Kishacoquillas Valley Watershed Assessment and Restoration Plan

Your Valley, Your Home, Your Watershed, Your Health

Sponsored By A Growing Greener Grant

Prepared by:
Mifflin County Conservation District
20 Windmill Hill #4
Burnham, PA 17009
June 2003

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This project was financed by a Pennsylvania Department of Environmental Protection (PADEP) Growing Greener Grant

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Notes About the Table of Contents

The Table of Contents are as they appear in the printed version. All Figures are listed where they are mentioned in the text. You will find the Maps, Restoration Plan, and Appendix in separate folders. There is additional information on this disk that is not included in the printed version.

Additional information- Folder

I. Chemical Data for each sample location- this is all of the raw data collected for each site

II. Macroinvertebrate Data- this includes data for all sample locations. This data was collected on the PADEP Unassessed Waters Form. This data was not used in the analysis.

Video-folder

I. Kishacoquillas – this video is a helicopter flight of the stream. There are no site references included on the video. Additional stream videos are available if they are helpful.

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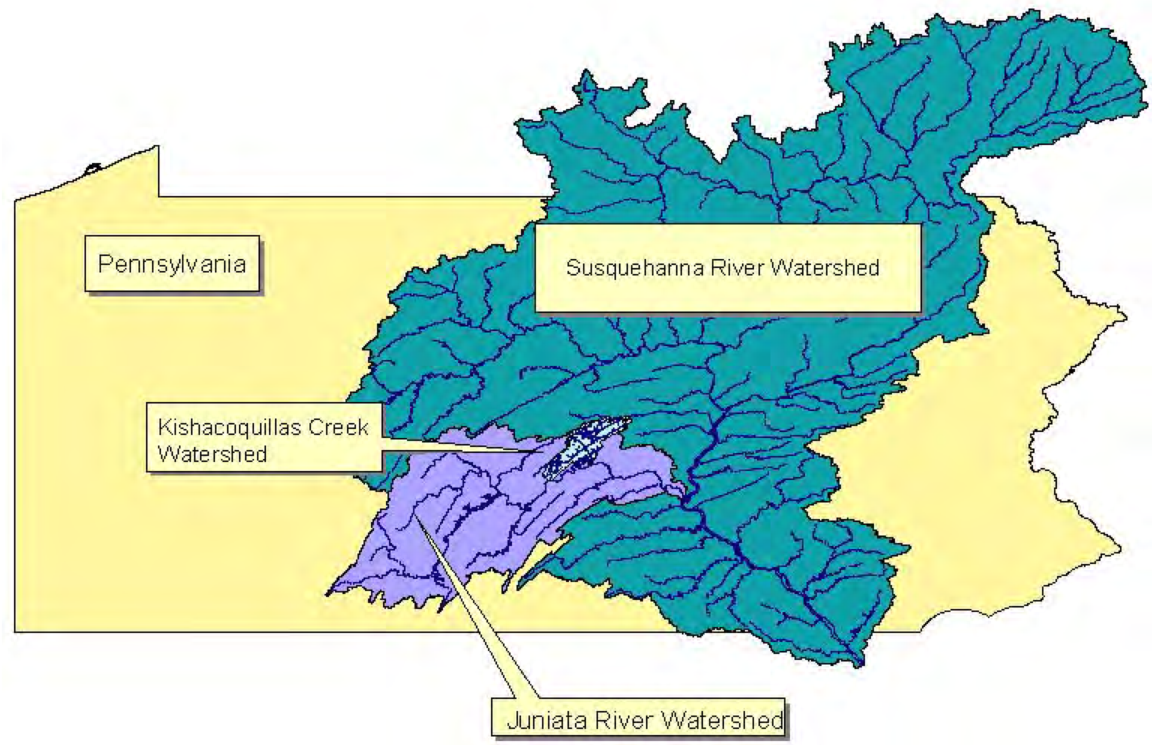
What is a Watershed?

A watershed is all the land which water flows across or under on its way to a stream, river, lake, or ocean. We all live in a watershed. How we treat the soil, water, air, plants and animals not only influences our immediate watershed, but also all watersheds down stream.

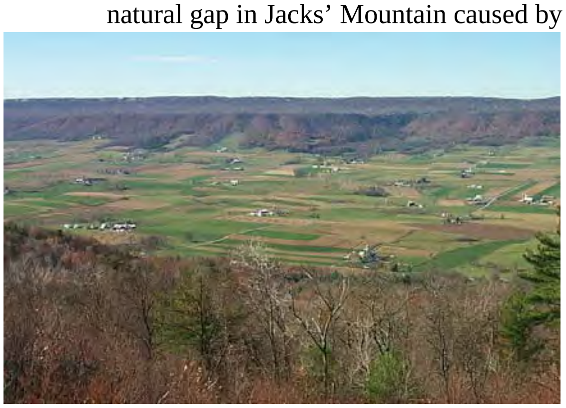


I. Kishacoquillas Creek Watershed Description

The Kishacoquillas Creek watershed is located almost entirely within the political boundary of Mifflin County, which lies in the Appalachian "Ridge and Valley" physiographic province of central Pennsylvania (See Figure 1, pg.7).

Kishacoquillas Creek, or Kish Creek as it is known locally, drains an area of 191 square miles (122,240 acres) and is a tributary of the Juniata River, which flows to the Susquehanna River. It is one of three watersheds in Mifflin County, and by size, the most significant. The Kish Creek watershed includes 44.3% of Mifflin County's 431 square miles (275,840 acres) and flows through all of the land use types the County has to offer.

