refuge outlet (SS2) was 35.99 mg/kg. Larger differences were observed in the Baker Brook and Buzzy Brook samples. The up gradient Baker Brook (BB1) sample had a Zn concentration of 28.97 mg/kg. Within the refuge (BB2), however, the Zn concentration in Baker Brook sediments rose to 48.27 mg/kg. In Buzzy Brook the up gradient sediment sample (18.89 mg/kg @ BZB1) concentration was one-half the concentration in the sample collected in the refuge interior (39.10 mg/kg @ BZB2).

5.2.2 Organophosphate Pesticides in Sediments - None of the 5 organophosphate pesticides included in the analytical scan were detected in any sediment samples.

5.2.3 Organochlorine Pesticides in Sediment - Except for a detection of **p,p'-DDD** in the upstream sample of Buzzy Brook (0.006 mg/kg), OC pesticides were not detected in sediments from Sunkhaze Stream or Buzzy Brook. In Baker Brook, however, over a dozen OC pesticides were detected in sediment. Most were found in concentrations at, or slightly above, the laboratory analytical detection limit. The OC pesticides that were detected clearly above detection limits in Baker Brook were ***beta* BHC** (BB2 @ 0.0155 mg/kg), ***p,p'*-DDD** in both samples (BB1 @ 0.0063 mg/kg, BB2 @ 0.0310 mg/kg), and ***p,p'*-DDE** in the refuge interior sample (BB2 @ 0.0155 mg/kg).

5.2.4 Total PCBs and PCB Congeners in Sediment - The highest ΣPCB concentration was found in the sediment sample collected from Baker Brook within the refuge (0.78 mg/kg @ BB2). Similar ΣPCB concentrations were found in samples taken from the up gradient Baker Brook (0.151 mg/kg @ BB1) and Buzzy Brook (0.203 mg/kg @ BZB1) locations. Of the six samples analyzed, the lowest ΣPCB concentrations were detected in Buzzy Brook within the refuge (BZB2 @ 0.024 mg/kg), and in both Sunkhaze Stream samples (SS1 @ 0.034 mg/kg, SS2 @ 0.029 mg/kg).

Twenty seven PCB congeners (4 with two or three co-eluting peaks) were detected in sediment samples. There was a uniform pattern of PCB congeners detected in up gradient and down gradient (i.e., refuge) sediment samples in Baker Brook and, to a slightly lesser extent, in Sunkhaze Stream. In Buzzy Brook, the PCB congener pattern (n = 20) in the up gradient sediment was clearly different than
the location within the refuge (n = 7). Non-*ortho* PCB congeners detected in sediment were PCB #126 and PCB #37 (co-eluted with PCB #42), while mono-*ortho* PCB congeners in sediment included PCB #105 and PCB #118 (co-eluted with PCB #108 and PCB #149). PCB#128, PCB #138, PCB #153, and PCB #180 were the only di-*ortho* congeners found in sediment samples.

5.2.5. Dioxins and Furans in Sediment - One dioxin compound, **octachlorodibenzo-*p*-dioxin** (OCDD), was detected in the Sunkhaze Stream sediment sample collected upgradient of the refuge, above the Stud Mill Road bridge, at a concentration of 0.00000314 mg/kg (parts-per-million). This concentration is more easily expressed as 3.14 ng/kg (parts-per-trillion).

5.2.6. Particle Size, and Total Organic Carbon - Particle size analyses measure the percentage of sand, silt, and clay in sediment samples. In general, the six sediment samples from three Sunkhaze Meadows NWR watercourses had similar texture characteristics. Sunkhaze Stream and Baker Brook sediments were sandy loams, and Buzzy Brook sediments were silt loams. Total Organic Carbon content ranged from 1.57% (SS2) to 3.47% (BB2).

5.3 FISH

Fish tissue samples were analyzed for trace elements (Table 10), organochlorine pesticides and total PCBs (Table 11), PCB congeners (Table 12), dioxins and furans, and lipid content. Dioxins and furans were not detected in fish samples. Fish tissue results are expressed as wet weight (WW) concentrations in µg/g (micrograms-per-gram = parts-per-million). In the fish tissue contaminant summaries, the use of BB and BZB denote the Sunkhaze Stream collection locations at the confluences with Baker Brook and Buzzy Brook. The Sunkhaze Stream fish collection locations at the confluences with Baker Brook and Buzzy Brook were approximately 4.8 km (2.9 mi) apart.

5.3.1. Trace Elements in Fish Tissue - Twelve of 19 trace elements included in the analytical scan were detected in fish tissue. Arsenic, boron, beryllium, cadmium, molybdenum, lead, and vanadium were not detected in fish tissue.

Aluminum (Al) - Aluminum levels in whole-body composite samples of chain pickerel were 14.45 µg/g (BB) and 20.94 µg/g (BZB), while the concentrations in yellow perch composite samples were 30.87 µg/g (BB) and 43.73 µg/g (BZB).

Barium (Ba) - The highest barium concentrations were found in the pickerel sample from the Sunkhaze Stream/Buzzy Brook confluence (0.70 µg/g) and the perch sample from the Sunkhaze Stream/Baker Brook confluence (0.56 µg/g). Conversely, lower barium concentrations were found in perch from Sunkhaze Stream/Buzzy Brook location (0.64 µg/g) and pickerel from Sunkhaze Stream/Baker Brook location (0.45 µg/g).

Chromium (Cr) - Chromium concentrations were particularly higher in yellow perch than in chain pickerel. The Cr concentrations in perch from Sunkhaze Stream/Buzzy Brook (13.20 µg/g) and Sunkhaze Stream/Baker Brook (10.59 µg/g) were several times higher than the pickerel Cr results. The Cr levels in Sunkhaze Stream pickerel collected near the confluences with Buzzy and Baker Brooks were 4.43 µg/g and 2.70 µg/g, respectively.

Copper (Cu) - Copper concentrations in fish tissue varied between species and collection location. In Sunkhaze Stream at Baker Brook, Cu was twice as high in yellow perch (1.61 µg/g) than in chain pickerel (0.82 µg/g), while in Sunkhaze Stream at Buzzy Brook the Cu concentration was higher in pickerel (3.14 µg/g) than in perch (1.94 µg/g).

Iron (Fe) - Iron was markedly higher in yellow perch samples (104.30 µg/g in BZB, 78.45 µg/g in BB) than in chain pickerel samples (41.44 µg/g in BZB, 19.47 µg/g in BB).

Mercury (Hg) - Mercury levels were higher in chain pickerel samples (0.89 µg/g BB, 0.59 µg/g BZB) than in yellow perch samples (0.31 µg/g BB, 0.22 µg/g BZB).

Magnesium (Mg) - Magnesium concentrations in fish tissue were relatively similar, ranging from 883.6 µg/g (pickerel BB) to 1,031.8 µg/g (perch BB).

Manganese (Mn) - Manganese was detected in all fish tissue samples with concentrations ranging from 5.33 µg/g (pickerel BB) to 20.35 µg/g (perch BZB).

Nickel (Ni) - Nickel was detected in three of four fish samples. In Sunkhaze Stream, Ni concentrations were higher in yellow perch (1.51 µg/g @ Baker Brook, 3.18 µg/g @ Buzzy Brook) than in pickerel (non-detect @ Baker Brook, 0.76 µg/g @ Buzzy Brook).

Selenium (Se) - Selenium concentrations were similar within species, with slightly higher levels occurring in yellow perch. In chain pickerel, Se was found at 0.21 µg/g (BB) and 0.16 µg/g (BZB), while in perch the levels were 0.36 µg/g (BB) and 0.32 µg/g (BZB).

Strontium (Sr) - Strontium was twice as high in the chain pickerel sample collected at the confluence with Buzzy Brook (20.31 µg/g) and lowest in the pickerel sample taken at the Baker Brook confluence (10.90 µg/g). In yellow perch composite samples, Sr was similar between locations with a slightly higher concentration found at the Sunkhaze Stream/Baker Brook confluence (17.97 µg/g) than at the confluence with Buzzy Brook (15.94 µg/g).

Zinc (Zn) - Zinc was considerably higher in the chain pickerel sample from the Sunkhaze Stream/Buzzy Brook confluence (79.51 µg/g) than in the pickerel sample from the outlet of Baker Brook (49.85 µg/g), or in either yellow perch sample (25.24 µg/g @ BB, 24.61 µg/g @ BZB).

5.3.2. Organochlorine Pesticides in Fish Tissue - Overall, organochlorine pesticides were rarely detected in fish tissue from Sunkhaze Meadows NWR. Only dieldrin (0.0023 µg/g) and one DDT metabolite, *p,p*'-DDE (0.0072 µg/g), were detected in one Sunkhaze Stream/Buzzy Brook yellow perch sample.

5.3.3. Total PCBs and PCB Congeners in Fish Tissue - ΣPCB concentrations in fish samples from the Sunkhaze Stream/Baker Brook confluence were 0.0036 µg/g in chain pickerel and non-detect in yellow perch, while at the Sunkhaze Stream/Buzzy Brook confluence ΣPCB concentrations were 0.0085 µg/g in chain pickerel and 0.0073 µg/g in yellow perch. Only three PCB congeners were detected in fish tissue: PCB #44, PCB #170, and PCB #172.

5.3.4. Dioxins and Furans in Fish Tissue - None of the 17 dioxin or furan compounds included in the scan were detected in chain pickerel tissue samples from Sunkhaze Meadows NWR. The method detection limit, however, was only 1 pg/g.

5.3.5. Lipid Content - Percent lipid was measured in each composite fish sample. The highest lipid content was found in the yellow perch composite sample from the Baker Brook/Sunkhaze Stream confluence (6.93 %), followed by the chain pickerel composite samples from the Buzzy Brook/Sunkhaze Stream (5.80 %) and Baker Brook/Sunkhaze Stream (1.57 %) confluences. The lipid content in the yellow perch composite sample from the Buzzy Brook/Sunkhaze Stream confluence was only 0.35 % and appears to be an analytical error.

5.4 QUALITY CONTROL

Quality control was accomplished through instrument calibration verification, replicate analyses, spike recoveries, and the analysis of standard reference material. Quality control results for the Sunkhaze Meadows NWR samples are considered within the acceptable limits of the PACF.

6. DISCUSSION

The primary purpose of this screening level survey was to determine if there were elevated contaminant levels in surface water, sediment, or fish at the Sunkhaze Meadows NWR. The two watercourses, Buzzy Brook and Baker Brook, in this survey were sampled because they were closest to potential contaminant source areas (i.e., the landfills) near the refuge. Sunkhaze Stream was selected because it is the major watercourse of the refuge.

6.1 Surface Water - Of 19 trace elements included in the analytical scan, only aluminum, boron, barium, beryllium, cadmium, iron magnesium, manganese, and strontium were detected in surface water. Arsenic, chromium, copper, mercury, molybdenum, nickel, lead, selenium, vanadium, and zinc were <u>not</u> detected. For organochlorines pesticides, none of the 22 compounds included in the scan were detected. PCBs, however, were detected in surface water. In four of six samples, 17 PCB congeners (15 with two having co-eluting peaks) were detected in surface water.

