

The South Branch of the Park River: An Environmental Impact Assessment and
Recommendations for Green Space Development

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I. Abstract

An environmental assessment of a site bordering a Wal-Mart construction project along the South Branch of the Park River in Hartford, CT was conducted by four Trinity College students from 2 September to 18 November 2003. Students performed comparative water chemistry and aquatic macroinvertebrate and community structure studies at the rural Mount Hope River in Ashford, CT. Historically, the South Branch of the Park River has been subject to pollution from industry, sewage, and urban runoff, and it has been channelized to control flooding. Habitat mapping indicated the presence of non-native invasive species and a riparian zone altered by development. Several state endangered, threatened, and special concern avian species frequent nearby locations. Evaluation of river discharge indicated streamflow values higher than 1979 and 1980 United States Geological Surveys, possibly reflecting high rainfall in the study period and the consequences of development. Biomonitoring studies using aquatic macroinvertebrates indicated the presence of organic pollution and environmental stress at the site based on the few taxonomic groups observed, dominance by a single taxa, and a low percentage of sensitive taxa. Chemical assessments of water quality indicated nitrate, sulfate, chloride, and phosphate concentrations, pH, and alkalinity levels within Environmental Protection Agency limits, but indicated compromised water quality compared to the Mount Hope River. Chemical analyses of soils (smoothed udorthents and urban land complex udorthents units) indicated levels of heavy metals lead, cadmium, arsenic, and chromium well within EPA limits, high soil nitrate levels, sufficient sulfate and pH levels, and variable chloride and phosphate levels. Community structure studies yielded few ground beetle specimens possibly due to the excessive rainfall. The Wal-Mart construction project will likely have a negative

impact on this site's currently good environmental health as a result of increased pollution and runoff. A green space is recommended to preserve the site and to augment community value.

II. Introduction

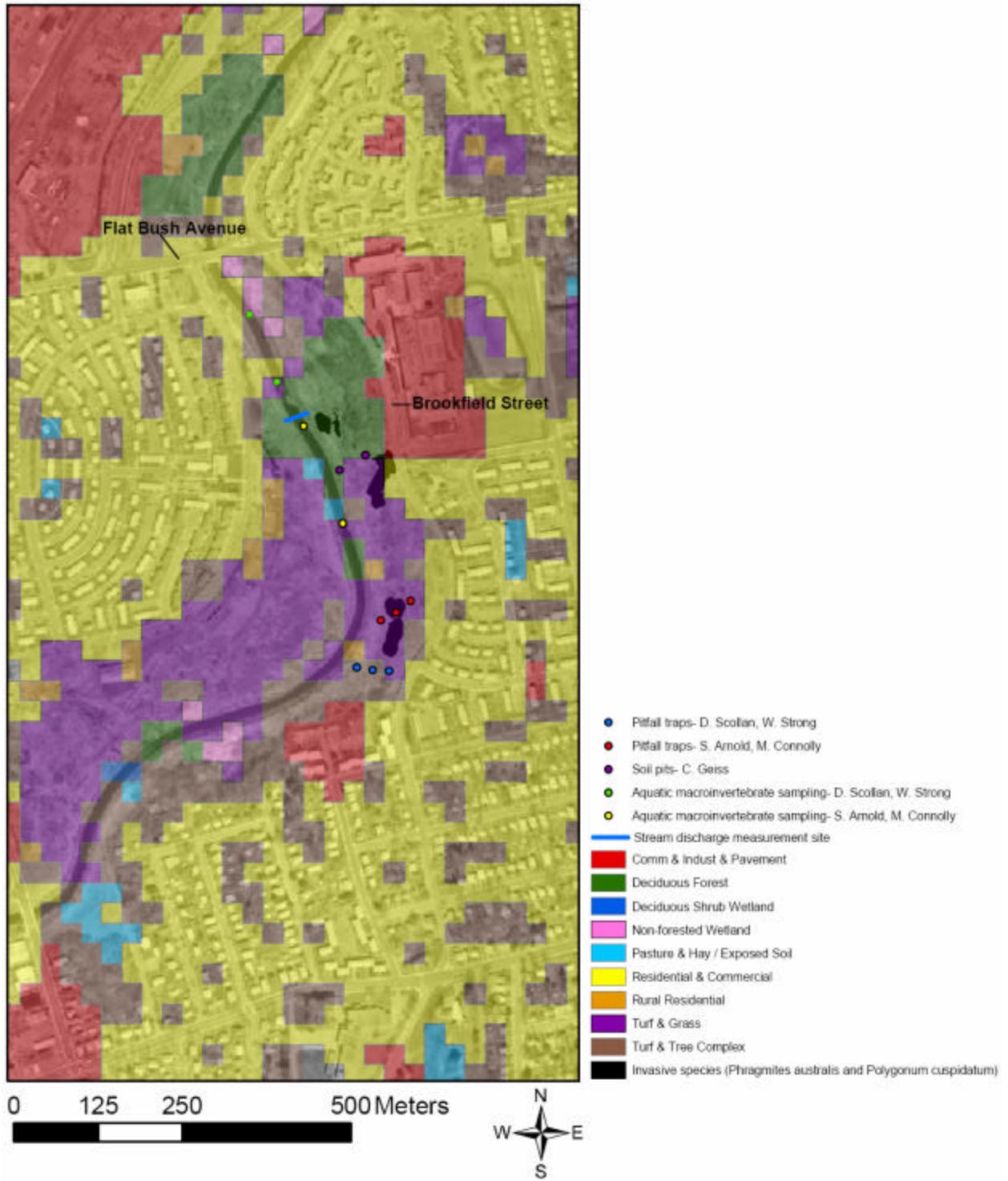
Environmental impact analyses address critical environmental concerns prior to the initiation of development projects. In examining an environmental system, one must pay particular attention to how projects will affect individual components of a system as well as the interactions between those parts. The physical, chemical, and biological effects of human actions can be determined using a variety of scientific measurements. However, it is also important to assess the inter-relationships between the physical, social, and cultural systems. In terms of the total environmental impact of a project, it is often necessary to evaluate concerns within global, regional, and local contexts (Black 1981). The goal of the Trinity College Methods in Environmental Science class was to conduct a site review and to develop an environmental assessment for an urban green space along the South Branch of the Park River in Hartford, CT. With the development of a new Wal-Mart and its parking facilities across the river from the urban green space site, a great deal of concern has been voiced by environmentalists that the construction will result in negative impacts on the environment.

Environmental analyses often consist of three steps including organizing the job, performing the assessment, and writing the Environmental Impact Statement (EIS) (Hyman and Stiffler 1988). The first phase of this analysis involved defining the problem and assembling an interdisciplinary team to conduct an investigation. A time frame for the completion of the environmental impact analysis was established. In the current study, four Trinity College undergraduate students under the direction of four professors in the disciplines of biology, chemistry, and geophysics examined the potential impact of the Wal-Mart construction on the environment and determined the suitability of a nearby site along the South Branch of the Park River as a greenway. Fieldwork was conducted from 2 September 2003 to 21 October 2003 at

the South Branch of the Park River, with the entire investigative team and Mr. Jack Hale of the Knox Parks Foundation present on 2 September 2003 to overview the site and the project (Figures 1-2). Comparative water chemistry and aquatic macroinvertebrate and community structure studies were performed at the rural Mount Hope River in Ashford, CT from 19 September 2003 to 2 October 2003 (Figure 3). Associated laboratory research in Trinity College facilities was conducted from 7 October 2003 to 18 November 2003. The second phase involved the actual environmental assessment in which team members identified and evaluated environmental factors likely to be positively or negatively affected by the planned action. The final phase of the analysis consisted of the reporting of the results of the assessment (Hyman and Stiftel 1988).

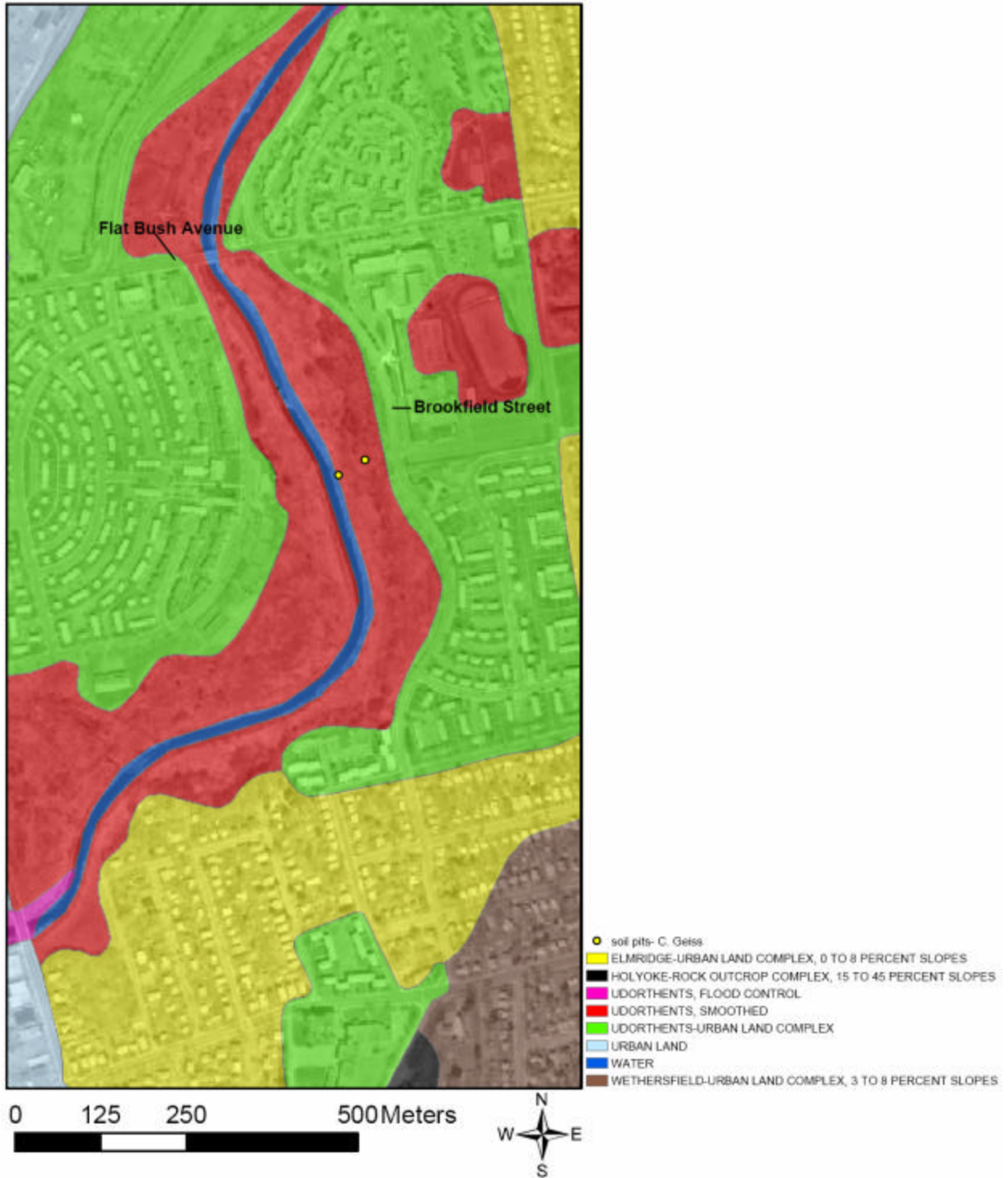
Our class examined several issues in preparing our environmental assessment including land use history, wetland regulations, habitat mapping, threatened and endangered species, stream flow dynamics, biomonitoring, water and soil chemistry, soil composition, and community structure. The following reports examine the abovementioned issues and predict future changes in environmental quality at the South Branch of the Park River study site as a result of development. Attention is given to the potential for development of a green space or urban park to benefit the citizens of Hartford, to provide habitat for wildlife, and to preserve and protect the beauty of the river site.

Figure 1. Sampling Locations, Land Use, Land Cover, and Habitat Types along the South Branch of the Park River (Hartford, CT)



DEP Photo: 1990

Figure 2. Physical Characterization of Soils along the South Branch of the Park River (Hartford, CT)



DEP Photo: 1990

Figure 3. Sampling Locations along the Mount Hope River (Ashford, CT)



DEP Photo: 1995

III. Land Use History along the South Branch of the Park River

The Park River and its surrounding watershed have served as vital resources for the residents of Hartford for many centuries. Like other great cities which have arisen on rivers, the settlers of Hartford depended on the river as a source of water for households, crops, and livestock, a transportation route for people and products, and a provider of food. However, as the city grew, the Park River also became a means by which the community could easily rid itself of its wastes. As a result of increased pollution of the river and seasonal flooding, city planners chose to redirect the course of the river through huge underground tunnels, thus making the waterway a less prominent and vital part of Hartford residents' lives. Currently, private and government organizations are attempting to return channelized portions of the urban river back to the people of Hartford and to improve the quality of life for residents of the Park River watershed (Wheeler 2002).