The mainstem of Kish Creek is located in Kishacoquillas Valley, known locally as "Big Valley" and is bounded by Stone Mountain to the north and Jacks Mountain to the south. Big Valley is approximately 30 miles long and 3 to 4 miles wide and lies across the northern part of the county. The stream originates near the village of Allensville in Menno Township. It flows northeasterly for approximately 15 miles through farmland and the village of Belleville, in Union Township, until it reaches the village of Reedsville, in Brown Township. In Reedsville, Kish Creek is joined by two major tributaries, Tea Creek, which originates in Brown Township, and Honey Creek, which originates in Armagh Township (See Figure 2, pg.8). At this confluence, the stream makes an abrupt turn to the southeast and flows through Mann's Narrows, a natural gap in Jacks' Mountain caused by Kish Creek. It flows through the village of Yeagertown and the Boroughs of Burnham and Lewistown to the Juniata River.



This assessment conducted by the Mifflin County Conservation District (frequently referred to as "we") with funding through a PADEP Growing Greener Grant, focused on 175 square miles (112,089 acres) within the townships of Menno, 24 square miles (15,087 acres); Union, 26 square miles (16,493 acres); Brown, 33 square miles (20,956 acres); and Armagh, 93 square miles (59,553 acres) (See Figure 2, pg. 8). It does not cover the two additional small tributaries that join Kish Creek on the south side of

Jack's Mountain, Hungry Run, which joins Kish Creek from the northeast in Derry Township, and Buck Run which joins Kish Creek from the southwest in Granville and Derry Townships.

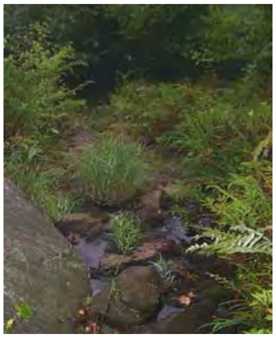
Geology

Kishacoquillas Valley is formed on an anticlinal (upward) fold in the sequence of Cambrian and Ordovician age limestone and dolomite formations that exceed 8,000 feet in thickness. The valleys occur in the central part of the fold, and in this physiographic setting, they overturn slightly to the northwest[11]. The ridges are primarily sandstone of the Tuscarora, Juniata and Bald Eagle Formations. The eastern end of the valley owes its more predominant ridge existence to the breaking up of the major fold into three smaller anticlines. These three anticlines form Havice, Treaster, and New Lancaster valleys[10].

The Cambro-Ordovician age structure determines what series of limestone beds are present. The oldest strata can be found in the center of the Kish Valley, with younger beds at the sides of the valley. Shale of the Reedsville Formation stratigraphically overlies the limestone sequence and generally crops out on the flanks of the adjacent quartzite and sandstone ridges, but is eroded from central parts of most valleys [11].

Limestone and Dolomite are Carbonate bedrock. Limestone is composed of carbonate sediment and the mineral calcite (calcium carbonate ($CaCO_3$)). Dolomite is similar to limestone, but has dolomite as the dominant mineral which is comprised of calcium magnesium carbonate [$CaMg(CO_3)_2$]. Carbonate dissolves when exposed to certain acids. This attribute makes it susceptible to caves, caverns, sinkholes and depressions caused when the calcite within the limestone dissolves[18]. The cavernous character of limestone allows streams to flow underground through channels, and then resurface again[11]. This is called Karst topography, and refers to any terrain where the topography as been formed mainly by the dissolving of rock[15].

The dominant limestone formations in the valley are Axemann, Bellefonte, Benner-Loysburg Undivided, Coburn-Nealmond Undivided, and Keyser-Tonoloway Undivided (See Figure 3, pg. 9). The Coburn-Nealmond Undivided formation is the first carbonate strata reached by runoff from the slightly acidic mountain ridges[11]. These formations have the greatest potential for developing sinkholes, large conduit passages, and caves[11]. Runoff continues to use the same paths of flow further enlarging these passages[11]. As the different carbonate beds appear in the center of the valley, the recharge is spread more evenly through existing fracture openings[11].



Ground Water Hydrogeology

Carbonate rocks are important sources of groundwater[18]. Groundwater flows laterally, generally in the same direction as surface water, following the natural gradient of the land[18]. Groundwater recharge is primarily from land-surface precipitation and runoff draining from mountain slopes. It is estimated that approximately 80 percent of runoff from mountain slopes infiltrates into the soil, or enters sinkholes in stream channels[1]. Most water from mountain streams that enters sinkholes returns to the surface as springs[11]. Sinkholes can also drain directly to the water table. These unique conduit passages formed in carbonate rocks make ground water in the Kish valley very susceptible to contamination[18].

The unique conduit passages formed in carbonate rocks make ground water in the Kish valley susceptible to contamination.

Annual precipitation in the Kish valley averages about 38 inches. Approximately 21 inches are returned to the atmosphere through evapotranspiration, 13 inches infiltrate into the soil for groundwater discharge, and the rest are lost as direct runoff. Groundwater available for use, expressed volumetrically over the basin area, is estimated at 0.62 million gallons per day per square mile [(Mgal/d)/mi2]. During drought years it is estimated that only 0.34 (Mgal/d)/mi2 are available for use[11].

Water tables rise and fall seasonally. Groundwater recharge is greatest during the months of October through April when temperatures are lowest and the vegetation is dormant[11].