Surface water results from Sunkhaze Meadows NWR are compared to the freshwater Criteria Maximum Concentration (CMC) and Criteria Continuous Concentration (CCC) in the National Recommended Water Quality Criteria for Priority Toxic Pollutants and Non-Priority Pollutants (EPA 1999) or to Maximum Contaminant Limits (MCLs) listed in the Safe Drinking Water Act of 1974.

In the National Water Quality Criteria, the CMC is an estimate of the highest concentration of a contaminant in surface water to which an aquatic community can be exposed *briefly* without resulting in an unacceptable effect, while the CCC is an estimate of the contaminant concentration to which an aquatic community can be exposed *indefinitely* without resulting in an unacceptable effect (EPA 1999). Of the nine trace elements detected in surface water samples, CMC or CCC values are promulgated only for aluminum, cadmium, and iron. A revised CCC value for PCBs has been proposed by EPA (EPA 1999).

In the Safe Drinking Water Act, MCLs are the highest amount of a contaminant allowed in drinking water. These limits are human-health based and not protective of ecological receptors, but they offer data points for comparison. Of the nine trace elements detected in surface water samples, there are MCL standards only for barium, beryllium, and cadmium.

Water samples collected in this refuge screening survey were unfiltered and particulate matter within the samples may explain elevated levels of some contaminant concentrations. Fish and wildlife within the refuge would encounter the same water and the use of unfiltered samples reflects ambient conditions for these ecological receptors. Due to equipment problems, pH and hardness were not measured during surface water sampling. Contaminants in surface water may be more toxic in acidic or hard water. The unavailability of pH and hardness information adds elements of uncertainty to the refuge surface water data.

Aluminum (Al) in Water - Aluminum is a non-priority pollutant in surface water. Charged forms of Al (e.g., Al^{3+}) can be particularly harmful to fish and wildlife under low pH (i.e., acidic) conditions. The recommended pH-dependent water quality criteria for Al are 750 µg/l (CMC) and 87 µg/l (CCC). Aluminum was detected (mean 110.7 µg/l, range: 87.1 - 130.8 µg/l) in all Sunkhaze Meadows NWR surface water samples at concentrations above the CCC. Concentrations of Al were highest in samples collected from the refuge interior locations of Buzzy Brook (130.8 µg/l @ BZB2) and Baker Brook (121.4 µg/l @ BB2). Most of this Al is presumed to be organic-bound and non-toxic (T. Haines. 1999. Personal communication). Although the refuge Al levels are higher than the CCC, footnotes in the water quality criteria for Al recognize that many high quality waters in the U.S. contain more than 87 µg/l. Consequently, total Al levels in refuge surface waters may not be a major concern, particularly since the waters do not appear to be highly acidic. Total Al at these levels in surface water are not unusual in northern Maine, particularly for highly-colored, organic waters like those found on the refuge (T. Haines. 1999. Personal communication).

Boron (B) in Water - Boron is an essential trace element for crops and species of fungi, bacteria, and algae (Eisler 1990). In freshwater systems, boron concentrations are typically less than 100 µg/l and rarely exceed 1,000 µg/l (USDOI 1998). Boron concentrations of 1,300 µg/l, 25,000 µg/l, and 200,000 µg/l in surface water are toxic to aquatic invertebrates, fish, and amphibians, respectively (USDOI 1998). Eisler (1990) suggested a boron criterion of < 1,000 µg/l for the protection of sensitive species of aquatic life. At Sunkhaze Meadows NWR, boron was detected in only two water samples at concentrations of 7.4 µg/l (Baker Brook, BB1) and 9.7 µg/l (Sunkhaze Stream, SS2). These detections are well below the protection criterion suggested by Eisler (1990).

Barium (Ba) in Water - Barium is a common earth metal. Barium combined with water or other chemicals such as sulfur or carbon produces salts and other compounds that are used by industry (ATSDR 1995). The U.S. Maximum Contaminant Level (MCL) for Ba in drinking water is 2,000 µg/l (40 CFR §141.62). Some states and Canadian provinces have much lower MCLs for Ba (e.g., Florida and British Columbia 1,000 µg/l). There is no ambient water quality criteria for Ba. Soluble Ba at concentrations in excess of 50,000 µg/l may be a toxic to aquatic life, however insoluble salts ($BaSO_4$, $BaCO_3$) are more likely to occur in the environment than soluble Ba salts (Flora *et al.* 1984).

Barium levels found in surface water from Sunkhaze Meadows NWR (mean 3.42 µg/l, range: 1.8 - 5.1 µg/l) are well below the MCL. Barium concentrations were similar in Sunkhaze Stream as it enters and leaves Sunkhaze Meadows NWR (3.2 and 3.5 µg/l). In Buzzy Brook, the Ba concentration was nearly twice as high at the perimeter of the refuge (5.2 µg/l @ BZB1) than inside the refuge (2.9 µg/l @ BZB2). Although Ba will accumulate in fish and other aquatic organisms (ATSDR 1995), the element is not usually considered a significant ecological threat in New England.

Beryllium (Be) in Water - Beryllium in surface water is similar to aluminum in that it is most toxic to fish under acidic conditions (Jagoe *et al.* 1993). Matey *et al.* (1996) found Be toxic to fish at concentrations exceeding 50 µg/l regardless of pH. In the same study, chronic exposure to Be at concentrations of 6.25 µg/l caused gill abnormalities in yellow perch (Matey *et al.* 1996). At Sunkhaze Meadows NWR, Be was detected in three of six surface water samples at concentrations of

0.5 µg/l (Buzzy Brook, BZB1), 0.6 µg/l (Baker Brook, BB1), and 0.7 µg/l (Sunkhaze Stream, SS2). Concentrations of Be in natural waters typically range from 0.001 - 1 µg/l (Malina 1996). The refuge data, when compared to toxicity values and the general range, suggest that levels are not elevated and acute or chronic toxicity to aquatic organisms from Be in surface water is unlikely.

Cadmium (Cd) in Water - Cadmium is a toxic element with no recognized biological benefits. It is a known teratogen, carcinogen and probable mutagen that has been implicated as the cause of severe deleterious effects on fish and wildlife (Eisler 1985). Concentrations of 0.8 to 9.9 µg Cd/l in freshwater were lethal to several species of aquatic insects, crustaceans, and fish, while concentrations of 0.70 to 570 µg/l were associated with sublethal effects such as decreased growth, inhibited reproduction, and population alterations (Eisler 1985). At Sunkhaze Meadows NWR, Cd was not detected in 4 of 6 surface water samples. Cadmium was detected in one sample from Baker Brook (BB1) and in one from Sunkhaze Stream (SS2), both at 0.6 µg/l. Based on the frequency of detection and low concentrations in surface water, we would not expect Cd to be a significant threat to fishery resources.

Iron (Fe) in Water - Iron is a common contaminant in surface water. Depending on the amount, water hardness and acidity, Fe in surface water generally occurs in three forms: ferrous iron (Fe^{++}), ferric iron (Fe^{+++}), and as iron bacteria (Jemison 1994). The recommended CCC for Fe is 1000 µg/l (EPA 1999). Lower Fe levels than the CCC were found on the refuge with concentrations ranging from 844.2 µg/l to 306.9 µg/l (mean 510.98 µg/l). The Fe levels in surface water were generally higher at collection locations along the periphery of the refuge than in the interior. Compared to the CCC (EPA 1999), the Fe levels in water from Sunkhaze Meadows NWR do not appear to be highly elevated.

Magnesium (Mg) in Water - Magnesium was detected in all six water samples from the refuge and its perimeter (mean 1126.1 µg/l, range: 599.2 µ/l - 1,930.0 µg/l). The typical concentration of the free ion Mg^{+2} in water is 4,100 µg/l (Malina 1996). Magnesium is generally not an ecological contaminant of concern. In fact, deficiencies of Mg likely have a greater negative impact on biota than higher doses (Aikawa 1991). The levels of Mg in water from Sunkhaze Meadows NWR do not appear to be highly elevated.

Manganese (Mn) in Water - Manganese is a common essential element. Under the Clean Water Act, Mn is considered a non-priority pollutant. Criteria have been developed for the protection of human health (consumption of water + organisms 50 µg/l, consumption of organisms only 100 µg/l; EPA 1999), but criteria have not been promulgated for the protection of aquatic biota. Total Mn in freshwater is highly variable with concentrations ranging from 2 µg/l to 4,000 µg/l (Moore 1991). Manganese concentrations in surface water samples from Sunkhaze Meadows NWR ranged from 18.8 µg/l - 98.6 µg/l (mean 43.53 µg/l).

Strontium (Sr) in Water - Strontium is a natural, alkaline earth metal with chemical properties similar to calcium. Strontium has 4 stable isotopes (^{84}Sr, ^{86}Sr, ^{87}Sr, ^{88}Sr) and 12 unstable isotopes (e.g., ^{90}Sr associated with nuclear fallout). The Sr level in sea water is approximately 8,000 µg/l , while concentrations in stream water may range from 20 - 40 µg/l (Åberg 1995). The mean Sr level in surface water from Sunkhaze Meadows NWR was 36.37 µg/l (range: 17.5 µg/l - 46.9 µg/l). The refuge Sr levels in surface water are within the range reported by Åberg (1995).

Polychlorinated Biphenyls (PCBs) in Water - Of the organochlorines included in the PACF analytical catalog, PCB was the only OC contaminant detected in surface water samples from Sunkhaze Meadows NWR. PCBs were detected in the surface water samples collected from Baker Brook and Sunkhaze Stream. The levels in these two watercourses (range: 0.139 µg/l - 2.965 µg/l) were highly elevated compared to the recommended CCC for PCBs of 0.014 µg/l (EPA 1999). Typically, PCBs are difficult to detect in surface water samples. PCB detections in surface water are often linked to particulate matter within unfiltered samples - the type of samples collected during the refuge screening survey.

6.2 Sediments - Trace elements detected in six Sunkhaze Meadows NWR sediment samples include aluminum, arsenic, barium, beryllium, cadmium, chromium, copper, iron, magnesium, manganese, molybdenum, nickel, lead, selenium, strontium, vanadium, and zinc (Table 7). Boron and mercury were not detected in sediment. Organochlorine contaminants detected in sediment samples were trace amounts of 14 pesticides and total PCBs (Table 8; PCB congeners in Table 9) and dioxin. Organophosphate contaminants were not detected in refuge sediments.

Not all contaminants are always bioavailable to fish and wildlife, or occur at concentrations that may pose a significant threat to fish and wildlife. Typically, aluminum, barium, beryllium, magnesium, molybdenum, strontium, and vanadium in sediment are not ecological contaminants of concern in New England. The other trace elements, however, can be harmful to fish and wildlife. Brief notes on the concentrations found on the refuge and the potential for effects are discussed below. PCBs and dioxin are highly lipophilic contaminants that bioaccumulate in fish and wildlife and biomagnify through food chains. Consequently, even at small concentrations, these organochlorine contaminants can pose a hazard to fish and wildlife. The sediment concentrations of PCBs and dioxin are also discussed.