Thomas Hooker and a group of followers originally settled near the mouth of the Park River in 1636. Over time, the settlers began to rely heavily upon the Park River as a source of energy to power their mills and factories and as a depository for wastes. By the mid 1800's, however, city leaders were ready to abandon the murky river, for it was causing a great deal of devastation as it brought diseases when the waters were low and destruction when waters were high. With the plans of Horace Bushnell in hand, the town hired contractors to create a public park in the center of the city in an attempt to revitalize the area and to restore the Park River to its former vibrant state. Unfortunately, though, their elaborate plans did not control the potential for the river to destroy property when at flood stage and to spread disease ("Park River" 2002).

The floods of 1936 and 1938 were particularly dramatic and resulted in many deaths and great damage for the city of Hartford. After suffering such enormous losses, city leaders felt fully

justified in seeking the assistance of the Army Corps of Engineers to design and construct adequate works to protect communities from further damage by floods. During the 1940s, the engineers changed the course of the Park River by burying it in a double-barreled, reinforced concrete pressure conduit extending from a point in Bushnell Park to the Connecticut River. Nevertheless, disaster struck again in August, 1955 as the combined effects from hurricanes “Connie” and “Diane” resulted in the greatest flood flow on record in the Park River at Hartford. According to the U.S. Geological Survey, a peak flow occurred on August 19, 1955 at the entrance to the Park River Conduit equaling 14,000 cfs. (cubic feet per second), only 4,000 cfs. shy of the conduit’s design capacity (Marston and Raymond 1958). After absorbing the flooding caused by the hurricanes of 1955, the city of Hartford refined and further developed the flood control system as engineers enclosed portions of both the North and South branches of the Park River. The installation of the Park River conduit cost approximately three million dollars and served to control the flow of the river through the city of Hartford, but unfortunately many residents forgot that this valuable urban river still existed within the confines of their city (Wheeler 2002).

Though the North and South branches of the Park River have been used as illegal dumping areas in the recent past, communities surrounding the river have begun to develop and carry out plans to enhance the social, economic, and environmental livelihood of the Park River watershed. The Eastern Connecticut Resource Conservation and Development Area is working with community, educational, and government partners including the Knox Parks Foundation, Trinity College, and the Connecticut DEP to beautify the area surrounding the South Branch of the Park River. The goal of this partnership is to “improve the quality of life for residents of the Park River watershed by ensuring that urban natural resources and environmental quality are

restored and maintained as assets which contribute to education and recreation opportunities” (Taylor 2000). Project leaders hope to accomplish this goal by converting the overgrown dump area surrounding the Southern Branch of the Park River into an urban greenway complete with benches, walking trails, and bike paths for public use.

Though the term greenway is rather new, linear open space designs have been used in North America for more than a century. Starting in the early 1860s, developers such as Frederick Law Olmsted recognized the potential ecological and social benefits of linear open spaces to connect parks to each other and to surrounding neighborhoods. Olmsted used linear connections in many of his designs, including parkways and open-space systems in Buffalo and Chicago as well as the Emerald Necklace in Boston (Smith and Hellmund 1993). With their ability to protect natural areas, to diminish the disruptive effects of habitat fragmentation on wildlife and water resources, and to provide places for recreation, it is no wonder that city planners around the world have chosen to integrate greenways into their landscapes (Little 1990).

Attention to wetland preservation is a key element in the development of a project such as the one at the Park River. It is apparent from a review of photographs taken in 1950 and in 1990 that the meandering course of the river and its associated riparian wetland have been significantly altered. The patterns of soil erosion and silt deposition, the bank contours, and the floodplain area have undoubtedly also changed. To a certain extent, riparian wetlands may still be present. Several regulations including the 401 Water Quality Certification involving the discharge of materials into navigable waters and the Inland Wetlands and Watercourses Act of 1972 regulating activities affecting inland wetlands and watercourses must be considered since the Park River revitalization project will likely influence the surrounding wetlands (“Inland Water” 1998).

To revitalize the South Branch of the Park River and develop a greenway system much like those established along waterways in other locales, community, educational, and government partners must work cooperatively. By conducting an environmental assessment for the urban green space and by reviewing regulations that exist at the federal, state, and city levels concerning wetlands, flood plains, endangered species, and land use, South Branch partners will be prepared to initiate the restoration of this site. The viability of the Park River, a “forgotten urban resource,” can and should be restored for all the people of Hartford (Taylor 2000).

IV. Habitat Mapping and Threatened and Endangered Species at the South Branch of the Park River

The South Branch of the Park River has had a dynamic history over the last few centuries, serving throughout this time as a vital resource for both human and wildlife populations. In recent times, man has disturbed this watershed region significantly by removing bankside vegetation, channelizing the river, and subjecting it to urban runoff. Human disturbance factors as well as physical, chemical, and biological characteristics of the landscape have determined the quality and quantity of vegetative types and wildlife species that inhabit this region. A diverse flora and fauna now compose the aquatic and terrestrial habitats of this system's riparian zone, and together they play a role in controlling the water quality of the river and the general ecological health of the area (Taylor 2000).

Although the South Branch of the Park River is highly degraded due to channelization and the introduction of invasive species, many trees, shrubs, and herbaceous plants thrive along the banks of the river. Native trees and shrubs including silver maple (*Acer saccharinum*), boxelder (*Acer negundo*), silky dogwood (*Cornus amomum*), and common elderberry (*Sambucus canadensis*) inhabit the wooded areas surrounding the waterway. The herbaceous vegetation at the site includes plants such as milkweed (*Asclepias* spp.) and many species of goldenrod (*Solidago* spp.). Unfortunately, many invasive non-native species such as purple loosestrife (*Lythrum salicaria*), Common Reed (*Phragmites australis*), Japanese Knotweed (*Polygonum cuspidatum*), and Queen Anne's lace (*Daucus carota*) have also become prevalent in this region (Sych 2000). Cutting or removal of the non-native invasive species may be a necessary component of a management plan to improve habitat conditions along the river.

In terms of determining the species of birds and mammals that live along the South Branch of the Park River, it is essential that a research team employ adequate sampling

techniques. By identifying specific variables associated with the layout of the region such as percent cover of a certain tree or shrub or the height and species composition of ground cover, researchers may gain a better understanding of whether a particular species inhabits the area. For example, regular coverage by systematic sampling is an effective means of determining the species of birds present in a specific location. Trained observers should concentrate on early morning coverage when birds are most active, examine all habitats at the study site, and sample across seasons (Robbins and Geissler 2003). With regard to examining the species of mammals present at the site, researchers may search along transects laid out in a stratified fashion throughout the landscape. Small mammal traps may be set at specific distances along the transects. To identify larger mammals, passive infrared cameras with sensor devices that detect motion and variations in body temperature could be placed along the transects. As with avian sampling and identification, it is important to conduct these surveys for mammals across all habitats and all seasons (Bowles and Whelan 1994).

Species sampling is a critical element of the biological evaluation of the South Branch of the Park River. The International Union for Conservation of Nature and Natural Resources has developed simple lists of categories and criteria for classifying species at high risk of global extinction. The Natural Diversity Data Base maintained by the Connecticut Department of Environmental Protection is a data bank for information on the biology, population status, and threats to the elements of natural diversity. This data base does not indicate that there are any extant populations of federal or state endangered, threatened or special concern species that occur at the study site, but species data bases show that the study area may be a region of concern for several avian species (Sych 2000).

For a development project such as the one impacting the South Branch of the Park River, it is critical that any associated impact on endangered, threatened, or special concern species be considered. Endangered refers to any native species known by biological research and inventory to be in danger of extinction throughout all or a considerable portion of its range, while a threatened species is likely to become an endangered species within the foreseeable future throughout all or a considerable portion of its range. Species of special concern are any native plant or any native nonharvested wildlife species recognized to have a restricted range or habitat in the state, to be at a low population level, or to be in such high demand by man that unrestricted taking of the species would counteract conservation efforts (“Endangered” 1998). The Federal Endangered Species Act (ESA) passed in 1973 is an expression of America’s concern about the decline of many wildlife species around the world. Administered by the Interior Department’s U.S. Fish and Wildlife Service (FWS) and the Commerce Department’s National Marine Fisheries Service (NMFS), this law calls for the listing of federally endangered and threatened species as well as for the development of recovery plans to restore species to health. Furthermore, the law requires federal agencies to consult with FWS and NMFS to ensure that a proposed action will not affect a listed species (Shogren and Tschirhart 2001). The protection of species is also achieved on the statewide level in Connecticut under the Connecticut Endangered Species Act of 1989. Conservation and management measures are taken to protect and restore endangered, threatened, and special concern species listed by the Commissioner of the Department of Environmental Protection (“Endangered” 1998).

Since over two-hundred endangered, threatened, and special concern species are listed by the Connecticut Department of Environmental Protection for Hartford County alone, it is likely that several of these species may be permanent or transient inhabitants of the region along the

South Branch of the Park River. Within the last two years, Dr. Joan Morrison has recorded the presence of American Kestrels (*Falco sparverius*), a species of special concern, within this area during the winter months. Also, she has documented several state endangered, threatened, and special concern species in nearby Hartford parks. For example, she has recorded the state endangered and federally threatened Bald Eagle (*Haliaeetus leucocephalus*), the state endangered Yellow-breasted Chat (*Icteria virens*) and Red-headed Woodpecker (*Melanerpes erythrocephalus*), the state threatened Cooper's Hawk (*Accipiter cooperii*), Blue-winged Teal (*Anas discors*)(nesting populations only), Great Egret (*Egretta alba*), and Snowy Egret (*Egretta thula*), and the special concern species Red-shouldered Hawk (*Buteo lineatus*), American Kestrel (*Falco sparverius*), Northern Parula (*Parula Americana*), Savannah Sparrow (*Passerculus sandwichensis*), and the Brown Thrasher (*Toxostoma rufum*). Restoration of habitat along the South Branch of the Park River may benefit the abovementioned species which have been sighted in close proximity to the site. It is possible that other endangered, threatened, and special concern amphibians, fish, invertebrates, mammals, plants, and reptiles may exist within the properties' habitats. For example, state threatened amphibians such as the Blue-spotted Salamander (*Ambystoma laterale*) and the Spring Salamander (*Gyrinophilus porphyriticus* spp.) may thrive within the riparian zone surrounding the Park River. With more thorough sampling and field investigations, other at risk species not yet identified may be found utilizing the region ("County Report" 2003).

In terms of the land use and land cover features associated with the South Branch of the Park River and its surrounding watershed, commercial, industrial, and pavement, deciduous forest, deciduous shrub wetland, non-forested wetland, pasture and hay/exposed soil, residential and commercial, rural residential, turf and grass, as well as the turf and tree complex land

features are present (Figure 1). Large herbaceous patches of non-native species including the common reed (*Phragmites australis*) and Japanese Knotweed (*Polygonum cuspidatum*) also inhabit the site (Figure 1). All of the data collected detailing the species and habitat types present will assist future researchers in the development of an effective management plan.

V. Stream Flow Dynamics of the South Branch of the Park River

Introduction

Even though streams and rivers comprise only a small portion of the surface area in most settings, flowing waters are an important component of the environment. Flowing waters continuously shape landscapes as they move water, sediments, chemicals, detritus, and biota from headwaters to floodplains. Streams and rivers are also unique in their unidirectionality, their integration with their drainage areas, their diverse biota, and their highly variable nature. With regard to their variability, rivers differ significantly in their annual flow patterns as well as in their levels of flow (Downes *et al.* 2002). To establish a profile of the South Branch of the Park River several measurements were taken on 21 October 2003 to determine the total river discharge.

Methods

First, our research team stretched a measuring tape across the two banks of the river from (41.44265° N, 72.42311°W) to (41.44263° N, 72.42317°W) (Figure 1). Since stream discharge (Q) is equal to area multiplied by volume, it was necessary to estimate the cross-sectional area of the streambed as well as the mean water velocity (Upp 1993). To approximate cross-sectional area, the stream channel was subdivided into fifteen rectangular channels, with the width of each rectangle equaling one meter. Total water depth from surface to bed was measured at the half meter mark of each rectangular channel. To obtain the cross-sectional area of the entire stream channel, our research team added up the areas of all the rectangular channels.

