A Watershed Management Plan for the Fall Kill, Dutchess County, New York

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Prepared by the: Fall Kill Watershed Committee

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Primary Authors:

Patrick Bean, Department of Environmental Science and Policy, Marist College, **Thomas R. Lynch**, Department of Environmental Science and Policy, Marist College, **David Burns**, Dutchess County Environmental Management Council.

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Executive Summary

The Fall Kill Watershed covers approximately 19.5 square miles and is entirely in Dutchess County New York. Portions of the Towns of Hyde Park, Clinton, Pleasant Valley and Poughkeepsie as well as the City of Poughkeepsie are within the watershed. Totaling the lengths of its main channel and that of its tributaries, the Fall Kill is approximately 38 miles long and discharges into the Hudson River in the City of Poughkeepsie.

Land use dramatically changes along the streams length. Areas in the northern headwaters contain wetlands, marshes and forested properties. As the creek flows southward, its riparian zone shrinks and then largely disappears. During the Great Depression the lower reaches of the Fall Kill were channelized and stone walls were constructed to contain the creek as it passed through the City of Poughkeepsie.

The condition of the Fall Kill has been evaluated by this and earlier studies that have measured; 1) various chemicals (nitrate, phosphate, sulfate, heavy metals, hydrocarbons, etc.) in stream water, stream sediments and in organisms, 2) bacteria levels (fecal coliforms and E. coli) in stream water, and 3) biological health using indicator organisms (macroinvertebrates and fish) living in the creek.

Chloride levels were high throughout the length of the creek but highest in the City of Poughkeepsie. Nutrient levels (nitrate and phosphate) were high in the middle reaches of the creek and in the City of Poughkeepsie. High levels of toxic heavy metals were observed in stream sediments in the City of Poughkeepsie. Both fecal coliform and *E. coli* bacteria were found in stream water at every sample location and the fecal coliform levels on the whole were very high. All of the fish species encountered in the Fall Kill were tolerant or moderately tolerant to pollution. Macroinvertebrate studies in the creek indicate most of its length is “slightly impacted” with the lower reaches are “moderately impacted”.   The aesthetics of the stream in the urbanized areas are impaired by significant quantities of trash in the streambed and by the poor condition of the stone walls used to channelize it.

Based on this data the health of the Fall Kill can be summarized as follows-
The entire length of the creek has been negatively impacted by human activity.
The region of the stream where deterioration is most noticeable is the stretch running through the City of Poughkeepsie. Trends for individual types of pollutants do not consistently improve with distance upstream from the mouth. Instead there are several "hot spots" of pollutants in the central and upper portions of the Fall Kill that need to be investigated further and remediated.

Recommendations are provided to protect and restore the water and habitat quality of the creek in both the rural/residential and urbanized reaches of the stream. Within the urbanized stretch, a long-term, comprehensive, and systematic effort is needed to address the many problems affecting the Fall Kill. In the middle and upper reaches, the pollution "hot spots" need to be investigated more fully and then remediated. In areas where healthy riparian buffer zones exist they should be maintained.

The Fall Kill Management Plan

The purpose of this document is to provide civic leaders, community groups, environmental organizations, and individual citizens interested in protection and restoration of natural ecosystems with a set of guidelines and recommendations for the management of the Fall Kill watershed. The Fall Kill is a small to moderate-sized stream that flows through five municipalities in Dutchess County, New York, before emptying at the City of Poughkeepsie into the Hudson River. The management plan describes the nature and status of current problems associated with the Fall Kill, a vision for what the Fall Kill could become, goals and objectives that must be met if that vision is to be achieved, and recommendations for specific actions to meet the goals. A section dealing with recent investigations conducted by scientists from Marist College and the Dutchess County Environmental Management Council provides the documentation of ongoing problems in the stream. The latter section also cites other studies that have reached similar conclusions about the water quality status of the Fall Kill.

Watersheds and their Importance

Streams like the Fall Kill are one directional, flowing water ecological systems that range in size from small temporary trickles to mighty rivers traveling thousands of miles and capable of reshaping the faces of continents. Only in the most narrow sense does a stream end at the visible water line along its banks. Except for water that is evaporated back into the atmosphere, all of the water falling on land eventually makes its way back to the ocean via streams and rivers. This land area on which precipitation falls and subsequently drains to an individual channel is known as a watershed. Everyone lives somewhere within a watershed. The water flowing past your legs as you wade or fish in a stream could have fallen anywhere on the land within the watershed that the stream and its tributaries drain. Known as surface runoff, this water is being transported back to the oceans from whence it came to close the great hydrologic cycle – the continuous circular movement of water that starts as evaporation from the oceans, and is followed by condensation, cloud formation, and precipitation in a variety of forms. In streams that flow throughout the year, the flow is dominated by groundwater inputs. Following infiltration into the soil after a rainfall, this water may have been moving through the porous rocks and sands of aquifers for decades or even centuries before it surfaces as a spring or a seep to see the light of day and complete its journey.

Conditions in a stream are intimately connected to, and reflective of, the entire watershed. The geology of the underlying rocks acting in consort with climate and biological organisms determine the properties of the soil. The chemical properties of emerging groundwater and surface runoff will depend on the geological and chemical nature of the materials present on the land and the various ways that land is used by the human inhabitants of the watershed. If the land in the watershed is contaminated with petroleum products or toxic chemicals from accidental spills or deliberate dumping, the contaminants will eventually appear in the stream. Removal of large quantities of vegetation, extensive soil erosion, or coverage of the land with impervious surfaces like concrete and asphalt anywhere in the watershed will have impacts on the stream or river that drains that watershed.

The chemical properties of the water and the physical properties of the channel will, in turn, affect the variety and abundance of the organisms making up the food chain of the ecosystem. As a result of changes in pH, temperature, oxygen levels, nutrient concentrations, depth, current velocities, composition of the bottom, access to sunlight, types of riparian vegetation, and a host of other variables, the biological populations vary. Any human activities in the watershed that alter these characteristics result in often undesirable changes in the stream such as increased frequency and severity of flooding, loss of valuable species like trout, growths of nuisance algae and plants, and/or contamination with fecal bacteria that preclude swimming and other recreational activities.

Almost any change in the physical, chemical, or biological environment of streams manifests itself as changes in the presence or absence of various types of aquatic organisms, their position within the stream, or their behavior with respect to time. To defend the integrity of stream ecosystems, all who care about these dynamic but fragile resources must strive to protect and manage the characteristics of the watershed because small and seemingly insignificant alterations in land use can accumulate to have profound and often unintended consequences in our aquatic resources.

Fall Kill Vision Statement

The upper Fall Kill can and should be a valuable resource both for human recreation and as a healthy habitat for complex and diverse plant and animal communities. This portion of the creek should have a nearly intact vegetative buffer zone with an overhead canopy of native trees and shrubs. The creek bed itself should not be modified by people and should contain hydrologically variable flow regimes including riffles, deep pools and runs of well oxygenated water. The plants along the banks should provide both large and small woody debris and leaves to the stream that will act as both food and habitat for many aquatic organisms. In order to achieve this vision, all significant sources of pollutants must be located, identified, and remediated and vegetative buffers must be maintained or expanded in a few areas. If these steps are taken, the upper Fall Kill will support diverse breeding populations of cool-water fish and healthy communities of invertebrate species. A wide buffer zone consisting of native shrubs and trees will help support a wide variety of birds, mammals, reptiles and amphibians.

The lower Fall Kill flows through a highly urbanized area and shows signs of water quality and habitat degradation. As a result, it is often ignored or considered a liability by local property owners. With a long-term systematic effort, the lower Fall Kill could be rehabilitated. The creek and its immediate environs should be transformed into an attractive community resource that is valued for its aesthetic, recreational, and biological attributes as well as its cultural role in the development and history of the City of Poughkeepsie. A series of pocket parks along the creek, enhanced by benches, attractive plantings, community gardens and interpretive signage or kiosks, linked together by footpaths or sidewalks will greatly increase community appreciation of the Fall Kill. Community groups, neighborhood associations, school groups, businesses and civic organizations will be encouraged to become involved in monitoring and maintenance of adopted creek segments. In order to achieve this vision several things must occur. The Fall Kill Watershed Committee encourages the City of Poughkeepsie to consider removing the stone walls channelizing the creek wherever feasible and to restore the banks to more natural contours. This option should be explored before a major wall restoration project is begun. In areas where wall removal isn't feasible, the stone walls should be repaired and maintained. The City should work with riparian landowners, civic groups and others to discourage the disposal of trash in the Fall Kill and to clean up the trash already present. Illegal sanitary discharges and leaking sewer pipes should be identified and eliminated in accordance with Federal MS4 regulations and in order to lower fecal coliform and nutrient levels in the creek. Then, with the addition of a system of pocket parks along its length, the Fall Kill would truly become a prized community asset.

Watershed Description

The Fall Kill watershed (also known as the Fallkill and as Fallkill Creek) is contained entirely within Dutchess County, NY, and covers approximately 12,476 acres or 19.5 square miles (Figure 1 and Table 1). The Fall Kill originates in northern Hyde Park and Clinton, and flows through Pleasant Valley, the Town of Poughkeepsie, and the City of Poughkeepsie where it enters the Hudson River. Approximately 28,500 people live within the watershed (U.S. Census Bureau, 2000). Based on existing zoning, the number of dwelling units in the watershed's municipalities could increase considerably in the future (Table 2). Over half of the watershed area and 65% of the stream's length is within the Town of Hyde Park (Table 2).

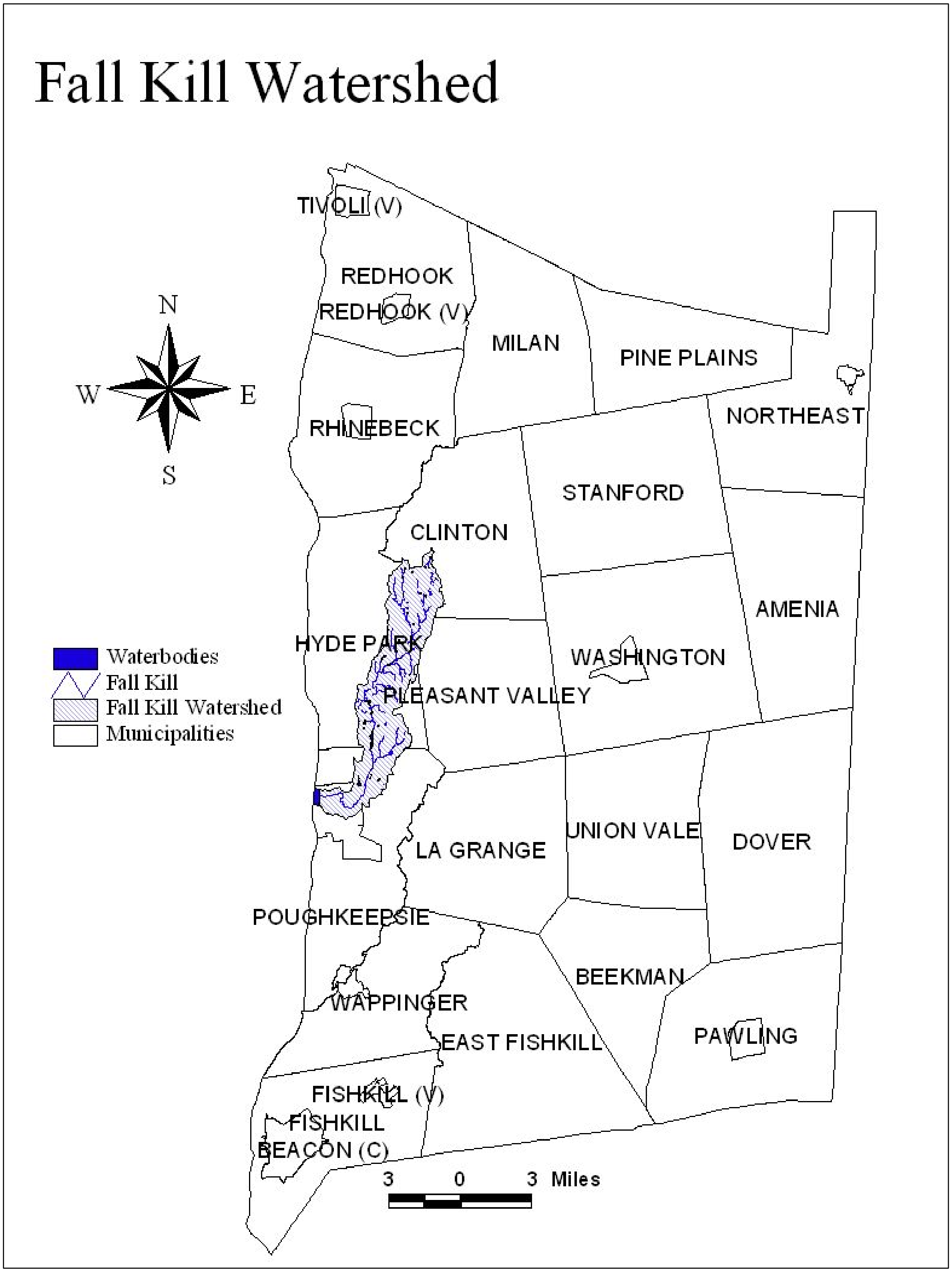
Table 1. Size and area characteristics of each municipality within the Fall Kill watershed.

Municipality	**Municipality Size (Acres)**	**Watershed Area in Municipality (Acres)**	**Percent of Municipality in Watershed**	**Percent of Watershed in Municipality**
Clinton	24,847	1,888	7.6%	15.1%
Pleasant Valley	21,201	613	2.9%	4.9%
Hyde Park	25,467	6,905	27.1%	55.3%
Town of Poughkeepsie	19,773	1,700	8.6%	13.6%
City of Poughkeepsie	3,649	1,301	35.7%	10.4%

Table 2. Stream mileage and watershed characteristics of the Fall Kill by municipality.

Municipality	Length of stream (miles) (includes tribs.)	Percent of stream miles	Estimated existing # of dwelling Units (DU)	Additional # of DU if built out
Clinton	4.8	12.3%	162	278
Pleasant V.	1.4	3.7%	56	181
Hyde Park	25.4	65.3%	2452	1978
T. of Pough.	4.2	10.8%	1165	3184
C. of Pough.	3.1	7.9%	3579	N.D.

Figure 1. Location of the Fall Kill watershed within Dutchess County, NY



The New York State Department of Environmental Conservation (NYSDEC) classifies the creek as a “Class C” stream, suitable for fishing, but not for bathing. In a 2000 report, the DEC listed the Fall Kill as a creek with known impaired aquatic life as a result of urban runoff and suspected nutrients (NYSDEC, 2000a).

The entire creek spans over 38 miles in length and is a third order stream where it enters the Hudson River in Poughkeepsie, NY. Stream ecologists often assign an order value to different stream segments. A first order stream is the smallest perennial stream that can be identified on United States Geological Service, 7.5 minute series, topographic maps. Two first order streams must converge to become a second order stream and two second order streams must meet before a stream segment reaches third order status. There are 11, 5.5, and 12.3 miles of first, second, and third order segments respectively making up the main channel of the Fall Kill and its tributaries. None of the tributaries appear to be individually named.

In 1995, approximately 43% of the land in the watershed, or 5,375 acres, was forested land or brush land. About 27.5% of the watershed, or 3,402 acres, was low, medium or high density residential. There were also approximately 780 acres of wetlands within the watershed. The remainder of the watershed consisted of croplands, pastures, public lands, service facilities, orchards, recreational lands, commercial strips and light manufacturing (Table 3).

Table 3. This table summarizes the dominant land uses within the Fall Kill Watershed, and constitutes 98% of the total land use in the watershed (DCEMC, 1998).

Type	Acres	Percent of Watershed
0Forested Land	5,375.1	43.5%
Residential	3,486.1	28.2%
Agricultural/Pasture	1,138.1	9.2%
Public/Recreational	991.9	8.0%
Wetlands	780.5	6.3%
Commercial Strip	325.4	2.6%
Light Manufacturing	12.5	0.1%

The Fall Kill forms just south of Leroy Mountain in Hyde Park at an elevation of 390 feet above sea level. The creek has a minimal slope of 0.03% or about 1.5 feet/mile between the Crum Elbow Road crossing and the dam at Fall Kill Park. The stream velocity and slope increases dramatically just west of Garden Street in the City of Poughkeepsie. From that area to the mouth of the creek at the Hudson River, the creek has a 3.35% gradient, or 177 feet/mile.

Areas in the northern reaches of the creek are generally undisturbed. Large wetlands, marshes and woodlots comprise the northern part of the watershed and play an important role in the creek's health, while providing habitat for a number of species. According to the NYSDEC, several threatened and endangered species and habitats are located in the watershed and are listed under the New York State Natural Heritage Program. The creek goes through a dramatic transformation as it flows downstream from its northern reaches in Hyde Park and Clinton to the City of Poughkeepsie and the Hudson River. Moving south from Hyde Park, riparian zones along the creek begin to shrink as the creek passes through residential development. Riffle zones are less common than pools north of the City of Poughkeepsie. Riffles occur at steeper gradients and faster stream velocities than pools and are important areas for aeration, sediment transport and fine particle removal, and also serve as important habitat for macroinvertebrates.. As the creek enters the City of Poughkeepsie, development creeps closer to the creek's edge. Wooded tracts of land are less common, and the landscape is dominated by streets, parking lots, commercial developments and other impervious surfaces.

The stream is channeled by the New Deal Era stone walls that quickly conduct water through the city and into the Hudson River. In several areas of the approximate 2.5 mile channelized stream segment, the walls have deteriorated significantly and have started to crumble into the creek due to undercutting of the foundation courses. In 2005, the City of Poughkeepsie was considering its engineering options and is researching grants to rehabilitate the walls. Wall repair will have to be planned and carried out with utmost consideration to the health and integrity of the riparian zone due to its vital role in maintaining a healthy stream ecosystem.

Aesthetic quality dramatically decreases in downstream segments, particularly in the City of Poughkeepsie where trash and litter are strewn throughout the creek. Plastic bottles, soda and beer cans, candy wrappers and other small pieces of litter can be found throughout, and may be attributed to littering or street run off. However, evidence of individuals using the creek as a dump site is readily seen. Large objects not easily washed down the creek such as couches, bikes, car tires, shopping carts, baby strollers, and auto parts are common in the channel below bridge crossings and high density residential areas bordering on the stream. This might indicate a lack of education concerning trash pick-up, laziness, a lack of caring, criminals using the creek as a dump site for stolen goods (e.g. bicycles), or the high cost and inconvenience associated with the proper disposal of large household items.

Watershed Geology and Soils

The bedrock geology of the Fall Kill Watershed consists primarily of sedimentary rocks (Figure 2). Approximately 78% of the watershed's bedrock is made up of graywacke and shale from the Austin Glen Formation. The remainder of the watershed includes sedimentary rocks varying from argillite, chert, slate and siltstone from the Taconic Melange, Normanskill Group and Mount Merino and Indian River Formations. According to the *Biodiversity Assessment Manual for the Hudson River Estuary Corridor*, the Austin Glen Formation bedrock is potentially calcareous, while the other formations are alkaline (Kiviat and Stevens, 2001). These properties help to insure that the stream is not overly sensitive to chronic inputs of acidic precipitation and that the stream and surface soils will be fairly productive due to weathering of nutrients from the bedrock

Soils are an important feature of any watershed because they are a source of plant nutrients, influence the type and extent of terrestrial vegetation, determine the susceptibility of the land to erosion by wind and water, and significantly influence flood frequency and severity through their ability to absorb precipitation. The Fall Kill Watershed is dominated by two soil combinations, Dutchess and Cardigan, and Nassau

Figure 2. Bedrock geology of the Fall Kill Watershed.