There are no nationally-accepted sediment effects criteria in the United States. Sediment sampling results from Sunkhaze Meadows NWR are compared to U.S. national or Canadian provincial guidelines and to biological effect concentrations (Persaud and Jaagumagi 1993, Long and Morgan 1992, Ingersoll *et al.* 1996, MacDonald *et al.* 2000). Basically, these guidelines or effect concentrations summarize the results of numerous toxicity tests with sediment-dwelling organisms from several regions of the continent. Guidelines or effect concentrations are not available for all sediment contaminants. Most of the ecologically-harmful contaminants have a proposed guideline.

Sediment quality guidelines are based on the potential for effects on sediment organisms. In Ingersoll *et al.* (1996), two sediment effect ranges are suggested: Effect Range - Low (ER-L), the 15th percentile, and Effect Range-Median (ER-M), the 50th percentile. As defined by Long and Morgan (1992), an ER-L is the concentration of a chemical in sediment below which adverse effects are rarely observed or predicted among sensitive species. An ER-M is the concentration of a chemical in sediment above which effects are frequently or always observed or predicted among most species. In Persaud and Jaagumagi (1993), three effect levels are proposed: No Effect Level (NEL), Lowest Effect Level (LEL) and Severe Effect Level (SEL). Sediments with contaminants that between the NEL and LEL are clean to marginally polluted. Sediment contaminant concentrations between the LEL and SEL, suggest marginally to significantly polluted sediments, while concentrations that exceed the SEL would be considered grossly polluted. In MacDonald *et al.* (2000), two effect concentrations are proposed: the Threshold Effect Concentration (TEC) and Probable Effect Concentration (PEC). The TEC is the concentration below which harmful effects are unlikely to be observed, while the PEC is the concentration above which harmful effects are likely to be observed. Sediment concentrations from Sunkhaze Meadows NWR are compared to the guidelines and effect concentrations listed above. The most current freshwater sediment effect concentration was used in most cases (e.g., MacDonald *et al.* 2000). However, if MacDonald *et al*. (2000) did not develop an effect concentration for a particular contaminant, the refuge value was compared to another guideline value (i.e., Ingersoll *et al.* 1996, Persaud and Jaagumagi 1993, Long and Morgan 1992).

Aluminum (Al) in Sediment - Low levels of Al were detected in refuge sediments (range: 4,201 - 8,167 mg/kg). The ER-L and ER-M for Al are 14,000 mg/kg and 58,000 mg/kg, respectively (Ingersoll *et al.* 1996), so Al in refuge sediment samples should not pose a great risk to refuge animals.

Arsenic (As) in Sediment - Arsenic, like Al, was not found in high concentrations compared to sediment effect concentrations or published guidelines. The range of As sediment concentrations on the refuge was non-detect to 1.80 mg/kg. The arsenic TEC and PEC suggested by MacDonald *et al*. (2000) of 9.79 and 33.0 mg/kg, respectively, are considerably higher than the levels found on the refuge. Consequently, the potential threat to sediment-dwelling organisms from As contamination should be low.

Cadmium (Cd) in Sediment - Cadmium was found in five of six refuge sediment samples (detectable range: 0.29 - 0.83 mg/kg). These levels are low compared to the Cd TEC (0.99 mg/kg) and PEC (4.98 mg/kg, MacDonald *et al.* 2000). Hence, minimal impact is expected to sediment biota from Cd.

Chromium (Cr) in Sediment - Chromium was detected in all sediment samples with concentrations ranging from 7.52 mg/g to 34.39 mg/kg. The TEC and PEC for Cr are 43.4 mg/kg and 111 mg/kg, respectively (MacDonald *et al.* 2000). Based on this comparison, Cr does not appear to be a contaminant of concern to sediment biota. Yellow perch analytical results, however, suggest Cr may be a potential problem in some fish species occurring on the refuge. The Cr fish tissue results are discussed in greater detail in Section 6.3.1.

Copper (Cu) in Sediment - Copper was detected in only two of six sediment samples, both from locations within the refuge. One sample in Baker Brook contained 17.53 mg Cu/kg, while a sample in Buzzy Brook contained 7.06 mg Cu/kg. The TEC for Cu is 31.6 mg/kg (MacDonald *et al.* 2000). Neither refuge sample was close to this lower guideline, indicating that Cu contamination in sediment is low at Sunkhaze Meadows NWR.

Iron (Fe) in Sediment - Iron was found in all sediment samples. Higher concentrations of Fe were found in the outlet samples of Baker Brook and Buzzy Brook (i.e., the interior of the refuge), than in sediment samples collected at the refuge perimeter. During the screening survey, Fe levels in sediment ranged from 0.32% to 1.27%. Sediment quality guidelines for this element vary. The ER-L and ER-M for Fe are 20% and 28%, respectively (Ingersoll *et al.* 1996), while the LEL and SEL are 2% and 4%, respectively (Persaud and Jaagumagi 1993). Whichever guideline is applied, the refuge concentrations of Fe in sediment are well below probable effect concentrations.

Manganese (Mn) in Sediment - Low levels of Mn were found in sediment during sampling. The highest concentration (303.60 mg/kg) was found at the outlet of Buzzy Brook, while the lowest level

(75.27 mg/kg) was found in Buzzy Brook near the refuge perimeter. The ER-L and ER-L for Mn are 730 mg/kg and 1,700 mg/kg, respectively (Ingersoll *et al.* 1996). All refuge sediment samples were well below the ER-L.

Nickel (Ni) in Sediment - Nickel was found in all six sediment samples (mean 12.29 mg/kg; range: 7.36 - 16.59 mg/kg). In general, Ni in sediment was detected in higher concentrations on the refuge than in up gradient areas. The TEC for Ni in sediment is 22.7 mg/kg, while the PEC is 48.6 mg/kg (MacDonald *et al.* 2000).

Lead (Pb) in Sediment - A Pb level below 35.8 mg/kg (i.e., TEC) is unlikely to cause harmful effects to sediment biota, while a concentration above 128 mg/kg is probably harmful to most sediment biota (i.e., PEC; MacDonald *et al.* 2000). Levels of Pb in sediment samples from the interior of the refuge and the perimeter ranged from 9.00 to 16.00 mg/kg. Compared to the TEC, these sediment levels on the refuge should not pose a hazard to sediment-dwelling biota.

Zinc (Zn) in Sediment - Zinc concentrations in sediment from Sunkhaze Meadows NWR were well below sediment effect guidelines. The highest Zn concentration of the six sediment samples was 48.27 mg/kg. This concentration is 2.5 times lower than the TEC (121 mg/kg) and nearly 10 times lower than the PEC (459 mg/kg; MacDonald *et al.* 2000).

Polychlorinated biphenyls (PCBs) in Sediment - Compared to published sediment effect guidelines, sediments in three samples are enriched with PCBs. The TEC and PEC for ΣPCBs in sediment are 0.06 mg/kg and 0.68 mg/kg, respectively (MacDonald *et al.* 2000). Both sediment samples from Baker Brook were contaminated with PCBs (0.15 mg/kg @ BB1, 0.78 mg/kg @ BB2). The Baker Brook sample collected within the refuge exceeded the PEC for GPCBs, suggesting that harmful effects in benthic biota are likely to be observed. The upstream sediment sample collected in Buzzy Brook, BZB1, (0.20 mg PCB/kg) was also elevated, but the level was between the TEC and PEC. Concentrations between these two guidelines suggest harmful effects to sediment biota may occur. The concentrations of ΣPCBs in sediment samples from Buzzy Brook (0.02 mg/kg) near the confluence with Sunkhaze Stream and in samples from Sunkhaze Stream (0.03 mg/kg in both) were not highly elevated.

Of the 27 PCB congeners detected in Baker Brook sediment samples, 26 were detected in both the upstream and refuge locations. This pattern of PCB congeners indicates that the composition of PCBs accumulating in Baker Brook sediments is similar. If the refuge sample, below the former Milford Municipal Landfill, had a different distribution of congeners than the upstream sediment sample, then the landfill could have been implicated as a contaminant source. However, the congener pattern is similar, suggesting the PCB contamination originates from an upstream source.

Dioxin in Sediment - Only one dioxin compound, octachlorodibenzo-*p*-dioxin (OCDD), was detected in a sediment sample. The sample (SS1) was collected above the Stud Mill Road bridge before Sunkhaze Stream enters the refuge. The sediment concentration, 3.14 ng/kg, was not highly elevated and should not present a significant risk to fish, mammals, or birds (Cook *et al.* 1993). For birds, fish, and mammals, (Van den Berg *et al.* 1998), the toxicity of OCDD is ten-thousand times less than the most toxic dioxin compound, 2,3,7,8-TCDD (i.e, toxic equivalency factor of 0.0001).

Grain Size and TOC - In addition to environmental contaminants, particle size and Total Organic Carbon (TOC) were measured in sediment. Grain size and contaminant concentrations are strongly correlated. Fine sediments with small particle sizes (e.g., clays and silts) generally exhibit higher contaminant concentrations (Horowitz 1991) than coarser sediments. Collections on the refuge were biased towards depositional areas containing fine sediments, so the maximum contaminant concentrations could be determined. Fine sediments dominated by silts and clays, however, were not found on the refuge or along the perimeter. Sediments from Baker Brook and Sunkhaze Stream were sandy loams, while sediments from Buzzy Brook were a less coarse, silt loam.

Total organic carbon (TOC) is strongly correlated to sediment grain size and has a role in the bioavailability of environmental contaminants (Horowitz 1991). TOC in sediment generally runs from a low of 1% to a high of 10%. Samples with high percentages (-7 to 10%) of TOC reflect depositional areas comprised of silts and clays and infused with organic material. Sediment samples collected from the refuge and along its perimeter had TOC levels ranging from 1.75 % to 3.47%. These levels of TOC are not unusual or extremely low, and should be considered adequate for reflecting existing contaminant concentrations.

6.3 Fish - Fish tissue data (µg/g, wet weight) are compared with values reported from national, regional, or state sources, or with levels reported in the scientific literature. For most organochlorine and trace elements, Sunkhaze Meadows NWR results are compared to national mean levels reported in the U.S. Fish and Wildlife Service's National Contaminant Biomonitoring Program (NCBP, Schmitt and Brumbaugh 1990, Schmitt *et al.* 1990). The NCBP tracks temporal and geographic trends in contaminant concentrations in composite samples of whole fish collected from 112 riverine stations throughout the United States. The latest results of the NCBP include fish collected in 1984. We recognize the limitations associated with the NCBP data sets, but find it useful in placing contaminant concentrations in a national context.