Flow velocity in the rectangular channels was also determined. As a result of friction with the streambed and stream banks as well as internal instability, stream velocity varies with depth and with position along the stream channel (Sych 2000). In an attempt to account for this variation, the velocity of the water was ascertained using two methods. In the first method, with

a bottle starting at the center of each rectangular interval, the time it took the object to move one meter downstream was recorded. In the second method, velocity was measured at ten centimeters below the water surface for twenty seconds at the midpoint of each interval using a propeller meter (MJP Geopacks Basic Flowmeter). This device counted how many times the propeller spun around during the twenty second intervals. To determine the water velocity for each interval, our research team examined a calibration chart provided by MJP Geopacks in which water velocity (m/s) was plotted as a function of revolutions per minute according to the equation $V = 0.000854C + 0.05$.

A recording stream gage was installed on 14 October 2003 (41.44265°N, 72.42311°W) to monitor water levels at fifteen minute intervals. Also, a place to measure fluid flow at varying water levels was established approximately twenty meters upstream from the bridge on Flat Bush Avenue in Hartford, CT. A gauging station was installed by marking the concrete wall every ten centimeters up to two-and-a-half meters in height. By measuring the width and water depth of the channel and by then timing how long it took a leaf to travel downstream between two caulked seams on the concrete (10.25 m in length), it was possible to determine total discharge. Repeated trips to the study site are necessary to evaluate how the amount of water that flows down the South Branch of the Park River varies after rain storms.

Results

Overall, three discharge values were determined using the abovementioned methods. When surface velocity was obtained by timing the movement of a float in the water, the amount of water passing down the river per second equaled one cubic meters per second (Table 1). A volume flow measurement of two cubic meters per second was calculated when water velocity was measured using a propeller meter (Table 2). Finally, when surface velocity was obtained by

timing the movement of a leaf across the surface of the water, the volume flow rate equaled three cubic meters per second at the bridge site (Table 3).

Conclusions

In evaluating the discharge values, it is important to note that only one significant figure is included for the results of each method. Many assumptions and uncertainties must be accounted for in our data. First, our research team approximated the cross-sectional area of the channel by a sum of rectangles and also estimated the velocity at a limited number of depths. Also, when timing the movement of the float in the water, it was assumed that the surface velocity of the shallow rectangular channels was equal to zero. Though the highest velocity usually occurs in the center of a channel near the surface and lower velocity readings are found near the bed and banks, it is likely that the surface velocities of the shallow rectangular channels were low but not equal to zero (Stream Flow Velocity 1998). Furthermore, several factors including inter-observer variation in measuring, the influence of wind on the measurements, and the impact of individuals serving as obstructions within the watercourse during measurements may have significantly affected the results. In addition, it is possible that the meter stick was not held completely vertical each time depth measurements were taken.

Taking into account the sources of error and assumptions associated with our methods, the results obtained provide only a rough estimate of the total quantity of water passing down the South Branch of the Park River per unit time. Since velocity was approximated to be zero along the surface of seven of the fifteen rectangular channels near the banks of the river, our research team likely underestimated the stream discharge with the float method of velocity determination. It was also difficult to determine water velocity near the banks of the river with the propeller method. At very shallow depths, it was not possible to submerge the propeller completely in the water for it to spin around. Therefore, this method likely underestimated stream discharge as

well. The final determination of stream discharge conducted upstream from the Flat Bush Avenue bridge potentially overestimated the flow velocity of the water. In this case, velocity was measured at the surface in the center of the channel where velocity is typically quite high.

In comparison to daily streamflow values obtained during the late 1970s and early 1980s by the United States Geological Survey (USGS), our research team calculated higher discharge values on 21 October 2003. The USGS reported a daily streamflow value of 29 cubic feet per second (0.82 cubic meters per second) on 21 October 1979 and a value of 18 cubic feet per second (0.51 cubic meters per second) on 21 October 1980 (“USGS” 1981). The higher discharge values calculated for 21 October 2003 may be due in part to the high levels of rainfall experienced this year. In October alone, 3.73 inches of rain has already fallen while the normal amount of precipitation for the period 01 October to 28 October is 3.42 inches at Bradley International in Hartford, CT. In terms of precipitation for the period 01 January to 28 October 2003, 46.33 inches of rain has fallen compared to the normal 37.98 inches (“Bradley International” 2003). Other rivers in the region such as the Connecticut River were also high during our study period. While the minimum gage height equaled 8.15 feet on 1 October 2003, the gage height equaled 19.83 on 31 October 2003 (“USGS” 2003).

To improve the quality of our measurements, our research team could increase our level of accuracy by making the width of the rectangular channels smaller when calculating the cross-sectional area of the streambed. Also, it would be beneficial to measure the water velocity at many depths within the rectangular channels to obtain a better estimate of velocity. It has been observed that mean water velocity can be estimated by taking measurements at a depth 0.6 of the distance from the surface to the bed (Stream Flow Velocity 1998). Velocity measurements taken in this study in the center of the channel reflected the theoretical expectation that measured

velocity would be highest at 0.10 meters below the surface and would be lowest at 0.60 meters below the water surface (Table 4). Furthermore, velocity measurements should be taken periodically at our study site near the Flat Bush Avenue bridge to determine how velocity varies over time. In terms of calibrating our gauging station we have installed, it will be necessary to measure the water velocity when the river is at high as well as at low levels. If the cross-sectional area of the study area is known and velocity is known, it is possible to determine the quantity of fluid that passes down that portion of the South Branch of the Park River per unit time. With this data, a calibration curve may be plotted examining the inter-relationship between gage height and stream discharge. This lab has provided some baseline data about the South Branch of the Park River and has also raised questions about how to improve our data collection to give a broad view of potential water discharge conditions at the site.

Table 1. Method One- Determination of the quantity of fluid that passes through the South Branch of the Park River ((41.44265° N, 72.42311° W) to (41.44263° N, 72.42317° W)) using a floating object to estimate water velocity

	Width of Rectangular Channels (m)	Depth of Rectangular Channels at midpoint (m)	Surface Velocity (m/sec.)	Discharge (m³/sec.)
	1	0.080	0.00	0.00
	1	0.125	0.00	0.00
	1	0.225	0.00	0.00
	1	0.405	0.00	0.00
	1	0.605	0.25	0.15
	1	0.800	0.33	0.26
	1	0.585	0.33	0.19
	1	0.500	0.50	0.25
	1	0.470	0.25	0.12
	1	0.495	0.33	0.16
	1	0.550	0.25	0.14
	1	0.645	0.25	0.16
	1	0.605	0.00	0.00
	1	0.295	0.00	0.00
	1	0.100	0.00	0.00
Total Discharge (m³/sec.)				1

Table 2. Method Two- Determination of the quantity of fluid that passes through the South Branch of the Park River ((41.44265° N, 72.42311° W) to (41.44263° N, 72.42317° W)) using a propeller meter to estimate water velocity

	Width of Rectangular Channels (m)	Depth of Rectangular Channels at midpoint (m)	Counts per Minute (C)	Velocity (m/sec.)	Discharge (m³/sec.)
	1	0.080	0	0.00	0.00
	1	0.125	0	0.00	0.00
	1	0.225	0	0.00	0.00
	1	0.405	0	0.00	0.00
	1	0.605	201	0.22	0.13
	1	0.800	462	0.44	0.35
	1	0.585	552	0.52	0.30
	1	0.500	621	0.58	0.29
	1	0.470	561	0.53	0.25
	1	0.495	519	0.49	0.24
	1	0.550	420	0.41	0.23
	1	0.645	261	0.27	0.17
	1	0.605	0	0.00	0.00
	1	0.295	0	0.00	0.00
	1	0.100	0	0.00	0.00
Total Discharge (m³/sec.)					2

Table 3. Method 3- Determination of the quantity of fluid that passes through the South Branch of the Park River (approximately twenty meters upstream from the bridge on Flat Bush Avenue in Hartford, CT) by timing how long it took for a leaf to travel downstream between two caulked seams on a concrete wall

Width (m)	Depth (m)	Velocity (m/sec.)	Total Discharge (m³/sec.)
18.3	0.51	0.27	3

Table 4. Fluctuation in stream velocity with relation to water depth (at the midpoint of the river) measured between (41.44265° N, 72.42311° W) and (41.44263° N, 72.42317° W)

Propeller Depth (m)	Revolutions per Minute (C)	Velocity (m³/sec.)
0.10	151	0.18
0.20	143	0.17
0.30	127	0.16
0.40	117	0.15
0.50	112	0.15
0.60	91	0.13

VI. Aquatic Macroinvertebrates as Biomonitorers of Water Quality in Urban and Rural Connecticut Rivers

Introduction

An environmental impact analysis is a critical prelude to determining the potential effects of proposed development projects on environmental systems. Methodology available for assessing the physical, chemical, and biological effects of human actions on water quality allows researchers to predict possible effects on individual components of these systems as well as on interactions between the components (Black 1981). Though chemical monitoring provides a “snap shot” of water quality at the time samples are collected, biomonitoring employs organisms to assess or monitor environmental conditions over an extended period of time (“Data Analysis” 2000). The objective of our study was to evaluate and to draw comparisons between the water quality of the South Branch of the Park River in Hartford, CT and of the Mount Hope River in Ashford, CT by using aquatic macroinvertebrates as biomonitorers.

The biota of rivers is both taxonomically diverse and species rich. The main groups within the biota include bacteria, fungi, micro- and macroalgae, bryophytes, macrophytes, microinvertebrates, macroinvertebrates, and vertebrates (Downes *et al.* 2002). Aquatic macroinvertebrates are ideal for use in biomonitoring since they are abundant in freshwater systems, sensitive to pollution and other disturbances, long-lived, and relatively easy to collect and identify (Rosenberg and Resh 1993). Therefore, aquatic macroinvertebrates act as continuous monitors of the waters they inhabit, allowing for long-term analysis of regular and intermittent discharges and varying concentrations of pollutants. Since benthic macroinvertebrates offer many advantages in biomonitoring, our research team examined these organisms in our water quality assessment at the two study sites.

Methods

On 20 September 2003, our research team sampled aquatic macroinvertebrates from the Mount Hope River at the Trinity College Field Station in Ashford, CT. Our study site was located upstream and north of where Connecticut Route 89 crosses over the Mount Hope River. The primary vegetative types observed near the study area included Gray Birch (*Betula populifolia*), Quaking Aspen (*Populus tremuloides*), White Oak (*Quercus alba*), and White Pine (*Pinus strobus*). To account for stream heterogeneity, macroinvertebrates were sampled from two run and two riffle microhabitats. Run microhabitats are found within smooth-flowing stretches of water, while riffle microhabitats are found within highly oxygenated water that is choppy at the surface (Downing and Rigler 1984). The sampled run microhabitats were located at (41.74040°N, 72.70698°W) and (41.84302°N, 72.16895°W), while the sampled riffle microhabitats were located at (41.74061°N, 72.70701°W) and (41.84325°N, 72.16892°W) (Figure 3). Aquatic macroinvertebrates were collected using a kick net method of sampling with a 1 x 1 m, 500 µm nytex screen attached to two poles. Sampling was accomplished by holding the kick net in an upright position and by disturbing one square meter of the substrate and underlying bed immediately upstream of the net for four minutes with kicking and rubbing of rock surfaces (Barbour *et al.* 1999). After each sample, macroinvertebrates were placed in vials (by microhabitat type) containing 95% ethanol to preserve the morphological features of the organisms. Each subsequent sampling was conducted sufficiently upstream from the previously sampled site so as not to be affected by any physical disturbance associated with the sampling of the previous site.

On 14 October 2003, our research team sampled aquatic macroinvertebrates from the South Branch of the Park River in Hartford, CT. Our study site was located upstream from the bridge on Flat Bush Avenue. The primary vegetative types observed near the study area

included Boxelder (*Acer negundo*), Common Reed (*Phragmites australis*), and Japanese Knotweed (*Polygonum cuspidatum*). Two run and two riffle microhabitats were sampled at the Hartford study site. The sampled run microhabitats were located at (41.44265°N, 72.42311°W) and (41.74054°N, 72.70857°W), while the sampled riffle microhabitats were located at (41.44265°N, 72.42311°W) and (41.73924°N, 72.70787°W) (Figure 1). Sampling procedure was identical to that employed on the Mount Hope River.