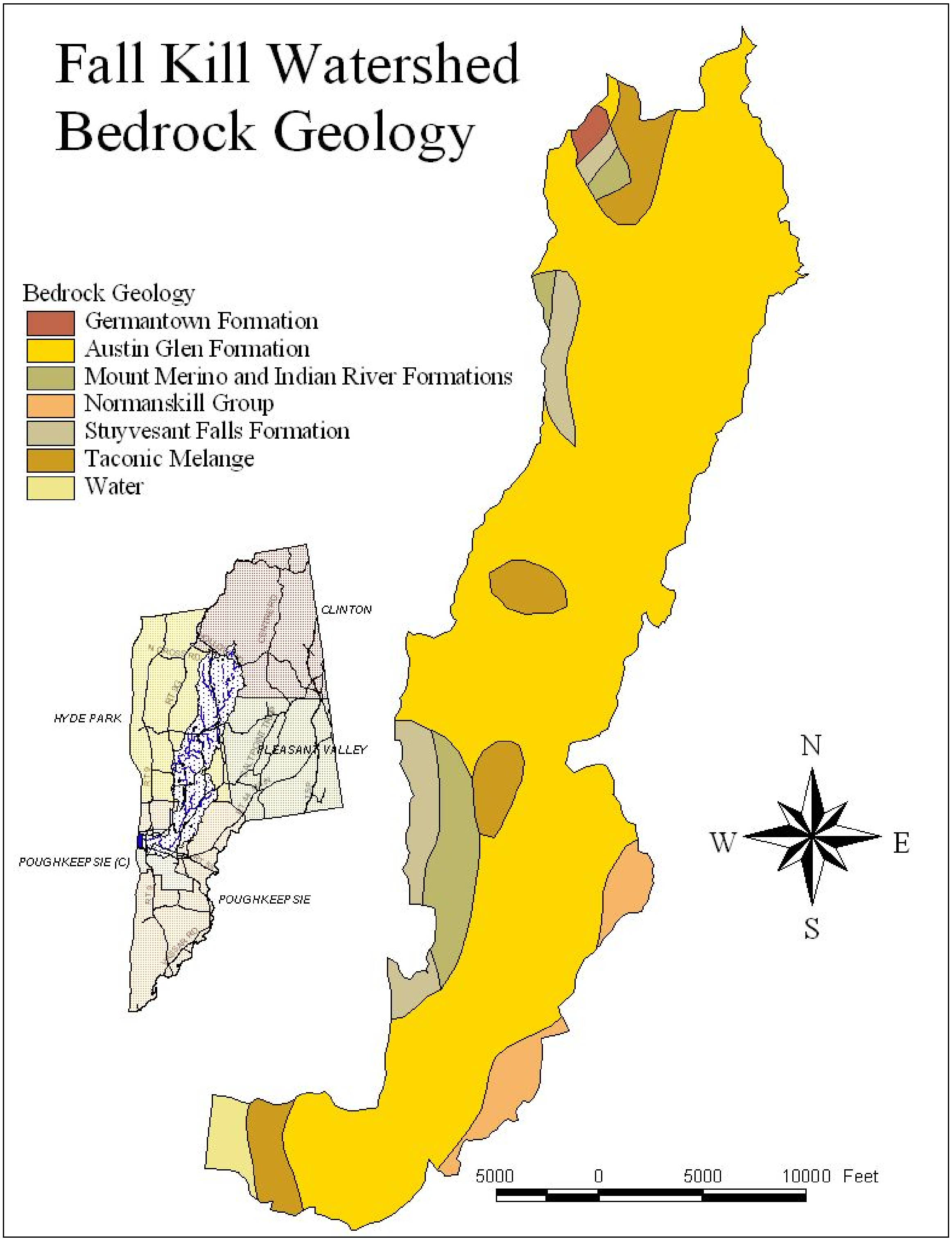
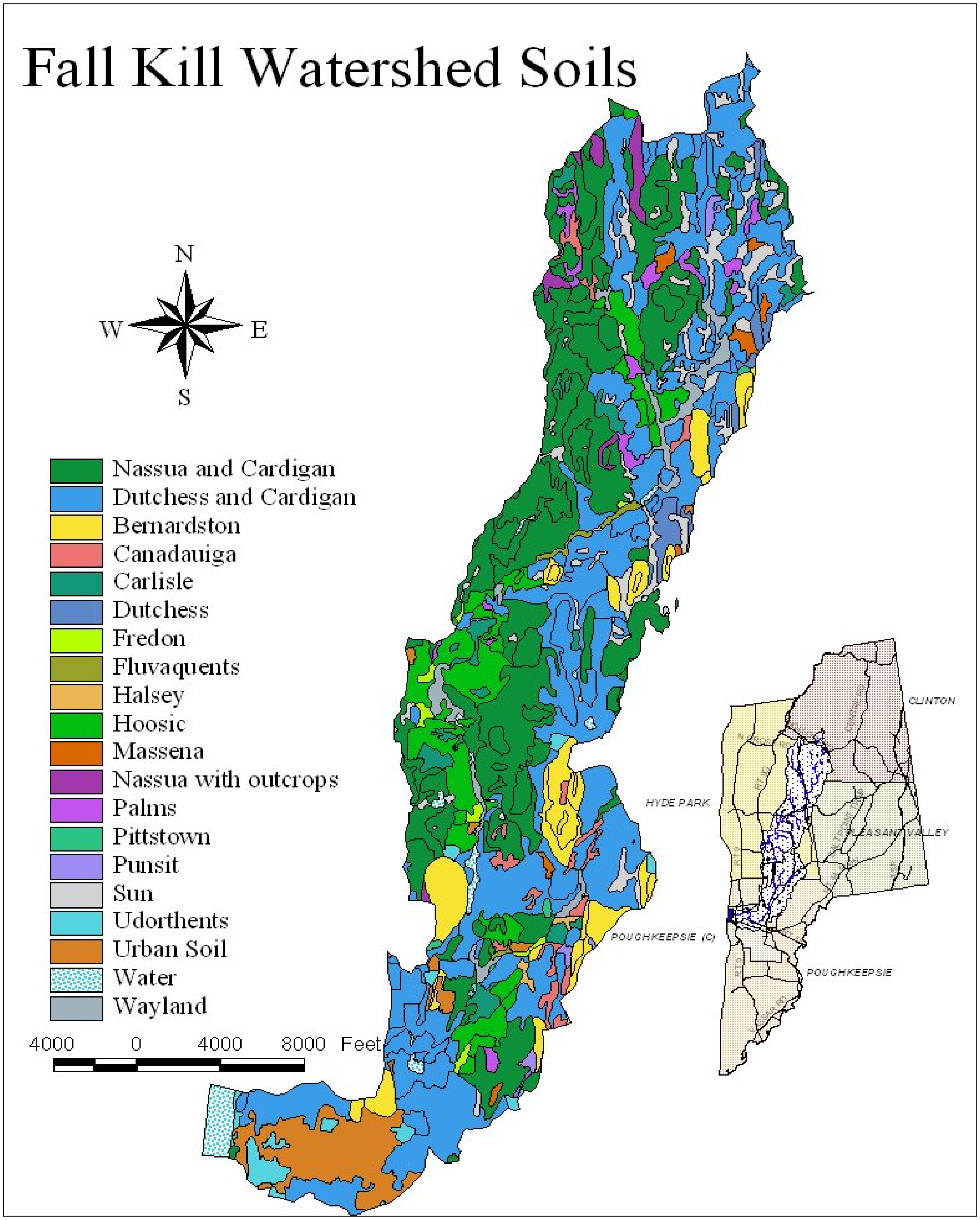


Figure 3. The different soil types within the Fall Kill Watershed.



and Cardigan (Figure 3). Both soil combinations drain well to excessively well, and make up nearly two-thirds of the watershed (Table 4). The remainder of the watershed is made up of seventeen different soils ranging from excessively poorly drained to well drained. These areas of poor drainage occur within or along the banks of the Fall Kill and in wetlands.

Table 4. The dominant soil types and their respective cumulative areas within the watershed. The drainage class for each soil type was obtained from the *Hudson River Corridor Biodiversity Manual* (Kiviat and Stevens, 2001)

Soil Type	Acres	Drainage Class
Dutchess with Cardigan	4,299	well drained
Nassau with Cardigan	3,605	somewhat excessively drained to well drained.
Hoosic	906	excessively to well drained
Bernardston	766	well drained
Urban Soil	584	
Sun	547	poor to very poorly drained
Wayland	258	poor to very poorly drained
Carlisle	234	very poorly drained
Canadauiga	178	poorly to very poorly drained
Palms	172	very poorly drained
Udorthents	172	excessively to somewhat poorly drained
Dutchess	144	well drained
Nassau with Outcrops	124	somewhat excessively drained
Massena	86	somewhat poorly to poorly drained
Fredon	61	somewhat poorly to poorly drained
Punsit	44	somewhat poorly drained
Fluvaquents	39	somewhat poorly to very poorly drained
Halsey	23	very poorly drained
Pittstown	19	moderately well drained

Septic systems built too close to the banks of the creek in excessively drained soils may result in fecal coliform and *E. coli* contamination of both the creek and drinking wells. Heavy rain-producing storms can cause severe flooding and bacterial contamination as the water flows quickly from the excessively drained soils into the poorly drained soils along the creek. Hyde Park experienced this problem with a storm on August 12, 2003. The residential area between Haviland Road and Roosevelt Road experienced severe flooding and damage caused by heavy rainfall (Figure 4). The soils within and along the banks of the creek in that area, Sun and Carlisle, are both considered very poorly drained, while the soil throughout the surrounding residential area, Hoosic, is very well drained. Impervious surfaces associated with suburban and rural development increase the rate and volume of runoff and compound the flooding problem.

Figure 4. Karl Rabe/Poughkeepsie Journal – This photo was taken on August 13, 2003 at the Haviland Mobile Park in Hyde Park after heavy rains caused the Fall Kill to flood.

Figure 5. The aerial photo shows the Fall Kill passing through a residential neighborhood between Haviland Road and Roosevelt Road. The area has been prone to flooding and is a suspected source of fecal coliforms because of the use and proximity of septic systems to the creek. (Photo courtesy of DCEMC)

Flow Charateristics of the Fall Kill

Discharge is the amount of water carried by a stream past a given point over some time interval. The unit most commonly used in the United States is cubic feet per second (cfs) where one cubic foot of water corresponds to 7.48 gallons. The United States Geological Survey (USGS) maintains an extensive network of gauging stations on streams and rivers throughout the country. Unfortunately not all streams have a gauging station. Due to budget cutbacks, the number of gauged streams in the network has been reduced in recent years. There is an old gauging station on the Fall Kill along Verazzano Boulevard in the City of Poughkeepsie that operated for an unknown period between 1931 and 1960 and again between 1993 and 1995. Data from this site indicate that the mean flow throughout the year was less than 30 cfs. Maximum flows during 1994 and 1995 were 225 and 232 cfs respectively. The median flow (50^{th} percentile) during the longer mid century term of record was 8.5 cfs, meaning the flow exceeded 8.5 cfs on only 50 percent of the days measurements were taken (usually daily). Discharges exceeding 20 cfs occurred only 30% of the time while flows of 3.6 and 0.9 cfs were exceeded 70% and 90% of the time respectively. The discharge characteristics of the stream may have changed significantly since these data were collected due to development and other land use changes within the watershed.

Recreational Assets and Open Spaces

Within the City of Poughkeepsie there is very little public access to the creek. There is the opportunity to create a greenway trail or public area for people to enjoy the creek along the north bank of the creek between Garden Street and Mount Carmel Avenue along Brookside Avenue and Verazzano Blvd. The Hoffman House along Water Street abuts the Fall Kill before it enters the Hudson River. The Hoffman House is in a historic area of the City of Poughkeepsie and is in a prime location for recreation with the falls of the creek, Waryas Park, and the Mid-Hudson Children's Museum nearby. Waryas Park also offers views of the Hudson River, the Poughkeepsie railroad bridge, the Mid-Hudson Bridge, and also provides a public boat launch area. The Hudson River Greenway passes through the aforementioned properties and allows people to experience the Hudson River with walking and biking trails that pass over the Fall Kill as it reaches the Hudson River. Further upstream in the center of Poughkeepsie, Malcolm X Park and Morse Elementary School along Mansion Street provide open space areas for recreation, and can become a potential staging area for creek festivals or other public functions. The watershed also includes College Hill Golf Course within the City of Poughkeepsie that borders on Morgan Lake, a popular urban fishery (Figure 6).

Outside of the city, there is significantly more open space with the Hyde Park Memorial Fields along Creek Road and recreational facilities at Dutchess Community College and local public schools. The watershed is generally lacking in nature preserves, hiking trails and other forms of access to the creek. With the cooperation of riparian landowners, the watershed has the potential to provide such amenities. The most promising of these areas is the county-owned Fall Kill Park along Creek Road (Figures 6 and 7). Fall Kill Park was once part of the Hudson River Psychiatric Center and the dam just north of Cream Street allowed the center to use the lake for ice production. The park opened as a public beach in 1968, but was closed in 1974 by the county because of reoccurring problems of contamination by fecal coliform bacteria. Currently, access to the park is limited and the area is underutilized. Improving access to the site could provide a great recreational opportunity for car-top boaters, fishermen, bird watchers, hikers, and photographers.

In Hyde Park, the Fall Kill passes through the historic Valkill property, which was built by President Franklin Delano Roosevelt for his wife, Eleanor. The property provided Eleanor and her friends a getaway from the large house, Springwood, on Route 9. Today, the Dutch fieldstone structure and open space is a draw for tourists and naturalists. Scenic Hudson recently purchased a parcel between Route 9 and Route 9G to create a trail connecting Valkill with FDR's Springwood property and the Vanderbilt property further north on Route 9. The three properties have open fields and serene areas available for Hudson River sightseeing, bird watching, picnicking, nature photography as well as historical buildings and the Presidential Library and Museum.

Figure 6. Surficial aquatic resources including, lakes, ponds, wetlands and stream segments within the Fall Kill Watershed.

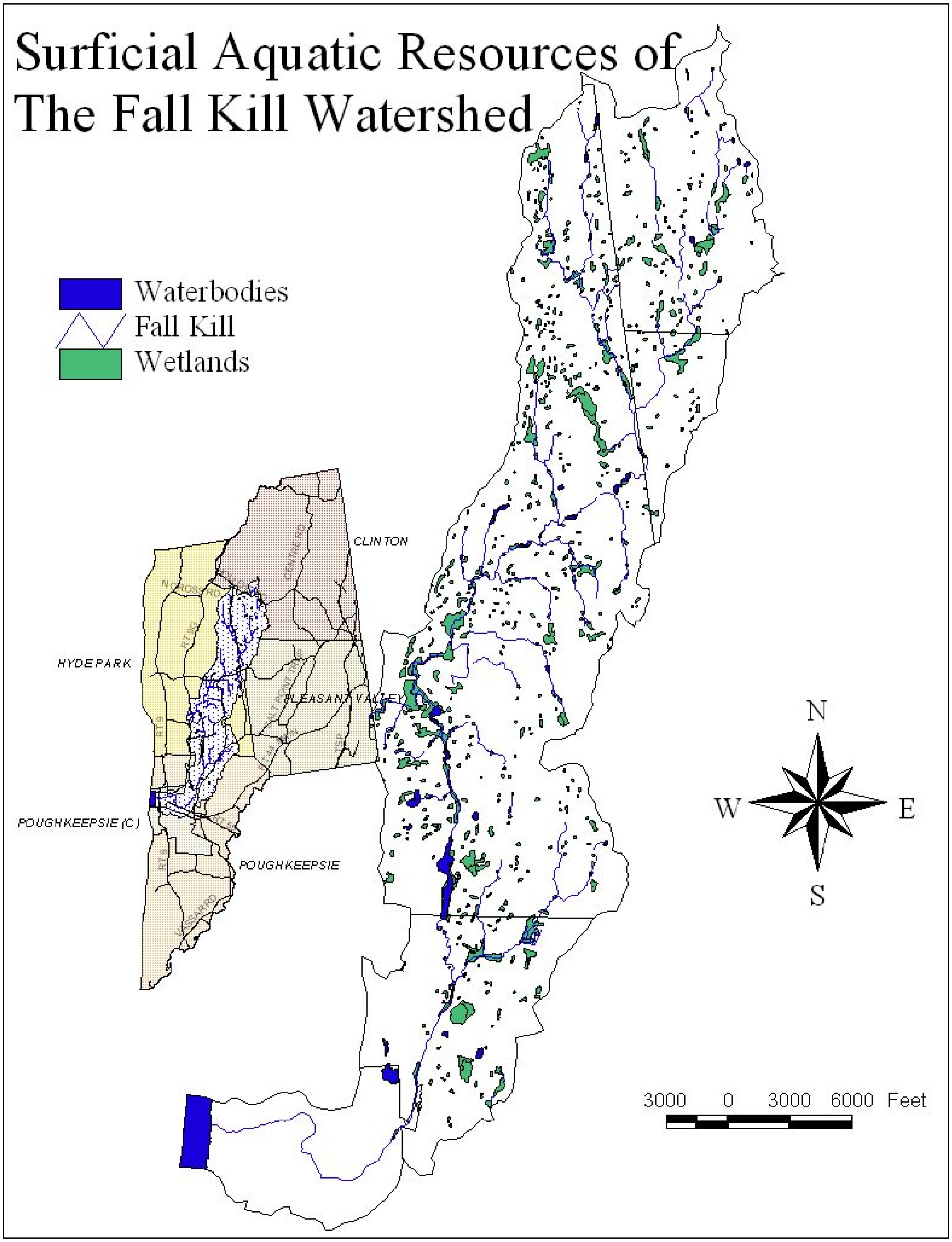
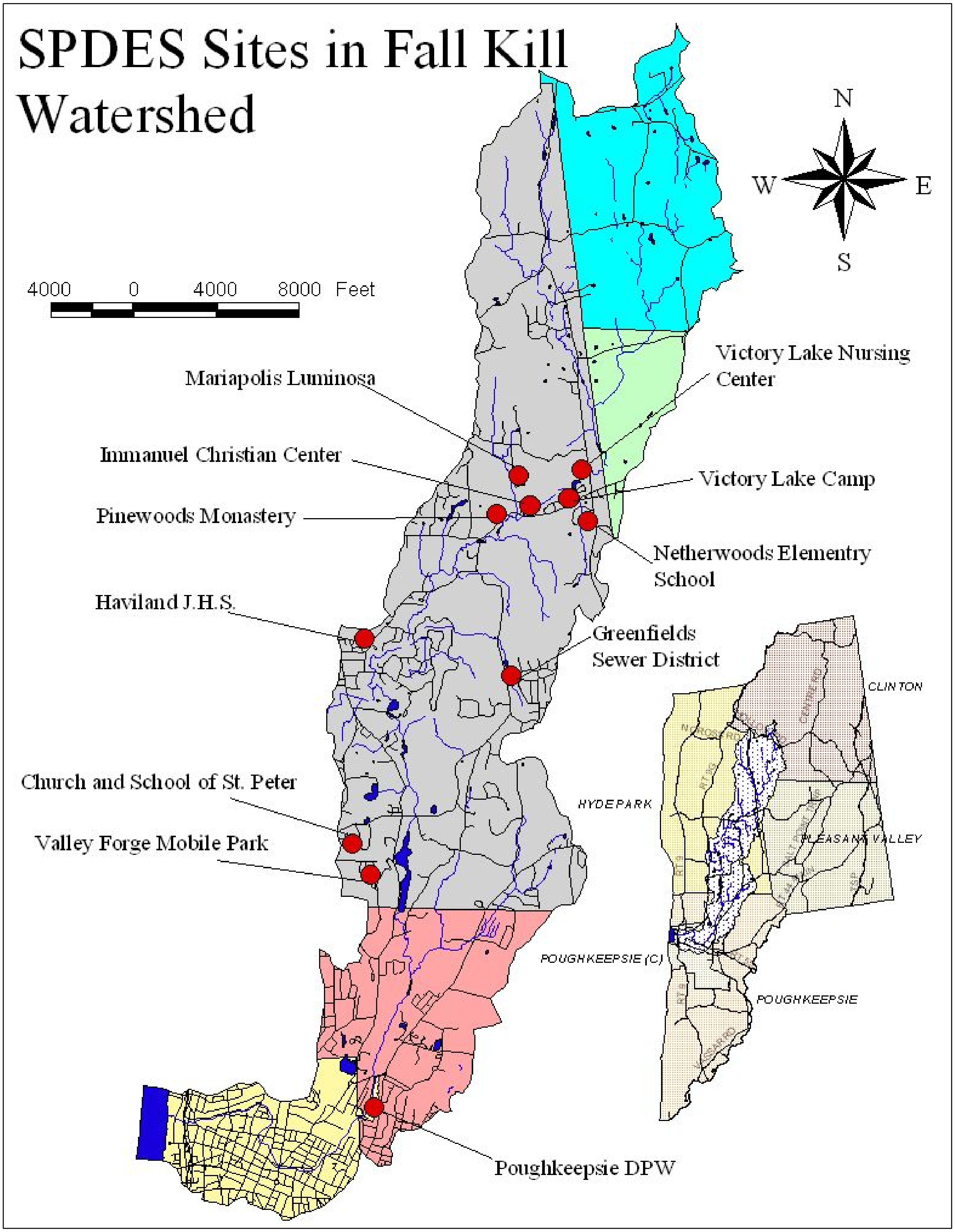


Figure 7. Aerial photo of Fall Kill Park and surrounding area in Hyde Park, NY.