Trace element results are also compared against results reported in EPA's Environmental Monitoring and Assessment Program (EMAP). The EMAP whole fish results for 167 lakes in the northeastern portion of the United States (New England states, New York, New Jersey) were recently reported by Yeardley *et al.* (1998). In the northeastern EMAP, between 1992 and 1994, six species of warm-water fish (e.g., largemouth bass, yellow perch) and 5 species of cold- water fish (e.g., brook trout, brown trout) were collected throughout the region and analyzed for 11 trace elements.

Other regional sources used for comparative purposes included fish tissue contaminant residue data from Massachusetts, Connecticut, and New Hampshire (USFWS, unpublished data; Mierzykowski *et al.* 1997a). State data sets that were used include mercury results reported by Stafford (1994), studies reported in the scientific literature (Friant 1979, Haines 1983), and tissue investigations by the Maine Department of Environmental Protection (DiFranco *et al.* 1995, Sowles *et al.* 1996) and the USFWS (Mierzykowski *et al.* 1997b, Mierzykowski *et al.* 1998).

Contaminant concentrations in fish from highly contaminated sites reported in the scientific literature are used to illustrate highly elevated values. Contaminant concentrations reported on a dry weight basis in any of these sources were converted to wet weight based on 75% moisture. The values reported in these various studies include many different species and sizes, fillet and whole-body concentrations, and fish collected from contaminated and uncontaminated sites. Overall, these different data sets are presented only for comparative purposes. For example, the geometric mean and 85th percentile concentrations reported in the NCBP have no regulatory significance or meaning with respect to potential hazard to fishery resources (May and McKinney 1981). They serve as reference points to distinguish elevated contaminant concentrations in fish. Our compilation of concentrations from regional, state, and literature sources should be similarly viewed.

6.3.1. Trace Elements - Trace elements detected in fish tissue from Sunkhaze Meadows NWR included aluminum, barium, chromium, copper, iron, mercury, magnesium, manganese, nickel, selenium, strontium, and zinc. Compared to state, regional, and national data, Sunkhaze Stream fish tissue contain elevated concentrations of aluminum, chromium, copper, iron, mercury, nickel, and zinc. Aluminum, barium, iron, magnesium, manganese, and strontium are generally not contaminants of concern in fish tissue in New England and will not be discussed in this report.

Chromium (Cr) in Fish - Trivalent Cr is an essential trace element for vertebrates. The hexavalent form of Cr, however, may cause adverse effects in the liver and kidney, and could also be a carcinogen (FDA 1993b, Environment Canada and Health Canada 1994). In the laboratory, Cr is a mutagen, carcinogen, and teratogen to several organisms (Eisler 1986b). Chromium bioaccumulates in fish gills, liver, and kidneys (Holdway 1988). In heavily contaminated areas, aquatic biota may accumulate high levels of Cr. Freshwater snails from the Sebasticook River in central Maine contained 22 to 440 µg Cr/g, dry weight (Duval *et al*. 1980).

The EMAP (Yeardley *et al*. 1998) mean total Cr concentration for fish in 105 northeastern U.S. lakes is 0.19 µg/g (range: 0.03 - 1.46 µg/g). To put the Sunkhaze Meadows NWR results into context, total chromium levels in fish reported in the scientific literature and field studies are also presented for comparative purposes. Average Cr concentrations in freshwater fish muscle may be less than 0.25 µg/g (Moore and Ramamoorthy 1984b). Levels of Cr in fish from 14 Ontario lakes averaged 0.23 µg/g, with a range of 0.19 to 0.27 µg/g (Johnson 1987). In Maine (Sowles *et al*. 1996), Cr in whole-body fish of several species from 35 locations ranged from 0.04 to 0.84 µg/g. In the Sudbury River system of Massachusetts, Cr levels in whole-body yellow perch ranged from 0.68 to 1.57 µg/g (Haines *et al*. 1997). In a Nashua River study at the Fort Devens Superfund Site in Massachusetts (Mierzykowski *et al*. 1997a), whole-body composite samples of yellow perch from the Nashua River had a mean Cr concentration of 13.51 µg/g (range: 0.89 µg/g - 44.63 µg/g).

Chromium concentrations detected in chain pickerel (mean 3.56 µg/g) and yellow perch (mean 11.89 µg/g) from Sunkhaze Stream are elevated compared to Maine, regional, and national data sets. The higher levels in perch rather than pickerel are not unusual. Perch move and forage widely, feeding on bottom organisms and ingesting sediment. Mathis and Cummings (1973) reported that omnivorous fish such as perch generally have higher Cr concentrations than carnivores (e.g., bass or pickerel). The source of Cr contamination in fish at Sunkhaze Meadows NWR is not known. In other refuge samples, Cr was not detected in elevated concentrations in surface water or sediment. QA/QC results do not indicate any problems in the fish Cr analyses; spike recoveries, duplicated analyses, and certified reference material analyses were within the acceptable range. It is not known if the Cr levels in perch and pickerel reflect contaminated sediment or prey that was accumulated from some other location on the refuge or from some location off the refuge

Chromium does not biomagnify in food chains and lower trophic levels in aquatic systems usually have higher Cr levels than fish (Friant 1979, Holdway 1988). Considering the elevated Cr levels in perch, it is possible that macroinvertebrates in the vicinity of the Cr source may have considerably higher concentrations of Cr. The impact of elevated Cr tissue levels to fish is not known. Similarly, an Action Level for Cr in fish tissue to protect human health has not been promulgated. For shellfish consumers, the FDA (1993) calculated a Cr level of concern of 13 µg/g - a level similar to the maximum Cr level in perch (13.20 µg/g) from Sunkhaze Meadows NWR.

Copper (Cu) in Fish - Copper is an essential element for vertebrates, and commonly found in fish tissue. Early life stages of salmonids are susceptible to waterborne Cu and teratogenic effects including lordosis, soliosis, kyphosis, and rigid coiling of the vertebral column (Birge and Black 1979) may result from exposure. Freshwater fish can regulate Cu over a wide range of concentrations, but will accumulate copper in excess of nutritional requirements if continually exposed to the element (Leland and Kuwabara 1985).

Moore and Ramamoorthy (1984b) suggested that even in polluted waters, fish muscle tissue concentrations seldom exceed 1 µg Cu/g. They also surmised that contaminated food is probably a more important source of copper than water. Copper concentrations in fish are usually higher in liver than other tissue, higher in fish from Cu-contaminated lakes than reference lakes, and higher in small fish than large fish of the same species (Eisler 1997). In New England, Cu concentrations above 1 µg/g in whole-body samples of fish are not unusual. In a study of Connecticut estuaries, Cu concentrations in white perch ranged from 1.5 µg/g to 55 µg/g (USFWS, unpublished data). Copper concentrations in yellow perch from the Sudbury River of Massachusetts (Eaton and Carr 1991) ranged from 0.30 µg/g to 29.5 µg/g (mean 4.87 µg/g). In a brook trout study at the U.S. Naval Air Station in Brunswick, Maine, the mean Cu level in adult fish was 1.77 µg/g (Mierzykowski *et al.* 1997b).

The NCBP (Schmitt and Brumbaugh 1990) geometric mean Cu concentration is 0.65 µg/g, the 85th percentile is 1.0 µg/g, and the maximum is 23.1 µg/g. The EMAP (Yeardley *et al.* 1998) mean Cu concentration for fish in 167 northeastern U.S. lakes is 0.89 µg/g (range: 0.06 - 21.84 µg/g). The mean levels of Cu in Sunkhaze Meadows NWR pickerel and perch are 1.98 µg/g and 1.77 µg/g, respectively. Copper concentrations in fish tissue collected at the refuge varied between species and collection location. In lower Sunkhaze Stream, at the confluence with Baker Brook, Cu was twice as high in yellow perch (1.61 µg/g) than chain pickerel (0.82 µg/g), while in upper Sunkhaze Stream, at the confluence with Buzzy Brook, the Cu concentration was higher in pickerel (3.14 µg/g) than in perch (1.94 µg/g). These Cu levels in pickerel and perch from the refuge exceed the NCBP and EMAP means, but are well below the maximums recorded in both programs and similar to mean concentrations reported in other New England fish studies.

Mercury (Hg) in Fish - Mercury is a mutagen, teratogen, and carcinogen which bioconcentrates in organisms and biomagnifies through food chains (Eisler 1987). Upper trophic level, long-lived, piscivorous fish species, such as bass and pickerel (Stafford and Haines 1997) or species at the top of extended food chains (Cabana *et al.* 1994), typically have higher Hg concentrations than lower trophic species (Akielaszek and Haines 1981). Methylmercury, an organic form of mercury, is a potent neurotoxin that accounts for over 95% of the total Hg in adult fish tissue (Grieb *et al.* 1990). Mercury accumulates in the axial muscle tissue (i.e., fillet) of fish (Schmitt and Finger 1987). Whole-body concentrations of 1-5 µg Hg/g may have chronic effects in trout, while concentrations of 10-20 µg/g could be lethal (Niimi and Kissoon 1994). Piscivorous birds and mammals are also at risk from Hg in fish tissue. Barr (1986) reported that loons feeding on fish with Hg concentrations of 0.30 to 0.40 µg/g appeared to have impaired reproduction. Mercury can be lethal to mink at dietary concentrations of 1.1 µg/g (Kucera 1983) and to river otter (*Lutra canadensis*) at dietary concentrations above 2 µg/g (O'Connor and Nielsen 1980).

The NCBP (Schmitt and Brumbaugh 1990) geometric mean Hg concentration is 0.10 µg/g and the 85th percentile is 0.37 µg/g. The EMAP (Yeardley *et al.* 1998) mean Hg (reported as MeHg, methylmercury) concentration for fish in 167 northeastern U.S. lakes is 0.18 µg/g (range: 0.01 - 2.93 µg/g). In a study of 120 randomly selected Maine lakes, the mean Hg level in chain pickerel was 0.88 µg/g (range: 0.58 - 1.22 µg/g), while in yellow perch the mean was 0.28 µg/g (range: 0.18 - 0.81 µg/g; Stafford and Haines 1997). The mean Hg levels in Sunkhaze Meadows NWR pickerel and perch are 0.74 µg/g and 0.27 µg/g, respectively. These levels, although higher than the NCBP and EMAP means, are similar to the species-specific, state-wide means reported by Stafford and Haines (1997). Mercury levels in fish from Sunkhaze Meadows NWR, however, should not be considered safe for consumption by humans or wildlife. Mercury is a contaminant of concern for piscivorous wildlife receptors throughout Maine. Eisler (1987) recommended a fish Hg concentration of 0.10 µg/g for the protection of sensitive piscivorous birds and mammals. Mercury levels in Maine lakes are currently high enough to cause moderate to high risk to loons and other piscivorous birds (BRI and MEDEP 1998).

The FDA Action Level for mercury in fish is 1.0 µg/g (FDA 1992). Several states, including Maine, have adopted lower action levels for the protection of human health. Maine has a fish consumption advisory threshold level of 0.43 µg Hg/g (Maine Department of Human Services 1997). Even lower levels or expanded consumption advisories have also been adopted because of mercury for vulnerable receptor groups such as pregnant women and children. These receptor groups are often advised to avoid eating any fish from many lakes and rivers (EPA 1995). The limited amount of fish data from Sunkhaze Meadows NWR suggests the state consumption advisory for Hg is also appropriate for refuge anglers seeking chain pickerel.