Soils

The predominant soil association in Kishacoquillas Valley is Hagerstown-Opequon- Murrill[16] (See Figure 4, pg. 10). These soils formed in material weathered from limestone and in standstone and siltstone colluvium overlying limestone.

Hagerstown soils make up 42 percent of the association. It is well drained, has moderate permeability, and moderate to high available water capacity. Opequon soils make up 25 percent of this association. It is a shallow soil type, has moderate to slow permeability, and very low available water capacity. Because of its shallow nature, it is more prone to erosion and practices to reduce erosion should be used during earth disturbance activities and tillage[16]. Murrill soils make up 12 percent of the association. It has moderate permeability and moderate to high available water capacity. Productivity is excellent with the Hagerstown- Opequon- Murrill association[16] however; there is a moderate hazard of erosion. Other soil types found in this soil association include Melvin, Newark, Nolin, and Penlaw. These rich valley soils are very productive as shown in Table 1.1 below.

Table 1.1 Yields Per Acre of Crop in Pasture

		Hagerstown (HaB)	Opequon (OpB)
Farm Product	Units	Average Yield	Average Yield
Corn	Bu/Ac	135	75
Corn-silage	Tons/Ac	27	15
Wheat	Bu/Ac	50	25
Alfalfa	Tons/Ac	5.5	3.0
Grass-legume Hay	Tons/Ac	3.5	2.5

Source: United States Department of Agriculture Soil Conservation Service Soil Survey of Juniata and Mifflin Counties Pennsylvania

The ridges are composed primarily of the Hazleton-Laidig-Buchanan soil association. These soils are formed from residual and colluvial materials weathered from acid sandstone and some shale. Slope ranges from 25-70 percent, and the soils are moderately deep, and extremely stony. Hazleton soils make up 26 percent of this association. They are deep well drained soils. Laidig soils make up 22 percent to this association. It has moderately slow permeability and moderate available water capacity. Buchanan soils make up 11 percent of the association. It has slow permeability and moderate available water capacity. All three of these soils are strongly to very strongly acidic throughout unlimed areas[16].

Well drained Dekalb and Leetonia soils, poorly drained Andover soils, and rubble land make up the remaining 41 percent of this association[16]. This association is mainly wooded because it is too stony for cultivation. The places that are less stoney are suited to farming uses if adequately managed to control erosion and conserve moisture.

Habitat

Historically, this area was covered with large stands of virgin growth forest. When settlers first came to this area, acres were cleared for agriculture as well as for the logging industry. Additionally, large forested areas were burned for charcoal which was used in the area's iron smelting plants. Pennsylvania forests then consisted of a variety of hardwood forests intermingled with large stands of eastern white pine and eastern hemlock. These forests were known as oak-pine forests. By the early 1900's, few of these original stands remained[25]. The second growth forests became to be known as the Chestnut-Oak Forests due to the dominant American chestnut along with the Red and White Oaks. Even though the white pine and hemlock are not the dominant canopy species, they are still common throughout the area. In the early 1900's, the chestnut blight, accidentally introduced on a nursery ship from Asia, wiped out much of the American chestnut[26]. The tree struggles to survive but does not make it much past the sapling stage. Because of this change in forest structure, the area has now become known as the mixed-oak forest which is prevalent throughout the "Ridge and Valley" region[27]. This structure consists of a mix of hardwoods including red oak, white oak, cherry, hickory, maple, yellow poplar. The dominant over story is now dominated by red and white oak[25], while the understory is dominated by the red maple and black cherry[27].

The Kish watershed plays host to a variety of birds. Owls including the great horned, barred, and screech, are native to the area. The ruby-throated humming bird is the only humming bird common to the area. Commonly found during the winter months are juncos, chickadees, nuthatches, house finches, purple finches, a few woodpeckers, cardinals, titmice, song sparrows, blue jays and crows just to name a few. Larger birds found in the area include wild turkey, the introduced ring-necked pheasant, a variety of hawks and eagles, ruffed grouse, and many different types of waterfowl[28].

Kishacoquillas watershed is home to a variety of large mammals such as white tailed deer, black bear, eastern coyote, raccoon, opossum, skunk, bobcat, red and gray foxes, and porcupine. Smaller mammals include eastern chipmunk, eastern cottontail, several kinds of shrew and mouse, and the groundhog or woodchuck. In 2001, 2,969 white-tail deer, 37 black bear, and 25 beaver were among the harvested animals within Mifflin County[28].

Also found in the area are four animal species of special concern identified by Pennsylvania Natural Diversity Inventory (PNDI). They include the endangered Indiana bat, the threatened eastern small-footed myotis (bat), watershrew and Northern myotis (bat). Three plant species of special concern are also listed. They include, roundleaf Serviceberry, northeastern bulrush, and trillium cernuum. See Table 1.2 for a table of PNDI species. Historically occurring in the area are animals now gone, such as elk, gray wolves and the extinct passenger pigeon and plants such as the orchid, and the showy lady's slipper[28].