On 28 October 2003, our research team used stereomicroscopes and taxonomic keys provided by Dr. Scott Smedley to classify each specimen to the order, and in some cases, the family level. Using the combined riffle and run microhabitat data for each river location, several aquatic biomonitoring indices including Taxa Richness, percent Composition of Dominant Taxa, Percent Ephemeroptera, Plecoptera, and Trichoptera (EPT) Taxa, and the Biotic Index were calculated (“Data Analysis” 2000).

Results

With regard to the Mount Hope River, 527 individual organisms were collected and identified, while only 47 organisms were collected and identified from the South Branch of the Park River. In terms of Taxa Richness, a greater number of taxonomic groups were represented in our samples from the Mount Hope River than were present in our samples from the South Branch of the Park River (Table 5). According to the Percent Composition of Dominant Taxa Index, 40% of organisms collected from the Mount Hope River were net-spinners of the order Trichoptera. Although this one taxonomic group was dominant, the species within it appeared to be diverse. Thirty-four percent of the organisms collected from the South Branch of the Park River were of the order Amphipoda, likely a single species. In terms of the Percent EPT, a greater percentage of the macroinvertebrates sampled was from one of these three orders for the Mount Hope River than for the South Branch of the Park River (Table 5). Finally, a Biotic Index

comparing the abundance of taxa and their tolerance to environmental stress was calculated for both study sites: the water quality of the Mount Hope River is excellent and organic pollution is unlikely, while the water quality of the South Branch of the Park River is good and there is likely some organic pollution present (Table 5) (“Data Analysis” 2000).

Conclusions

It was the initial premise of this study that the water quality of the South Branch of the Park River in Hartford, CT has been significantly degraded by sewer overflow, urban runoff, littering and roaming house pets (Sych 2000). This biological investigation verifies that the South Branch of the Park River is not as healthy in terms of water quality as the Mount Hope River in rural Ashford, CT. In terms of the Taxa Richness Index, which measures the diversity of organisms in the invertebrate community, a greater number of taxonomic groups are represented in the Mount Hope River samples compared to the South Branch of the Park River samples; this indicates that the water and habitat quality are likely more favorable at the Mount Hope River site. According to the Percent Composition of Dominant Taxa Index, a high percent contribution by a single taxon indicates community imbalance (Downes *et al.* 2002). In the case of the Mount Hope River, the large number of net-spinning caddisflies of varying types dominate the taxonomic profile but they also contribute to the high EPT levels for this location. Overall, this finding should be viewed as a favorable indicator for low levels of pollution at the Mount Hope River site. On the other hand, at the South Branch of the Park River, species of the order Amphipoda dominated the organisms observed. The few taxonomic groups observed there may indicate environmental stress. The approximate ten-fold difference in the number of individuals between the two sites further suggests that the water quality at the South Branch of the Park River is compromised.

With the EPT levels for the Mount Hope River and the South Branch of the Park River being 73% and 26%, respectively, it is apparent that the water quality at the rural location is higher according to this biomonitoring standard. The Biotic Indices, which correlate with excellent conditions at the Mount Hope River and good conditions at the South Branch of the Park River, also indicate a disparity in the water quality and degree of organic pollution at the two sites. Although these biological indices provide an excellent general categorization of water quality and environmental health over an extended period of time, it is critical that further quantification of water quality be conducted using chemical and physical standards of measurement.

Table 5. Taxa Richness, Percent Composition of Dominant Taxa, Percent Ephemeroptera, Plectoptera, and Trichoptera (EPT), and the Biotic Index for the Mount Hope River in Ashford, CT and the South Branch of the Park River in Hartford, CT

	Mount Hope River	South Branch of the Park River
Taxa Richness	10	6
Percent Composition of Dominant Taxa	40% Trichoptera net-spinners	34% Amphipoda
Percent EPT	73%	26%
Biotic Index	3.53	4.51

Appendix

Taxa Richness:

Mount Hope River – Plecoptera + Ephemeroptera + Anisoptera + Trichoptera (case-builders) + Trichoptera (net-spinners) + Corydalidae + Coleoptera + Chironomidae + Tipulidae + Hirudinea = **10** taxonomic groups

South Branch of the Park River – Zygoptera + Trichoptera (net-spinners) + Coleoptera + Chironomidae + Amphipoda + Turbellaria = **6** taxonomic groups

Percent Composition of Dominant Taxa:

Mount Hope River –
Trichoptera (net-spinners) $209/527 = 0.40$
 $0.40 \times 100 = \mathbf{40\%}$

South Branch of the Park River –
Amphipoda $16/47 = 0.34$
 $0.34 \times 100 = \mathbf{34\%}$

Percent EPT

Mount Hope River –
 $36 + 141 + 1 + 209 = 387 = \text{Total EPT}$
 $387/527 = 0.73$
 $0.73 \times 100 = \mathbf{73\%} = \text{Percent EPT}$

South Branch of the Park River –
 $12 = \text{Total EPT}$
 $12/47 = 0.26$
 $0.26 \times 100 = \mathbf{26\%} = \text{Percent EPT}$

Biotic Index

Taxon	Pollution Tolerance Value	Total # (Mount Hope River)	Total # (South Branch of the Park River)	Total Tolerance Value (Mount Hope River)	Total Tolerance Value (South Branch of the Park River)
Plecoptera	1.0	36	0	36	0
Ephemeroptera	3.6	141	0	507.6	0
Anisoptera	2.0	4	0	8	0
Zygoptera	7.0	0	1	0	7
Trichoptera					
casebuilders	1.8	1	0	1.8	0
net-spinners	3.8	209	12	794.2	45.6
Megaloptera					
Corydalidae	0	26	0	0	0
Sialidae	4.0	0	0	0	0
Coleoptera	4.6	101	9	464.6	41.4
Diptera					
Chironomidae	6.0	5	2	30	12
Simuliidae	6.0	0	0	0	0
Tipulidae	3.0	3	0	9	0
Amphipoda	4.0	0	16	0	64
Isopoda	6.0	0	0	0	0
Decapoda	7.0	0	0	0	0
Oligochaeta	8.0	0	0	0	0
Hirudinea	8.0	1	0	8	0
Turbellaria	6.0	0	7	0	42
Gastropoda	7.0	0	0	0	0
Totals		527	47	1859.2	212

Mount Hope River-

Total Tolerance Value/ Total # Individuals = $1859.2/527 = 3.53$

Biotic Index = 3.53 = Excellent Water Quality

South Branch of the Park River

Total Tolerance Value/ Total # Individuals = $212/47 = 4.51$

Biotic Index = 4.51 = Good Water Quality

VII. Chemical Composition of Water and Soil along Urban and Rural Connecticut Rivers

Introduction

The South Branch of the Park River has had a dynamic history over the last few centuries, serving throughout this time as a vital resource for both human and wildlife populations. In recent times, man has disturbed this watershed region significantly by removing bankside vegetation, channelizing the river, and creating urban runoff (Sych 2000). Chemical standards of measurement in conjunction with biological indices provide an excellent general categorization of soil and water quality and environmental health over an extended period of time. Soil and water quality monitoring are defined as the sampling and analysis of soil and water constituents and conditions. These studies often focus upon major ions such as nitrate, chloride, sulfate, and phosphate which are known to cause significant environmental distress in excess amounts. The magnitude of their effects can be influenced by properties such as pH and alkalinity (Soil and Plant Analysis Council 2000).

The presence of nitrates in soils is essential for plant growth. However, excess nitrates in soil can increase the risk of contamination of ground or surface water. Together with phosphorus, heightened nitrate levels may accelerate eutrophication, resulting in increases in aquatic plant growth and changes in dissolved oxygen and temperature. Sources of nitrates include wastewater treatment plants, runoff from fertilized lawns and cropland, runoff from animal manure storage areas, and industrial discharges (McBride 1994).

Chloride is similar to nitrate in solubility and mobility in the soil. Though small amounts of chlorides are required for normal cell functions in plant and animal life, high levels of chloride can contaminate freshwater streams and lakes. Chlorides may enter surface waters from rocks containing chlorides, agricultural runoff, wastewater from industries, or oil well wastes (Clapp *et al.* 2001).

The sulfate anion in soil is the primary form of sulfur absorbed by plants. The sulfate anion is easily adsorbed by clay and iron and aluminum oxides, and adsorption increases with pH. Sulfate is also the most common form of sulfur in natural waters and can be reduced to sulfide and hydrogen sulfide under low oxygen conditions. Increased sulfate loads originating from polluted surface water and groundwater may stimulate severe eutrophication and sulfide toxicity in freshwater systems (Soil and Plant Analysis Council 2000).

In soil and water, the element phosphorus usually exists as part of a phosphate molecule. Since phosphate is often in short supply in freshwater systems, a small increase in phosphate can result in accelerated plant growth, algal blooms, low dissolved oxygen, and the death of certain fish, invertebrates, and other aquatic animals. Phosphate is also taken up by plants from soils, utilized by animals that consume plants, and returned to soils as organic residues decay in soils. Sources of phosphate include wastewater treatment plants, runoff from fertilized lawns and cropland, failing septic systems, runoff from animal manure storage areas, disturbed land areas, and drained wetlands (Marx *et al.* 1999).

Alkalinity is a measure of the capacity of a stream to neutralize acids from rainwater or wastewater. It is affected by rocks, soil, pH activity, and industrial wastewater discharge into a stream. Total alkalinity (mg/L CaCO₃) is the amount of acid needed to restore a sample to pH 4.5, at which point all alkaline compounds in the sample are consumed. pH is a term used to indicate the alkalinity or acidity of a substance, and it affects many chemical and biological processes in soil and in water. Low pH may allow toxic elements and compounds to become mobile and available for uptake by plants and animals (Volunteer Stream Monitoring 1997).

The focus of our current laboratory investigation was to quantify and to assess nitrate, chloride, sulfate, and phosphate levels as well as to determine the pH and alkalinity of water

samples taken from the South Branch of the Park River in Hartford, CT and the Mount Hope River in Ashford, CT. Also, pH and nitrate, chloride, sulfate, and phosphate levels were determined for soil samples taken from multiple locations along the South Branch of the Park River.

Methods

Samples in this investigation were prepared using U.S. Environmental Protection Agency (EPA) methods 9045C, 300.0, and 310.1. The EPA method 300.0 involving ion chromatography of soil ions was modified in our investigation. Since the soil had been previously mixed for pH analyses, the slurries of deionized water and soil were not mixed for 10 minutes using a magnetic stirring device as indicated in article 11.7 of the method. Also, the slurries of soil and deionized water were filtered through 0.20 μ m membrane type filters as opposed to the 0.45 μ m filter indicated in the method. Investigators also modified EPA method 310.1 in this investigation. Instead of using a 50 mL buret as indicated in the method, a HACH digital titrator was utilized. Furthermore, instead of utilizing 0.02 N or 0.1 N titrant, 0.16 N sulfuric acid titrant was used in this study. The main instruments used in this study included a Mettler AE 160 Balance to measure soil samples, a Magnestir mixer (Scientific Products, 115 volt) to prepare soil samples for pH analysis, a Handheld pH/mV/Temperature Meter (IQ Scientific Instruments, Inc., Model IQ150) to measure to soil and water pH, and the ICS-90 Ion Chromatography System in coordination with the software program PeakNet (Dionex 2001) to analyze anions present in the soil and water samples. The soil samples were taken at six different locations at the South Branch of the Park River, specifically at 25 meter (41.73731°N, 72.70762°W and 41.73794°N, 72.70719°W), 50 meter (41.73727°N, 72.70734°W and 41.73804°N, 72.70692°W), and 75 meter (41.73726°N, 72.70705°W and 41.73820°N, 72.70666°W) sites along two different transects. These sampling locations correspond with the ground beetle trapping sites, as discussed in

chapter ten. In terms of water samples, the sampled run microhabitats were located at (41.74040°N, 72.70698°W) and (41.84302°N, 72.16895°W), while the sampled riffle microhabitats were located at (41.74061°N, 72.70701°W) and (41.84325°N, 72.16892°W) at the Mount Hope River.

Results

The ion chromatography analysis of soil and water anions provided concentration (ppm) data for nitrate, sulfate, chloride, and phosphate in the samples (Tables 7-10). Results for the anions were further analyzed by comparing concentration values of the samples with those of the method blank (Table 6). pH meter readings for the soil samples and pH and alkalinity values for the water samples were also determined (Tables 11-12).