Nickel (Ni) in Fish - Nickel accumulates in aquatic organisms, but does not biomagnify through food chains (Moore and Ramamoorthy 1984b, Eisler 1998). In fish tissue, Ni causes alterations in gill structure, separation of the epithelial layer from the pillar cell system, cauterization and sloughing, and necrosis of the epithelium (Eisler 1998). Ni occurring in the tissues of some piscivorous bird species may reflect metal concentrations in prey items. For example, Custer *et al.* (1986) in a Rhode Island study of common terns (*Sterna hirundo*) found the highest Ni concentrations in tern liver tissue (up to 0.25 µg/g) where the main prey item, killifish (*Fundulus* spp.), also had the highest Ni concentration (0.52 µg/g). Outridge and Scheuhammer (1993) suggested that mammals and birds may have the ability to regulate Ni assimilation at dietary concentrations up to 25 µg/g. They also reported that chronic Ni exposure at dietary concentrations of 10 - 50 mg/kg body weight/day may reduce growth and survival in mammals.

The EMAP (Yeardley *et al.* 1998) mean Ni concentration for fish in 167 northeastern U.S. lakes is 0.21 µg/g (range: 0.05 - 0.97 µg/g). Jenkins (1980) suggested a preliminary estimate of Ni in freshwater fish from uncontaminated areas of < 0.2 to 2.0 µg/g, but cautioned that more data were needed. Compared to the EMAP results, Ni was found in elevated concentrations in yellow perch from Sunkhaze Stream (1.51 µg/g at Baker Brook confluence, 3.18 µg/g at Buzzy Brook confluence). A lower level of Ni was found in the chain pickerel sample collected from the confluence with Buzzy Brook (0.76 µg/g). Nickel was not found in the pickerel sample collected at the outlet of Baker Brook.

Nickel levels in Sunkhaze Meadows NWR fish may be less of a risk to ecological receptors than to human receptors. Adverse effects may occur in young birds with Ni diets containing more than 200 µg/g and in adults with diets less than 800 µg Ni/g. In mammal studies, normal growth and survival occurred with daily diets containing Ni levels of 0.80 - 40 µg/g, while reduced growth and survival occurred with diets containing 500 - 2,500 µg/g (Eisler 1998). The proposed Ni dietary criterion for the protection of sensitive human receptors, however, is less than 1.0 µg/g (Eisler 1998). Based on this Ni human-health criterion, yellow perch in Sunkhaze Stream may pose a risk to sensitive human receptors.

Zinc (Zn) in Fish - Zinc is an essential element for vertebrates. Although it is an uncommon occurrence in aquatic systems, fish with diets deficient in Zn can experience reduced growth and increased mortality (Spry *et al*. 1988). Generally, Zn is efficiently regulated by wildlife and tissue concentrations are not reliable indicators of exposure (Beyer and Storm 1995). Spry *et al*. (1988) found no toxic effects in rainbow trout from exposure to high dietary and waterborne concentrations of Zn based on growth, mortality, major plasma ions, hematocrit, or plasma protein. However, Eisler (1993) reported that elevated concentrations of waterborne Zn have adverse effects on growth, survival, behavior, and reproduction of sensitive fish, with early life stages being the most sensitive.

The NCBP (Schmitt and Brumbaugh 1990) geometric mean Zn concentration is 21.7 µg/g and the 85^{th} percentile is 34.2 µg/g. The EMAP (Yeardley *et al.* 1998) mean Zn concentration for fish in 167 northeastern U.S. lakes is 21.1 µg/g (range: 8.8 - 63.7 µg/g). In a study of Cd and Zn from an industrially-contaminated lake, Murphy *et al.* (1978) reported Zn concentrations ranging from 34.7 to 56.2 µg/g and 19.7 to 29.7 µg/g for bluegill and largemouth bass, respectively. Citing several sources, Murphy *et al*. (1978) reported average Zn whole fish concentrations from uncontaminated areas ranging from 12 µg/g to 43 µg/g. In a study of golden shiners at the U.S. Naval Air Station in Brunswick, Maine, Zn concentrations ranged from 35.5 µg/g to 55.9 µg/g (mean 49.72 µg/g; Mierzykowski and Carr 1999).

Compared to the NCBP and EMAP data, Zn concentrations in yellow perch (mean 24.93 µg/g) from Sunkhaze Stream were not highly elevated. The Zn levels in chain pickerel (mean 64.68 µg/g), however, were elevated. The source of Zn in fish tissue at Sunkhaze Meadows NWR is not known. Typically, the accumulation of Zn in fish is directly correlated with the concentration of Zn in the ambient water (Balasubramanian *et al.* 1995). However, Zn was not detected in refuge surface water samples. Zinc was found in sediment samples, but the levels in the two fish species from the refuge contradict the expected rate of accumulation. Zinc is likely to be found in higher concentrations in omnivores than carnivores (Mathis and Cummings 1973). In refuge samples, Zn concentrations were considerably higher in the predaceous chain pickerel than in the omnivorous yellow perch. Since tissue levels are not reliable measures of exposure, and waterborne Zn is a greater risk to receptors than dietary Zn, the Zn levels in fish from Sunkhaze Meadows may not be a significant concern for fish, wildlife, and humans.

6.3.2 Organochlorine Pesticides - As noted in the results section, only dieldrin (0.0023 µg/g) and one DDT metabolite, *p,p*'-DDE (0.0072 µg/g), were detected in one Sunkhaze Stream fish sample. In both instances, the levels were not highly elevated compared to national and regional data.

6.3.3. Polychlorinated Biphenyls - Total PCB concentrations in fish tissue samples were determined by summing the results of congener-specific analyses (Table 9). PCBs are lipophilic compounds that bioconcentrate in organisms (EPA 1980), and biomagnify in food chains (Eisler 1986a). In fish, acute toxicity from PCBs is low, while chronic toxicity is relatively high (Murty 1986). PCB accumulations can adversely affect egg survival and fry development in fish (Hogan and Brauhn 1975). Niimi (1996) reported that fish from higher trophic levels in uncontaminated freshwater environments had PCB concentrations in the low µg/kg (ppb) range, while higher trophic level fish from contaminated waters had PCB levels in the low µg/g (ppm) range. In riverine systems, biomagnification of PCBs has occurred more from the ingestion of contaminated prey (i.e., trophic transfer) than uptake from water (Zaranko *et al.* 1997). Fish with tissue PCB concentrations greater than 50 µg/g may experience adverse changes in growth and reproduction (Niimi 1996). PCBs are also common contaminants in piscivorous birds and mammals. Certain mammals may be particularly at risk from PCBs. Mink (*Mustela vison*), for example, are extremely sensitive to PCBs, and diets with PCB concentrations of 0.67 µg/g could lead to reproductive failure (Ringer 1983).

The geometric mean PCB concentration reported for the NCBP (Schmitt *et al.* 1990) is 0.39 µg/g. In the Maine component of the Regional Environmental Monitoring and Assessment Program (REMAP, DiFranco *et al.* 1995), PCB concentrations (expressed as Aroclor 1254 and 1260) ranged from 0.009 to 0.186 µg/g in whole fish. In Sunkhaze Stream, ΣPCB concentrations in chain pickerel were 0.004 µg/g at the Baker Brook confluence and 0.008 µg/g at the Buzzy Brook confluence. In yellow perch from Sunkhaze Stream, ΣPCB was not detected at the Baker Brook confluence and found at 0.007 µg/g at the Buzzy Brook confluence.

The ΣPCB concentrations in chain pickerel and yellow perch from Sunkhaze Stream do not exceed the whole-body protection criterion of 0.40 µg/g proposed by Eisler and Belisle (1996). The ΣPCB levels are also below the dietary protection criterion for piscivorous wildlife of 0.10 µg/g listed in the Great Lakes Water Quality Agreement of 1978 (IJC 1989), and the fish flesh criterion of 0.11 µg/g developed by New York State for the protection of piscivorous wildlife in the Niagara River (Newell *et al.* 1987).

The FDA promulgated a Tolerance Level for PCBs of 2 µg/g for edible portions of fish sold commercially (FDA 1992). The State of Maine (Maine Department of Human Services 1997) advises no consumption of fish if PCB concentrations are greater than 0.044 µg/g (cancer endpoint) or 0.160 µg/g (non-cancer endpoint). Limited consumption is advised if PCB levels are between 0.011 - 0.044 µg/g (cancer endpoint) or 0.040 - 0.160 µg/g (non-cancer endpoint). The fish samples collected from Sunkhaze Stream were composites of whole-body fish. Skinless fillet samples from these fish would likely have much lower ΣPCB concentrations. Consequently, exceedances of the ΣPCB FDA tolerance level and Maine consumption advisory levels would not be expected in Sunkhaze Stream fish.

7. SUMMARY, CONCLUSIONS, & RECOMMENDATIONS

7.1 Summary of Sampling Results

7.1.1 Surface water - Six surface water samples were analyzed for trace elements, organochlorine pesticides, and PCBs.

- Nine trace elements were detected in surface water samples - Al, B, Ba, Be, Cd, Fe, Mg, Mn, and Sr. Only Al was found at concentrations above the chronic exposure criterion (i.e., CCC) of the Clean Water Act's Ambient Water Quality Criteria. The Al level in surface water at Sunkhaze Meadows NWR, however, is not unusual or highly elevated for northern Maine. The AWQC recognizes that many high quality waters in the United States may have Al levels above the chronic exposure criterion. Consequently, Al in surface water at the refuge should not be considered a significant risk to fish and wildlife.

- Organochlorine pesticides were not detected in any surface water samples.

- Polychlorinated biphenyls were detected in Baker Brook and Sunkhaze Stream surface water samples. The levels of ΣPCBs detected in Baker Brook (max. 2.862 µg/l) and Sunkhaze Stream (max. 2.965 µg/l) surface water samples exceeded the CCC of the AWQC (0.014 µg/l, EPA 1999) by orders of magnitude. PCBs were not detected in Buzzy Brook surface water.

7.1.2 Sediment - Six sediment samples were analyzed for trace elements, organophosphate pesticides, organochlorines pesticides, PCBs, dioxins, and furans.

- Trace element concentrations in sediment were not elevated and, in most cases, were well below sediment effect guidelines.

- Organophosphate pesticides, such as carbaryl and carbofuran, were not detected in any sediment samples, the only medium analyzed for this suite of compounds.

- Several organochlorine pesticides were detected in sediments from Baker Brook. The levels were not highly elevated; most concentrations were at, or slightly above, the method detection limit.