Key for Table 1.2 –

G1 – Critically imperiled	S1 – Critically Imperiled	B – Breeding
G2 – Imperiled	S2 – Imperiled	N – Non-breeding
G3 – Vulnerable	S3 – Vulnerable	LE – Listed Endangered
G4 – Apparently Secure	S4 – Apparently Secure	PE – Pennsylvania Endangered
G5 – Secure	S5 – Secure	PT – Pennsylvania Threatened
G? – Unranked	S? – Unranked	CR – Candidate Rare
	SU – Unrankable	TU – Tentatively Undetermined

Table 1.2 Pennsylvania Natural Diversity Inventory of Species and Ecological Communities within the Kishacoquillas Watershed

Species and Ecological Communities Tracked by PNDI within the Kishacoquillas Watershed						
Scientific Name	Common Name	State Rank	Global Rank	Federal Status	State Status	Proposed State Status
Mammals						
SOREX PALUSTRIS ALBIBARBIS	WATER SHREW	S3	G5T5			CR
MYOTIS SODALIS	INDIANA OR SOCIAL MYOTIS	SUB,S1N	G2	LE	PE	PE
MYOTIS LEIBII	EASTERN SMALL-FOOTED MYOTIS	S1B,S1N	G3		PT	PT
MYOTIS SEPTENTRIONALIS	NORTHERN MYOTIS	S3B,S3N	G4			CR
Geologic Features						
SPRINGS	SPRINGS	S?	G?			
Invertebrates						
CAECIDOTEA PRICEI	PRICE'S CAVE ISOPOD	S2S3	G3G4			
STYGOBROMUS ALLEGHENIENSIS	ALLEGHENY CAVE AMPHIPOD	S2S3	G4			
STYGOBROMUS STELLMACKI	STELLMACK'S CAVE AMPHIPOD	S1	G1G2			
Plants						
AMELANCHIER SANGUINEA	ROUNDLEAF SERVICEBERRY	S1	G5		TU	PE
SCIRPUS ANCISTROCHAETUS	NORTHEASTERN BULRUSH	S3	G3	LE	PE	PT
TRILLIUM CERNUUM		S3	G5		N	TU

Source: Pennsylvania Natural Diversity Inventory (http://www.dcnr.state.pa.us/forestry/pndi/rank.htm)

Climate

The climate for Mifflin County is classified as humid continental. The primary source of moisture is the Gulf of Mexico, and most of the weather systems affecting the area originate in the Midwest. Prevailing winds are from the southwest. The Atlantic Ocean is a secondary source of moisture. The Appalachian Mountains to the west of Mifflin County, cause the moisture to precipitate out of frontal systems. The average annual rainfall is about 38 inches. Summertime temperatures may reach or exceed 90 degrees F with nighttime lows in the upper 50's. Cloud cover is at a minimum during the summer when 60 percent of the possible sunshine is received and the nights are clear[16]. Thunderstorms occur on an average of 22 days each year.

Winter temperatures average in the upper 30's with nighttime lows in the 20's. Subzero temperatures occur on an average of 2 days each winter. The first significant snowfall usually occurs in late November, and the last snowfall usually occurs in mid-March. The average annual snowfall amounts to about 28 inches[16].

Spring and fall temperatures average 70 degrees. The average dates of the final spring freeze and first fall freeze are April 25 and October 15 respectively. The average growing season is 173 days. Damage due to wind and hail associated with severe thunderstorms is recorded each year[16].

People In the Watershed

History of the Area

The first known human inhabitants of this region were the Paleo-Indians over 11,000 years ago. They were hunter-gatherers who lived in small nomadic bands. Tribes in Pennsylvania began to develop into more distinct groups during the Late Woodland period of approximately 1000A.D. At this time, farming of corn, beans, and squash became well established and the bow and arrow were introduced as new methods for hunting.

The Susquehannock were the most prosperous tribe in central Pennsylvania during the early colonial period, with settlements of up to 3000 people. The Juniata Iroquois, also known as the Standing Stone People, also inhabited the area. The European fur trade became an important source of goods, but also degraded the Native American culture by introducing diseases, alcohol, land grabbing, and furthering inter-tribal conflicts[4]. When the Dutch began giving firearms to the Five Nations of Iroquois in New York, the local Susquehannock and Juniata Iroquois were displaced by the New York Iroquois[13 & 4].

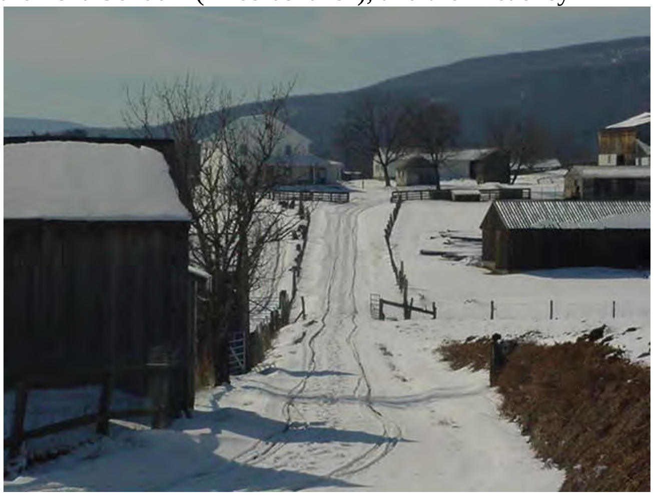
The Shawnee occupied the area from 1725 to the late 1750's. The valley was officially named in 1754, after a well-respected Shawnee chief , Chief Kissikahquelas, or Kishacoquillas. Chief Kishacoquillas (meaning, "the snakes have gone into their dens.") led the Shawnee's village of Ohessen, but he was most widely regarded for his loyalty and conciliatory efforts to keep the Shawnee neutral in the pending French and Indian War[13].

By the time of the Albany Purchase in 1754 when most of western Pennsylvania was purchased from the Iroquois League of Six Nations by the colonial government only a few scattered Indian villages remained in Kishacoquillas Valley. This began the period of the first European immigrant settlers[4].