With regard to nitrate levels, concentrations at or below 90 mg/L are known to have no adverse effects on warmwater fish. Furthermore, the maximum concentration of nitrate allowed in human drinking water is 10 mg/L (Quality Criteria for Water 1986). None of the nitrate concentrations in this study exceeded those limits. However, it was found that nitrate concentrations of the water samples from the South Branch of the Park River were greater than those from the Mount Hope River (Table 7).

In terms of sulfate levels, the maximum amount of sulfate allowed in human drinking water is 250 mg/L. Also, more than half of good fishing waters have sulfate concentrations below 32 mg/L (HACHS Kits 2001). Though none of the sulfate concentrations in this study exceeded those limits, the sulfate concentrations of the water samples from the South Branch of the Park River were higher than those from the Mount Hope River (Table 8). Also, there was a general trend toward increased sulfate concentrations for the South Branch of the Park River from 13.2124 mg/L on 16 September 2003 to 19.9580 mg/L on 21 October 2003, possibly

indicating that the water there decreased in quality over time or may have been affected by increased runoff associated with the extremely rainy season.

Chloride often receives attention from researchers interested in freshwater fish since these organisms are extremely sensitive to changes in concentration of this anion. In one study, it was found that the chronic limits of chloride for the freshwater crustacean *Daphnia pulex* are 372.1 mg/L (Ambient Water Quality 1988). None of the chloride concentrations in this study exceeded those limits. The chloride concentrations of the water samples from the South Branch of the Park River were higher than those from the Mount Hope River with the highest chloride concentration for the Park River equaling 41.0873 mg/L on 21 October 2003 and the highest chloride concentration for the Mount Hope River equaling 14.7768 mg/L on 20 September 2003 for a riffle microhabitat (Table 9).

In this study, minimal levels of phosphate were detected in the water samples from both study sites. In the samples where phosphate was detected, phosphate levels for samples from the South Branch of the Park River were higher than those from the Mount Hope River (Table 10). The pH values for the South Branch of the Park River ranged from 7.25 to 8.36, while the alkalinity values ranged from 48 to 124 mg/L CaCO₃. The pH values at the Mount Hope River ranged from 6.51 to 7.09, while the alkalinity values ranged from 24 to 28 mg/L CaCO₃ (Table 12). Since the best pH range for the growth of algae is 7.5 to 8.4, there is likely more organic pollution present in the South Branch of the Park River than the Mount Hope River (pH Water Quality 2003). In terms of alkalinity, the National Technical Advisory Committee recommends a minimum alkalinity of 20 mg/L CaCO₃ in freshwater systems (Quality Criteria for Water 1986). The alkalinity values of all water samples in this study exceeded the 20 mg/L CaCO₃

minimum, indicating that adequate amounts of alkalinity are maintained in the South Branch of the Park River and the Mount Hope River to buffer pH within tolerable limits.

With regard to soil analysis, nitrate concentrations in soil are considered to be excessive if they exceed 30 ppm (Marx *et al.* 1999). In this investigation, all of the nitrate concentrations in soil samples taken from along the South Branch of the Park River exceeded those limits (Table 7). In this study, all of the sulfate concentrations in the soil samples were greater than 10 ppm, a level of sulfate considered sufficient on a low, medium, sufficient scale (Table 8). Chloride concentrations in soil are considered high if they exceed 8 ppm, medium if they range from 4-8 ppm, and low if they range from 0-4 ppm (Marx *et al.* 1999). In this study, the chloride concentrations of four of the six soil samples exceeded the high concentration level, and two of the samples contained low chloride concentrations (Table 9). In terms of phosphate, levels above 0.1 mg/L makes plants grow at a higher rate than normal. In this study, half of the samples contained phosphate concentrations that exceeded the 0.1 mg/L level (Phosphate Testing 2003) (Table 10). Soil pH is important to plants because it influences the form of many elements in the soil, and it influences soil microbial processes. Most crops grow best if the soil pH is between 6.0 and 7.5 (Marx *et al.* 1999). In this study, the pH of all soil samples fell within that range (Table 11).

Conclusions

Overall, it was the initial premise of this study that the water quality of the South Branch of the Park River in Hartford, CT has been significantly degraded by sewer overflow, urban runoff, littering and roaming house pets (Sych 2000). Chemical and biological investigations verify that the South Branch of the Park River is not as healthy in terms of water quality as the Mount Hope River in rural Ashford, CT. The Biotic Indices, which correlate with excellent conditions at the Mount Hope River and good conditions at the South Branch of the Park River,

indicated a disparity in the water quality and degree of organic pollution at the two sites. The current chemical investigation indicates that higher anion concentrations and pH levels at the South Branch of the Park River may also be indicative of lower water quality in comparison to the Mount Hope River.

The majority of ion concentrations for soil samples taken from along the South Branch of the Park River fell within acceptable limits. It does not appear from these chemical analyses that there is a need for any soil remediation prior to development. Further chemical and physical assessments of soil and water quality at multiple sites and times will serve as essential tools in formulating recommendations for the final development of the South Branch of the Park River.

Table 6. The measured concentration (mg/L) of nitrate, sulfate, chloride, and phosphate in the four standard solutions (0.1, 1.0, 10.0, and 100.0 ppm anions) and the method blank

	Nitrate (mg/L)	Sulfate (mg/L)	Chloride (mg/L)	Phosphate (mg/L)
Method Blank	0.0454	0.2680	0.0423	0.0581
0.1 ppm	0.1087	0.2840	0.1297	0.1728
1.0 ppm	0.9569	1.1460	0.9308	1.8127
10.0 ppm	9.7518	9.8231	9.4429	19.3853
20.0 ppm	20.1262	20.0802	20.2819	40.3169

Table 7. The concentration of nitrate in water samples from the South Branch of the Park River and the Mount Hope River in Ashford, CT and in soil samples from along the South Branch of the Park River in Hartford, CT. Samples were analyzed on 11 November 2003 unless otherwise indicated.

	[NO ₃ ⁻] in water samples (mg/L)	[NO ₃ ⁻] in soil samples (ppm)
SPR 9/16/03 (inj.date 9/25/03)	2.2885	
SPR 9/23/03 (inj. Date 9/25/03)	2.3370	
SPR 9/23/03	0.9014	
SPR 9/30/03 filtered 9/30/03 stored 4°C	3.5542	
SPR 9/30/03 stored 4°C filtered 11/11/03	2.2240	
SPR 10/21/03	2.7098	
MHR dsws riffle (9/20/03) 41.84325°N, 72.16892°W	0.2017	
MHR dsws run (9/20/03) 41.84302°N, 72.16895°W	0.0901	
MHR same riffle (9/20/03) 41.74061°N, 72.70701°W	0.0996	
MHR same run (9/20/03) 41.74040°N, 72.70698°W	0.1254	
SPR same 25 m soil (9/16/03) (41.73794°N, 72.70719°W)		257
SPR same 50 m soil (9/16/03) (41.73804°N, 72.70692°W)		226
SPR same 75 m soil (9/16/03) (41.73820°N, 72.70666°W)		272
SPR dsws 25 m soil (9/16/03) (41.73731°N, 72.70762°W)		287
SPR dsws 50 m soil (9/16/03) (41.73727°N, 72.70734°W)		42.0
SPR dsws 75 m soil (9/16/03) (41.73726°N, 72.70705°W)		354

Table 8. The concentration of sulfate in water samples from the South Branch of the Park River and the Mount Hope River in Ashford, CT and in soil samples from along the South Branch of the Park River in Hartford, CT. Samples were analyzed on 11 November 2003 unless otherwise indicated.

	[SO ₄ ²⁻] in water samples (mg/L)	[SO ₄ ²⁻] in soil samples (ppm)
SPR 9/16/03 (inj.date 9/25/03)	13.2124	
SPR 9/23/03 (inj. Date 9/25/03)	6.6722	
SPR 9/23/03	6.9298	
SPR 9/30/03 filtered 9/30/03 stored 4°C	15.3494	
SPR 9/30/03 stored 4°C filtered 11/11/03	15.2152	
SPR 10/21/03	19.9580	
MHR dsws riffle (9/20/03) 41.84325°N, 72.16892°W	5.8955	
MHR dsws run (9/20/03) 41.84302°N, 72.16895°W	5.7287	
MHR samc riffle (9/20/03) 41.74061°N, 72.70701°W	5.8442	
MHR samc run (9/20/03) 41.74040°N, 72.70698°W	5.7932	
SPR samc 25 m soil (9/16/03) (41.73794°N, 72.70719°W)		50.9
SPR samc 50 m soil (9/16/03) (41.73804°N, 72.70692°W)		29.7
SPR samc 75 m soil (9/16/03) (41.73820°N, 72.70666°W)		28.2
SPR dsws 25 m soil (9/16/03) (41.73731°N, 72.70762°W)		27.1
SPR dsws 50 m soil (9/16/03) (41.73727°N, 72.70734°W)		35.7
SPR dsws 75 m soil (9/16/03) (41.73726°N, 72.70705°W)		23.6

Table 9. The concentration of chloride in water samples from the South Branch of the Park River and the Mount Hope River in Ashford, CT and in soil samples from along the South Branch of the Park River in Hartford, CT. Samples were analyzed on 11 November 2003 unless otherwise indicated.

	[Cl] in water samples (mg/L)	[Cl] in soil samples (ppm)
SPR 9/16/03 (inj.date 9/25/03)	25.9315	
SPR 9/23/03 (inj. Date 9/25/03)	13.0983	
SPR 9/23/03	13.3559	
SPR 9/30/03 filtered 9/30/03 stored 4°C	36.3006	
SPR 9/30/03 stored 4°C filtered 11/11/03	33.8365	
SPR 10/21/03	41.0873	
MHR dsws riffle (9/20/03) 41.84325°N, 72.16892°W	14.7768	
MHR dsws run (9/20/03) 41.84302°N, 72.16895°W	14.2334	
MHR same riffle (9/20/03) 41.74061°N, 72.70701°W	14.5358	
MHR same run (9/20/03) 41.74040°N, 72.70698°W	14.4692	
SPR same 25 m soil (9/16/03) (41.73794°N, 72.70719°W)		15.2
SPR same 50 m soil (9/16/03) (41.73804°N, 72.70692°W)		26.7
SPR same 75 m soil (9/16/03) (41.73820°N, 72.70666°W)		13.8
SPR dsws 25 m soil (9/16/03) (41.73731°N, 72.70762°W)		0.760
SPR dsws 50 m soil (9/16/03) (41.73727°N, 72.70734°W)		1.20
SPR dsws 75 m soil (9/16/03) (41.73726°N, 72.70705°W)		15.1

Table 10. The concentration of phosphate in water samples from the South Branch of the Park River and the Mount Hope River in Ashford, CT and in soil samples from along the South Branch of the Park River in Hartford, CT. Samples were analyzed on 11 November 2003 unless otherwise indicated.