Waste Disposal in the Fall Kill Watershed

The entire areas of the City and Town of Poughkeepsie that fall within the Fall Kill watershed are covered by a central sewage treatment system. The towns of Hyde Park, Clinton, and Pleasant Valley do not have central sewage systems and instead rely on individually owned septic systems or larger onsite systems requiring State Pollution Discharge Elimination System (SPDES) Permits (Figure 8). The SPDES program was instituted to help protect public health and the health of our resources and environment. SPDES permits are required by the NYSDEC for discharges of 1,000 gallons per day of wastewater into surface or groundwater. The wastewater should be treated before being released. In 2005, there were eleven sites within the Fall Kill Watershed with a SPDES permit (NYSDEC, 2005). The sites were concentrated in the northern part of the watershed in Hyde Park. Ten of the eleven sites including the Greenfields Sewer District, have permits for sanitary waste. The sewer district treats the waste from a newer development and discharges the effluent into an unnamed tributary of the Fall Kill. The City of Poughkeepsie Department of Public Works is the only SPDES site not in Hyde Park and is permitted to discharge miscellaneous waste. The cumulative maximum daily discharge for all sites equals 299,100 gallons per day.

Figure 8. SPDES sites within the Fall Kill watershed.



Watershed Protection and Resotration Objectives

Efforts to conserve and enhance the beauty and natural functions of the Fall Kill generally fall into the following categories:

Improve the water quality to the point that the stream could be upgraded from Class C to Class B (capable of supporting swimming and other forms of contact recreation).

Protect open space along the creek to provide habitat for fish and wildlife as well as places where humans can interact with the natural world.

Maintain functionally adequate riparian buffer zones where they already exist and work with adjacent land owners to enhance those areas where the vegetated buffer has been removed or damaged. Healthy riparian zones increase biological diversity and provide natural corridors for movement of organisms.

Provide more public access to the creek and increase recreational opportunities for the public to enhance a sense of community ownership and caring.

Develop educational programs to inform the public and policy makers about the ecological and historical significance of the creek.

Establish an intermunicipal agreement to encourage mutual cooperation in the development of watershed-wide strategic plans for land use, planning and financing of stream restoration projects, coordination of educational outreach programs, enlistment of community groups as stream caretakers, and acquisition and maintenance of environmental monitoring data.

Threats to the Fall Kill

Fecal coliform bacteria

In past and current studies of the Fall Kill, fecal coliform bacteria (including *Escherichia coli*) were found at high levels throughout the Fall Kill. Numbers were highly variable with respect to location and time. Levels often exceeded public health guidelines established for primary contact of the general public. The presence of these bacteria indicates that the Fall Kill is receiving inputs of fecal matter from warm blooded organisms. The most likely sources for the Fall Kill include raw or poorly treated sewage from leaking pipes, illegal connections, leaking septic systems, surface runoff from areas hosting large concentrations of waterfowl, or urban runoff containing pet waste.

Fecal coliforms are gram-negative, rod-shaped bacteria harbored in the intestinal tracts of warm blooded animals. Fecal coliforms are identified by their ability to ferment lactose at 44.5 ^{o}C. *Escherichia coli* (*E. coli)* is a commonly occurring fecal coliform and although these bacteria are generally considered to be harmless themselves, they indicate the possible presence of pathogenic bacteria. However, some strains such as the 0157.H7 strain of *E. coli* can cause severe illness and diarrhea and in some cases has caused the death of young children.

The presence of fecal coliforms may not directly affect aquatic organisms such as fish and macroinvertebrates, but the presence of the bacteria could indicate an increased biological oxygen demand (BOD) being placed on the stream ecosystem due to decomposing sewage. The increased BOD could lower the availability of dissolved oxygen to aquatic organisms that would impair their normal respiration and metabolism.

Plant nutrients – especially nitrogen and phosphorus.

<u>Nitrogen</u>

Nitrogen is found in ecosystems in various organic forms, and in inorganic forms such as nitrate (NO_3^-), nitrite (NO_2^-) the ammonium ion (NH_4^+) and as ammonia (NH_3). Ammonia and nitrate are the forms that are most readily available to green plants and are widely used by farmers to increase crop production. In a similar manner, nitrate in excessive amounts can cause massive growths of rooted aquatic plants or algal blooms when present in surface waters. This type of excessive algal and plant growth is readily observed at Fall Kill Lake along Creek Road.

High concentrations of nitrate can also present a human health concern when present in drinking water. Any water that contains nitrate concentrations of 44 mg/L (equivalent to 10 mg/L nitrate-nitrogen for EPA and NYSDOH standards) or higher has the potential to cause methemoglobinemia, or "blue baby" disease in children. (McCasland et al., 1998). Although the human health standard for nitrate consumption has little correlation with stream health, high levels of nitrate in both surface and groundwater usually indicate widespread nonpoint source pollution of sewage inputs, fertilizer runoff from farms, lawns, and golf courses, and from urban stormwater runoff. Conversion of nitrogen oxides originating in automobile exhaust and industrial emissions to nitric acid and subsequent deposition as acidic precipitation is also a source (Smith et al., 1991).

Concentrations of nitrate in the Fall Kill ranged from 0.3 to 1.2 mg/L. Based upon average concentrations found in water samples from 85 sites in relatively undeveloped watersheds across the United States, the median concentrations of nitrate-nitrogen and total nitrogen were 0.087 and 0.26 mg/L respectively (Clark et al., 2000). However, due to present and past land uses, the undeveloped watershed concentrations (below 0.26 mg/L) of total N rarely occur in Dutchess County in 2004.

Phosphorus

Recent studies described later in the plan detected high phosphate concentrations throughout the Fall Kill. This is an ongoing threat because phosphorus is a nutrient that is essential to plant growth. Inorganic phosphate (orthophosphate) is the form that is available to, and needed by, plants. Plants assimilate orthophosphate from the surrounding water and convert it to organic phosphorus. In freshwater ecosystems phosphate tends to be the nutrient that is least available for plant growth. Consequently, phosphate is often the limiting factor that controls the amount of plant growth. Small additions to surface waters can result in large amounts of plant growth and algal blooms. The most likely sources of phosphate inputs include animal wastes, human wastes, fertilizer, detergents, eroded soils from disturbed land, road salts (anticaking agent), and stormwater runoff.

Based upon the average concentrations found in water samples from 85 sites across the United States in relatively undeveloped watersheds, the median concentrations of total phosphorus and orthophosphate as P were 0.022 and 0.010 mg/L respectively (Clark et al., 2000). In general, any concentration over 0.05 mg/L of orthophosphate will likely have an impact on surface waters (Behar, 1996). However, in many streams and lakes, concentrations of PO_4 as low as 0.01 mg/L can have a significant impact on water resources by causing a proliferation of aquatic vegetation and phytoplankton. In order to control eutrophication (the excessive growth of plants and algae), the USEPA recommended limiting phosphate concentrations to 0.05 mg/L in waters that drain to lakes and ponds, and 0.1 mg/L in free flowing rivers and streams (USEPA, 1996). Phosphate concentrations in the Fall Kill ranged between 0.05 and 0.12 mg/L.

Dissolved solids

Dissolved solids are organic or inorganic chemicals that are dissolved in the water. Common inorganic dissolved solids include; calcium, magnesium, sodium, potassium, chloride, sulfate, nitrate, and phosphate. Humic, fulvic, and tannic acids are organic dissolved compounds found in watersheds dominated by bogs or coniferous forests. Surface and groundwater contains variable amounts of dissolved solids depending on geological conditions, type and depth of soils, land use, and contributions of contaminants from point and nonpoint sources like stormwater runoff of salts applied to roads during winter deicing operations.

Conductivity refers to the ability of water to carry an electric current and is dependent on the amount of dissolved solids present in the water. Studies of inland fresh waters indicate that streams supporting good mixed fisheries have a conductivity range of 150 to 500 µmhos/cm (uS/cm) (USEPA, 1997). Conductivity values in the Fall Kill ranged from 320 uS/cm in upstream locations to over 700 uS/cm at downstream locations.

Elevated temperatures during the summer

Water temperature is a critically important attribute of aquatic systems as it regulates the metabolic rates of many organisms, influences the ability of water to hold oxygen and other gases, often enhances the toxicity of pollutants, and may exceed the tolerance range of aquatic organisms. Temperature is influenced by removal of shade cover in the riparian zone, impoundment of water behind dams, discharges of hot water, or stormwater runoff, particularly after brief showers on warm summer afternoons. High water temperatures were detected during the warm summer months at many sampling locations along the Fall Kill.

Inorganic and organic contaminants

Petroleum hydrocarbons result from the accidental or deliberate discharge of petroleum - based fuels and lubricants into aquatic systems often via improper disposal into storm drains that flow directly into nearby waterbodies. Some may be directly toxic to aquatic life while others may lead to the development of cancerous-like lesions in the tissues and organs of invertebrates and fish.

Another type of contaminant found in the sediment at some locations along the Fall Kill were trace metals. Many trace metals occur naturally at low concentrations. Some trace metals are essential to normal biochemistry and metabolism. Elevated concentrations can lead to toxicity and transfer through the food chain to higher organisms. Some trace metals like mercury and lead have no known beneficial biological function.

Trash and litter

While the presence of large items of household trash, construction materials, and litter don’t have a direct effect on the biological structure and function of streams, they do create public safety issues associated with exposed nails, trip hazards, and cuts from broken glass and jagged metal objects. Large quantities of litter detract from the aesthetic enjoyment of the resource and causes people to devalue and abuse the resource.

Loss or degradation of the riparian zone

Riparian zones are distinctive bands of vegetation bordering streams and rivers. These zones provide habitat for wildlife associated with aquatic systems such as birds, amphibians, turtles, beavers, mink, muskrats, and raccoons. The linear arrangement of these transitional areas also serves as a corridor for the migration of wildlife between otherwise disconnected open spaces. The riparian vegetation shades the stream during the warmer months of the year helping to keep water temperatures within the tolerance range of aquatic organisms. Leaves, blossoms, and other types of vegetation fall into the stream throughout the year and become an important food source for the entire aquatic community in small to medium-sized streams. The rooted vegetation in the riparian zone helps to stabilize the banks and thereby reduce the severity of erosion and loss of property. If stormwater flows are dispersed before they enter the riparian zone, the vegetation will help to lower the concentrations of suspended solids, plant nutrients, and toxic chemicals. These values are lost when development is allowed to encroach into the riparian zone or when riparian landowners replace riparian trees, shrubs, and groundcovers with lawns down to the water’s edge.

Increase in impervious surfaces

As development in a watershed intensifies, more and more of the land is converted to impervious surfaces associated with roads, sidewalks, parking lots, and rooftops. Precipitation falling on these surfaces is quickly shuttled to storm drains and from there into the nearest stream. Stormwater runoff radically changes the flow rates and volume of water carried by the receiving stream. The result is an increasing frequency and severity of flooding at downstream locations. The flooding causes erosion of the stream banks resulting in either a widening or deepening of the channel as the stream tries to adjust to the larger volume of water it is expected to carry. Surface runoff from impervious surfaces often carries large amounts of litter, oils, greases, toxic chemicals, and pet waste.

The increase in impervious surfaces also reduces the recharge of groundwater aquifers thereby threatening the quantity of water available in the future to communities dependent on wells. Due to falling water tables, communities may be forced to bring in water from other locations using a centralized water system of pumps, storage tanks, and pipelines. The development of this type of infrastructure would obviously be very expensive. Reduced groundwater recharge will also affect stream flows during periods of low precipitation as water tables drop and groundwater inputs to stream channels decline.

Management Practices

Urban Land, High Density Zones

Litter/Solid Waste - Solid waste is the most visible problem within the City of Poughkeepsie. Litter ranging from candy wrappers to couches can be found on the banks and within the stream channel especially between Smith Street and the mouth of the Fall Kill at the Hudson River. A thorough clean-up of the three-mile segment is necessary, using resources available to the municipality as well as utilizing volunteers from not-for-profit organizations and community groups. Following the clean-up, several measures should be taken. The stream should be regularly monitored for signs of improper trash disposal. Anti-dumping ordinances should be enforced where they exist and promulgated where they do not. Riparian landowners and residents should be encouraged to report any incidents of illegal dumping observed on or near their property. The disposal of large objects that are not readily transported downstream except by very high flows (refrigerators, couches, etc) should be vigorously investigated and prosecuted if the offending parties can be identified. Educational materials describing the effects of illegal dumping and littering on aesthetic quality, property values, as well as impacts on water quality and habitat should be provided to all riparian landowners. Visible signage conveying the message of “No Dumping” or “No Littering” should be placed at street crossings and areas easily accessible to the public. Storm drains should also be labeled as “Drains Directly into Fall Kill. All storm drains should be cleaned out regularly.

Fecal Coliform Bacteria – Fecal coliform bacteria and E. *coli* were consistently high within the city. Since the area around the creek is urbanized with very little habitat for wildlife capable of creating that much bacteria, the source is most likely from upstream sources, pet wastes in urban storm runoff, and/or faulty or illegal sewer pipes. Dye tests should be conducted in the sewer system to check for leaks. Damaged sewer pipes should be quickly sealed or replaced. Another possible source of coliforms further upstream in the creek is the presence of Canada geese. Riparian landowners should be encouraged not to mow their lawns to the water’s edge. Taller vegetation should be grown near the creek as this is a proven deterrent to geese.

High Conductivity and Salinity – Conductivity and salinity were consistently the highest in the City of Poughkeepsie. This can be attributed to dissolved solids getting into the creek either through storm drains, faulty sewer lines or direct runoff into the stream. Road salt is stored at the Poughkeepsie DPW yard along the Fall Kill and can be a source as well. Materials stored at Poughkeepsie DPW should be covered and vegetative buffers or runoff barriers should be placed around the materials or storage units. The city also includes approximately 39 miles of road within the watershed. Road deicing in the winter causes dissolved salts to run into the creek during melts, possibly causing a toxic shock to vegetation and wildlife. As noted in an Institute of Ecosystems Studies Report, freshwater salinity in Hudson River tributaries has been increasing at an alarming rate over the past 30 years. The study warns that within the next century many freshwater sources will be toxic to aquatic life as the salt accumulates in the environment (Shapley, 2005). Calcium magnesium acetate is a safer deicer than sodium chloride. Although it is more expensive, calcium magnesium acetate is less corrosive and has little impact on vegetation and organisms. Storm drain basins should be cleaned following the snow season to remove salt and sand deposits, and streets should be swept to remove the deposits as well.

Heavy Metal Contaminated Soils – Heavy metals have been found in sediment samples from the Fall Kill in the City of Poughkeepsie. Current or historical sources of the metals should be investigated, and hot spots should be remediated.

Education – Informative kiosks or signs placed around public areas of the creek can educate citizens about the history of the Fall Kill, its biological characteristics, and ways to protect the creek. Students and teachers from Poughkeepsie schools can also use the creek as a tool to teach about aquatic wildlife, and also to instill recycling and proper trash disposal practices on the city's youth. The more people know about the creek, how it works, and the potential impacts of our actions, the more the city can spur actions involving private and community stewardship. – A city-wide event tentatively called Fall Kill Week that includes guided tours of the creek, poster displays in government and community buildings, stream clean-ups, and community outreach can instill community pride in the creek and further stewardship initiatives.

Riparian Buffers – Riparian zones are narrow throughout the city, as many properties and buildings are upon the creek's edge. Even though the riparian zones are narrow, the coverage of the creek with a canopy of trees within the City of Poughkeepsie is beneficial in keeping water temperature down. Removing trees within the riparian zone should be strictly discouraged unless the tree is deemed a risk to cause significant property damage or harm to human health. Unaltered stretches of riparian zone should be kept intact to protect the creek from direct sunlight and from unfiltered runoff of contaminated stormwater. Riparian zones should be enhanced with grasses, shrubs and young trees where space is available. The buffer zones should not be used as dumping areas for garbage or yard debris.

Designate Areas of Concern - Compile a database of areas prone to garbage dumping, buildings or industries causing possible environmental impacts (see junkyard aerial photo), and areas creating large amounts of storm water runoff. The city should work together with the owners of these properties to alleviate the problems, such as new runoff controls or riparian buffers. The city can then monitor areas prone to garbage dumping with increased police patrols or inspections of the sites in order to alleviate the problem.

Continue Aquatic Research – Biological and chemical assessments of the creek should continue in order to track the health of the creek. The success of clean-ups and enacted management practices can be followed with continued research, and the successful rehabilitation of the creek as seen by research data can reinforce the idea of stewardship and rehabilitation of the creek.

Implement Plan for Wall Rehabilitation – Some elected officials and residents have voiced their concerns for the crumbling walls. The channel formed by the walls limits the available habitat for aquatic organisms and severely restricts access by people. If the walls are deemed important for historical reasons, a small section should be rehabilitated for historic purposes. The remaining areas of wall, where public safety and flooding concerns allow, should be left to crumble to help form valuable habitat for fish and macroinvertebrates.

Participate in Government and Elect Capable Officials Who Will Revitalize the Creek – It is important for this committee and community to initiate change on the creek on a biological and economic front. The community should stress the importance and potential of the creek to the livelihood of the City of Poughkeepsie. If officials are failing to meet these demands, the community should participate in various ways including voting, writing letters to their representatives and attending community meetings.

Management - Suburban Areas

Riparian Zones and wetland buffers – Buffer zones have remained intact for the most part, but there are several zones of concern. Riparian zones should not just include large trees that provide shade to the creek, but also shrubs and grasses that prevent nutrients and suspended particles from running into the stream or wetlands.

Protection from further development – Further development along the creek should look to protect riparian zones, use crowned roads without curbs and have innovative storm water runoff plans. These plans can include man-made wetlands or buffer zones that filter the storm water before entering the creek, as opposed to directly flowing into the creek from a pipe.

Litter – Although litter is rarely found within the creek north of the City of Poughkeepsie, litter is often found along roads near the creek. The problem is much different than the City's litter because the litter is smaller and more inclined to flow downstream with little impediment instead of creating large piles of trash. Trash along roads and near the stream crossings should be cleared, and signs of "No Littering" and the "Fall Kill Creek" signs posted.

Pesticides and Fertilizers – Fertilizers and pesticides can easily get into the creek in suburban areas, especially in areas where lawns have replaced riparian buffers. The towns and other organizations should work to educate residents about the adverse effects that fertilizers and pesticides have on the creek, and educate them on alternative methods. If lawns are near the edge of the creek, a five-foot wide strip of grass should be left to grow higher in order to provide habitat and essential root systems.

Clean storm drain catch basins – Storm drains and catch basins should be cleaned several times a year, and after the last snowfall in order to remove sand and possibly deicing materials from the basins to prevent further runoff problems.

Change Road Salt – Salts used to deice roads can easily wash into the creek and accumulate in soils in suburban areas as well. The less toxic calcium magnesium acetate should be considered.

Cleaning Septic Tanks Regularly – Septic tanks should be pumped every one to two years to prevent tank failure and leaching into the creek. Failure to clean septic tanks regularly can lead to long-term problems for the residents and neighbors, such as failing leach fields thereby harming the health of the creek.

Limit Impervious Surfaces – Limiting the area of impervious surfaces on new development is vital to the health of the creek and the property protection of residents abutting the creek. The area between Haviland Road and Roosevelt Road has been prone to flooding, and with an increase of impervious surfaces dumping sediment and water into the creek, the problem will only get worse. New roads could be made narrower, and parking lots could use other types of materials such as pavers with slots to allow for water to infiltrate into the ground.

Crowned Roads – New roads and road improvement projects should be crowned in order to run water off the sides into grass or vegetative areas. Doing so limits the amount of water running into storm drains, and also creates the opportunity to recharge aquifers, while reducing infrastructure costs.

Removal of dams – If feasible, remove small dams (less than 3' high) from the Fall Kill in order to improve stream flow and prevent obstruction for migrating organisms.

Allow Greater Public Access to Fall Kill Park – Currently, access to the county owned land is limited to the area around the dam. Opening up the area would allow for further recreational usage of the site, including fishing, canoeing, kayaking, bird watching and hiking.

Current Studies and Background Information on Environmental Attributes

The Fall Kill was assessed in the summers of 2004 and 2005 by researchers from Marist College and the Dutchess County Environmental Management Council. The analysis consisted of water chemistry, analysis of water and sediment for trace metals and petroleum hydrocarbons , fecal coliform bacteria, the biologic community - including macroinvertebrates and fish, and a brief habitat assessment.