The Scotch-Irish were the first European immigrants to arrive in Kishacoquillas Valley. They are credited with clearing the land and establishing a systematic scheme of local government. They moved farther west as more permanent farmers began to appear. The first Germans to move to the area were members of the Church of the Brethren. The Amish began to arrive in the early 1790's[13]. They found Kishacoquillas Valley, what we now call 'Big Valley', to have rich soils and limestone that made for very productive farms. Big Valley's largest industry is still agriculture, in part because of the large Amish population living there. Farming practices in the area range from modern

agricultural technologies, to the Amish's practices used since the 18th century. Today, the Brethren and the Amish still thrive side-by-side in the county.

The family farm is an important feature of the Amish society, both as a means of income, and as an ideal setting for developing a wholesome way of life. Three distinct Amish groups can be identified in the valley. They are the "Old Church" ("Alt Gmay", now called the Byler Church), the "Old School" ("Nebraskans"), and the "Peachey Church". In the local community, these groups are often referred to by the color of their carriage tops. The Byler Church is known as "Yellow-toppers", Nebraskans are known as "White-toppers", and the Peachey Church is known as "Black-toppers"[13]. These visible differences represent just a glimpse of the cultural differences of the groups. Though there are differences in the three lifestyles, all have retained an Amish identity.



This identity is based on a deep religious belief system that calls for members to live a life of simplicity, community, peace, and in an increasingly material world, non-conformity. To a visitor of the valley, one would see this represented by the continued use of horses for transportation and farm work, plain clothes, one-room school houses, lack of electricity in their buildings, the continued use of a Germanic language, hand-crafted items, and the lack of mechanized equipment.

Demographics

Table 1.3 Mifflin County Census Population Data

Census Year	*Mifflin County Population*
1970	45,268
1980	46,908
1990	46,197
2000	46,486

The 2000 Census collected demographic data on Mifflin County. The county population was estimated to be 46,486 people with 12,916 of those people living in the Kish watershed. Refer to Table 1.3 for census data from the previous four censuses or Table 1.4 for in-depth census data from Mifflin County. The Census did not designate what percent of the population in the county is Amish. The majority of the Amish people in Mifflin County reside in the Kish watershed. According to the Mifflin County GIS Department, there are 279 Amish parcels totaling 22,446 acres (20% of total agricultural acres) in Big Valley. There are only 11 Amish parcels totaling 571.92 acres (.037%) outside of the Kish watershed. These farms are all located in Decatur Township. (See Figure 5, pg. 20).

Table 1.4 In-depth Mifflin County Census Data

	Menno	**Union**	**Brown**	**Armagh**	**Mifflin County**	**Pennsylvania**
Population	1,763	3,313	3,852	3,988	46,486	12,281,054
% male	48.8	45.9	48.9	50.5	48.2	48.3
% female	51.2	54.1	51.1	49.5	51.8	51.7
% white	97.5	99.3	98.8	98.8	98.5	85.4
median Age (years)	25	39.5	37.9	37.4	38.8	38.0

Travel Routes

Roads

There are twenty public roads that intersect the watershed. Three roads provide access to the southern half of Mifflin County; six roads provide access to Centre County; seven roads provide access to Huntingdon County; and four roads provide access to Snyder County. Federal Highway 322 provides direct access from Harrisburg to State College and is one of two federal roads that bisect Mifflin County. With the exception of Federal Highway 322 which does not allow horses, these main roads transport a variety of traffic from the horse and buggy, to farm machinery, to tractor-trailers. Not all twenty public roads are maintained in the winter, further restricting winter travel options, especially for the Amish.

Two of the three roads that connect the southern portion of Mifflin County to the Kish Creek watershed, travel through Mann's Narrows. The third, Jack's Mountain Road travels up and over the top of Jack's Mountain. Jack's Mountain Road connects Big Valley to the southwestern portion of Mifflin County. It begins just west of Belleville on Wills Rd. and ends up south of McVeytown. At the crest of this road, one can look into Big Valley or Ferguson Valley. This road is maintained in the winter, and is a favorite stopping point as it offers breathtaking views.

All roads leading to Centre County from the Kish Creek watershed, with the exception of 322, are forest roads. They include Havice Valley Road, which leads to Poe Paddy in the Penns Creek watershed, Milheim-Siglerville Pike, Stillhouse Hollow Road, Stone Creek Road and Little Poe Road.

State Route 655 goes from Federal Highway 22 in Huntingdon County to Federal Highway 322 in Mifflin County along the center of Big Valley and is the main travel route for most vehicular traffic within Big Valley. Six additional routes connect the Kish

Creek watershed to Huntingdon County. Front Mountain Road also travels through the valley on the edge of Jack's Mountain. State Route 305, or Greenwood Road, provides access to popular hunting and recreation areas on the Mifflin County- Huntingdon County Line. It travels over Stone Mountain and through Rothrock State Forest and Greenwood Furnace State Park. Other roads to Huntingdon include Barrville Mountain Road, Kettle Road, Chestnut Spring Road, and Allensville Mountain Road.

New Lancaster Valley Road is the main travel route through the watershed to Snyder County. Reeds Gap State Park, a popular recreation area that provides swimming, camping, fishing, hiking, and other outdoor activities, is located along this road. Other roads to Snyder County from the watershed include Knob Ridge Road, Treaster Valley Road, and Longwell Draft Road. Refer to Figure 6, pg. 21 for a map of the county roads.