- PCBs were detected in sediments from Baker Brook, Buzzy Brook, and Sunkhaze Stream. Total PCB sediment level in Baker Brook sediment (n = 2, 0.78 mg/kg, 0.15 mg/kg) exceeded the probable effect concentrations (0.67 mg/kg) and threshold effect concentration (0.06 mg/kg). One Buzzy Brook sediment sample had a ΣPCB concentration (0.20 mg/kg) above the threshold effect concentration. Neither Sunkhaze Stream sediment sample exceeded the threshold effect concentration. The source of PCB contamination in Baker Brook is not known. The pattern of PCB congeners in sediment from upstream and refuge samples, however, suggests the former Town of Milford Municipal Landfill is not the source of PCBs in Baker Brook.

- A single detection of one dioxin compound, octachlorodibenzo-*p*-dioxin (OCDD), was found in a sediment sample from Sunkhaze Stream collected immediately upstream of the refuge. The concentration of 0.00000314 mg/kg (ppm), more easily expressed as 3.14 ng/kg (ppt, parts-per-trillion), was not highly elevated compared to sediment guidelines. Moreover, OCDD has a potency ten thousand times less than the most toxic dioxin compound - 2,3,7,8-TCDD. Furans were not detected in sediment samples.

7.1.3 Fish - Two composite samples of whole-body chain pickerel and two composites of whole-body yellow perch were analyzed for trace elements, organochlorine pesticides, and PCBs. Both pickerel samples were also analyzed for dioxins, and furans.

- Compared to Maine, regional, and national studies; elevated levels of chromium, copper, nickel, mercury, and zinc were detected in Sunkhaze Stream fish tissue. Chromium levels in Sunkhaze Stream chain pickerel and yellow perch are highly elevated compared to other data sets. Mercury levels in chain pickerel exceed statewide consumption advisory levels promulgated by the Maine Department of Environmental Protection. Copper and zinc levels in pickerel and perch are also elevated compared to national fish tissue studies, but the levels are not unusual for the New England region.

- Organochlorine pesticides were not commonly observed in the four fish samples. Dieldrin and DDE were found at low levels in a yellow perch composite sample collected from the Buzzy Brook/Sunkhaze Stream confluence.

- PCBs were found at low concentrations in three of four fish samples and undetected in the fourth sample.

- Dioxin and furan compounds were not detected in chain pickerel composite samples, the only fish samples analyzed for these compounds. (Note: Due to budget limitations, yellow perch composite samples were not analyzed for dioxins and furans). The method detection limit for these samples was 1 pg/g or 1 part-per-trillion. This method detection limit at the time of sampling (circa 1995) is fairly high by current standards. Since the chain pickerel is the top-level fish predator in Sunkhaze Stream, we would not expect other sportfish species in the refuge to have higher levels of dioxin or furans. However, fish species with higher lipid content that are not sought by anglers, such as suckers, may contain detectable levels of dioxins and furans above the state background concentrations 0.40 pg/g (MEDEP 2000). These non-sportfish are frequently the prey of fish-eating birds (e.g., bald eagle, osprey). It is not known, therefore, if ecological receptors may be at risk from dioxin and furan contamination in fish from Sunkhaze Meadows NWR.

7.2 Conclusions

Based on limited surface water, sediment, and fish sampling, the Sunkhaze Meadows NWR does not appear to be significantly contaminated with the trace elements, organophosphate pesticides, or organochlorine pesticides included in this study.

PCB concentrations in Baker Brook sediment and surface water samples, however, are elevated. Similarly, Sunkhaze Stream surface water samples also contain high levels of PCBs.

Two landfills along the north and south borders of the Sunkhaze Meadows NWR do not appear to be significant local contaminant sources for the refuge. Although, malformed frogs have been collected down gradient from one landfill, the Fort James sludge landfill along the Stud Mill Road, the cause of the malformations is not known. Further investigation in the borrow pit ponds may be necessary if contaminants are linked to malformations.

7.3 Recommendations

Follow-up contaminant work for the Sunkhaze Meadows National Wildlife Refuge includes:

- Collect sediment samples and aquatic biota (fish and/or invertebrates) above beaver dams on Baker Brook for PCB analysis. Sediment data suggest that PCBs may be accumulating in the brook. Additional sampling will define the nature and extent of PCB contamination in the brook. Collection and analysis (filtered and unfiltered) of surface water samples from Baker Brook and Sunkhaze Stream will be necessary to confirm PCB levels in water.

- Measure water quality parameters for 30-day periods during high (i.e., spring) and low flow (i.e., late summer) periods to develop better baseline data.

- Collect for contaminant analysis surface water, sediment, and tissue samples from the borrow pit ponds. In 1997 and 1998, frog anatomical abnormalities were found in this location. A third survey conducted in 1999 did not find any abnormalities. However, the 1999 survey methodology was different and limited to one species, the northern leopard frog (*Rana pipiens*). While it remains uncertain what role contaminants may play in frog malformations, analysis of media from the ponds for environmental contaminants, particularly pesticides, may be useful.

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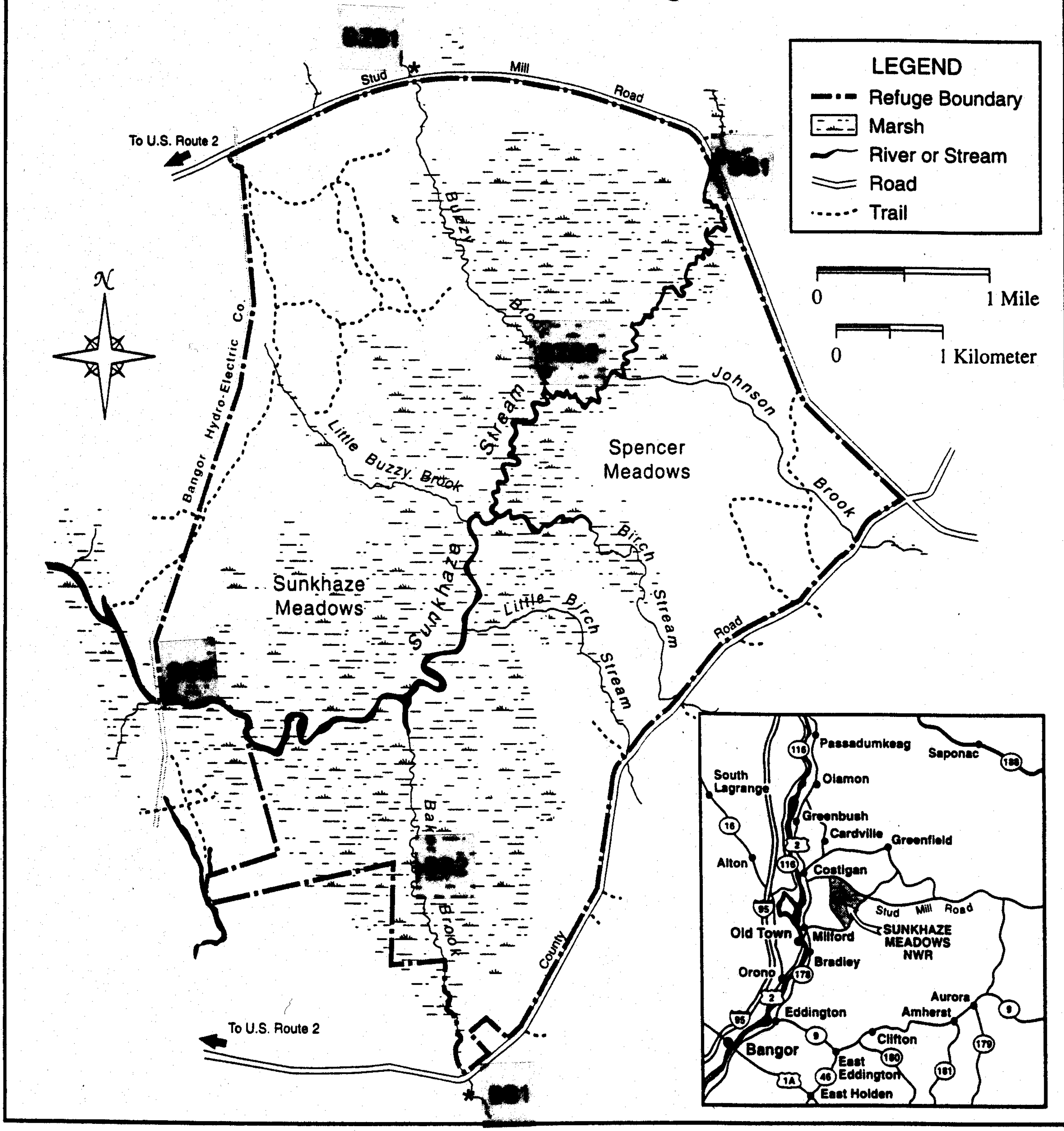
FIGURES

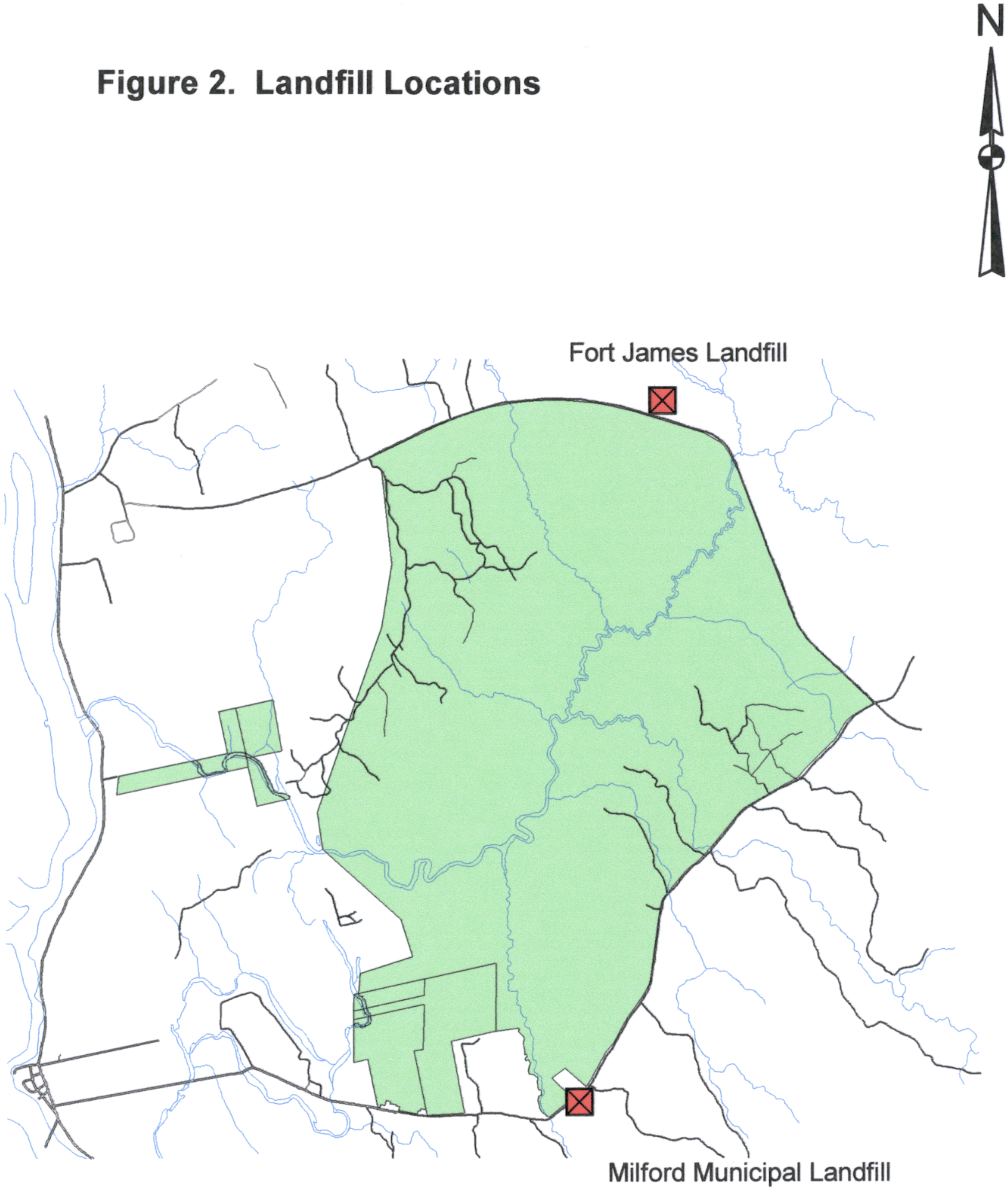
Figure 1.