Macroinvertebrate Sampling Rationale

Benthic macroinvertebrates (BMI) can be simply defined as animals without backbones that are larger than 0.5 millimeter and live at least a portion of their life cycles in or on the bottom of a body of water (Dates and Byrne, 1996). In freshwater systems these animals may live on rocks, logs, sediment, debris and aquatic plants during their various life stages. A few common examples of BMIs include crustaceans such as crayfish, mollusks such as clams and snails, aquatic worms, and the immature forms of aquatic insects such as stoneflies, caddisflies, mayflies and true flies.

BMIs function at the lower levels of the aquatic food chain, with many feeding on algae, dead particulate organic matter (detritus), and bacteria. Some shred and eat leaves and other organic matter that enters the water, and others are predators. Because of their abundance and position in the aquatic food chain, BMIs play a critical role in the natural flow of energy and nutrients through the aquatic system (Covich et al., 1997). For example, Sweeney (1993) demonstrated in a second order stream, that leaf litter and woody debris were primarily consumed in the forested woodlot where the debris originated, rather than being washed downstream. Also, as organisms die, they decay, leaving behind nutrients that are reused by aquatic plants and other animals in the food chain. Insects fill the roles of predators, parasites, herbivores, saprophages, and pollinators, among others, which indicate the pervasive ecological and economic importance of this group of animals in both aquatic and terrestrial ecosystems (Rosenberg et al., 1986).

Biological monitoring is an attractive methodology for documenting water quality for several reasons. First, the community collected at a given site reflects the water quality at that site over several weeks, months, or years. The alternative methodology of grabbing a water sample reflects the water quality at the instant the sample is collected (i.e. a snap shot image). Second, the community-based approach protects the biological integrity of the water body, and doesn’t focus on a limited number of chemical parameters. Third, samples can be preserved in reference libraries for future application; this provides a convenient routine of summer collection and winter analysis. Finally, biological assessments tend to be much more cost effective than chemical analysis. Table 5 lists the rationale for biomonitoring in New York State (Bode et al., 2002).

Table 5 – Rationale for the analysis of macroinvertebrate communities to determine water quality of streams and rivers in New York State (Bode et al., 2002)

1. Benthic Macroinvertebrates (BMIs) are sensitive to environmental impacts;
2. BMIs are less mobile than fish, and thus can avoid discharges;
3. They can indicate the effects of spills, intermittent discharges, and lapses in treatment;
4. They are indicators of overall, integrated water quality, including synergistic effects and substances lower than detectable limits;
5. They are abundant in most streams, and are relatively easy and inexpensive to sample;
6. They are able to detect non-chemical impacts to the habitat, such as siltation or thermal change;
7. They are readily perceived by the public as tangible indicators of water quality;
8. They can often provide an on-site estimate of water quality;
9. They bioaccumulate many contaminants to concentrations that analysis of their tissues is a good monitor of toxic substances in the aquatic food chain;
10. They provide a suitable endpoint to water quality objectives.

Biological assessments have been used by many states to evaluate the effectiveness of water quality programs, particularly for nonpoint source impact determinations (USEPA, 2002). For example, biological assessment models have been tested with field data and the results suggested that macroinvertebrate data collected for establishing the degree of water quality impairment can also be used to identify the impairment source with reasonable accuracy (Murray et al., 2002). The Ohio EPA employs biological response signatures, based on biological, chemical, physical, bioassay, pollution source, and watershed characteristics, that consistently indicate one type of impact over another (Yoder, 1991). In New York State, the first recorded biological monitoring effort dates from 1926-1939, but the regulatory role of stream biological monitoring did not begin in New York until after the passage of the Federal Water Pollution Control Act Amendments of 1972 (Clean Water Act). The primary objective of New York State's program was to evaluate the relative biological health of the state's streams and rivers through the collection and analysis of macroinvertebrate communities (Bode et al., 2002).

Standardized protocols for benthic macroinvertebrate monitoring were developed in the mid-1980s due to the need for cost-effective habitat and biological survey techniques (Plafkin et al., 1989). The primary driver of the development was limited economic resources available to states with miles of unassessed streams. It was also recognized that it was crucial to collect, compile, analyze, and interpret environmental data rapidly to facilitate management decisions and resulting actions for control and/or mitigation of impairment. Therefore, the conceptual principles of rapid bioassessment protocols (RBPs) were as follows; cost-effective, yet scientifically valid procedures, provisions for multiple site investigations in a field season, quick turn-around of results for management decisions, easily translated to management and the public, and environmentally benign procedures (Barbour et al. 1999).

NYS DEC Community Assessment

The Fall Kill is listed on the New York State Priority Waterbodies List (PWL) for remediation (NYSDEC, 2000). According the PWL (2000), the Fall Kill is impaired from Haviland Road in Hyde Park to its confluence with the Hudson River. The stream uses that are being impaired by pathogens and debris include aquatic life and aesthetics (NYSDEC, 2000). Other suspected types of pollutants include nutrients, sediment, oxygen demand, and unknown toxicity (NYSDEC, 2000). Potential sources of the pollution include failing septic systems (upstream), industrial and municipal sources, construction operations, and the College Hill golf course (NYSDEC, 2000).

The NYS DEC conducted biological sampling in the Fall Kill in 1997 in order to assess general water quality for the PWL and establish a baseline set of data (Bode et al., 1998). In the seven-mile stretch of the Fall Kill that was sampled, water quality declined in a linear manner from upstream to downstream (Figure 9). The biological community at Haviland Road was slightly impacted and resembled both a natural community and a community impacted by nutrient additions (Bode et al., 1998). The invertebrate community at Smith Street was reflective of a community found downstream of a golf course (Bode et al., 1998). The community at Verazzano Blvd pointed strongly towards impacts from municipal and industrial wastes from urban runoff and the dumping of trash (Bode et al., 1998). Basic water chemistry analyzed at the sites wouldn't seem to limit the biological community (Table 6).

Table 6. Fall Kill Chemical Data Collected 9-04-97 (Bode et al., 1998)				
Site	02	03	04	05
Time	10:15	11:10	12:15	12:45
Temperature (ºC/ºF)	15.2/59.4	17.4/63.3	16.9/62.4	16.9/62.4
Specific Conductance (µmhos)	378	543	510	716
Dissolved Oxygen (mg/L)	8.4	5.8	7.0	9.2
pH	7.7	7.4	7.5	8.0

In 2001, Bode et al. (2001) conducted a more in-depth study of the impacted segment between station four and five (Figure 10). Municipal and industrial water quality impacts were indicated by impact source determinations at both stations four and five (Bode et al., 2001). Impact source determination is a procedure that employs invertebrate community type and models to determine the primary impact to water quality. Station 4, Smith Street, was assessed as slightly impacted and station 5, Garden Street, was assessed as moderately impacted (Bode et al., 2001). Tissue analysis of hellgrammites (station 4) and fish (station 5) showed elevated levels of PAHs at both sites, selenium at the upstream site, and DDD, DDE and PCBs at the downstream site (Bode et al., 2001).

Sampling in 2004-05

In the summer of 2004, water quality, fish and macroinvertebrate samples were taken from four stations along the creek; Dorsey Lane, Hyde Park (designated FK 5.8 where the 5.8 designates miles upstream from mouth) , Cream Street, Town of Poughkeepsie (FK 4.6), Smith Street/Salt Point Turnpike, Town and City of Poughkeepsie border (FK 3.1), and Verazzano Boulevard, City of Poughkeepsie (FK 0.45) (Figure 10). Three more sites were added during the summer of 2005. Valkill National Park, Hyde Park (FK 6.8) was added at the beginning of the summer because of the continuous presence of water

Figure 9 – Monitoring Station Locations from the 1997 New York State DEC Biological Assessment.

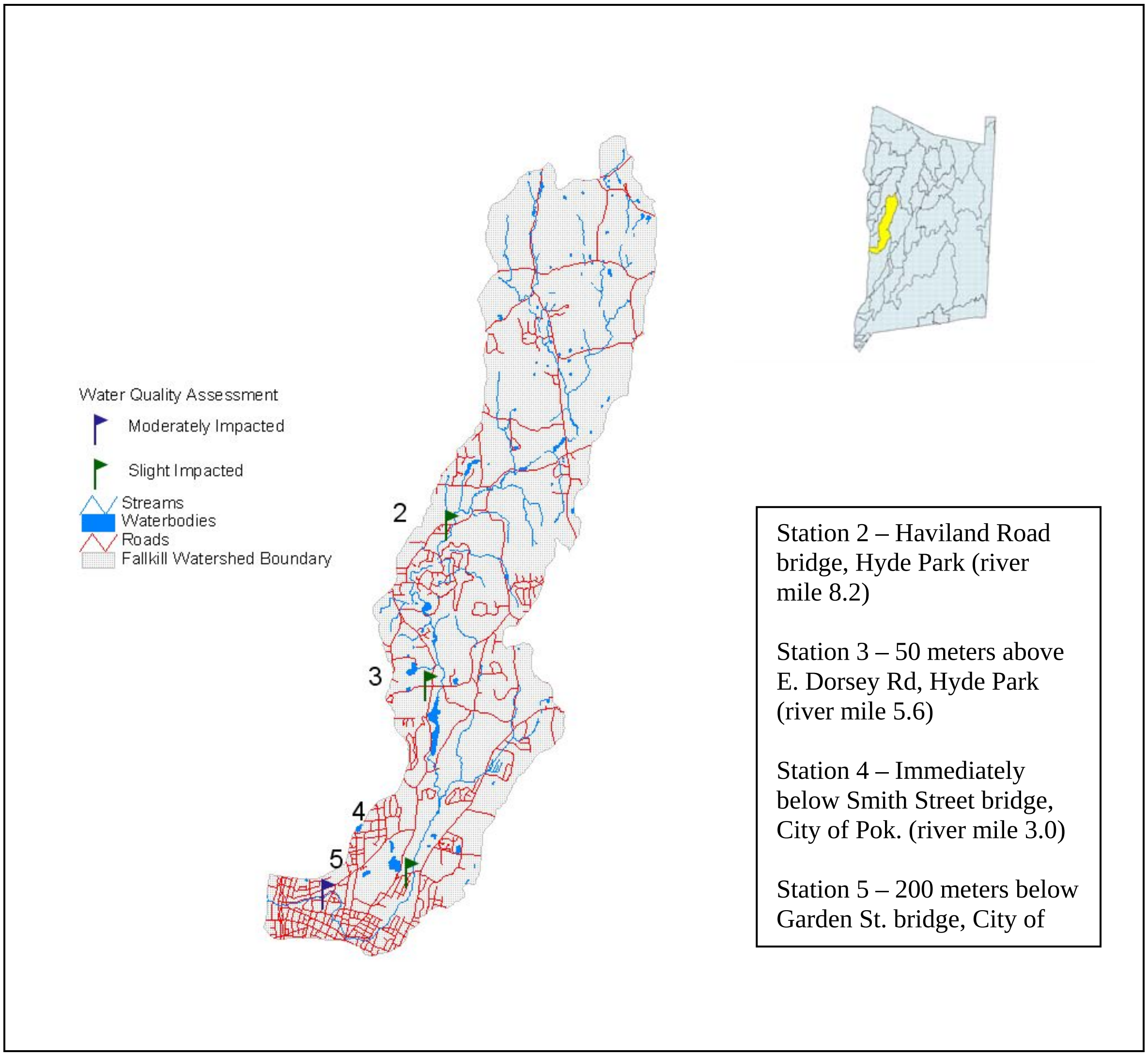
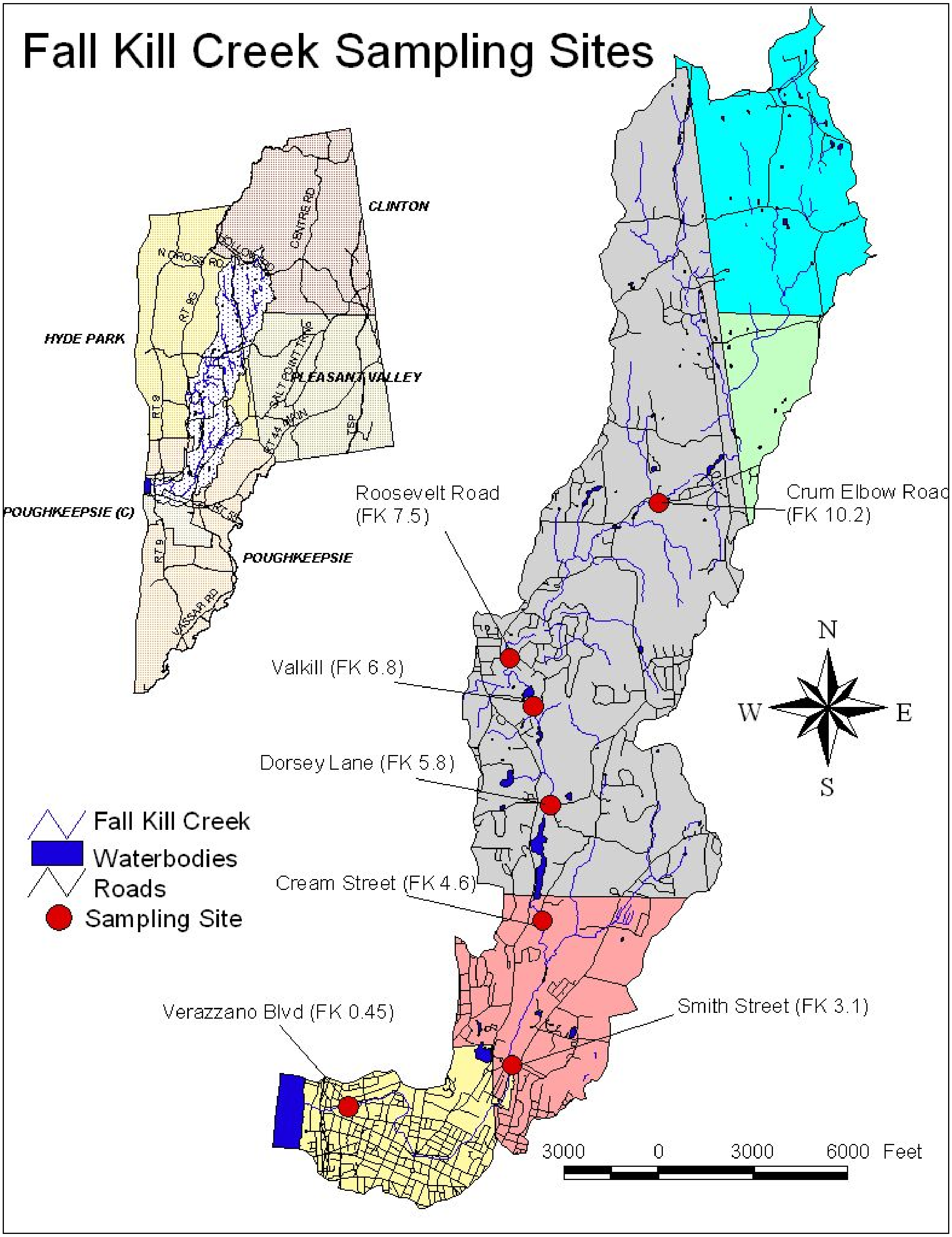


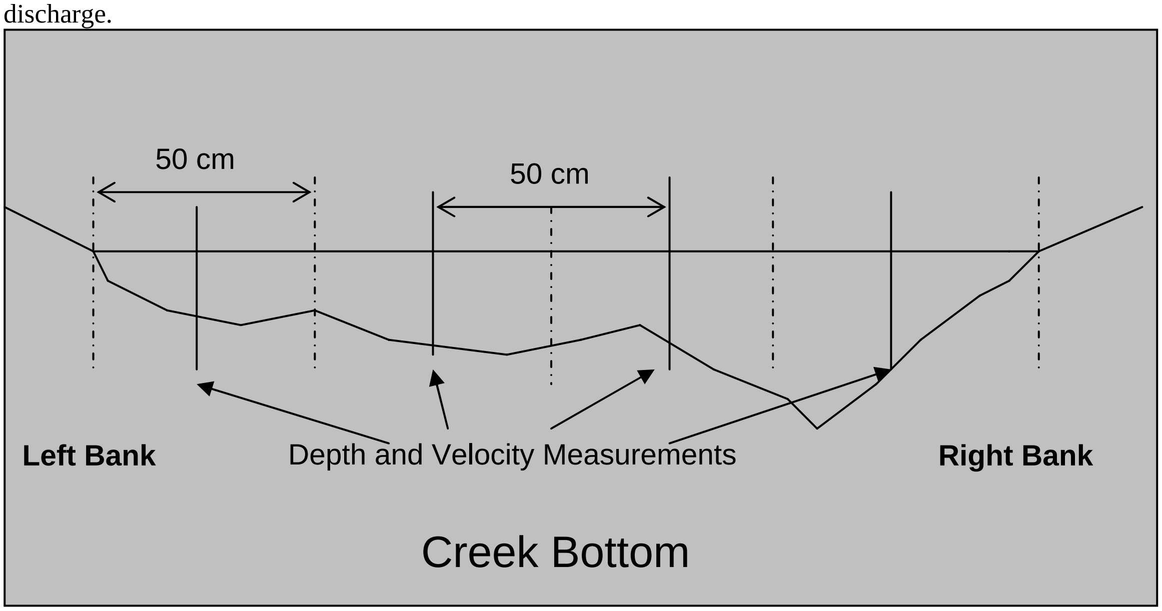
Figure 10. Sampling sites along the Fall Kill. In 2004, sampling sites included Verazzano Blvd, Smith St, Cream St, and Dorsey Lane. In 2005, the aforementioned sites were sampled as well as Valkill, Roosevelt Road and Crum Elbow Road.



fowl were suspected as a possible source of coliform bacteria. After noticing that many of the NYSDEC State Pollution Discharge Elimination System (SPDES) permits occurred in the northern part of the watershed, Crum Elbow Road, Hyde Park (FK 10.2) was added as a sample site. Finally, at the end of the summer, Roosevelt Road, Hyde Park (FK 7.5) was added as a sample site because of the high bacteria counts observed a short distance downstream at Valkill and because it is in a residential area that uses septic systems.

At each site, the temperature, ambient conductivity, specific conductance and salinity were measured using a Yellow Springs Instrument (YSI) Model 33 Salinity/Conductivity/Temperature/Meter. Discharge was measured at Verazzano Boulevard using the protocol described in Gore (1996). Using a meter stick and a current velocity meter, the stream depth and velocity were taken at 50 cm intervals across the channel in order to calculate the discharge. The method is described in more detail in the caption below (Figure 11).

Figure 11. The diagram shows a stream cross section in order to illustrate the procedure for stream discharge determination. Depth and velocity measurements are taken at the center of 50 cm intervals. The stream velocity in cm/sec is then multiplied by the depth (cm) and by 50 cm in order to find the discharge cm^3/sec for each 50 cm interval. The discharge in each interval is then summed to find the total stream discharge.



On each sampling date, two water samples were taken at each site. For the first sample, clean 200 ml amber plastic bottles were rinsed three times with stream water immediately before sample collection. These samples were taken back to the lab for pH and turbidity measurements using an Orion pH meter and a Nephelometric Turbidity meter respectively.