KV Railroad

The Kishacoquillas Valley Railroad (KV Railroad) ran nine miles from Belleville to Reedsville, on the east side of Kish Creek between 1893-1940. Dr. John P. Getter, a local physician, is heralded as the "Father of the KV Railroad" because it was his dedication that actually made the railroad a reality[22]. The Amish were supporters from the start and were also instrumental in establishing and maintaining the railroad, which was used to transport produce and livestock[13 & 22]. One of the railroad's nicknames, "the Ol' Hook and Eye," is a reference to the Amish method of fastening their clothes and demonstrates the contribution the Amish made to the railroad.

On the nine mile trip, which during the last 12 years of operation was expanded an additional seven miles to the Pennsylvania main line in Lewistown, a traveler only needed to signal the conductor and the train would stop. The railroad served the people of the area and provided convient transportation. In 1940, after years of subsidy from Dr. Getter, the railroad closed. It had become too costly to maintain[22].

Today, the rails are gone, but the area serves as a pleasant and relatively flat, walking trail from Belleville to Reedsville.

Current Landuse

The two most predominant land uses within the watershed, comprising nearly 90 percent of the land, are forestry and agriculture (See Figure 7, pg. 22). A large portion of Stone Mountain is State Forest land. The average farm size in Mifflin County is 106 acres[34]. Many small businesses related to agriculture can be found in the valley, including harness shops, farm stores, roadside produce stands, farm implement dealers, and a milk co-operative and cottage cheese manufacturer. Small towns are mostly located along SR 322, or other well traveled roads. Besides forestry and agriculture, other major industries include Case-New Holland, a major manufacturer of agricultural equipment, two limestone quarries and numerous saw mills and pallet shops. Standard Steel is also within the Kish watershed, but not within our study limits.

Projected Landuse

According to Paths and Bridges to the 21st Century: Mifflin County Comprehensive Plan 2000, most of the watershed is projected to be "Rural Development" areas, or "Natural Resource" areas. The purpose of Rural Development Areas are to help preserve the existing agricultural and natural resource production economies, and also to protect the quality of the groundwater supply, the open space and the rural character presently found in these areas. Natural Resource areas delineate those areas unsuitable for development and protect the county's environmentally sensitive resources. Currently developed areas and areas with improved infrastructure, specifically roads, facilitate higher density development. (Figure 8, pg. 23).

Portions of Milroy and Reedsville are projected as "Unzoned High Growth (Industrial & Commercial)" with "Village Centers" in the villages themselves. Belleville and Allensville are also projected as "Village Centers". There are twelve "Limited Growth Areas" in the watershed including six in Menno township, three in Union Township, two in Brown Township, and one in Armagh Township. An area around Milroy is projected as "Unzoned High Growth (Residential)". The area surrounding Belleville is projected as "Zoned High Growth Area (Residential)" as are a few locations in Milroy and Reedsville. Portions of Belleville are also projected as "Zoned High Growth Areas (Commercial & Industrial)"[15] (Table 1.5).

Table 1.5 Mifflin County's Future Land Use Plan Classifications
Source: Paths and Bridges to the 21st Century: Mifflin County Comprehensive Plan 2000

Rural Development Area	To help preserve the existing agricultural and natural resource production economies, and rural character, as well as protect the culture that is unique to the County's Plain Sect population.
Natural Resource Protection Area	To delineate those areas unsuitable for development and to protect the County's environmentally sensitive resources.
High Growth (residential) (Industrial & Commercial)	Encourage the development of this urban fringe area by designating appropriate areas for medium and high density residential development as well as commercial and industrial uses.
Village Centers	Delineates developed areas such as Allensville, Belleville, Milroy, and Reedsville. These areas have mixed residential, commercial, industrial and public uses, and generally do not have zoning. Furthermore, they have lot sizes equaling one acre or less, may have access to water or sewer, and are within ½ mile of a state highway.
Limited Growth Areas	Encourage the development of livable, planned communities that promote a variety of residential opportunities, provide public facilities, goods and services, adequate open space and recreational opportunities, and employment at a neighborhood scale.

Water Use

Drinking Water

The Mifflin County GIS Department has 5,793 parcels recorded in the Kish watershed. Of those parcels, 2,315 (40%) receive municipal water, 1,898 parcels (33%) have "other" water, and 1,580 parcels (27%) have "neither" (See Figure 9, pg. 24). "Other" sources of water include wells, springs, and mountain streams. Municipal water is supplied by the Lewistown Municipal Water Authority, or the Allensville Municipal Authority, which serves 195 customer connections, and Menno Water Association which serves 47 customer connections[15].

Water Treatment

Municipal sewer service is provided for 1,985 parcels; 2,231 parcels are recorded as having septic systems; and 1,577 parcels have "neither" (See Figure 10, pg. 25). It is interesting to note that when one looks at the number of hookups to municipal sewer sources verses the number of parcels, some of these parcels have multiple hookups. 2,735 municipal sewer hookups are recorded in the Kish watershed on 1,985 parcels. There are 840 in Armagh Township, 1,079 in Brown Township, 816 in Union Township and 0 in Menno Township.

In Armagh Township, the Armagh Township Municipal Authority collects and transfers sewage from the Milroy and Mt. Pleasant areas to the Brown Township Municipal Authority Wastewater Treatment Plant. The Mifflin County Comprehensive Plan states that only a small portion of Armagh Township is served by sanitary sewer and approximately 88 percent of the township's on-lot systems are failing or malfunctioning.

The Brown Township Municipal Authority serves the Reedsville, Lumber City, Church Hill, and Taylor Park areas of the township as well as providing treatment for sewage from Armagh Township. This facility uses approximately 50 to 60 percent of its 600,000 gallon per day capacity depending on the time of year[15].