	[PO ₄ ³⁻] in water samples (mg/L)	[PO ₄ ³⁻] in soil samples (ppm)
SPR 9/16/03 (inj.date 9/25/03)	0.1852	
SPR 9/23/03 (inj. Date 9/25/03)	0.4358	
SPR 9/23/03	0	
SPR 9/30/03 filtered 9/30/03 stored 4°C	0.3835	
SPR 9/30/03 stored 4°C filtered 11/11/03	0	
SPR 10/21/03	0.0250	
MHR dsws riffle (9/20/03) 41.84325°N, 72.16892°W	0.0251	
MHR dsws run (9/20/03) 41.84302°N, 72.16895°W	0.0285	
MHR same riffle (9/20/03) 41.74061°N, 72.70701°W	0	
MHR same run (9/20/03) 41.74040°N, 72.70698°W	0	
SPR same 25 m soil (9/16/03) (41.73794°N, 72.70719°W)		0.092
SPR same 50 m soil (9/16/03) (41.73804°N, 72.70692°W)		1.93
SPR same 75 m soil (9/16/03) (41.73820°N, 72.70666°W)		0.644
SPR dsws 25 m soil (9/16/03) (41.73731°N, 72.70762°W)		0
SPR dsws 50 m soil (9/16/03) (41.73727°N, 72.70734°W)		0
SPR dsws 75 m soil (9/16/03) (41.73726°N, 72.70705°W)		0.478

Table 11. pH of soil samples from along the South Branch of the Park River in Hartford, CT

	pH	Temperature (°C)
SPR same 25 m soil (9/16/03) (41.73794°N, 72.70719°W)	6.63	26.9
SPR same 50 m soil (9/16/03) (41.73804°N, 72.70692°W)	6.74	26.5
SPR same 75 m soil (9/16/03) (41.73820°N, 72.70666°W)	6.39	25.6
SPR dsws 25 m soil (9/16/03) (41.73731°N, 72.70762°W)	7.13	25.1
SPR dsws 50 m soil (9/16/03) (41.73727°N, 72.70734°W)	7.47	26.6
SPR dsws 75 m soil (9/16/03) (41.73726°N, 72.70705°W)	6.90	26.3

Table 12. pH and alkalinity of water samples from the South Branch of the Park River in Hartford, CT, the Mount Hope River in Ashford, CT, the Quinnipiac River, and Dr. David Henderson's well

	pH	Alkalinity (mg/L CaCO ₃)
SPR (9/23/03)	7.25	48
SPR (9/30/03)	7.58	100
SPR (10/21/03)	8.36	124
SPR (11/9/03)	8.01	100
MHR same riffle (9/20/03) 41.74061°N, 72.70701°W	6.51	80
MHR same run (9/20/03) 41.74040°N, 72.70698°W	6.63	84
MHR dsws riffle (9/20/03) 41.84325°N, 72.16892°W	7.09	24
MHR dsws run (9/20/03) 41.84302°N, 72.16895°W	7.09	28
Quinnipiac River	7.48	24
Henderson well	6.37	24

Appendix

Sample calculation to determine the concentration of ions in soil:

SAMC 25m Chloride:

$$(1.529 \mu\text{g anion/mL}) \times (200 \text{ mL slurry}/20.02102 \text{ g soil}) \times (10^3 \text{ g soil/kg soil}) \times (10^3 \text{ mg anion}/10^6 \mu\text{g anion}) = 15.24 \text{ mg/kg (ppm)}$$

Sample calculation to determine alkalinity of water samples:

$$\text{South Branch of the Park River (9/23/03): } ((0.12 \text{ mL sulfuric acid titrant} \times 0.16 \text{ N sulfuric acid} \times 50,000) / 20 \text{ mL sample}) = 48 \text{ mg/L CaCO}_3$$

VIII. Chemical Composition of Soil along the South Branch of the Park River

Introduction

Human disturbance factors as well as physical, chemical, and biological characteristics of the landscape have combined to form the ecological profile of the South Branch of the Park River in Hartford, CT. It is essential to quantify chemical and physical changes that have occurred at the site to determine the course of future development at this location. The chemical and physical character of the soil have a direct bearing on the possible need for any soil remediation or soil protection practices prior to development. Since it is possible that the site may contain community food gardens or playground areas in the future, it is critical that soil sampling be conducted to determine possible heavy metal contamination (Sych 2000). The focus of our current laboratory investigation was to quantify and to assess the levels of lead, cadmium, arsenic, and chromium at multiple locations along the South Branch of the Park River using inductively-coupled plasma-atomic emission spectroscopy (ICP-AES).

Methods

Samples in this investigation were prepared using U.S. Environmental Protection Agency (EPA) methods for both soil sample preparation (Method 3050B-Acid Digestion of Sediments, Sludges, and Soils) and associated quantitative analysis of lead, cadmium, arsenic, and chromium by ICP-AES (Method 6010B- Inductively Coupled Plasma-Atomic Emission Spectroscopy). The samples were taken at six different locations, specifically at 25 meter (41.73731°N, 72.70762°W and 41.73794°N, 72.70719°W), 50 meter (41.73727°N, 72.70734°W and 41.73804°N, 72.70692°W), and 75 meter (41.73726°N, 72.70705°W and 41.73820°N, 72.70666°W) sites along two different transects. These sampling locations correspond with the ground beetle trapping sites, as discussed in chapter ten. To correct for moisture within the soil

samples, dry weight samples were prepared for each of the six sites by heating 10 gram samples in a DigiPrep digester at 150 degrees Celcius for 48 hours.

Two test preparations were made from each of the locations. In addition, two recovery samples and two interference samples were prepared, one of each from a 50 meter location (41.73804°N, 72.70692°W) and from a 75 meter location (41.73726°N, 72.70705°W). The samples were mixed to obtain homogeneity, sieved using a US #10 sieve, weighed using a Mettler AE 160 Balance to between 0.9 and 1.1 grams, and placed in Digtubes. One Digtube without soil was prepared as a method blank for our analysis. The recovery samples were spiked with 250 µL of a Fisher stock lead solution (1000 ppm stock). Trace metal grade hydrochloric acid was added to the 10 ml line of each of the Digtubes; 2.5 ml of trace metal grade nitric acid was then added to each of the Digtubes. Plastic watch glasses were placed on each tube, and the tubes were placed in a DigiPrep digester where they were heated at 150 degrees Celcius/hour to 95 degrees and then held for 15 minutes. Ten ml of 1000 ppm iron standard solution and 10 ml of 1000 ppm aluminum standard solution was added to each of the two interference determination tubes. Milli-Q water (distilled, deionized) was added to the 50.0 ml mark on all tubes. Caps were placed on the tubes, and the solutions were mixed thoroughly.

The ICP-AES Spectrometer (Thermo Jarrell Ash Enviro 36) was calibrated using a calibration blank (10% HCl from trace metal grade) and six calibration solutions prepared in 10% by volume of Trace Metal Grade hydrochloric acid (1.0 ppm mixed element standard containing Pb, 10.0 ppm mixed element standard containing Pb, 100.0 ppm mixed element standard containing Pb, 1.0 ppm mixed element standard containing Ag, 10.0 ppm mixed element standard containing Ag, and 100.0 ppm mixed element standard containing Ag). A CPI Soil B solution (1:10 dilution of Soil B, QC Standard ICP of soils) was also run to assess the

accuracy of our results against a known standard solution. Dr. David Henderson assisted with the preparation of calibration solutions, with the lighting of the ICP torch, and with the use of the computer software (Questron SpecWin2000) associated with data acquisition in this investigation. For each analysis, 5 ml of sample was removed from the top of a Digtube and filtered through a 0.2 μ n Altech syringe microfilter into a clean plastic sample cup. All samples were analyzed by ICP-AES. The two prepared soil samples from 25 meters (41.73731°N, 72.70762°W) and the method blank were accidentally thrown away prior to analysis. A 10% hydrochloric acid (from trace metal grade) was run as a method blank in our analysis.

Results

The ICP analysis provided concentration (ppm) and intensity (nm) data for 21 elements. Our study focused upon the outcomes for lead, cadmium, arsenic, and chromium (Table 13). Results for lead were further analyzed by preparing a calibration plot using our two lead calibrators and method blank (Table 14, Figure 4). Using the equation for our linear trendline calibration plot, concentration values for the varying intensity values determined by the spectrometer were obtained (Table 15). In addition, each lead concentration was corrected for moisture content of the sample and for sample size to allow for proper comparisons with EPA standards (Table 15, Appendix). Cadmium, arsenic, and chromium spectrometer concentrations in the samples and spikes were also corrected for moisture content and for sample size (Table 16).

Percent recovery of lead from the matrix spike samples was calculated for this study. This process was conducted to determine if the sample preparation had extracted all the lead from the samples. In accordance with article 8.3 of EPA Method 3050B, this procedure allows researchers to determine precision and bias. Since soil samples are often not homogeneous, a 95% to 105% recovery was expected. The percent recovery for the SAMC 50m site was 93.2%

(Appendix). The percent recovery for the DSWS 75m site was 88.4%. The percentages determined may indicate that not all the lead within the samples was being extracted due either to chemical or physical interference, to instrumental drift, or to some other experimental error (Soil and Plant Analysis Council 2000).

Interference with lead analysis attributable to iron and aluminum were also assessed in this study. According to Article 3.1.4 and Table 2 of EPA Method 6010B, aluminum at the 100 mg/L level interferes with lead concentration readings to the degree of 0.17 mg/L. According to EPA methods, the value of 0.17 mg/L should be added to the listed concentration of lead. According to Table 2 of EPA Method 6010B, there should be no interference with lead readings from iron at the 100mg/L or the 1000mg/L levels. Interference should be expressed as lead concentration equivalents arising from the 100mg/L of the interference element. Our procedure called for the addition of 10 ml of 1000 ppm iron standard solution and 10 ml of 1000 ppm aluminum standard solution to the interference determination samples; this is equivalent to the addition of 200mg/L aluminum $[10\text{ml Al} \times (\text{L}/1000\text{ml}) \times (1000\text{mg/L}) = 10\text{mg Al}/50 \text{ ml sample} = 200\text{mg/L Al}]$ and iron $[10\text{ml Fe} \times (\text{L}/1000\text{ml}) \times (1000\text{mg/L}) = 10\text{mg Fe}/50 \text{ ml sample} = 200\text{mg/L Fe}]$. Thus, an additive effect of 0.34 mg/L should be expected for aluminum and 0.0 mg/L for iron. The values obtained in this study for interference of aluminum with lead were 2.06 ppm (mg/L) for the 50m interference test and 0.949 ppm (mg/L) for the 75m interference test. The value of 2.06 ppm (mg/L) was less than 0.34 mg/L from the standard 50 meter test values of 1.97 ppm (mg/L) and 1.92 ppm (mg/L), and the value of 0.949 ppm (mg/L) was greater than the standard 75 meter test values of 0.972 ppm (mg/L) and 1.04 ppm (mg/L). This failure to detect expected interference of aluminum with lead may be due to other spectral or non-spectral

interferences associated with testing of the samples or due to investigator correction for aluminum interference.

Since large quantities of lead, cadmium, arsenic, and chromium are a cause of public health problems and environmental concern for a wide range of biota, the EPA has set limits for these toxic elements in air, water, and soil (McBride 1994). With regard to soil, the EPA limits for lead are 400 mg/kg for residential soil. With our corrected readings ranging from 33.1 mg/kg to 145 mg/kg, there is no apparent soil contamination with lead at the site. The EPA limit for cadmium in residential soil is 37 mg/kg; our corrected concentration readings ranged from 4.35 mg/kg to 7.88 mg/kg, indicating that cadmium concentrations do not exceed the acceptable EPA standard at the South Branch of the Park River site. The EPA limits for arsenic (noncancer endpoint) in residential soil are 22 mg/kg and the limits for arsenic (cancer endpoint) are 0.39 mg/kg. Since our concentration readings were all 0.0 mg/kg, there appears to be no cause for concern with regards to arsenic contamination at the site. For chromium, the EPA standard for residential soil is 210 mg/kg. The range of our readings was 36.3 mg/kg to 48.8 mg/kg, indicating again that the EPA limits for this heavy metal are not exceeded at the study site (EPA Region 2002).

Assessment of accuracy with the CPI Soil B solution indicated that a margin of error existed within our methodology. The quality control soil solution (1:10 dilution of Soil B) was expected to indicate 6.0 ppm lead from ICP-AES analysis, but the spectrometer reading obtained in this study was 4.91 ppm. This variation of 18% may indicate that all other spectrometer readings obtained may contain an element of error and that repetition of the analyses is warranted.

Conclusions

The results of this initial study are encouraging with regards to soil contamination with the heavy metals lead, cadmium, arsenic, and chromium at the South Branch of the Park River study site. Low levels of these elements were detected in all the study samples, indicating that this site may be suitable for a greenway and trails along the river. Repetition of this study is indicated based upon the variation from expected quality control readings and upon the unintentional loss of blanks and two 25m samples. The blanks would have been critical in determining the possibility of contamination within the study method. Further chemical and physical assessments of soil quality at multiple sites will serve as essential tools in formulating recommendations for the final development of the South Branch of the Park River.