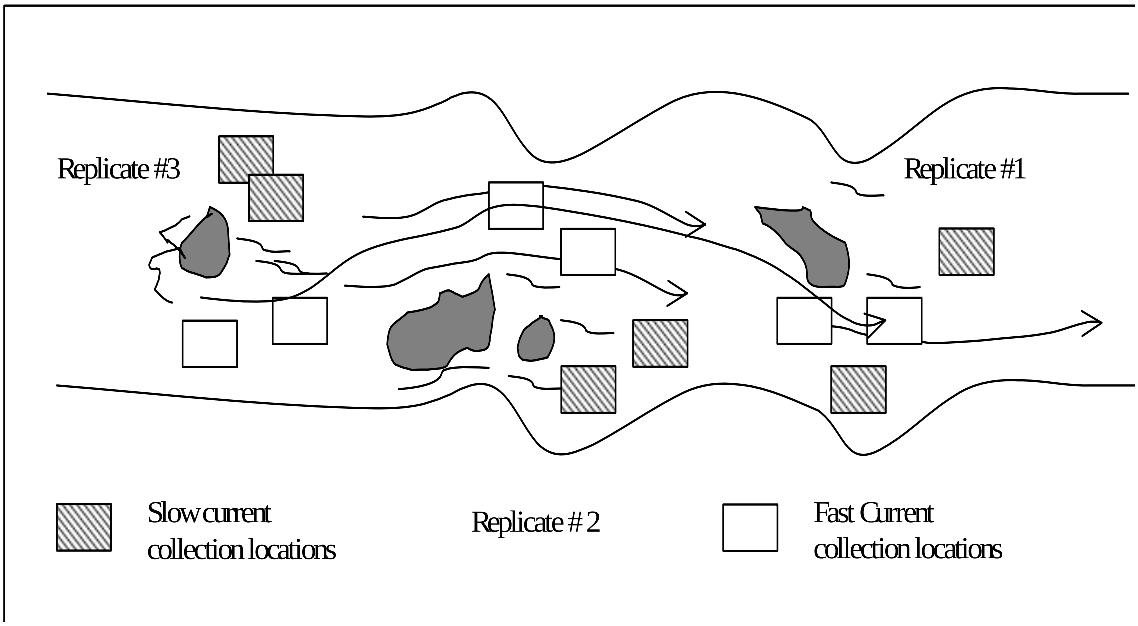
The second sample was obtained for fecal coliforms and *E. coli* bacteria and was collected in autoclaved glass bottles. The bottles were rinsed with stream water before collection and following collection, the bottles were placed in a cooler with ice and brought back to the lab for analysis.

As described in *Standard Methods for the Examination of Water and Wastewater*, the number of fecal coliform and *E. coli* colonies per 100 mL of stream water were determined using the membrane filtration method (Clesceri et al., 1998).

Macroinvertebrate Sampling Methods

During the summer of 2004 rectangular kick nets (30 cm x 50 cm) were used for the collection of macroinvertebrate samples. The nets had a mesh size between 500-600 microns, which is consistent with 80% of the biomonitoring programs in the United States (N=90) (Carter and Resh, 2001). The Fall Kill study employed the more traditional method of the single habitat approach, which concentrates on riffles as a means of standardizing assessments among sites. At each site, a 100-meter stream section with appropriate riffle habitat was selected. Starting downstream and moving upstream, composite samples were collected from three individual sampling locations in riffle habitat. Each of the three replicates consisted of four different “kicks” in two fast and two relatively slow current velocities in each riffle area (Figure 12). Larger rocks, sticks, and other debris were washed and removed before the composite sample was sieved with a U.S. no. 30 standard sieve (0.5 mm) and transferred to a quart jar. Ethyl alcohol (95%) was added to preserve the samples. This macroinvertebrate sampling methodology was consistent with the recommendations of the U.S. Environmental Protection Agency’s Rapid Bioassessment Protocols (Barbour et al., 1999).

Figure 12. Example of a three composite sample (adapted from Dates and Byrne, 1996).



In the lab invertebrates were identified to the family level and enumerated. The analysis of macroinvertebrate samples was completed using a variety of metrics, which range from the total number of families present to the percent similarity index of a predefined unimpacted community. New York State has a model community that was developed by the Department of Environmental Conservation based on several years of collection and analysis (Novak and Bode, 1992). Family richness is simply the total number of different families in the subsample. The total number of different families of the orders Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies) are also recorded as the EPT value. The EPT orders contain many organisms intolerant to pollution. The biotic index was developed by William Hilsenhoff (1988), and assigns each group a value based on its tolerance to organic pollution. Hilsenhoff developed the macroinvertebrate-based family level tolerance values by comparing the occurrence of each family with the average biotic index of streams in which they occurred in the greatest numbers. The family-level index was used for deciding which streams, or which watersheds, should be analyzed closer for organic pollution impacts (Hilsenhoff, 1988). Finally, organism density per sample was included to demonstrate the density of organisms at each site. Organism density per sample is an estimate of the total number of individuals in the sample. In general, density will increase with the addition of organic matter and/or habitat improvement (Dates and Byrne, 1996). However, density will decrease with lower habitat quality and/or water quality degradation.

Once the various metrics were recorded, they were combined to determine the overall community health of the site. To this end, a combined scaled ranking of the metric values was completed through a biological assessment profile. A conversion formula, based on the expected range for each index within each category of impact for the appropriate waterbody and sampling method, transforms the individual metrics into a common scale of water quality ranging from 0 to 10 (Bode et al., 2001). After all family-level index values were converted to a common scale value, the values were averaged to obtain a score describing the overall assessment of water quality into one of four categories of impact (Smith and Bode, 2004). The categories of impact in New York State include, nonimpacted (pristine community), slightly impacted, moderately impacted, and severely impacted (very degraded system).

Fish Sampling Method

During the summer of 2004, researchers from Marist College, Dutchess County EMC and Dr. Robert Schmidt from Simon's Rock College and Hudsonia, Inc. sampled fish communities at Verazzano Blvd (FK 0.45), Smith St (FK 3.1), Cream St. (FK 4.6) and Dorsey Lane (FK 5.8). A backpack shocker was used to stun the fish while personnel with hand held nets scooped the stunned fish from the water. A seine was also set up 10 meters downstream from the shocker to collect any stunned fish missed by the netters. The fish species were identified, counted, and measured for length at each sampling site. Following identification, the fish were released back into the Fall Kill.

Results

The physical and chemical results show that the Fall Kill is a warm water, moderately well oxygenated, and slightly alkaline stream (Table 7).

Table 7. Fall Kill mean water temperature and dissolved oxygen content collected in the summer of 2004.						
Site	Mean Temperature (Degrees Celsius)	SD	Mean Dissolved Oxygen	SD	Mean pH	SD
Dorsey Lane	21.1	1.23	5.7	0.69	7.5	0.21
Cream St	22.7	0.85	6.6	2.1	7.4	0.22
Smith St	21.5	0.61	7	0.45	7.5	0.05
Verazzano Blvd	20.8	0.65	8.5	0.5	7.7	0.09

Temperature and Dissolved Oxygen

Temperature readings were obtained five times during the summer of 2004 and weekly from June 22, 2005 to August 16, 2005. Samples were taken between 9 A.M. and 11:30 A.M. in both years. On any given sampling date the water temperature throughout the creek varied by about 3-4 ^{o}C. Water temperatures occasionally reached 28 ^{o}C, with temperatures most likely topping off above 30 ^{o}C on warm sunny afternoons. Areas where riparian zones remained intact or where the creek was significantly shaded had the lowest temperatures. The highest temperatures were found in areas where dams slowed the flow of water, i.e. Cream Street (below the dam at Fall Kill Park), at Valkill and at the Reach Out Family Worship Center on Crum Elbow Road.

In 2004, the dissolved oxygen levels varied by location in the stream but showed some improvement in the lower reaches due to an increase in the stream gradient, the amount of riffles, and more extensive canopy coverage by riparian trees. The dissolved oxygen content at Dorsey Lane (FK 5.8) and Cream Street (FK 4.6) were negatively affected by Fall Kill Lake. (Table 7). Dissolved oxygen readings from 8/16/05 showed saturation levels below 50% at Cream Street and the remaining upstream sites. The impoundment of the water allowed the water temperatures to rise. As water temperature increases, its ability to hold dissolved oxygen decreases. In addition, the lake provided habitat for numerous plant species. It is hypothesized that once the aquatic plants died, bacteria proliferated. As the dead plants decomposed, oxygen levels dropped. However, neither the DO, temperature or pH levels were sufficiently abnormal to have drastically limited the macroinvertebrate community.

Nitrate and phosphate concentrations were highest at the most upstream site sampled and exceeded recommended levels for healthy stream ecosystems. The high levels of these plant nutrients help to fuel the prolific growth of algae and aquatic plants in Fall Kill Reservoir. Levels of the nutrients at Cream Street (immediately below the reservoir) are much lower indicating removal and retention probably as plant biomass in the reservoir. Chloride levels are also high throughout the potion of the system studied. These ion concentrations indicate that there is a significant source of contamination somewhere upstream of Dorsey Lane.

Table 8. Nutrient analysis (ppm) of water samples from the Fall Kill, summer 2004. Values are means based on four samples taken at weekly intervals for each site.

Site	Chloride	Nitrate	Phosphate	Sulfate
Dorsey Lane	60.51	1.20	0.120	19.3
Cream Street	59.58	0.35	0.058	13.06
Smith Street	61.44	0.70	0.051	15.70
Verazzano Blvd.	80.40	1.15	0.048	19.30

Conductivity

The conductivity readings found throughout the study were highest in the residential areas surrounding the creek in Hyde Park and throughout the stream segment in the City of Poughkeepsie. As noted by the EPA, sewage can increase the conductivity because of the presence of chlorides, nitrates and phosphates. However, conductivity is also dependent on other factors such as geology.

On August 11, 2005, the conductivity was taken at sixteen street and stream crossings in the watershed (Table 9). The conductivity at Haviland Rd in Hyde Park just upstream

Table 9. Conductivity and salinity results taken at 16 different street and stream crossings on August 11, 2005.

Streat/Stream Crossing	Temp (^oC)	Specific Conductivity (µS at 25 oC)	Salinity (ppt)	Miles Upstream
Quaker Lane	25	350	0.2	11
Crum Elbow Road	26.1	324	0.2	10.2
Haviland Road	27.3	348	0.2	8.67
Roosevelt (2)	24.3	470	0.2	8.16
Roosevelt (1)	21.6	658	0.3	7.5
Valkill	28.8	576	0.3	6.8
Dorsey Lane	25.8	556	0.2	5.8
Cream St	24.9	441	0.2	4.6
Smith St	24.3	485	0.2	3.1
Mansion St (2)	24.3	693	0.3	2.25
Winnekee	24.7	713	0.3	2.03
North Hamilton	25.9	712	0.3	1.53
Mansion St (1)	24.6	701	0.3	1.33
Garden Street	24.2	671	0.3	0.93
Carmel Avenue (Verazzano)	23.4	719	0.4	0.45
Water Street	24	750	0.4	0.07

of a mobile park was 348 microseimens (uS). Less than 0.5 miles downstream at the next crossing, the conductivity jumped to 470 uS. From there through the residential area (Figure 5) the conductivity rose to 658 uS (Table 9). The residential development in this area is very dense, built upon well drained soils along the creek, and each home and trailer uses septic tanks for waste treatment. Given the close proximity of the development to the creek, as well as the high bacteria counts and high conductivity, direct discharges or leaching from septic fields are suspected sources of the contaminants.

Trace Metals and Petroleum Hydrocarbons

As noted previously, several heavy metals were found at high levels in both the Fall Kill sediment and macroinvertebrates (Bode et al, 2001). In the summer of 2005, sediment and water samples from Verazzano Blvd (FK 0.45) and Smith Street (FK 3.1) were sent to Smith Environmental Labs in Hyde Park for trace metal and hydrocarbon analysis (Table 10). According to protocols used by the NYSDEC in a Hudson River Sediment and Biological Survey (NYSEDEC, 2000b), measured lead and zinc values exceeded the threshold effect concentration (TEC) and probable effects concentration (PEC) thresholds at both Verazzano Blvd and Smith Street. The TEC represents the concentration above which adverse effects on sediment-dwelling organisms are likely to be observed. The PEC is the level below which adverse effects on organisms are not expected to occur. Not all heavy metals have TEC and PEC thresholds. The TEC for zinc is 121 ppm and the PEC 459 ppm. For lead, the TEC is 35.9 ppm and PEC 128 ppm. The sediment at Verazzano was found to exceed the PEC level for lead and the TEC level for zinc, while at Smith St, both zinc and lead were found at or above the TEC levels.

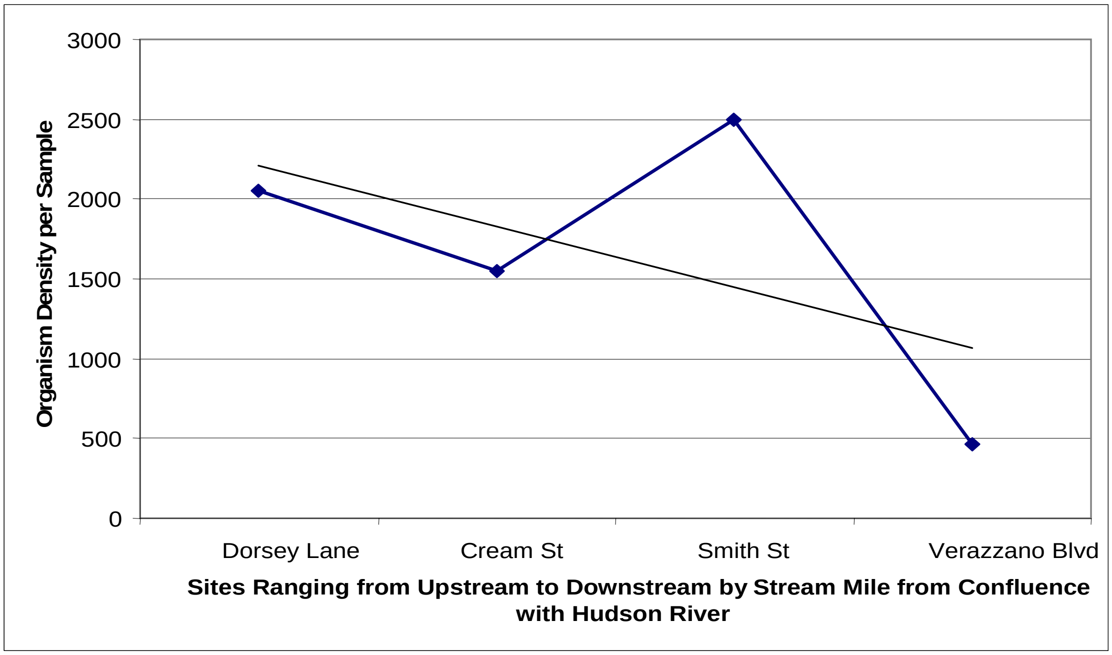
Table 10**.** Heavy metals found in sediment from Verazzano Blvd and Smith St on 7/20/05 as analyzed by Smith Environmental Labs in Hyde Park, NY.

Metal	Verazzano Blvd (ppm)	Smith St (ppm)
Arsenic	9	< 5
Chromium	15	11
Copper	< 50	16
Lead	220	61
Nickel	< 20	15
Silver	11	4.3
Thallium	15.5	19
Zinc	380	120

<u>Macroinvertebrates</u>

The macroinvertebrate results indicated the Fall Kill ranged from slightly impacted through the majority of the stream's length to moderately impacted in its lower reaches (Figure 13). The organism density per sample varied from upstream to downstream with the most macroinvertebrates inhabiting Smith Street (FK 3.1) and the fewest at Verazzano Blvd (FK 0.45) (Figure 13). The decrease in organism density is particularly acute between Smith Street and Verazzano Boulevard which is also the most hydraulically altered section of the stream.

Figure 13. Macroinvertebrate organism density per sample plotted from upstream to downstream from 2004 collection. Trendline represents a decrease in density from upstream to downstream.



The EPT family richness and total family richness also demonstrated a drop off in community health at Verazzano Blvd (FK 0.45) (Figure 14). The expected ranges for family richness and EPT richness based on 100-organism subsamples of kick samples in most streams in New York State are described in table 8 (Smith and Bode, 2004).

Figure 14. Ephemeroptera, Plecoptera, and Trichoptera (EPT) and total family richness values averaged by site from upstream to downstream (2004).

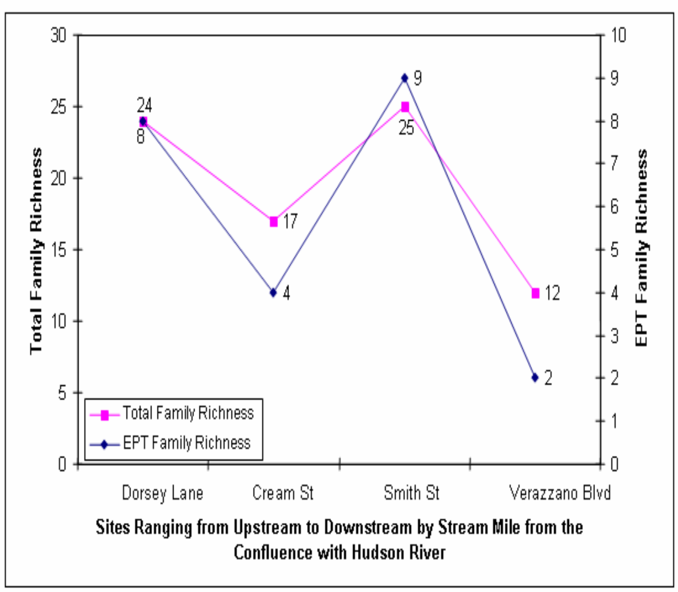


Table 11 - Stream impact classification based on the family richness and EPT richness of 100-organism subsamples.

	Non - Impacted	Slightly Impacted	Moderately Impacted	Severely Impacted
Family Richness	> 13	10 - 13	7 - 9	< 7
EPT Richness	> 7	3 - 7	1 - 2	0

The community at Dorsey Lane (FK 4.6) was impacted by Fall Kill Lake, which is located approximately 0.25 miles (0.4 km) upstream of the sample collection site. Therefore, poor macroinvertebrate metrics may represent impacts on habitat from the creek being impounded and are not necessarily caused by other aquatic contaminants. Total family richness (TFR) values fall within the non-impacted category, with the lone exception of Verazzano Blvd (FK 0.45) (slightly impacted) (Figure 14). EPT values indicated Dorsey Lane (FK 5.8) and Smith Street (FK 3.1) were nonimpacted. Cream Street (FK 4.6) was slightly impacted (upstream dam), and Verazzano Blvd (FK 0.45) was moderately impacted (Figure 14 and Table 11).

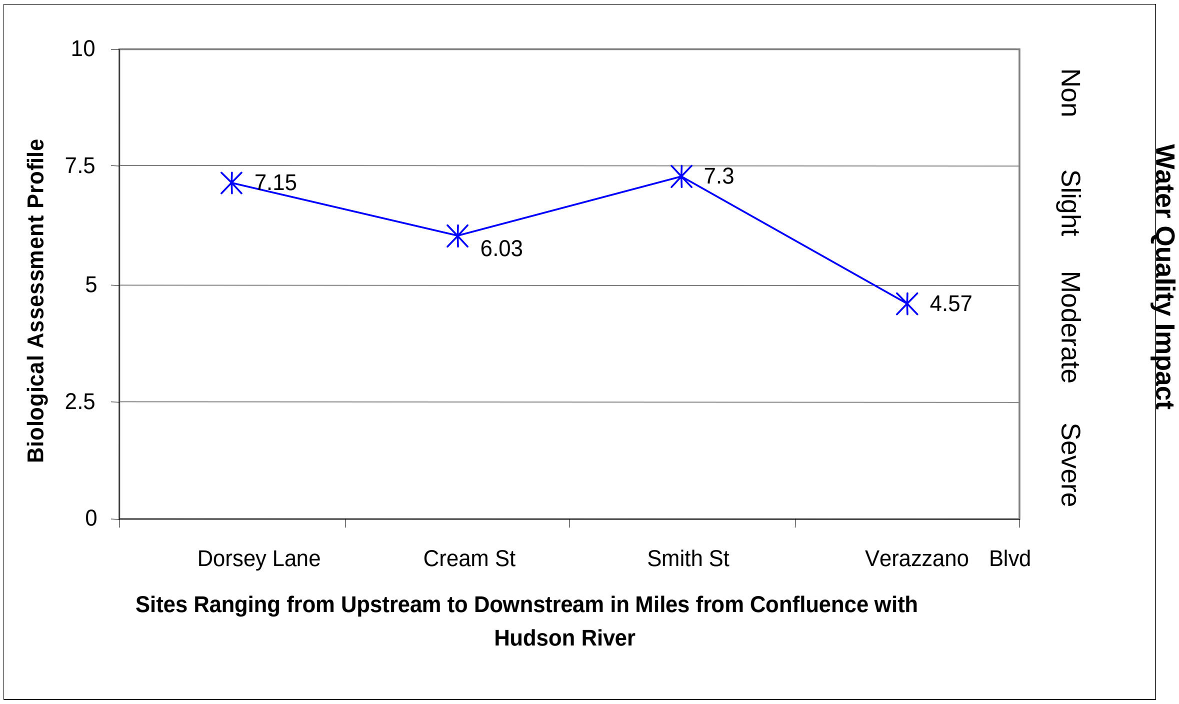
Once the percent model affinity, biotic index, total family richness, and EPT values were determined, they were combined on a common scale to provide an overall assessment of community health. To this end, a combined scaled ranking of the metric values was completed through a biological assessment profile. A conversion formula, based on the expected range for each index within each category of impact for the appropriate water body and sampling method, transforms the individual metrics into a common scale of water quality ranging from 0 to 10 (Bode et al., 2001) (Table 12).