The Municipal Authority of Union Township servers approximately 816 customers in the Belleville area and uses approximately 33% of its 650,000 gallon per day capacity depending on the time of year. Menno Township is currently without a transfer or treatment facility and all portions of the townships are served by on-lot systems[15].

There are a number of outhouses throughout the watershed. A visual survey of Menno Township counted 30 outhouses, although this survey did not determine if these outhouses were in current use, what sort of base they had, or how the waste was being stored or treated. Many of these outhouses were either at private cabins, or Amish households and schools. It is unknown at this time how these outhouses affect water quality.

Stormwater

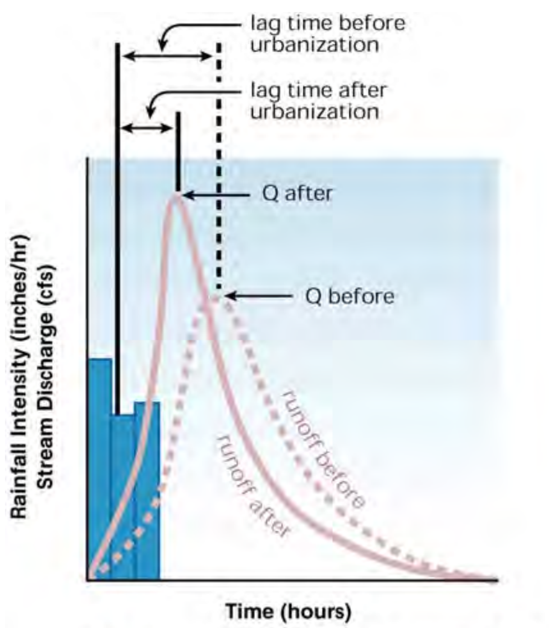
As our county continues to grow, stormwater runoff, the water that is not infiltrating into the ground and flows over land during a rain or snow melt event, is becoming more of a problem. In areas that are heavily urbanized, stormwater runoff is routed to streams which are in turn stabilized using "hard armor" techniques such as concrete walls to negate the impacts of these periodic high velocity events which cause erosion and unstable bank conditions otherwise.

Any increases in the amount of impervious surface disrupts the water cycle. Impervious surfaces are defined as any surface that does not allow water to infiltrate into the ground. Some examples of impervious surfaces include rooftops, all concrete and macadam surfaces and hard packed dirt. During a rain event, rain should be infiltrating into the ground and percolating to the groundwater table. Streams rise slowly because the increase in water is coming from the increase in ground water, not discharge from the storm event itself. Figure 11, pg. 19 illustrates water runoff rates are higher post urbanization. When rain falls on a road, roof, or other impervious surface, it can not infiltrate and so it is no longer available to recharge that groundwater aquifer. Along roadways, stormwater is often directed to a storm drain which outlets into a stream. When stormwater flows over surfaces such as roads, it picks up pollutants such as highway salts, oils and other car related fluids. The artificially increased volume not only burdens the stream, but contaminates it as well.

Stormwater is not only harmful to the natural environment, it can be a nuisance to people as well. Poorly designed development can increase erosion, cause flooding around a foundation or open area that did not previously have standing water, and erode and over burden streams causing the channel pattern to change and possibly threaten existing structures. In order to manage the possible threats of stormwater to developments and water quality, the State has adopted a Stormwater Management Act.

All counties are required to regulate drainage and stormwater management activities by the authority of the Act of October 4, 1978, P.L. 84, the Stormwater Management Act (Act 167). To assist counties with this task, PADEP's stormwater management program administers a grant program under Act 167 for counties to prepare watershed plans to manage stormwater runoff from new land development activities[33]. The goal of watershed wide stormwater management planning is to foster the development of a consistent set of local rules and regulations to protect and improve the capacity of natural stream channels and the quality of surface and ground water throughout the State[32].

Plans are implemented by municipalities through the enactment or amendment of local ordinances[32]. Mifflin County is currently reviewing a draft Act 167 Stormwater Management Plan for the Kish Creek Watershed which should be completed soon. Once adopted by the County Commissioners, each Municipality in the Kish Watershed must adopt the provisions of the model ordinance. This ordinance will regulate the stormwater runoff based on pre-development and post-development condition. In some areas, post-development run-off or release rates will be required to be 75% of pre-development release rates. There are many different examples of stormwater control plans available. For more information on what you can do, consult the Restoration Plan.



– A comparison of hydrographs before and after urbanization. The discharge curve is higher and steeper for urban streams than for natural streams.
In Stream Corridor Restoration: Principles, Processes, and Practices (10/98).
Interagency Stream Restoration Working Group (15 federal agencies)(FISRWG).

Figure 11 Comparisons of Hydrographs before and after urbanization.

II. Assessment

The Clean Water Act of 1972 is the primary federal law that protects our nation's waters, including lakes, rivers, aquifers and coastal areas. It was enacted in response to growing public concern about serious and widespread water pollution[39].

Water quality standards are the combination of water uses such as water supply, recreation and aquatic life to be protected, and the water quality criteria necessary to protect them.

The Clean Water Act (CWA) provides standards, technical tools and financial assistance to address the many causes of pollution and poor water quality (EPA website). Each state is responsible for ensuring that the waters within its boundaries comply with the CWA, and all states must identify and report on water quality. The information is compiled into a biennial *National Water Quality Inventory* report to Congress[6]. In Pennsylvania, the responsibility for compliance falls on the Department of Environmental Protection (PADEP).