SUNKHAZE MEADOWS
National Wildlife Refuge



• Collection Location

Figure 2. Landfill Locations



TABLES

Table 1. Coordinates of collection locations

Location - Types of Sample	Latitude	Longitude
BB1 - Baker Brook 1, surface water & sediment	N44^o 56' 21"	W068^o 33' 43"
BB2 - Baker Brook 2, surface water & sediment*	N44^o 57' 54"	W068^o 34' 08"
BZB1 - Buzzy Brook 1, surface water & sediment	N45^o 01' 21"	W068^o 34' 03"
BZB2 - Buzzy Brook 2, surface water & sediment*	N44^o 59' 49"	W068^o 33' 07"
SS1 - Sunkhaze Stream 1, surface water & sediment	N45^o 01' 00"	W068^o 31' 51"
SS2 - Sunkhaze Stream 2, surface water & sediment	N44^o 58' 15"	W068^o 35' 55"
BB2F1& F2 - Baker Brook, fish (chain pickerel, yellow perch)*	N44^o 58' 16"	W068^o 34' 11"
BZB2F1& F2 - Buzzy Brook , fish (chain pickerel, yellow perch)*	N44^o 59' 45"	W068^o 33' 06"

* Approximate location determined with digitized mapping program (i.e., TopoScout®).

Table 2. Metrics for individual fish in composite samples from Sunkhaze Meadows NWR.

Sample No.	Species	Total Length (cm)	Total Weight* (g)	Lipid Content** (%)
BB2F1	Chain Pickerel	34.5	454	
	Chain Pickerel	49.6	992	
	Chain Pickerel	28.4	159	
n=3	Mean	37.5	535	1.57
	Standard Deviation (SD)	10.91	422.6	
BB2F2	Yellow Perch	21.1	170	
	Yellow Perch	25.3	312	
	Yellow Perch	29.3	340	
	Yellow Perch	27.6	326	
	Yellow Perch	25.3	312	
n=5	Mean	25.7	292	6.93
	SD	3.08	69.2	
BZB2F1	Chain Pickerel	33.7	369	
	Chain Pickerel	17.1	31	
n=2	Mean	25.4	200	5.80
	SD	11.74	238.5	
BZB2F2	Yellow Perch	20.6	170	
	Yellow Perch	19.5	164	
	Yellow Perch	25.5	312	
n=3	Mean	21.9	215	0.35
	SD	3.19	83.5	

* Weight recorded in ounces and converted to grams.
** Lipid content of composite sample

Table 3. Elements and compounds in analytical catalog

Trace Elements	Organophosphates	PCB Congeners	
Al	aldicarb	PCB# 7	PCB# 137
As	carbaryl	PCB# 8	PCB# 138
B	carbofuran	PCB# 15	PCB# 141
Ba	methiocarb	PCB# 16/32*	PCB# 146
Be	methomyl	PCB# 18	PCB# 149
Cd	oxamyl	PCB# 22	PCB# 151
Cr		PCB# 24	PCB# 153
Cu	Dioxins & Furans	PCB# 25	PCB# 156/171/202*
Fe	2,3,7,8-TCDD	PCB# 26	PCB# 158
Hg	2,3,7,8-TCDF	PCB# 28	PCB# 167
Mg	1,2,3,7,8-PeCDD	PCB# 29	PCB# 170
Mn	1,2,3,4,7,8-HxCDD	PCB# 33	PCB# 172
Mo	1,2,3,6,7,8-HxCDD	PCB# 37/42*	PCB# 174
Ni	1,2,3,7,8,9-HxCDD	PCB# 40	PCB# 177
Pb	1,2,3,4,6,7,8-HpCDD	PCB# 41/64*	PCB# 178
Se	OCDD	PCB# 44	PCB# 180
Sr	1,2,3,7,8-PeCDF	PCB# 45	PCB# 183
V	2,3,4,7,8-PeCDF	PCB# 46	PCB# 185
Zn	1,2,3,4,7,8-HxCDF	PCB# 47/48*	PCB# 187/182/159*
	1,2,3,6,7,8-HxCDF	PCB# 49	PCB# 188
Organochlorines	1,2,3,7,8,9-HxCDF	PCB# 50	PCB# 189
Aldrin	2,3,4,6,7,8-HxCDF	PCB# 52	PCB# 191
alpha BHC	1,2,3,4,6,7,8-HpCDF	PCB# 60/56*	PCB# 194
alpha chlordane	1,2,3,4,7,8,9-HpCDF	PCB# 66	PCB# 195
beta BHC	OCDF	PCB# 70	PCB# 196
cis -nonachlor		PCB# 74	PCB# 200
delta BHC		PCB# 82	PCB# 201
dieldrin		PCB# 83	PCB# 205
endrin		PCB# 84	PCB# 206
gamma BHC		PCB# 85	PCB# 209
gamma chlordane		PCB# 87	PCB# UNK
HCB		PCB# 88	
Heptachlor		PCB# 92	* Co-elutes
heptachlor epoxide		PCB# 97	
mirex		PCB# 99	
o ,p '-DDD		PCB# 101	
o ,p '-DDE		PCB# 105	
o ,p '-DDT		PCB# 107/108/144*	
oxychlordane		PCB# 110/77*	
p ,p '-DDD		PCB# 118/108/149*	
p ,p '-DDE		PCB# 126	
p ,p '-DDT		PCB# 128	
PCB-TOTAL		PCB# 129	
trans -nonaclor		PCB# 136	

Table 4. Trace elements in surface water, ug/l.

SURFACE WATER

Element	Baker Brook		Buzzy Brook		Sunkhaze Stream	
	BB1	BB2	BZB1	BZB2	SS1	SS2
Al	111.7	121.4	119.9	130.8	93.3	87.1
As	nd	nd	nd	nd	nd	nd
B	7.4	nd	nd	nd	nd	9.7
Ba	4.0	1.8	5.1	2.9	3.2	3.5
Be	0.6	nd	0.5	nd	nd	0.7
Cd	0.6	nd	nd	nd	nd	0.6
Cr	nd	nd	nd	nd	nd	nd
Cu	nd	nd	nd	nd	nd	nd
Fe	704.1	372.8	844.2	515.8	322.1	306.9
Hg	nd	nd	nd	nd	nd	nd
Mg	951.2	599.2	1930.0	1082.0	1017.0	1177.0
Mn	98.6	23.7	44.3	32.6	43.2	18.8
Mo	nd	nd	nd	nd	nd	nd
Ni	nd	nd	nd	nd	nd	nd
Pb	nd	nd	nd	nd	nd	nd
Se	nd	nd	nd	nd	nd	nd
Sr	29.7	17.5	46.9	35.2	45.0	43.9
V	nd	nd	nd	nd	nd	nd
Zn	nd	nd	nd	nd	nd	nd

ug/l = ppb

nd = non-detect

Table 5. Organochlorines in surface water, ug/l

SURFACE WATER

Compound	Baker Brook BB1	Baker Brook BB2	Buzzy Brook BZB1	Buzzy Brook BZB2	Sunkhaze Stream SS1	Sunkhaze Stream SS2
aldrin	nd	nd	nd	nd	nd	nd
alpha BHC	nd	nd	nd	nd	nd	nd
alpha chlordane	nd	nd	nd	nd	nd	nd
beta BHC	nd	nd	nd	nd	nd	nd
cis -nonachlor	nd	nd	nd	nd	nd	nd
delta BHC	nd	nd	nd	nd	nd	nd
dieldrin	nd	nd	nd	nd	nd	nd
endrin	nd	nd	nd	nd	nd	nd
gamma BHC	nd	nd	nd	nd	nd	nd
gamma chlordane	nd	nd	nd	nd	nd	nd
HCB	nd	nd	nd	nd	nd	nd
heptachlor	nd	nd	nd	nd	nd	nd
heptachlor epoxide	nd	nd	nd	nd	nd	nd
mirex	nd	nd	nd	nd	nd	nd
o ,p '-DDD	nd	nd	nd	nd	nd	nd
o ,p '-DDE	nd	nd	nd	nd	nd	nd
o ,p '-DDT	nd	nd	nd	nd	nd	nd
oxychlordane	nd	nd	nd	nd	nd	nd
p ,p '-DDD	nd	nd	nd	nd	nd	nd
p ,p '-DDE	nd	nd	nd	nd	nd	nd
p ,p '-DDT	nd	nd	nd	nd	nd	nd
PCB-TOTAL*	0.192	2.862	nd	nd	2.965	0.139
trans -nonachlor	nd	nd	nd	nd	nd	nd

ug/l = ppb

nd = non-detect

* Based on congener-specific analyses

Table 6. PCB congeners in surface water, ug/l

SURFACE WATER

	Baker Brook		Buzzy Brook		Sunkhaze Stream	
Congener	BB1	BB2	BZB1	BZB2	SS1	SS2
PCB# 15	nd	nd	nd	nd	0.113	nd
PCB# 22	nd	0.433	nd	nd	1.710	nd
PCB# 28	nd	0.262	nd	nd	0.169	nd
PCB# 33	nd	0.109	nd	nd	nd	nd
PCB# 44	nd	0.329	nd	nd	0.135	nd
PCB# 47/48	nd	0.105	nd	nd	nd	nd
PCB# 49	nd	0.105	nd	nd	nd	nd
PCB# 50	nd	0.388	nd	nd	0.260	nd
PCB# 52	nd	0.244	nd	nd	0.127	nd
PCB# 60/56	0.192	nd	nd	nd	0.190	0.139
PCB# 66	nd	0.133	nd	nd	nd	nd
PCB# 70	nd	0.123	nd	nd	nd	nd
PCB# 101	nd	0.141	nd	nd	nd	nd
PCB# 138	nd	0.180	nd	nd	0.261	nd
PCB# 170	nd	0.310	nd	nd	nd	nd
Total PCBs	0.192	2.862	nd	nd	2.965	0.139

nd = non-detect

Table only lists detected congeners. Seventy-five congeners were included in analytical scan.