Table 13. The concentration (ppm) and intensity (nm) of Lead, Cadmium, Arsenic, and Chromium in soil samples prepared for analysis from the South Branch of the Park River in Hartford, CT

Sample Location	[Pb](ppm), intensity (nm)	[Cd] (ppm), intensity (nm)	[As] (ppm), intensity (nm)	[Cr] (ppm), intensity (nm)
SAMC 25m (41.73794°N, 72.70719°W) -#1	2.19, 96.8	0.112, 23.7	0.0, -109	0.72, 538
SAMC 25m (41.73794°N, 72.70719°W) -#2	2.17, 96.2	0.118, 25.3	0.0, -28.6	0.724, 542
SAMC 50m (41.73804°N, 72.70692°W) -#1	1.97, 87.2	0.0783, 14.8	0.0, -59.2	0.594, 418
SAMC 50m (41.73804°N, 72.70692°W) -#2	1.92, 85.0	0.0751, 14.0	0.0, -53.2	0.564, 389
DSWS 50m (41.73727°N, 72.70734°W) -#1	0.51, 22.9	0.0828, 16.0	0.0, -649	0.75, 566
DSWS 50m (41.73727°N, 72.70734°W) -#2	0.49, 22.0	0.0796, 15.2	0.0, -718	0.72, 538
SAMC 75m (41.73820°N, 72.70666°W) -#1	1.75, 77.6	0.083, 16.1	0.0, -6.84	0.671, 491
SAMC 75m (41.73820°N, 72.70666°W) -#2	1.78, 79.0	0.0833, 16.2	0.0, -58.7	0.638, 460
DSWS 75m (41.73726°N, 72.70705°W) -#1	0.972, 43.2	0.0634, 10.9	0.0, -93.6	0.559, 384
DSWS 75m (41.73726°N, 72.70705°W) -#2	1.04, 46.1	0.0671, 11.9	0.0, -187	0.586, 410
SAMC 50m recovery (41.73804°N, 72.70692°W)	6.58, 290	0.0795, 15.2	0.0, -93.5	0.591, 415
SAMC 50m interference (41.73804°N, 72.70692°W)	2.06, 91.3	0.0937, 18.9	0.0, -691	0.626, 448
DSWS 75m recovery (41.73726°N, 72.70705°W)	5.39, 238	0.0603, 10.1	0.0, -49.1	0.525, 352
DSWS 75m interference (41.73726°N, 72.70705°W)	0.949, 42.2	0.08, 15.3	0.0, -609	0.588, 411
Method blank	0.0,-0.0198	0.02, -0.547	0.0, 395	0.155, -0.347

Table 14. The concentration (ppm) and intensity (nm) of lead in the two lead calibrators (1.0 ppm mixed element standard containing Pb and 10.0 ppm mixed element standard containing Pb) and method blank

	[Pb] (ppm)	Intensity (nm)
1.0 ppm mixed element standard containing Pb	1.0	44.6
10.0 ppm mixed element standard containing Pb	10.0	441
Method blank	0	-0.0198

Table 15. Lead spectrometer concentrations, lead concentrations calculated from the calibration curve, and lead concentrations corrected for moisture content and for sample size in the samples and spikes.

Sample Number	Spectrometer readings for concentrations (ppm)	Calibration curve values for concentrations (ppm)	Proportion of dry/wet weight, sample weight (g)	Concentration values corrected for moisture content and for sample size (mg/kg)
SAMC 25m -#1	2.19	2.19	0.735, 1.0804	138
SAMC 25m -#2	2.17	2.18	0.735, 1.0192	145
SAMC 50m -#1	1.97	1.97	0.763, 1.0431	124
SAMC 50m -#2	1.92	1.92	0.763, 1.0188	123
DSWS 50m -#1	0.51	0.51	0.772, 0.9960	33.2
DSWS 50m -#2	0.49	0.49	0.772, 0.9583	33.1
SAMC 75m -#1	1.75	1.76	0.797, 1.0301	107
SAMC 75m -#2	1.78	1.79	0.797, 1.0426	107
DSWS 75m -#1	0.972	0.975	0.711, 0.9445	72.4
DSWS 75m -#2	1.04	1.04	0.711, 1.0202	71.7
SAMC 50m recovery	6.58	6.58	0.763, 1.0304	418
SAMC 50m interference	2.06	2.07	0.763, 1.0437	129
DSWS 75m recovery	5.39	5.40	0.797, 0.9582	353
DSWS 75m interference	0.949	0.953	0.797, 1.0392	57.3

Table 16. Cadmium, arsenic, and chromium spectrometer concentrations and concentrations corrected for moisture content and for sample size in the samples and spikes.

Sample Number	Proportion of dry/wet weight, sample weight (g)	[Cd] (ppm), [Cd] corrected* (mg/kg)	[As] (ppm), [As] corrected* (mg/kg)	[Cr] (ppm), [Cr] corrected* (mg/kg)
SAMC 25m -#1	0.735, 1.0804	0.112, 7.05	0.0, 0.0	0.72, 45.3
SAMC 25m -#2	0.735, 1.0192	0.118, 7.88	0.0, 0.0	0.724, 48.3
SAMC 50m -#1	0.763, 1.0431	0.0783, 4.92	0.0, 0.0	0.594, 37.3
SAMC 50m -#2	0.763, 1.0188	0.0751, 4.83	0.0, 0.0	0.564, 36.3
DSWS 50m -#1	0.772, 0.9960	0.0828, 5.38	0.0, 0.0	0.75, 48.8
DSWS 50m -#2	0.772, 0.9583	0.0796, 5.38	0.0, 0.0	0.72, 48.7
SAMC 75m -#1	0.797, 1.0301	0.083, 5.05	0.0, 0.0	0.671, 40.9
SAMC 75m -#2	0.797, 1.0426	0.0833, 5.01	0.0, 0.0	0.638, 38.4
DSWS 75m -#1	0.711, 0.9445	0.0634, 4.35	0.0, 0.0	0.559, 41.6
DSWS 75m -#2	0.711, 1.0202	0.0671, 4.63	0.0, 0.0	0.586, 40.4
SAMC 50m recovery	0.763, 1.0304	0.0795, 5.06	0.0, 0.0	0.591, 37.6
SAMC 50m interference	0.763, 1.0437	0.0937, 5.88	0.0, 0.0	0.626, 39.3
DSWS 75m recovery	0.797, 0.9582	0.0603, 3.95	0.0, 0.0	0.525, 34.4
DSWS 75m interference	0.797, 1.0392	0.08, 4.83	0.0, 0.0	0.588, 35.5

*corrected for moisture content and for sample size

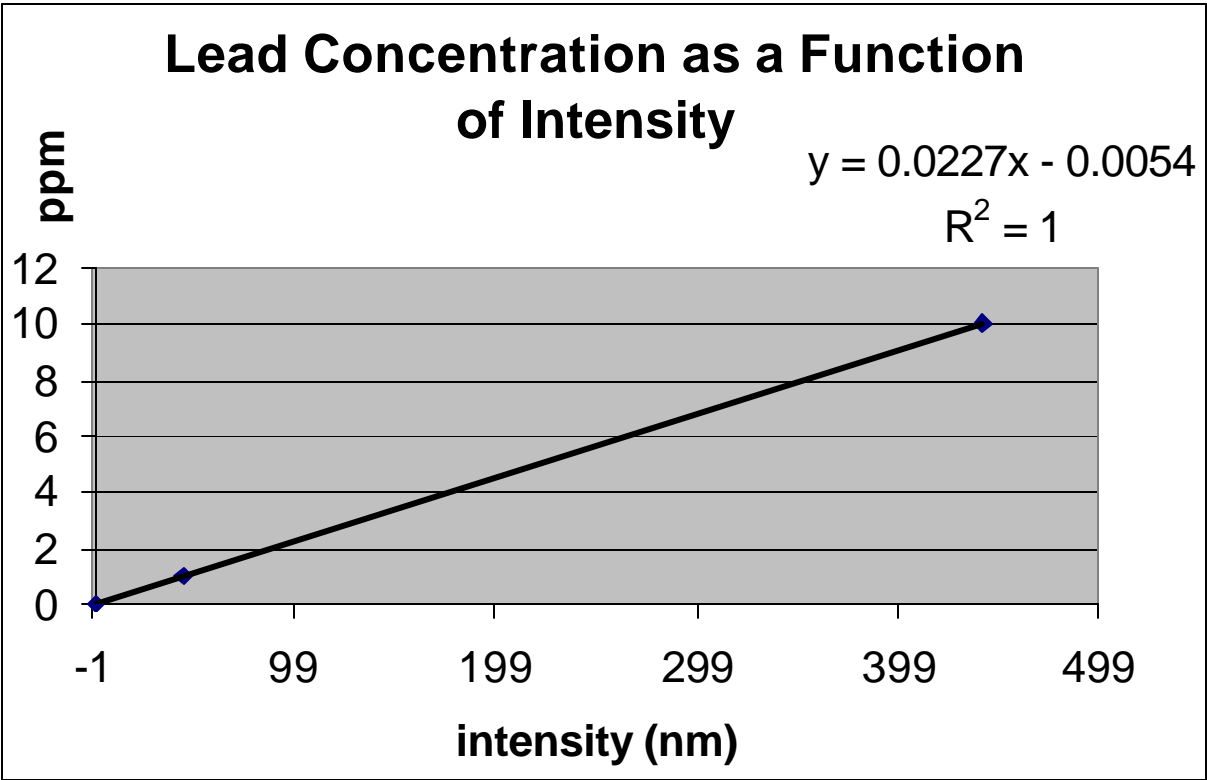


Figure 4. Calibration plot of lead concentration (ppm) as a function of intensity data (nm) using the two lead calibrators (1.0 ppm mixed element standard containing Pb and 10.0 ppm mixed element standard containing Pb) and method blank

Appendix

Sample calculation to correct for moisture content of the sample and for sample size to allow for proper comparisons with EPA standards:

SAMC 25m #1

Moisture correction: (grams of dry sample and digitube – grams digitube)/(grams wet sample prior to heating) = $(17.9374 - 10.3120) / (10.3750) = 0.735$

$(2.19 \mu\text{g Pb/g soil}) \times (1 \text{ g} / 1 \text{ ml}) \times (50 \text{ ml solution} / (.735 \times 1.0804 \text{ g soil})) \times (10^3 \text{ g soil} / 1 \text{ kg soil}) \times (10^3 \text{ mg Pb} / 10^6 \mu\text{g Pb}) = 137.9 \text{ mg Pb} / 1 \text{ kg soil}$

Sample calculation to determine % recovery:

SAMC 50m recovery

$(6.58 \mu\text{g Pb} / 1 \text{ ml}) \times 50 \text{ ml solution} = 329 \mu\text{g Pb}$ for spiked soil

$(1.92 \mu\text{g Pb} / 1 \text{ ml}) \times 50 \text{ ml solution} = 96 \mu\text{g Pb}$ for unspiked soil in SAMC 50m #2
known amount of spike = 250 μL

$((329 - 96) / 250) \times 100 = 93.2\%$ recovery

IX. Physical Characterization of Soils along the South Branch of the Park River

An understanding of the soil components in an ecosystem is critical to the evaluation of the quality of the environment. Although there is no standardized definition of soil, soil scientists describe the substance as the unconsolidated mineral or organic matter at the earth's surface that has been changed by pedogenic processes. Over time, soils are constantly altered as a result of physical, chemical, biological, and anthropogenic processes. Soils may become polluted as a result of chemical contamination from excessive amounts of pesticides and fertilizers. Other forms of soil pollution and degradation include erosion, compaction, and saline contamination (Pierzynski *et al.* 1994). The focus of our current field investigation on 30 September 2003 was to understand the surficial geology of the South Branch of the Park River watershed and to determine the physical nature of soils in this region.

Though the sedimentary bedrock at the study site is approximately 200 million-years old, the loose unconsolidated sediments were all deposited less than 30,000 years ago during the last major ice age to cover Connecticut. After the ice retreated north 14,000 years ago, a large deposit of sand and gravel near Rocky Hill, Connecticut dammed the Connecticut River forming Glacial Lake Hitchcock. Over time, fine silts and clay settled out of the glacial lake. When the dam in Rocky Hill was breached 12,000 years ago, Glacial Lake Hitchcock drained quickly and the valleys of the North and South Branches of the Park River were created. Since then, both branches of the Park River have moved back and forth across their flood plains depositing thin layers of fine grain sands and gravel alluvium on top of the finer grained lake bottom sediments (Sych 2000).

It was the initial premise of this study that the soil quality along the South Branch of the Park River has been significantly disturbed by sewer outflow, urban runoff, littering, and

roaming house pets. In this study, two soil pits were dug along the terrestrial region extending from the eastern edge of the South Branch of the Park River toward Brookfield Street (Figure 2). It was determined that the soil is the same color throughout, that the soil is dense, partly due to the lack of organic matter in the soil, and that the soil is wet. The fact that the soil was so moist may be due in part to the high levels of rainfall experienced during the Fall 2003 season.