Table 12 - The biological assessment profile scoring criteria which consists of a combination of the individual metric values of percent model affinity, biotic index, total family richness and EPT values.

Impact Scale	Impact Classification
0 - 2.5	Severely Impacted
2.5 – 5	Moderately Impacted
5 - 7.5	Slightly Impacted
7.5 – 10	Nonimpacted

According to the assessment profile, Dorsey Lane (FK 5.8) was the healthiest and Verazzano Blvd (FK 0.45) was the least healthy (Figure 15). Results from Dorsey Lane

Figure 15. Biological assessment profile (BAP) values on a normalized scale (0 to 10). Values represent the BAP variation in the slightly impacted segment (FK 5.8- FK 3.1) and moderately impacted site (FK 0.45) of the normalized scale.



(FK 5.8) and Cream Street (FK 3.1) indicated the water quality was slightly impacted, most likely from nonpoint source pollutants. Verazzano Blvd (FK 0.45) was moderately impacted by urban sources of pollution. These 2004 findings are similar to the 1997 findings of the NYSDEC (Bode et al., 1998), indicating little change in water quality in the intervening years.

Fish Results

Fish samples were taken at Dorsey Lane (FK 5.8), Cream St (FK 4.6), Smith St (FK 3.1), and Verazzano Blvd (FK 0.45) on June, 18, 2004 and August 26, 2004. A total of 375 fish, representing 15 different species, were caught, identified and released during the summer of 2004 (Table 13). The highest fish total and species richness, or variety of species, was found at Smith St (FK 3.1) (Table 14). The Shannon-Wiener Diversity Index (H^I) was used to compare the species richness and evenness of each sampling area. The index assigns a value based on the different types of species found and the number of individuals from each species. A higher diversity index, as seen at Smith St (FK 3.1), shows a wider variety of species present compared to the low value seen at Verazzano Blvd (FK 0.45) which is dominated by a single species.

Table 13 - The different types of fish species found throughout the Fall Kill, including the number of fish caught, and the respective pollution tolerance of each.

Species	Total Fish Caught (2004)	Pollution Tolerance
American Eel	15	Tolerant
Blacknose Dace	57	Tolerant
Bluegill	56	Tolerant
Brown Bullhead	1	Tolerant
Cutlips Minnow	40	Moderately Tolerant
Golden Shiner	1	Tolerant
Large Mouth Bass	9	Moderately Tolerant
Long Nose Dace	1	Moderately Tolerant
Pumpkinseed	10	Moderately Tolerant
Red Breasted Sunfish	5	Moderately Tolerant
Red-Fin Pickerel	5	Moderately Tolerant
Tessellated Darter	108	Moderately Tolerant
White Sucker	54	Tolerant
Yellow Bullhead	10	Tolerant
2 - Lined Salamander	3	-
	Total = 375	

Dorsey Lane (FK 5.8) and Smith Street (FK 3.1) had the healthiest fish communities based on the species richness, diversity index, number of fish caught, and the pollution tolerance of the fish caught. Cream Street (FK 4.6) and Verazzano Boulevard (FK 0.45) fish catches were smaller, less diverse and included species tolerant to pollution. The community at Cream Street (FK 4.6) is likely impacted by the dam at Fall Kill Park about a quarter-mile upstream. The channelization of the Fall Kill through the City of Poughkeepsie creates minimal habit for fish because of the high current velocity, and the fish that did inhabit the urban section of the creek were hampered by the poor water quality.

Table 14 - Species richness, Shannon-Wiener Diversity Index, dominant species, and total fish caught at each site during the summer of 2004.

Site	Date	Species Richness	Shannon-Wiener Diversity Index (H')	Dominant Species	Total Fish
Dorsey Lane	6/18/2004	8	1.34	Bluegill (22)	36
Dorsey Lane	8/26/2004	5	1.12	Bluegill (31)	48
Cream Street	6/18/2004	3	0.87	Cutlips Minnow (4)	6
Cream Street	8/26/2004	7	0.85	Cutlips Minnow (23)	34
Smith Street	6/18/2004	9	1.21	Tessellated Darter (43)	70
Smith Street	8/26/2004	10	1.47	Tessellated Darter (58)	123
Verazzano Blvd	6/18/2004	3	0.63	White Sucker (26)	34
Verazzano Blvd	8/26/2004	3	0.68	White Sucker (18)	24

Fecal Coliforms

Fecal coliform and *E. coli* bacteria were found at each of the sampling sites. Fecal coliform counts on the whole were extremely high, consistently above the New York State Department of Health's 200 colonies/100ml threshold for safe swimming. The highest counts were found at Valkill and Cream Street, with mean and median values over 10,000 colonies/100ml. *E. coli* was found sporadically at the five northernmost sites, and consistently at Smith Street and Verazzano Boulevard. Downstream of Smith Street, the Fall Kill turns into an urban creek, where there are very few warm-blooded animals capable of producing fecal coliforms and *E. coli* besides humans and pets. The bacteria could be coming from a leaky sewer line or storm sewer run-off. However because of the lack of rain in July and August there was very little storm runoff during the 2005 sampling period, thus indicating a leaking sewer line or illegal discharges as the most likely source.

When Roosevelt Road was added as a sample site in mid to late summer of 2005, high bacteria counts were obtained. The residential area between Haviland Road and Valkill could be the source of the bacteria as the entire area uses septic tanks.

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Appendices

Appendix Table 1 - Water chemistry data taken from four test sites during the summer of 2004.

Site	Date	Temperature (^oC)	Specific Conductivity (uS at 25 ^{o}c)	Salinity (ppt)	pH	Turbidity (ntu)	Dissolved Oxygen (mg/L)	Hardness (mg/L)	Calcium (mg/L)	Magnesium (mg/L)	Alkalinity
Dorsey Lane	6/18/2004	22.3	347	0.2	7.76	-	4.5	112	36.1	5.4	95
Dorsey Lane	7/14/2004	22	583	0.3	7.26	3	5.6	132	42.5	6.3	112
Dorsey Lane	7/26/2004	20.8	335	0.2	-	-	-	140	33.7	13.6	74
Dorsey Lane	8/19/2004	21	380	-	7.44	1.3	-	120	45.7	1.4	112
Dorsey Lane	8/26/2004	19.4	407	0.2	7.5	-	6.9	-	-	-	-
Cream Street	6/18/2004	25.7	390	0.2	6.8/7.05	-	7.29	88	36.1	0	70
Cream Street	7/14/2004	23.2	471	0.3	7.31	2.1	6.5	156	49.7	7.7	129
Cream Street	7/26/2004	21.5	427	0.2	-	-	-	168	48.9	11.1	110
Cream Street	8/19/2004	22.5	363	-	7.6	1.2	-	116	48.9	1.5	103
Cream Street	8/26/2004	20.8	345	0.2	7.5	-	8.2	-	-	-	-
Smith Street	6/18/2004	23.1	393	0.2	7.44	-	6.64	112	36.9	4.8	92
Smith Street	7/14/2004	20	519	0.2	7.46	1.8	4.2	150	48.9	6.8	126
Smith Street	7/26/2004	22.1	448	0.2	-	-	-	176	44.1	16	114
Smith Street	8/19/2004	22	393	-	7.55	2	-	164	52.1	8.2	110
Smith Street	8/26/2004	20.1	396	0.2	7.5	-	7.9	-	-	-	-
Verazzano Blvd	6/18/2004	22.6	481	0.2	7.68	-	8	112	36.1	5.4	94
Verazzano Blvd	7/14/2004	19	640	0.3	7.83	2.3	5.6	164	54.1	7	141
Verazzano Blvd	7/26/2004	21.6	494	0.2	-	-	-	180	54.5	10.7	119
Verazzano Blvd	8/19/2004	21	458	-	7.84	4	-	176	52.1	11	126
Verazzano Blvd	8/26/2004	19.7	476	0.2	7.6	-	9	-	-	-	-

Appendix Table 2 - Water chemistry data taken from seven test sites during the summer of 2005.

Site	Date	Temperature (^oC)	Specific Conductivity (uS at 25 ^oC)	Salinity (ppt)	pH	Turbidity (ntu)	Dissolved Oxygen (ppm)	Percent Oxygen Saturation	Discharge (f3/s)
Crum Elbow Rd	7/13/2005	25.1	284	0.1	7.21	1	-	-	-
Crum Elbow Rd	7/20/2005	27.1	271	0.1	7.77	2	-	-	-
Crum Elbow Rd	7/26/2005	24.0	287	0.1	6.89	1	-	-	-
Crum Elbow Rd	8/2/2005	24.8	308	0.1	7.42	2	-	-	-
Crum Elbow Rd	8/9/2005	24.5	320	0.2	6.87	3	-	-	-
Crum Elbow Rd	8/16/2005	23.6	340	0.2	7.08	2	2	23.6	
Roosevelt Rd	8/2/2005	21.2	589	0.3	7.29	3	-	-	-
Roosevelt Rd	8/9/2005	21.6	671	0.3	6.85	4	-	-	-
Roosevelt Rd	8/6/2005	20.2	647	0.3	7.12	5	2.5	26.9	
Valkill	6/22/2005	23.1	488	0.2	7.46	-	-	-	-
Valkill	6/29/2005	26.3	533	0.3	7.08	2.2	-	-	-
Valkill	7/6/2005	24.2	457	0.2	7.08	4	-	-	-
Valkill	7/13/2005	24.4	444	0.2	7.17	3	-	-	-
Valkill	7/20/2005	27.3	405	0.2	6.95	3	-	-	-
Valkill	7/26/2005	24.3	498	0.2	7.05	3	-	-	-
Valkill	8/2/2005	25.7	556	0.3	7.48	4	-	-	-
Valkill	8/9/2005	25.3	585	0.3	7.1	4	-	-	-
Valkill	8/16/2005	24.6	615	0.3	7.2	3	4.2	50.4	
Dorsey Lane	6/22/2005	21.6	472	0.2	7.48	-	-	-	-
Dorsey Lane	6/29/2005	25.4	518	0.3	7.5	1.5	-	-	-
Dorsey Lane	7/6/2005	23.4	444	0.2	7.43	2	-	-	-
Dorsey Lane	7/13/2005	23.6	430	0.2	7.13	2	-	-	-
Dorsey Lane	7/20/2005	26.2	426	0.2	7.18	2	-	-	-
Dorsey Lane	7/26/2005	23.5	459	0.2	7.01	2	-	-	-
Dorsey Lane	8/2/2005	24.0	522	0.3	7.64	14	-	-	-
Dorsey Lane	8/9/2005	24.0	555	0.3	7.67	5	-	-	-
Dorsey Lane	8/6/2005	22.3	560	0.3	7.19	4	4.4	52.6	
Cream St	6/22/2005	22.4	428	0.2	7.48	-	-	-	-

Site	Date	Temperature (^{o}C)	Specific Conductivity (uS at 25 ^{o}C)	Salinity (ppt)	pH	Turbidity (ntu)	Dissolved Oxygen (ppm)	Percent Oxygen Saturation	Discharge (f3/s)
Cream St	7/6/2005	24.6	455	0.2	7.25	1	-	-	-
Cream St	7/13/2005	24.2	453	0.2	7.3	2	-	-	-
Cream St	7/20/2005	27.6	437	0.2	7.56	3	-	-	-
Cream St	7/26/2005	24.2	442	0.2	7.07	3	-	-	-
Cream St	8/2/2005	23.4	441	0.2	7.32	4	-	-	-
Cream St	8/9/2005	24.5	430	0.2	7.57	6	-	-	-
Cream St	8/16/2005	21.2	461	0.2	7.08	2	3.94	45.2	-
Smith St	6/22/2005	21.6	472	0.2	7.48	-	-	-	-
Smith St	6/29/2005	24.0	457	0.2	7.32	2.8	-	-	-
Smith St	7/6/2005	22.6	482	0.2	7.16	3	-	-	-
Smith St	7/13/2005	22.8	484	0.2	7.43	4	-	-	-
Smith St	7/20/2005	25.3	464	0.2	7.71	3	-	-	-
Smith St	7/26/2005	21.9	453	0.2	7.27	3	-	-	-
Smith St	8/2/2005	23.0	497	0.2	7.65	4	-	-	-
Smith St	8/9/2005	22.7	470	0.2	7.69	5	-	-	-
Smith St	8/6/2005	21.6	484	0.2	7.25	14	4.9	55	-
Verazzano Blvd	6/22/2005	19.3	566	0.3	7.95	-	-	-	-
Verazzano Blvd	6/29/2005	23.3	593	0.3	7.82	1.6	-	-	1.63
Verazzano Blvd	7/6/2005	21.8	597	0.3	7.77	2	-	-	4.09
Verazzano Blvd	7/13/2005	21.5	605	0.3	7.93	3	-	-	3.71
Verazzano Blvd	7/20/2005	24.4	563	0.3	7.81	3	-	-	9.01
Verazzano Blvd	7/26/2005	21.2	646	0.3	7.64	2	-	-	1.46
Verazzano Blvd	8/2/2005	22.5	756	0.4	8.14	3	-	-	-
Verazzano Blvd	8/9/2005	22.3	718	0.4	8.23	3	-	-	-
Verazzano Blvd	8/16/2005	21.1	675	0.3	7.63	1	8.04	91.2	0.46

Appendix Table 3 - Results of trace metal and total hydrocarbon in sediment and water samples from Smith St and Verazzano Blvd taken on 7/21/05 are seen on the table below. The data was analyzed by Smith Laboratory in Hyde Park, NY.

Parameter	Smith Street Sediment (ppm)	Verazzano Blvd Sediment (ppm)	Smith Street Water (ppm)	Verazzano Blvd Water (ppm)
Antimony	< 4.0	< 4.0	< 0.003	0.004
Arsenic	< 5.0	9	< 0.005	< 0.005
Beryllium	< 0.6	< 2.0	< 0.001	< 0.001
Cadmium	< 3.0	< 10	< 0.002	< 0.002
Chromium	11	15	< 0.002	< 0.002
Copper	16	< 50	< 0.003	0.004
Lead	61	220	< 0.001	0.002
Mercury	< 0.20	< .20	< 0.0004	< 0.0004
Nickel	15	< 20	< 0.01	< 0.01
Selenium	< 5.0	< 5.0	< 0.004	< 0.004
Silver	4.3	11	< 0.002	< 0.002
Thallium	19	15.5	< 0.001	< 0.001
Total Petroleum Hydrocarbons	2000 *	280	< 5	< 5
Zinc	120	380	0.01	0.015

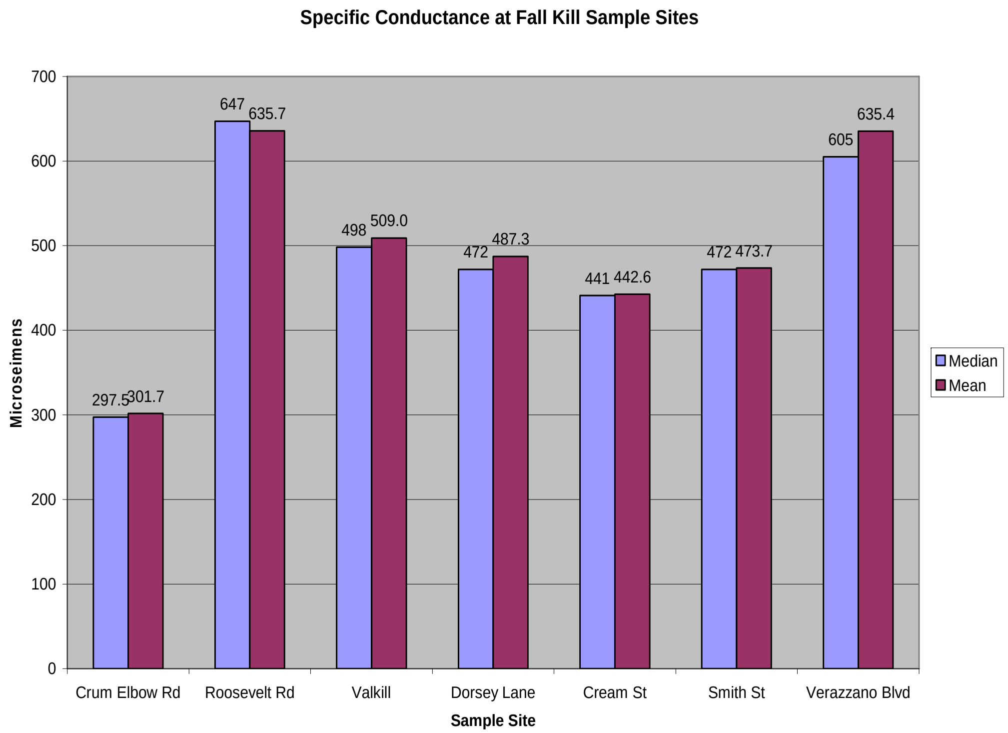
* Sample extract highly colored; results may be biased high

Appendix Table 4 - On August 11, 2005, temperature, conductivity and salinity were tested at several street and stream crossings within the watershed to investigate the change in water chemistry throughout the stream.

Streat/Stream Crossing	Temp (^oC)	Specific Conductivity (µS at 25 ^oC)	Salinity (ppt)	Miles Upstream
Quaker Lane	25	350	0.2	11
Crum Elbow Road	26.1	324	0.2	10.2
Haviland Road	27.3	348	0.2	8.67
Roosevelt (2)	24.3	470	0.2	8.16
Roosevelt (1)	21.6	658	0.3	7.5
Valkill	28.8	576	0.3	6.8
Dorsey Lane	25.8	556	0.2	5.8
Cream St	24.9	441	0.2	4.6
Smith St	24.3	485	0.2	3.1
Mansion St (2)	24.3	693	0.3	2.25
Winnekee	24.7	713	0.3	2.03
North Hamilton	25.9	712	0.3	1.53
Mansion St (1)	24.6	701	0.3	1.33
Garden Street	24.2	671	0.3	0.93
Carmel Avenue (Verazzano)	23.4	719	0.4	0.45
Water Street	24	750	0.4	0.07

Appendix Table 5 - Water chemistry data taken from the summer of 2005.