ug/l = ppb

Table 7. Trace elements in sediments, mg/kg DW

SEDIMENT

Element	Baker Brook		Buzzy Brook		Sunkhaze Stream	
	BB1	BB2	BZB1	BZB2	SS1	SS2
Al	5088	8167	4201	6764	4357	7380
As	nd	1.24	0.86	1.80	0.95	1.09
B	nd	nd	nd	nd	nd	nd
Ba	27.04	30.50	20.31	30.92	34.36	30.38
Be	0.50	0.37	0.73	0.47	0.49	0.69
Cd	0.77	nd	0.83	0.31	0.29	0.73
Cr	30.15	34.39	7.52	30.26	13.27	17.32
Cu	nd	17.53	nd	7.06	nd	nd
Fe	5950	12750	3153	11260	6667	9354
Hg	nd	nd	nd	nd	nd	nd
Mg	1679	2966	875	2646	1635	2321
Mn	149.70	290.60	75.27	303.60	258.50	181.10
Mo	nd	nd	nd	nd	nd	5.156
Ni	11.83	16.59	7.36	15.46	9.56	13.54
Pb	13.58	13.61	10.49	16.00	9.00	15.25
Se	0.50	nd	nd	nd	0.50	nd
Sr	16.24	13.83	10.99	14.54	8.53	13.35
V	9.43	13.15	5.45	12.61	7.70	11.36
Zn	28.97	48.27	18.89	39.1	33.04	35.99
TOC%	1.75	3.47	3.42	2.77	1.71	1.57

mg/kg = ppm; DW = dry weight
nd = non-detect

Table 8. Organochlorines in sediments, mg/kg DW **SEDIMENT**

	Baker Brook		Buzzy Brook		Sunkhaze Stream	
Compound	BB1	BB2	BZB1	BZB2	SS1	SS2
aldrin	nd	nd	nd	nd	nd	nd
alpha BHC	nd	nd	nd	nd	nd	nd
alpha chlordane	0.0021	0.00775	nd	nd	nd	nd
beta BHC	0.0021	0.01550	nd	nd	nd	nd
cis -nonachlor	0.0021	0.00775	nd	nd	nd	nd
delta BHC	nd	0.00775	nd	nd	nd	nd
dieldrin	0.0021	0.00775	nd	nd	nd	nd
endrin	nd	nd	nd	nd	nd	nd
gamma BHC	nd	nd	nd	nd	nd	nd
gamma chlordane	0.0021	0.00775	nd	nd	nd	nd
HCB	nd	nd	nd	nd	nd	nd
heptachlor	nd	nd	nd	nd	nd	nd
heptachlor epoxide	nd	nd	nd	nd	nd	nd
mirex	0.0021	0.00775	nd	nd	nd	nd
o ,p '-DDD	0.0021	0.00775	nd	nd	nd	nd
o ,p '-DDE	0.0021	0.00775	nd	nd	nd	nd
o ,p '-DDT	0.0021	0.00775	nd	nd	nd	nd
oxychlordane	nd	nd	nd	nd	nd	nd
p ,p '-DDD	0.00629	0.03100	0.00563	nd	nd	nd
p ,p '-DDE	0.0021	0.01550	nd	nd	nd	nd
p ,p '-DDT	0.0021	0.00775	nd	nd	nd	nd
PCB-TOTAL*	0.15104	0.78280	0.20275	0.02394	0.03366	0.02948
trans -nonachlor	nd	0.00775	nd	nd	nd	nd

nd = non-detect

mg/kg = ppm, DW = dry weight

* Based on congener-specific analyses

Table 9. PCB congeners in sediments, mg/kg DW

SEDIMENT

Congener	Baker Brook BB1	Baker Brook BB2	Buzzy Brook BZB1	Buzzy Brook BZB2	Sunkhaze Stream SS1	Sunkhaze Stream SS2
PCB# 28	0.00210	0.00775	0.00563	nd	0.00168	nd
PCB# 37/42	0.00419	0.01550	0.01130	0.00368	0.00337	nd
PCB# 41/64	0.01260	0.27100	0.06190	nd	0.00842	nd
PCB# 44	0.00629	0.01550	nd	nd	nd	nd
PCB# 49	0.00210	0.00775	0.00563	0.00184	0.00168	0.00268
PCB# 50	0.00419	0.01550	0.00563	0.00184	nd	0.00268
PCB# 52	0.00210	0.00775	0.00563	nd	0.00168	0.00268
PCB# 66	0.00629	0.03100	0.00563	nd	nd	nd
PCB# 84	nd	nd	0.00563	nd	nd	nd
PCB# 87	0.00629	0.02330	nd	nd	nd	nd
PCB# 101	0.00210	0.01550	nd	nd	nd	nd
PCB# 105	0.01050	0.04650	0.00563	nd	nd	nd
PCB# 118/108/149	0.00629	0.03100	0.00563	nd	nd	nd
PCB# 126	0.01050	0.03880	0.00563	nd	nd	nd
PCB# 128	0.00629	0.03100	0.00563	nd	nd	nd
PCB# 138	0.01890	0.03100	0.01130	0.00553	0.00505	0.00536
PCB# 149	0.00629	0.02330	0.01690	0.00553	0.00505	0.00804
PCB# 153	0.00629	0.02330	0.01690	0.00368	0.00505	0.00536
PCB# 167	0.00210	0.00775	nd	nd	nd	nd
PCB# 172	0.00210	0.00775	0.00563	0.00184	0.00168	0.00268
PCB# 180	0.00419	0.02330	0.00563	nd	nd	nd
PCB# 187/182/159	0.00210	0.00775	nd	nd	nd	nd
PCB# 188	0.00210	0.00775	nd	nd	nd	nd
PCB# 195	0.00838	0.0310	0.00563	nd	nd	nd
PCB# 200	nd	0.00775	nd	nd	nd	nd
PCB# 206	0.00838	0.03100	0.00563	nd	nd	nd
PCB# 209	0.00838	0.02330	0.00563	nd	nd	nd
Total PCBs	0.15104	0.78280	0.20275	0.02394	0.03366	0.02948

nd = non-detect mg/kg = ppm, DW = dry weight

Table only lists detected congeners. Seventy-five congeners were included in analytical scan.

Table 10. Trace elements in whole fish composite samples, ug/g WW **FISH**

Element	Sunkhaze Stream			
	Baker Brook Confluence		Buzzy Brook Confluence	
	BB2F1	BB2F2	BZB2F1	BZB2F2
	C. Pickerel	Y. Perch	C. Pickerel	Y. Perch
Al	14.45	30.87	20.94	43.73
As	nd	nd	nd	nd
B	nd	nd	nd	nd
Ba	0.45	0.56	0.70	0.64
Be	nd	nd	nd	nd
Cd	nd	nd	nd	nd
Cr	2.70	10.59	4.43	13.20
Cu	0.82	1.61	3.14	1.94
Fe	19.47	78.45	41.44	104.30
Hg	0.89	0.31	0.59	0.22
Mg	883.6	1031.8	965.1	971.2
Mn	5.33	15.91	13.90	20.35
Mo	nd	nd	nd	nd
Ni	nd	1.51	0.76	3.18
Pb	nd	nd	nd	nd
Se	0.21	0.36	0.16	0.32
Sr	10.90	17.97	20.31	15.94
V	nd	nd	nd	nd
Zn	49.85	25.24	79.51	24.61

ug/g = ppm; WW = wet weight

nd = non-detect

Table 11. Organochlorines in whole fish composites, ug/g WW **FISH**

Compound	Sunkhaze Stream: Baker Bk Confluence BB2F1 C. Pickerel	Sunkhaze Stream: Baker Bk Confluence BB2F2 Y. Perch	Sunkhaze Stream: Buzzy Bk Confluence BZB2F1 C. Pickerel	Sunkhaze Stream: Buzzy Bk Confluence BZB2F2 Y. Perch
aldrin	nd	nd	nd	nd
alpha BHC	nd	nd	nd	nd
alpha chlordane	nd	nd	nd	nd
beta BHC	nd	nd	nd	nd
cis -nonachlor	nd	nd	nd	nd
delta BHC	nd	nd	nd	nd
dieldrin	nd	nd	nd	0.0023
endrin	nd	nd	nd	nd
gamma BHC	nd	nd	nd	nd
gamma chlordane	nd	nd	nd	nd
HCB	nd	nd	nd	nd
heptachlor	nd	nd	nd	nd
heptachlor epoxide	nd	nd	nd	nd
mirex	nd	nd	nd	nd
o ,p '-DDD	nd	nd	nd	nd
o ,p '-DDE	nd	nd	nd	nd
o ,p '-DDT	nd	nd	nd	nd
oxychlordane	nd	nd	nd	nd
p ,p '-DDD	nd	nd	nd	nd
p ,p '-DDE	nd	nd	nd	0.00722
p ,p '-DDT	nd	nd	nd	nd
PCB-TOTAL*	0.00359	nd	0.00850	0.00727
trans -nonachlor	nd	nd	nd	nd

nd = non-detect

ug/g = ppm, WW = wet weight

* Based on congener-specific analyses

Table 12. PCB congeners in whole fish composites, ug/g WW **FISH**

	Sunkhaze Stream			
	Baker Bk Confluence		Buzzy Bk Confluence	
Congener	BB2F1	BB2F2	BZB2F1	BZB2F2
	C. Pickerel	Y. Perch	C. Pickerel	Y. Perch
PCB# 44	nd	nd	nd	0.00233
PCB# 170	nd	nd	0.00850	nd
PCB# 172	0.00359	nd	nd	0.00494
Total PCBs	0.00359	nd	0.00850	0.00727

nd = non-detect

Table only lists detected congeners. Seventy-five congeners were included in analytical scan.

ug/g = ppm, WW = wet weight

APPENDICES

Appendices A through D provided upon request.

Contact:

Environmental Contaminant Specialist
U.S. Fish & Wildlife Service
1033 South Main Street
Old Town, Maine 04468
(207) 827-5938

APPENDIX A

TRACE ELEMENTS

Analytical Laboratory:
Research Triangle Institute

APPENDIX B

ORGANOPHOSPHATE PESTICIDES

Analytical Laboratory:
PATUXENT ANALYTICAL CONTROL FACILITY
USFWS

APPENDIX C

ORGANOCHLORINE PESTICIDES AND PCBS

Analytical Laboratory:
Geochemical & Environmental Research Group
Texas A&M

APPENDIX D

DIOXINS AND FURANS

Analytical Laboratory:
Geochemical & Environmental Research Group
Texas A&M