We also examined the soil mapping units found in the South Branch of the Park River region. The (smoothed) udorthents and the (urban land) udorthents complex are the main soil units present at our study site (Sych 2000)(Figure 2). The (smoothed) udorthents unit consists of very deep, somewhat excessively drained to moderately well drained soils that have been changed by cutting or filling. It is typically found in and adjacent to urban areas, industrial areas, and school yards. In some regions, fill consists of materials such as broken concrete, household garbage, and vegetable debris. The (urban land) udorthents complex consists of areas of very deep, somewhat excessively drained to moderately well drained soils that have been changed by cutting and filling and areas where the soil surface is covered by impervious materials. It is typically found along highways and interchanges, around school and apartment complexes, and industrial areas. In some regions, fill consists of materials such as broken concrete, household garbage, and vegetable debris. The impervious materials include parking lots, streets, and buildings (Sych 2000).

Overall, the characteristics of both the (smoothed) udorthents and (urban land) udorthents complexes are variable. Further on-site investigations examining physical properties of the soil such as bulk density and texture, permeability, infiltratability, and water-holding capacity are warranted to determine the suitability of the site for human and wildlife use (Pierzynski *et al.* 1994).

X. Ground Beetles as Indicators of Community Structure along Urban and Rural Connecticut Rivers

Introduction:

A diverse flora and fauna compose the terrestrial habitats along the South Branch of the Park River in Hartford, CT and along the Mount Hope River in Ashford, CT (Taylor 2000). The specific number of species and their relative abundances provide indices of the biological diversity of communities. Investigators examined ground beetles (family Carabidae) as indicators of the number of other sympatric taxonomic groups present and as the basis for comparisons between the community structure and land use patterns of the two study sites. Carabids were sampled since they are well-known taxonomically, well-known ecologically, easy to sample, abundant, relatively diverse in terms of species numbers and habitat, and good indicators of environmental health (Caro and Doherty 1999; Rykken *et al.* 1997). Furthermore, with a preference for moist lowland forested areas near the edges of streams, ponds, lakes, and rivers, it was expected that large numbers of ground beetles would be collected at the two study sites. Finally, in terms of species-level distribution and historical records, carabids are the best known beetle family in Connecticut, serving as excellent organisms to sample in this investigation (Krinsky and Oliver 2001).

Methods:

On 16 September 2003, our research team placed 30 pitfall traps in the ground along the South Branch of the Park River in Hartford, CT to sample ground beetles. Our study site was located upstream from the bridge on Flat Bush Avenue. The primary vegetative types observed near the study area included Cottonwood (*Populus deltoides*), Goldenrod spp. (*Solidago* spp.), and Japanese Knotweed (*Polygonum cuspidatum*). To sample as many microhabitats as possible, two transects were laid out extending 75 m from the eastern edge of the South Branch of the Park River toward Brookfield Street. One transect was laid out across a flat stretch of land, while a

second transect was established across an area of increasing elevation. Three clusters of five traps were installed at 25 m, 50 m, and 75 m away from the river along each transect. The 25 m clusters of pitfall traps were located at (41.73794°N, 72.70719°W) and (41.73731°N, 72.70762°W), the 50 m clusters at (41.73804°N, 72.70692°W) and (41.73727°N, 72.70734°W), and the 75 m clusters at (41.73820°N, 72.70666°W) and (41.73726°N, 72.70705°W); each site was flagged for ease of re-locating it (Figure 1). At each cluster, four pitfall traps were placed at the corners of a 5 m x 5 m square, and a fifth pitfall trap was placed in the center of the square approximately 3.5 m away from the pitfall traps located at each corner. Traps consisted of a plastic cup with its base perforated with five evenly spaced holes (1.5 cm diameter). This cup was nested within another plastic container (14 cm deep, 11.5 cm diameter at mouth), leaving a space in which 40 mL of food-grade propylene glycol, the specimen preservative, was placed. Holes were dug, and the pitfall traps were marked for location and were sunk into the ground with the top rim of the pitfall traps at ground level, taking care not to introduce any soil into the traps. A piece of plywood (15 x 15 cm) elevated 2.5 cm by four rubber spacers attached at each corner was placed above each trap to keep out rain and to provide camouflage. The pitfall traps were retrieved from the South Branch of the Park River site on 29 September 2003.

On 19 September 2003, our research team placed 30 pitfall traps in the ground along the Mount Hope River in Ashford, CT to sample ground beetles. Our study site was located upstream and north of where Connecticut Route 89 crosses over the Mount Hope River. The primary vegetative types observed near the study area included Gray Birch (*Betula populifolia*), Quaking Aspen (*Populus tremuloides*), and White Oak (*Quercus alba*). Three clusters of five traps were installed at 25 m, 50 m, and 75 m away from the river along two geographically similar transects extending from the western edge of the Mount Hope River toward Varga Road.

The 25 m clusters of pitfall traps were located at (41.84224°N, 72.16834°W) and (41.84236°N, 72.16856°W), the 50 m clusters at (41.84216°N, 72.16881°W) and (41.84220°N, 72.16883°W), and the 75 m clusters at (41.84208°N, 72.16909°W) and (41.84215°N, 72.16909°W) (Figure 3). Sampling procedure was identical to that employed at the South Branch of the Park River. The pitfall traps were retrieved from the Mount Hope River site on 2 October 2003.

Traps were covered after retrieval and transported to the Environmental Science laboratory for storage. In Dr. Scott Smedley's laboratory, ground beetle specimens were removed from the propylene glycol using a strainer, rinsed with tapwater, and stored in individual vials of 70% EtOH labeled according to their pitfall trap locations. Specimen labels were generated, and the carabids were mounted according to methods described by Borror *et al.* (1976). Ground beetle specimens were identified to the species level by Dr. William Krinsky of Yale University.

Results:

Six ground beetles were collected, three from the South Branch of the Park River, representing the species *Harpalus rubripes* and *Amara exarata*, and three from the Mount Hope River, representing the species *Amphasia interstitialis* and *Pterostichus lucublandus* (Table 17). *H. rubripes* and *A. interstitialis* were collected in this study and documented for the first time in Hartford and Ashford, CT, respectively.

Conclusion:

Given the small number of ground beetle species and the few individuals collected in the pitfall traps, species diversity indices were not calculated. The fact that the uncommon, introduced *H. rubripes* has been previously identified on asphalt and other unnatural surfaces (Krinsky and Oliver 2001) may have some relevance to its discovery at the Hartford study site; further sampling is needed to draw conclusions on its possible adaptability to urban settings. It is

likely that few ground beetles were collected at the two study sites since many of the pitfall traps had been uplifted from the ground by the end of the experimental periods possibly due to heavy precipitation. From 16 September to 29 September, 4.67" of rainfall was recorded in Hartford, CT ("Daily Climate Data HFD" 2003). From 19 September to 02 October, 2.32" of rainfall was recorded near Ashford in Willimantic, CT ("Daily Climate IJD" 2003). All of the specimens were collected at the 25 meter sites which were typically the moistest of the three trapping distances. Furthermore, Finnamore *et al.* (2002) suggest trapping from April to October in temperate latitudes to fully sample a site or habitat throughout the period when surface-active arthropods are most active. Future studies of populations at the South Branch of the Park River and the Mount Hope River should focus on more comprehensive evaluations of all microhabitats under varying seasonal and climatic conditions.

Table 17. Species of Ground Beetles Collected along the South Branch of the Park River in Hartford, CT and along the Mount Hope River in Ashford, CT

Location	Number Collected, Species
Mount Hope River, 25m SW (41.84224°N, 72.16834°W)	2, <i>Amphasia interstitialis</i>
Mount Hope River, 25m W (41.84236°N, 72.16856°W)	1, <i>Pterostichus lucublandus</i>
South Branch of the Park River 25m E, 25m N (41.73731°N, 72.70762°W)	2, <i>Harpalus rubripes</i>
South Branch of the Park River 25m N (41.73731°N, 72.70762°W)	1, <i>Amara exarata</i>

XI. Conclusions and Recommendations

The increasing development and urbanization of past decades have prompted city leaders around the world to reserve land for parks, gardens, nature reserves, and recreational open space. Linear open space designs known as greenways have grown in popularity as a means of habitat and natural area protection in cities (Endicott 1993). In Hartford, CT, community, educational, and government partners are working cooperatively to restore, maintain, and enhance the environmental, social, and cultural viability of the Park River watershed (Taylor 2000). The goal of this study was to conduct a site review of an area adjacent to a construction project and to develop an environmental assessment for an urban green space along the South Branch of the Park River in Hartford. Investigators examined several issues in preparing this environmental assessment including land use history, wetland regulations, habitat mapping, threatened and endangered species, stream flow dynamics, biomonitoring, water and soil chemistry, soil composition, and community structure.

Riparian zones play an important role in maintaining water quality, aquatic habitat, and productivity of freshwater systems. Though the South Branch of the Park River and its surrounding watershed have served as a vital resource for human and wildlife populations in the past, man has altered this region in recent decades by removing bankside vegetation, channelizing the river, introducing invasive species, and degrading water quality through sewer overflow, urban runoff, littering, and roaming house pets (Wheeler 2002). Presently, large fields bordering the river provide a unique and valuable habitat for such a developed region. State endangered, threatened, and special concern birds have been documented in nearby Hartford parks, and it is likely that many organisms may be permanent or transient inhabitants of the region along the South Branch of the Park River. Urban influences from the Wal-Mart

construction project such as pollutants and runoff may alter the structure of the ecosystem (Sych 2000). Construction efforts are also likely to affect stream flow and may have an impact on how often the plain floods. Taking into account that the calculated discharge values for the river in October 2003 were higher than those obtained during the late 1970s and early 1980s by the United States Geological Survey, it is possible that new development projects such as the construction of Wal-Mart will put further strains on the river conduit's design capacity ("USGS" 1981). To some degree, this current study was affected by the overabundance of rainfall during the study period; for example, it may have compromised the effectiveness of the community studies involving ground beetles.

Chemical and biological investigations verify that the South Branch of the Park River is not as healthy in terms of water quality as the Mount Hope River in rural Ashford, CT. Though anion concentrations and pH levels did not exceed limits set by the Environmental Protection Agency for freshwater systems at either site, anion concentrations and pH levels were higher at the urban location. Determination of water quality using aquatic macroinvertebrates as biomonitors of water quality indicated that the water and habitat quality at the South Branch of the Park River is compromised. The biomonitoring studies indicated the presence of organic pollution and environmental stress at the site based on the few taxonomic groups observed, dominance by a single taxa, and a low percentage of sensitive taxa. Construction efforts will likely add excess amounts of nitrate, chloride, sulfate, and phosphate to the river and will further contaminate fish and wildlife habitat. The magnitude of their effects may be influenced by fluctuating pH and alkalinity levels. Overall, the current state of the South Branch of the Park River does not warrant immediate remediation.

Analyses of soil samples taken from this urban site corroborate the degree of disturbance related to human activity over many decades. The results of this study are encouraging, though, with regards to soil contamination with the heavy metals lead, cadmium, arsenic, and chromium along the South Branch of the Park River. Low levels of these elements were detected in all the study samples, indicating that this site may be suitable for a community garden or playground area. In soil sample analysis, soil nitrate levels were high, sulfate and pH levels were sufficient to support plant growth, and chloride and phosphate levels were variable. Examination of the (smoothed) udorthents and the (urban land) udorthents complex soil types at the site revealed that the soil is the same color throughout, that the soil is dense, partly due to the lack of organic matter in the soil, and that the soil is wet.

Overall, extensive development and flood control modifications within the South Branch of the Park River watershed have greatly affected the diversity and function of habitats within the freshwater system and riparian area and have impacted river water quality. A unique opportunity exists to develop the green space along this branch of the Park River into an urban greenway. By removing some of the non-native inferior and aggressive species and by restoring natural river features such as vegetation and bank structure, the river channel and surrounding habitat may be slowly restored to their former vibrant states. This greenway has the potential to improve water quality, provide wildlife habitat, protect a variety of natural and historic resources, and offer opportunities for urban residents to experience nature (Little 1990).

The Park River has traditionally served the practical and aesthetic needs of the citizens of Hartford. It inspired the productive and creative thought of Hartford's famous author Mark Twain, and it has served as the site of some of Trinity College's longstanding traditions ("Welcome" 2003). In the mid to late 1800s Trinity students, dressed in costumes and

accompanied by music, engaged in nocturnal rituals near the Park River to burn their mathematics textbooks (“Burning of Conic Sections” 2003). With such a rich history, there is good reason for embarking upon the type of renewal projects considered in this assessment. With careful planning and the judicious use of resources, the South Branch of the Park River can be restored to its former beauty and vibrancy for future generations of Hartford’s citizens to enjoy. Further biological, chemical, and physical assessments of the South Branch of the Park River and its surrounding riparian zone will serve as essential tools in formulating final plans for the development of this site as an urban greenway.

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