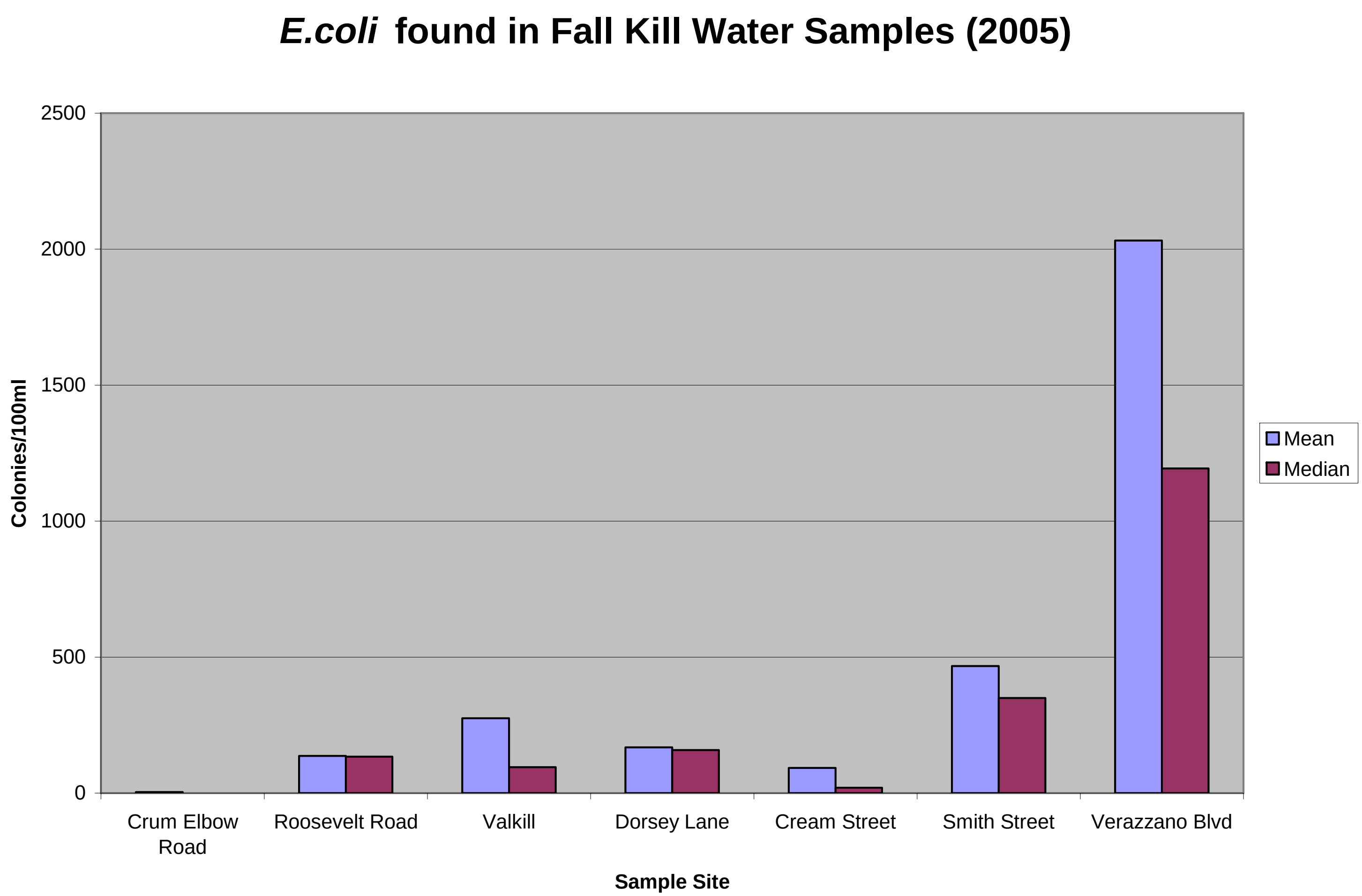
	pH	Temperature (^oC)			Specific Conductance (μS at 25 ^oC)			Salinity (ppt)	Turbidity (ntu)
Site	**Range**	**Range**	**Median**	**Mean**	**Range**	**Median**	**Mean**	**Range**	**Range**
Crum Elbow Rd	6.89 - 7.77	23.6 - 27.1	24.7	24.9	271 -340	297.5	301.7	0.1 - 0.2	1.0 - 3.0
Roosevelt Rd	6.85 - 7.29	20.2 -21.6	21.2	21.0	589 -671	647	635.7	0.3	3.0 - 5.0
Valkill	6.95 - 7.48	23.1 -27.3	24.6	25.0	405 - 615	498	509.0	0.2 - 0.3	2.2 - 4.0
Dorsey Lane	7.01 - 7.67	21.6 - 26.2	23.6	23.8	426 - 560	472	487.3	0.2 - 0.3	1.5 - 14.0
Cream St	7.07 - 7.66	21.2 - 27.6	24.2	23.8	428 - 461	441	442.6	0.2	1.0 - 6.0
Smith St	7.16 - 7.69	21.6 - 25.3	22.7	22.8	453 - 497	472	473.7	0.2	2.8 - 14.0
Verazzano Blvd	7.63 - 8.23	19.3 - 24.4	21.8	21.9	563 - 756	605	635.4	0.3 -0.4	1.0 - 3.0



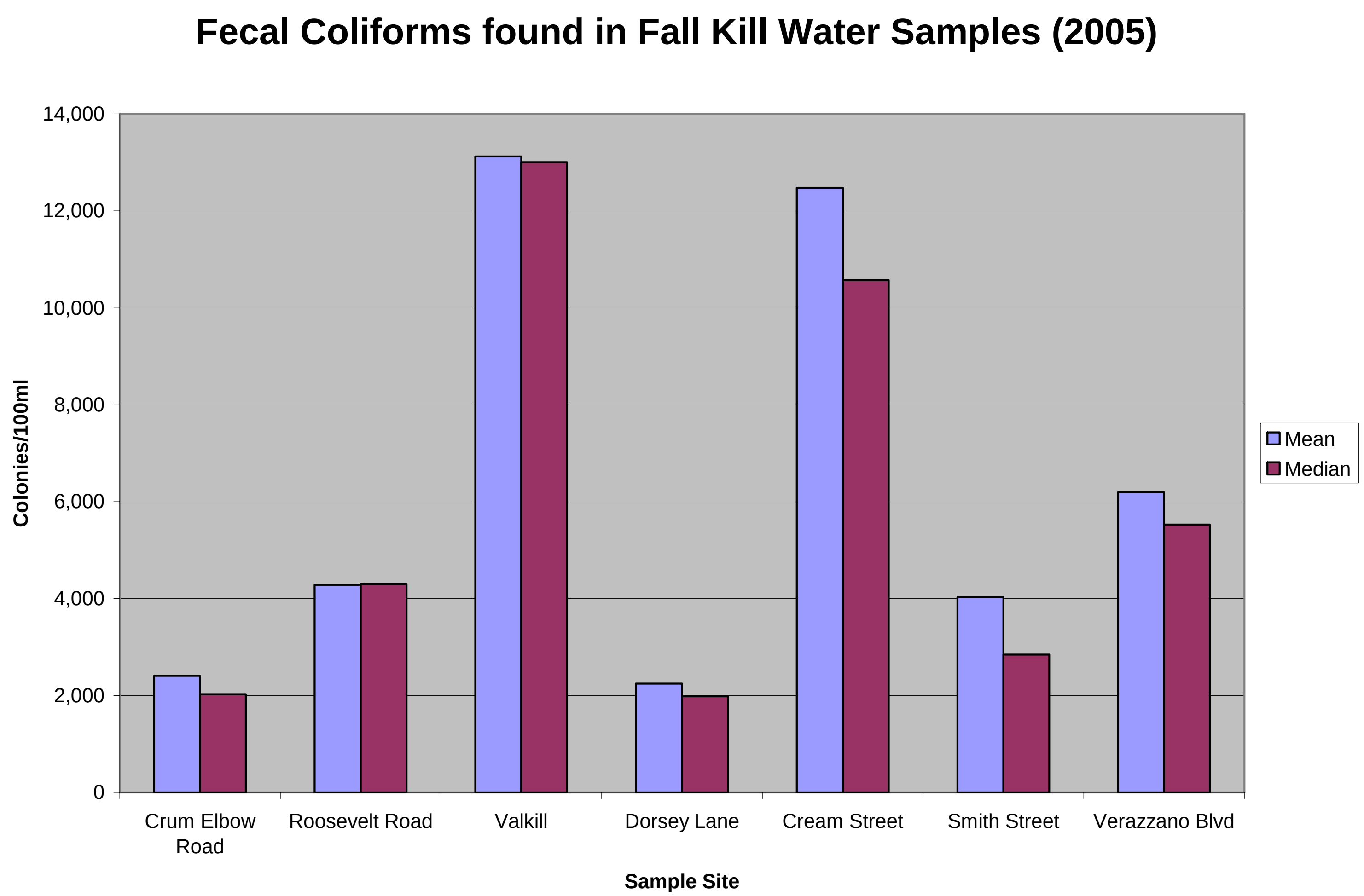
Appendix Figure 1 - Mean and median specific conductance at the seven sample sites during the summer of 2006.

Appendix Table 6 - Mean and median fecal coliform and *E. coli* colonies per 100 ml of stream water at the seven sample sites during the summer of 2005.

	pH	**Temperature (^{o}C)**			**Specific Conductance (µS at 25 ^{o}C)**			**Salinity (ppt)**	**Turbidity (ntu)**
Site	**Range**	**Range**	**Median**	**Mean**	**Range**	**Median**	**Mean**	**Range**	**Range**
Crum Elbow Rd	6.89 - 7.77	23.6 - 27.1	24.7	24.9	271 -340	297.5	301.7	0.1 - 0.2	1.0 - 3.0
Roosevelt Rd	6.85 - 7.29	20.2 -21.6	21.2	21.0	589 -671	647	635.7	0.3	3.0 - 5.0
Valkill	6.95 - 7.48	23.1 -27.3	24.6	25.0	405 - 615	498	509.0	0.2 - 0.3	2.2 - 4.0
Dorsey Lane	7.01 - 7.67	21.6 - 26.2	23.6	23.8	426 - 560	472	487.3	0.2 - 0.3	1.5 - 14.0
Cream St	7.07 - 7.66	21.2 - 27.6	24.2	23.8	428 - 461	441	442.6	0.2	1.0 - 6.0
Smith St	7.16 - 7.69	21.6 - 25.3	22.7	22.8	453 - 497	472	473.7	0.2	2.8 - 14.0
Verazzano Blvd	7.63 - 8.23	19.3 - 24.4	21.8	21.9	563 - 756	605	635.4	0.3 -0.4	1.0 - 3.0



Appendix Figure 2 – Mean and median *E. coli* concentrations found at the seven sample sites during the summer of 2005.



Appendix Figure 3 – Mean and median fecal coliform concentrations at the seven sample sites during the summer of 2005.

Appendix Table 7 - The number and type of fish species caught at each sample site on the Fall Kill during the two sampling dates during the summer of 2004.

6/18/2004

Site	Yellow Bullhead	Blacknose Dace	White Sucker	Tessellated Darter	Red-Fin Pickerel	Bluegill	American Eel	Cutlips Minnow	Red Breasted Sunfish	Large Mouth Bass	Pumpkin Seed	Brown Bullhead	2-Lined Salamander	Golden Shiner	Total
Dorsey Lane	-	1	-	2	-	22	1	-	1	5	3	-	-	1	36
Cream St	1	-	-	-	1	-	-	4	-	-	-	-	-	-	6
Smith St	2	13	-	43	1	1	5	-	-	-	1	1	3	-	70
Verazzano Blvd	1	7	26	-	-	-	-	-		-	-	-	-	-	34
Total	4	21	26	45	2	23	6	4	1	5	4	1	3	1	146

8/26/2004

Site	Yellow Bullhead	Blacknose Dace	White Sucker	Tessellated Darter	Long Nose Dace	Red-Fin Pickerel	Bluegill	American Eel	Cutlips Minnow	Red Breasted Sunfish	Large Mouth Bass	Pumpkin Seed	Total
Dorsey Lane	-	2	-	5	-	-	31	-	-	-	4	6	48
Cream St	3	2	1	-	-	-	1	3	23	1	-	-	34
Smith St	2	27	9	58	1	3	1	6	13	3	-	-	120
Verazzano Blvd	1	5	18	-	-	-	-	-	-	-	-	-	24
Total:	***6***	***36***	***28***	***63***	***1***	***3***	***33***	***9***	***36***	***4***	***4***	***6***	***226***

Site					Fallkill - Dorsey - F4			
Date Sampled					7/14/04			
Replicate		1	2	3				
	T	D	D	D	Avg. D	% Comp	T x D	
Ephemeroptera								
Baetidae	6			1	0.33	0.06	2.00	GC
Baetiscidae	4				0.00	0.00	0.00	GC
Caenidae	6				0.00	0.00	0.00	GC
Ephemerellidae	2				0.00	0.00	0.00	GC
Ephemeridae	4				0.00	0.00	0.00	GC
Heptageniidae	3		89	20	36.33	7.08	109.00	GC
Leptophlebiidae	4				0.00	0.00	0.00	GC
Metretopodidae	2				0.00	0.00	0.00	GC
Isonychidae	2				0.00	0.00	0.00	FC
Polymitarcylidae	2				0.00	0.00	0.00	GC
Potamanthidae	4				0.00	0.00	0.00	GC
Siphlonuridae	7		6	7	4.33	0.84	30.33	GC
Tricorythidae	4		1		0.33	0.06	1.33	GC
Subtotal					41.33	8.06	142.67	
Plecoptera								
Capniidae	3				0.00	0.00	0.00	SH
Chloroperlidae	0				0.00	0.00	0.00	PR
Leuctridae	0				0.00	0.00	0.00	SH
Nemouridae	2				0.00	0.00	0.00	SH
Peltoperlidae	0				0.00	0.00	0.00	SH
Perlidae	3				0.00	0.00	0.00	PR
Perlodidae	2				0.00	0.00	0.00	PR
Pteronarcyidae	0				0.00	0.00	0.00	SH
Taeniopterygidae	2				0.00	0.00	0.00	SH
Subtotal					0.00		0.00	
Trichoptera								
Brachycentridae	2				0.00	0.00	0.00	GC
Glossosomatidae	1		4		1.33	0.26	1.33	SC
Helicopsychidae	3				0.00	0.00	0.00	SC
Hydropsychidae	5		575	19	198.00	38.60	990.00	FC
Hydroptilidae	6				0.00	0.00	0.00	SC
Lepidostomatidae	1				0.00	0.00	0.00	SH
Leptoceridae	4				0.00	0.00	0.00	SH
Limnephilidae	4				0.00	0.00	0.00	SC
Molannidae	6				0.00	0.00	0.00	SC
Odontoceridae	0				0.00	0.00	0.00	SH
Philopotamidae	3		113	12	41.67	8.12	125.00	FC
Phryganeidae	4				0.00	0.00	0.00	SH
Polycentropodidae	6		1	6	2.33	0.45	14.00	PR
Psychomyiidae	2				0.00	0.00	0.00	GC
Rhyacophilidae	1				0.00	0.00	0.00	PR
Sericostomatidae	3				0.00	0.00	0.00	SH
Pupa							0.00	
Subtotal					243.33	47.43	1130.33	
Diptera								
Athericidae	4				0.00	0.00	0.00	PR
Blephariceridae	0				0.00	0.00	0.00	SC

Ceratopogonidae	6			0.00	0.00	0.00	PR
Chironomidae	6	74	73	49.00	9.55	294.00	GC
Empididae	6	3		1.00	0.19	6.00	PR
Simuliidae	5	1		0.33	0.06	1.67	FC
Tabanidae	5			0.00	0.00	0.00	PR
Tipulidae	4		1	0.33	0.06	1.33	SH
Subtotal				50.67		303.00	
Megaloptera							
Corydalidae	4	6		2.00	0.39	8.00	PR
Sialidae	4			0.00	0.00	0.00	PR
Subtotal				2.00		8.00	
Lepidoptera							
Pyralidae	5			0.00	0.00	0.00	SH
Subtotal				0.00		0.00	
Coleoptera							
Dryopidae	5			0.00		0.00	SC
Elmidae	5	201	81	94.00	18.32	470.00	GC
Psephenidae	4	2	3	1.67	0.32	6.67	SC
Hydrophilidae				0.00	0.00	0.00	
Gyrinidae			1	0.33	0.06	0.00	
Subtotal				96.00	18.71	476.67	
Odonata							
Aeshnidae	5			0.00	0.00	0.00	PR
Calopterygidae	6			0.00	0.00	0.00	PR
Coenagrionidae	8			0.00	0.00	0.00	PR
Cordulegastridae	3			0.00	0.00	0.00	PR
Corduliidae	2			0.00	0.00	0.00	PR
Gomphidae	4			0.00	0.00	0.00	PR
Lestidae	9			0.00	0.00	0.00	PR
Libellulidae	2			0.00	0.00	0.00	PR
Macromiidae	2			0.00	0.00	0.00	PR
Subtotal				0.00		0.00	
Amphipoda							
Gammaridae	6	1	2	1.00	0.19	6.00	GC
Talitridae	8		24	8.00	1.56	64.00	GC
Crangonyctidae	6	47		15.67	3.05	94.00	GC
Haustoriidae				0.00	0.00	0.00	GC
Subtotal				24.67	4.81	164.00	
Isopoda							
Asellidae	8	90	7	32.33	6.30	258.67	SH
Subtotal				32.33		258.67	
Decapoda							
Cambaridae	6			0.00	0.00	0.00	GC
Subtotal				0.00		0.00	
Other							
Class Oligochaeta	9		1	0.33	0.06	3.00	GC
Class Hirudinea	7			0.00	0.00	0.00	PR
Class Gastropoda	7	1		0.33	0.06	2.33	SC
Class Pelecypoda	6	31	14	15.00	2.92	90.00	FC
Class Mesoueliidae				0.00	0.00	0.00	
Water mite				0.00	0.00	0.00	
Veliidae (Hemiptera)				0.00	0.00	0.00	
Class Corixidae				0.00	0.00	0.00	
Turbellaria				0.00	0.00	0.00	

Platyhelminthes	6		10	11	7.00	1.36	42.00	
Planaria					0.00	0.00	0.00	
Unidentified					0.00	0.00	0.00	
Subtotal					22.67		137.33	
Total					513.00	179.01		
# squares picked	9	3	3	3				
% squares picked	0.250							
Organism D/Sample	2052.00							
Tot. Family Richness	24						sample	lesser
EPT Family Richness	8				Ephem	40	8.06	8.06
Biotic Index	5.11				plec	5	0	0
% Model Affinity	44.22				Tri.	10	47.43	10
Normalized Profile	7.15				Cole	10	18.7	10
% Scraper	0.65				Olig	5	0.06	0.06
% Filtering Collector	49.71				other	10	16.22	10
% Gathering Collector	40.806				Chiron	20	9.55	6.1
% Predator	1.0396					100	100.02	44.22
% Shredder	6.3678							
					Normalized profile			
						actual	profile	
Ephemeroptera	8.0572							
Plecoptera	0				TFR	24	10	
Trichoptera	47.433				EPT	8	8.33	
Coleoptera	18.713				HBI	5.11	6.11	
Chironomidae	9.5517				PMA	44.22	4.15	
Oligochaeta	0.065						28.59	
Other	16.179						7.1475	

Site				Cream Street (FK 4.6)			
Date Sampled				7/14/2004			
Replicate		1	2	3			
	T	**D**	**D**	**D**	**Avg. D**	**% Comp**	**T x D**	
Ephemeroptera								
Baetidae	6				0.00	0.00	0.00	GC
Baetiscidae	4				0.00	0.00	0.00	GC
Caenidae	6	1		2	1.00	0.26	6.00	GC
Ephemerellidae	2				0.00	0.00	0.00	GC
Ephemeridae	4				0.00	0.00	0.00	GC
Heptageniidae	3				0.00	0.00	0.00	GC
Leptophlebiidae	4				0.00	0.00	0.00	GC
Metretopodidae	2				0.00	0.00	0.00	GC
Isonychidae	2				0.00	0.00	0.00	FC
Polymitarcylidae	2				0.00	0.00	0.00	GC
Potamanthidae	4				0.00	0.00	0.00	GC
Siphlonuridae	7				0.00	0.00	0.00	GC
Tricorythidae	4				0.00	0.00	0.00	GC
Subtotal					1.00	0.26	6.00	
Plecoptera								
Capniidae	3				0.00	0.00	0.00	SH
Chloroperlidae	0				0.00	0.00	0.00	PR
Leuctridae	0				0.00	0.00	0.00	SH
Nemouridae	2				0.00	0.00	0.00	SH

Peltoperlidae	0			0.00	0.00	0.00	SH
Perlidae	3			0.00	0.00	0.00	PR
Perlodidae	2			0.00	0.00	0.00	PR
Pteronarcyidae	0			0.00	0.00	0.00	SH
Taeniopterygidae	2			0.00	0.00	0.00	SH
Subtotal				0.00		0.00	
Trichoptera							
Brachycentridae	2			0.00	0.00	0.00	GC
Glossosomatidae	1		1	0.33	0.09	0.33	SC
Helicopsychidae	3			0.00	0.00	0.00	SC
Hydropsychidae	5	111	259	123.33	31.90	616.67	FC
Hydroptilidae	6			0.00	0.00	0.00	SC
Lepidostomatidae	1			0.00	0.00	0.00	SH
Leptoceridae	4			0.00	0.00	0.00	SH
Limnephilidae	4			0.00	0.00	0.00	SC
Molannidae	6			0.00	0.00	0.00	SC
Odontoceridae	0			0.00	0.00	0.00	SH
Philopotamidae	3	19	6	8.33	2.16	25.00	FC
Phryganeidae	4			0.00	0.00	0.00	SH
Polycentropodidae	6			0.00	0.00	0.00	PR
Psychomyiidae	2			0.00	0.00	0.00	GC
Rhyacophilidae	1			0.00	0.00	0.00	PR
Sericostomatidae	3			0.00	0.00	0.00	SH
Pupa				0.00			
Subtotal				132.00	34.14	642.00	
Diptera							
Athericidae	4			0.00	0.00	0.00	PR
Blephariceridae	0			0.00	0.00	0.00	SC
Ceratopogonidae	6			0.00	0.00	0.00	PR
Chironomidae	6	39	51	30.00	7.76	180.00	GC
Empididae	6		1	0.33	0.09	2.00	PR
Simuliidae	5			0.00	0.00	0.00	FC
Tabanidae	5			0.00	0.00	0.00	PR
Tipulidae	4		1	0.33	0.09	1.33	SH
Subtotal				30.67		183.33	
Megaloptera							
Corydalidae	4			0.00	0.00	0.00	PR
Sialidae	4				0.00	0.00	PR
Subtotal				0.00		0.00	
Lepidoptera							
Pyralidae	5			0.00	0.00	0.00	SH
Subtotal				0.00		0.00	
Coleoptera							
Dryopidae	5			0.00	0.00	0.00	SC
Elmidae	5	199	183	127.33	32.93	636.67	GC
Psephenidae	4			0.00	0.00	0.00	SC
Hydrophilidae				0.00	0.00	0.00	
Subtotal				127.33	32.93	636.67	
Odonata							
Aeshnidae	5			0.00	0.00	0.00	PR
Calopterygidae	6			0.00	0.00	0.00	PR
Coenagrionidae	8			0.00	0.00	0.00	PR
Cordulegastridae	3			0.00	0.00	0.00	PR

Corduliidae	2				0.00	0.00	0.00	PR
Gomphidae	4				0.00	0.00	0.00	PR
Lestidae	9				0.00	0.00	0.00	PR
Libellulidae	2				0.00	0.00	0.00	PR
Macromiidae	2				0.00	0.00	0.00	PR
Subtotal					0.00		0.00	
Amphipoda								
Gammaridae	6	12		16	9.33	2.41	56.00	GC
Talitridae	8	3		1	1.33	0.34	10.67	GC
Crangonyctidae	6	10		12	7.33	1.90	44.00	GC
Haustoriidae					0.00	0.00	0.00	GC
Subtotal					18.00		110.67	
Isopoda								
Asellidae	8	19		132	50.33	13.02	402.67	SH
Subtotal					50.33		402.67	
Decapoda								
Cambaridae	6				0.00	0.00	0.00	GC
Subtotal					0.00		0.00	
Other								
Class Oligochaeta	9			3	1.00	0.26	9.00	GC
Class Hirudinea	7				0.00	0.00	0.00	PR
Class Gastropoda	7			1	0.33	0.09	2.33	SC
Class Pelecypoda	6	3		15	6.00	1.55	36.00	FC
Class Mesoueliidae					0.00	0.00	0.00	
Acariformes (Water mite)		1			0.33	0.09	0.00	
Veliidae (Hemiptera)					0.00	0.00	0.00	
Class Corixidae					0.00	0.00	0.00	
Turbellaria					0.00	0.00	0.00	
Platyhelminthes	6	33		26	19.67	5.09	118.00	
Planaria					0.00	0.00	0.00	
Unidentified					0.00	0.00	0.00	
Subtotal					27.33		165.33	
Total					386.67	167.33		
# squares picked	9	3	3	3				
% squares picked	0.250							
Organism D/Sample	1546.67							
Tot. Family Richness	17						sample	lesser
EPT Family Richness	4				Ephem	40	0.26	0.26
Biotic Index	5.55				plec	5	0	0
% Model Affinity	38.32				Tri.	10	34.14	10
Normalized Profile	6.03				Cole	10	32.93	10
% Scraper	0.17				Olig	5	0.26	0.26
% Filtering Collector	35.60				other	10	22.68	10
% Gathering Collector	45.8621				Chiron	20	7.76	7.76
% Predator	0.08621					100	98.03	38.28
% Shredder	13.1034							
					Normalized profile			
Ephemeroptera	0.25862					actual	profile	
Plecoptera	0				TFR	17	10	
Trichoptera	34.1379				EPT	4	6	
Coleoptera	32.931				HBI	5.55	4.92	
Chironomidae	7.75862				PMA	38.32	3.2	

Oligochaeta	0.25862						24.12	
Other	24.6552						6.03	

Site			**Smith Street (FK 3.1)**					
Date Sampled			**7/14/2004**					
Replicate		**1**	**2**	**3**				
	T	**D**	**D**	**D**	**Avg. D**	**% Comp**	**T x D**	
Ephemeroptera								
Baetidae	6	1	2	5	2.67	0.43	16.00	GC
Baetiscidae	4				0.00	0.00	0.00	GC
Caenidae	6				0.00	0.00	0.00	GC
Ephemerellidae	2				0.00	0.00	0.00	GC
Ephemeridae	4				0.00	0.00	0.00	GC
Heptageniidae	3	6		1	2.33	0.37	7.00	GC
Leptophlebiidae	4				0.00	0.00	0.00	GC
Metretopodidae	2				0.00	0.00	0.00	GC
Isonychidae	2				0.00	0.00	0.00	FC
Polymitarcylidae	2				0.00	0.00	0.00	GC
Potamanthidae	4				0.00	0.00	0.00	GC
Siphlonuridae	7				0.00	0.00	0.00	GC
Tricorythidae	4				0.00	0.00	0.00	GC
Subtotal					5.00	0.80	23.00	
Plecoptera								
Capniidae	3				0.00	0.00	0.00	SH
Chloroperlidae	0				0.00	0.00	0.00	PR
Leuctridae	0				0.00	0.00	0.00	SH
Nemouridae	2				0.00	0.00	0.00	SH
Peltoperlidae	0				0.00	0.00	0.00	SH
Perlidae	3	1	3	8	4.00	0.64	12.00	PR
Perlodidae	2				0.00	0.00	0.00	PR
Pteronarcyidae	0				0.00	0.00	0.00	SH
Taeniopterygidae	2				0.00	0.00	0.00	SH
Subtotal					4.00		12.00	
Trichoptera								
Brachycentridae	2				0.00	0.00	0.00	GC
Glossosomatidae	1				0.00	0.00	0.00	SC
Helicopsychidae	3				0.00	0.00	0.00	SC
Hydropsychidae	5	78	111	632	273.67	43.76	1368.33	FC
Hydroptilidae	6				0.00	0.00	0.00	SC
Lepidostomatidae	1			8	2.67	0.43	2.67	SH
Leptoceridae	4			1	0.33	0.05	1.33	SH
Limnephilidae	4				0.00	0.00	0.00	SC
Molannidae	6				0.00	0.00	0.00	SC
Odontoceridae	0				0.00	0.00	0.00	SH
Philopotamidae	3	30	42	12	28.00	4.48	84.00	FC
Phryganeidae	4				0.00	0.00	0.00	SH
Polycentropodidae	6	2	1		1.00	0.16	6.00	PR
Psychomyiidae	2				0.00	0.00	0.00	GC
Rhyacophilidae	1				0.00	0.00	0.00	PR
Sericostomatidae	3				0.00	0.00	0.00	SH
Pupa					0.00	0.00	0.00	
Uenoidae			12		4.00	0.64	0.00	
Subtotal					309.67	49.52	1462.33	

Diptera								
Athericidae	4				0.00	0.00	0.00	PR
Blephariceridae	0				0.00	0.00	0.00	SC
Ceratopogonidae	6				0.00	0.00	0.00	PR
Chironomidae	6	35	53	124	70.67	11.30	424.00	GC
Empididae	6	1	2	3	2.00	0.32	12.00	PR
Simuliidae	5	3		1	1.33	0.21	6.67	FC
Tabanidae	5				0.00	0.00	0.00	PR
Tipulidae	4			1	0.33	0.05	1.33	SH
Subtotal					74.33		444.00	
Megaloptera								
Corydalidae	4				0.00	0.00	0.00	PR
Sialidae	4			5	1.67	0.27	6.67	PR
Subtotal					1.67		6.67	
Lepidoptera								
Pyralidae	5				0.00	0.00	0.00	SH
Subtotal					0.00		0.00	
Coleoptera								
Dryopidae	5				0.00	0.00	0.00	SC
Elmidae	5	28	186	258	157.33	25.16	786.67	GC
Psephenidae	4		8	2	3.33	0.53	13.33	SC
Hydrophilidae					0.00	0.00	0.00	
Gyrinidae		1		1	0.67	0.11	0.00	
Subtotal					160.67	25.80	800.00	
Odonata								PR
Aeshnidae	5				0.00	0.00	0.00	PR
Calopterygidae	6	1			0.33	0.05	2.00	PR
Coenagrionidae	8		1	1	0.67	0.11	5.33	PR
Cordulegastridae	3				0.00	0.00	0.00	PR
Corduliidae	2				0.00	0.00	0.00	PR
Gomphidae	4				0.00	0.00	0.00	PR
Lestidae	9				0.00	0.00	0.00	PR
Libellulidae	2				0.00	0.00	0.00	PR
Macromiidae	2				0.00	0.00	0.00	
Subtotal					1.00		7.33	
Amphipoda								GC
Gammaridae	6	20	38	96	51.33	8.21	308.00	GC
Talitridae	8				0.00	0.00	0.00	GC
Crangonyctidae	6				0.00	0.00	0.00	GC
Haustoriidae					0.00	0.00	0.00	
Subtotal					51.33		308.00	
Isopoda								SH
Asellidae	8	15	2		5.67	0.91	45.33	
Subtotal					5.67		45.33	
Decapoda								GC
Cambaridae	6				0.00	0.00	0.00	
Subtotal					0.00		0.00	
Other								GC
Class Oligochaeta	9		1		0.33	0.05	3.00	PR
Class Hirudinea	7				0.00	0.00	0.00	SC
Class Gastropoda	7	2	1	1	1.33	0.21	9.33	FC
Class Pelecypoda	6		21		7.00	1.12	42.00	
Class Mesoueliidae					0.00	0.00	0.00	
Acariformes (Water mite)					0.00	0.00	0.00	

Veliidae (Hemiptera)					0.00	0.00	0.00	
Class Corixidae					0.00	0.00	0.00	
Turbellaria					0.00	0.00	0.00	
Platyhelminthes	6	1	9		3.33	0.53	20.00	
Planaria					0.00	0.00	0.00	
Unidentified					0.00	0.00	0.00	
Subtotal					12.00		74.33	
Total					625.33	176.23		
# squares picked	9	3	3	3				
% squares picked	0.250							
Organism D/Sample	2501.33							
Tot. Family Richness	25							lesser
EPT Family Richness	9				Ephem	40	0.8	0.8
Biotic Index	5.09				plec	5	0.64	0.64
% Model Affinity	42.79				Tri.	10	49.52	10
Normalized Profile	7.3				Cole	10	25.8	10
% Scraper	0.75				Olig	5	0.05	0.05
% Filtering Collector	49.57				other	10	11.99	10
% Gathering Collector	45.5224				Chiron	20	11.3	11.3
% Predator	1.54584					100	100.1	42.79
% Shredder	1.43923							
					Normalized profile			
						actual	profile	
Ephemeroptera	0.79957				TFR	25	10	
Plecoptera	0.63966				EPT	9	9.17	
Trichoptera	49.5203				HBI	5.09	6.14	
Coleoptera	25.693				PMA	42.79	3.91	
Chironomidae	11.3006						29.22	
Oligochaeta	0.0533							
Other	11.9936						7.305	

Site Verazzano Blvd (FK 0.45)

Date Sampled 7/14/2004

Replicate		**1**	**2**	**3**				
	T	**D**	**D**	**D**	**Avg. D**	**% Comp**	**T x D**	
Ephemeroptera								
Baetidae	6				0.00	0.00	0.00	GC
Baetiscidae	4				0.00	0.00	0.00	GC
Caenidae	6				0.00	0.00	0.00	GC
Ephemerellidae	2				0.00	0.00	0.00	GC
Ephemeridae	4				0.00	0.00	0.00	GC
Heptageniidae	3				0.00	0.00	0.00	GC
Leptophlebiidae	4				0.00	0.00	0.00	GC
Metretopodidae	2				0.00	0.00	0.00	GC
Isonychidae	2				0.00	0.00	0.00	FC
Polymitarcylidae	2				0.00	0.00	0.00	GC
Potamanthidae	4				0.00	0.00	0.00	GC
Siphlonuridae	7	1	19	15	11.67	10.14	81.67	GC
Tricorythidae	4				0.00	0.00	0.00	GC
Subtotal					11.67	10.14	81.67	
Plecoptera								

Capniidae	3				0.00	0.00	0.00	SH
Chloroperlidae	0				0.00	0.00	0.00	PR
Leuctridae	0				0.00	0.00	0.00	SH
Nemouridae	2				0.00	0.00	0.00	SH
Peltoperlidae	0				0.00	0.00	0.00	SH
Perlidae	3				0.00	0.00	0.00	PR
Perlodidae	2				0.00	0.00	0.00	PR
Pteronarcyidae	0				0.00	0.00	0.00	SH
Taeniopterygidae	2				0.00	0.00	0.00	SH
Subtotal					0.00	0.00	0.00	
Trichoptera								
Brachycentridae	2				0.00	0.00	0.00	GC
Glossosomatidae	1				0.00	0.00	0.00	SC
Helicopsychidae	3				0.00	0.00	0.00	SC
Hydropsychidae	5	41	53	34	42.67	37.10	213.33	FC
Hydroptilidae	6				0.00	0.00	0.00	SC
Lepidostomatidae	1				0.00	0.00	0.00	SH
Leptoceridae	4				0.00	0.00	0.00	SH
Limnephilidae	4				0.00	0.00	0.00	SC
Molannidae	6				0.00	0.00	0.00	SC
Odontoceridae	0				0.00	0.00	0.00	SH
Philopotamidae	3				0.00	0.00	0.00	FC
Phryganeidae	4				0.00	0.00	0.00	SH
Polycentropodidae	6				0.00	0.00	0.00	PR
Psychomyiidae	2				0.00	0.00	0.00	GC
Rhyacophilidae	1				0.00	0.00	0.00	PR
Sericostomatidae	3				0.00	0.00	0.00	SH
Pupa								
Subtotal					42.67	37.10	213.33	
Diptera								
Athericidae	4				0.00	0.00	0.00	PR
Blephariceridae	0				0.00	0.00	0.00	SC
Ceratopogonidae	6				0.00	0.00	0.00	PR
Chironomidae	6	6	7	8	7.00	6.09	42.00	GC
Empididae	6	1			0.33	0.29	2.00	PR
Simuliidae	5				0.00	0.00	0.00	FC
Tabanidae	5				0.00	0.00	0.00	PR
Tipulidae	4				0.00	0.00	0.00	SH
Subtotal					7.33	6.38	44.00	
Megaloptera								
Corydalidae	4				0.00	0.00	0.00	PR
Sialidae	4				0.00	0.00	0.00	PR
Subtotal					0.00	0.00	0.00	
Lepidoptera								
Pyralidae	5				0.00	0.00	0.00	SH
Subtotal					0.00	0.00	0.00	
Coleoptera								
Dryopidae	5				0.00	0.00	0.00	SC
Elmidae	5	3		3	2.00	1.74	10.00	GC
Psephenidae	4				0.00	0.00	0.00	SC
Hydrophilidae					0.00	0.00	0.00	
Subtotal					2.00	1.74	10.00	
Odonata								

Aeshnidae	5				0.00	0.00	0.00	PR
Calopterygidae	6				0.00	0.00	0.00	PR
Coenagrionidae	8				0.00	0.00	0.00	PR
Cordulegastridae	3				0.00	0.00	0.00	PR
Corduliidae	2				0.00	0.00	0.00	PR
Gomphidae	4				0.00	0.00	0.00	PR
Lestidae	9				0.00	0.00	0.00	PR
Libellulidae	2				0.00	0.00	0.00	PR
Macromiidae	2				0.00	0.00	0.00	PR
Subtotal					0.00	0.00	0.00	
Amphipoda								
Gammaridae	6	53	18	26	32.33	28.12	194.00	GC
Talitridae	8				0.00	0.00	0.00	GC
Crangonyctidae	6	3	3	14	6.67	5.80	40.00	GC
Haustoriidae					0.00	0.00	0.00	GC
Subtotal					39.00	33.91	234.00	
Isopoda								
Asellidae	8	6	5	7	6.00	5.22	48.00	SH
Subtotal					6.00	5.22	48.00	
Decapoda								
Cambaridae	6	2		1	1.00	0.87	6.00	GC
Subtotal					1.00	0.87	6.00	
Other								
Class Oligochaeta	9	9	3	1	4.33	3.77	39.00	GC
Class Hirudinea	7	1			0.33	0.29	2.33	PR
Class Gastropoda	7				0.00	0.00	0.00	SC
Class Pelecypoda	6				0.00	0.00	0.00	FC
Class Mesoueliidae					0.00	0.00	0.00	
Water mite					0.00	0.00	0.00	
Veliidae (Hemiptera)					0.00	0.00	0.00	
Class Corixidae					0.00	0.00	0.00	
Turbellaria					0.00	0.00	0.00	
Platyhelminthes	6		2		0.67	0.58	4.00	
Planaria					0.00	0.00	0.00	
Unidentified						0.00	0.00	
Subtotal					5.33	4.64	45.33	
Total					115.00	200.00		
# squares picked	9	3	3	3				
% squares picked	0.250							
Organism D/Sample	460.00						sample	lesser
Tot. Family Richness	12				Ephem	40	10.14	10.14
EPT Family Richness	2				plec	5	0	0
Biotic Index	5.93				Tri.	10	37.1	10
% Model Affinity	41.74				Cole	10	1.74	1.74
Normalized Profile	4.57				Olig	5	3.77	3.77
% Scraper	0.00				other	10	41.15	10
% Filtering Collector	37.10				Chiron	20	6.1	6.1
% Gathering Collector	56.52					100	100	41.75
% Predator	0.58							
% Shredder	5.217							

			Normalized profile		
Ephemeroptera	10.14			actual	profile
Plecoptera	0		TFR	12	6.5
Trichoptera	37.1		EPT	2	3.75
Coleoptera	1.739		HBI	5.93	4.28
Chironomidae	6.087		PMA	41.74	3.75
Oligochaeta	3.768				18.28
Other	41.16				4.57

Appendix Table 9 - Soil types found within the Fall Kill watershed and their respective characteristics.

Soil Type	Acres	Organic or Mineral	Phase(s)	Parent Material	Drainage Class
Dutchess with Cardigan	4299.4	M	Silt loam	Till	well drained
Nassua with Cardigan	3604.7	M	shaly silt loam to channery silt loam, very rocky	Till	somewhat excessively drained to well drained.
Hoosic	906.2	M	Gravelly sandy loam to cobbly loam	Outwash	excessively to well drained
Bernardston	766.5	M	Silt loam to very stony silt loam	Till	well darined
Urban Soil	584.3	-	-	-	
Sun	547.1	M	Silt loam to loam, extremely stony	Till	poor to very poorly drained
Wayland	257.8	M	Silt loam to mucky silt loam	Alluvium	poor to very poorly drained
Carlisle	234.1	O	Muck	Organic	very poorly drained
Canadauiga	178.4	M	Silt loam	Lacustrine	poorly to very poorly drained
Palms	172.3	O	Muck	Organic	very poorly drained
Udorthents	171.7	M	Variable	Disturbance (fill)	excessively to somewhat poorly drained
Dutchess	144.2	M	Silt loam	Till	well drained
Nassua with Outcrops	124.4	M	shaly silt loam to channery silt loam, very rocky	Till	somewhat excessively drained
Massena	86.0	M	Silt loam	Till	somewhat poorly to poorly drained
Fredon	61.0	M	Silt loam to loam	Outwash	somewhat poorly to poorly drained
Punsit	43.6	M	Silt loam	Till	somewhat poorly drained
Fluvaquents	38.8	M	Variable	Alluvium	somewhat poorly to very poorly drained
Halsey	23.2	M	Mucky silt loam to silt loam	Outwash	very poorly drained
Pittstown	18.8	M	Silt loam to gravelly silt loam	Till	moderately well drained

Appendix Table 10 - State Pollution Discharge Elimination Systems (SPDES) Permit sites within the Fall Kill watershed according to the NYSDEC.

Site	Road	Town	Type of Waste	Discharge Limit (gallons per day)
Victory Lake Nursing Center	Quaker Lane	Hyde Park	Sanitary	14,100
Netherwood Elementry School	Netherwood Road	Hyde Park	Sanitary	11,600
Victory Lake Camp	Crum Elbow Road	Hyde Park	Sanitary	41,900
Mariapolis Luminosa	Cardinal Road	Hyde Park	Sanitary	24,700
Immanuel Christian Center	Crum Elbow Road	Hyde Park	Sanitary	2,100
Pinewoods Monastery	Crum Elbow Road	Hyde Park	Sanitary	5,000
Haviland Junior H.S.	Haviland Road	Hyde Park	Sanitary	32,400
Greenfields Sewer District	Cream Street	Hyde Park	Sanitary	132,000
Valley Forge Mobile Park	Bircher Avenue	Hyde Park	Sanitary	5,200
Church and School of St. Peter	Violet Ave	Hyde Park	Sanitary	15,400
Poughkeepsie DPW	Howard Street	Poughkeepsie	Miscellaneous	14,700
				299,100