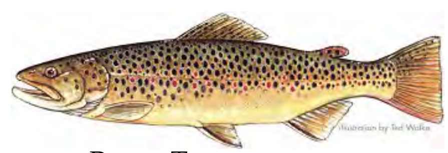
The standards for water quality can be found in the Commonwealth of Pennsylvania, Pennsylvania Code, Title 25, Environmental Protection, Chapter 93, Water Quality Standards. Chapter 93 outlines protected water uses, statewide water uses, and the water quality standards that protected water uses must meet. The criteria associated with statewide uses apply to all surface waters unless specifically exempt. Water bodies that do not meet water quality standards may be assigned a total maximum daily load (TMDL) (CWA Section 303(d)), which quantifies the loading capacity of a waterbody for a given stressor and ultimately provides a quantitative scheme for allocating loadings among pollutant sources[6].

As required by CWA, PADEP conducted an assessment of all the streams in Pennsylvania. The assessment of the Kishacoquillas Watershed showed impairment in certain areas (See Figure 12, pg. 31). The reasons stated for impairment included siltation and nutrients from agriculture. The Mifflin County Conservation District applied for, and received funding to conduct a more comprehensive assessment.

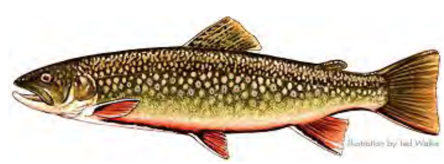
Protected Water Uses:

"Water uses which shall be protected, and upon which the development of water quality criteria shall be based, are set forth, and accompanied by their identifying symbols." PA Code Title 25. Chapter 93. The following list of aquatic life definitions are the protected water use classifications that the water quality standards are designed to meet.

Rainbow Trout



Brown Trout



Brook Trout

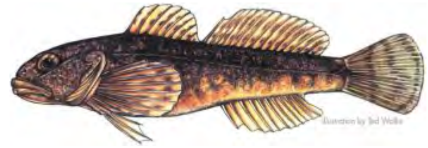
Aquatic Life Definitions

CWF- *Cold Water Fishes*- Maintenance or propagation, or both, of fish species including the family Salmonidae and additional flora and fauna which are indigenous to a cold water habitat.

MF- *Migratory Fishes*- Passage, maintenance and propagation of anadromous and catadromous fishes and other fishes which ascend to flowing waters to complete their live cycle

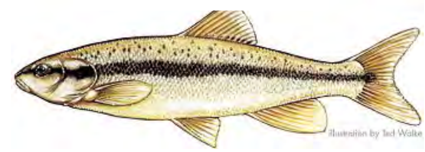
TSF- *Trout Stocking*- Maintenance of stocked trout from February 15 to July 31 and maintenance and propagation of fish species and additional flora and fauna which are indigenous to a warm water habitat.

Special Protection:
HQ- *High Quality Waters*- 93.4b Defines what criteria a stream must meet to qualify it as a HQ stream. The water quality of High Quality Waters shall be maintained and protected.



Slimy Sculpin

Longnose Dace



Blacknose Dace

Illustrations used with permission from:
PA Fish & Boat Commission
http://www.fish.state.pa.us

Designation of streams within the Kishacoquillas Watershed

According to PA Code Title 25, Chapter 93 Water Quality Standards, the Kish Creek basin from its source to the confluence with Tea Creek has a designated protected water use classification of CWF (Cold Water Fisheries). This part of the mainstem is locally referred to as the West Branch of Kish Creek. From its confluence with Tea Creak
to the mouth, where it meets the Juniata River, Kish Creek formally has a Chapter 93 classification of TSF (Trout Stocked Fisheries).

The two major subbasins, which constitute the northeastern portion of the project area, are considered Special Protection Waters. Tea Creek, with a basin of 12.0 square miles, is classified HQ-CWF (High Quality Cold Water Fisheries); Honey Creek, with a 93.3 square mile basin, is HQ-CWF, MF (High Quality Cold Water Fisheries, Migratory Fishes). Both Tea Creek and the lower 3 miles of Honey Creek are Class A Wild Trout Waters, according to the PA Fish and Boat Commission (PA F&BC). A 2.4 mile stretch of the mainstem of Kish Creek, downstream from the project area and all of the Frog Hollow basin, is also considered Class A Wild Trout Water. PADEP has upgraded the “existing use” of these two areas to HQ-CWF. (See Figure 13, pg. 32) for PADEP stream class designations). Other portions of the mainstem and the Honey Creek subbasin (including Treaster Run, Lingle, Havice, and upper Honey creeks) are stocked annually by the PA Fish & Boat Commission. Refer to Table 2.1 and Table 2.2 for the criteria listed as “critical use” for the statewide uses HQ, CWF, TSF, MF and Water Contact (WC). Refer to Title 25. Chapter 93 for a complete list of all criteria surface waters must meet.

Table 2.1 Specific Water Quality Criteria (Source: Pennsylvania Code Title 25. Chapter 93)

Parameter	Criteria	*Critical Use
Alkalinity	Minimum 20 mg/l as CaC03, except where natural conditions are less.	CWF, TSF, MF
Bacteria	(Fecal coliform/ 100 ml)- During the swimming season (May 1 through September 30), the maximum fecal coliform level shall be a geometric mean of 200 per 100 milliliters (ml) based on a minimum of five consecutive samples each sample collected on different days during a 30-day period. No more than 10% of the total samples taken during a 30-day period may exceed 400 per 100 ml.	**WC
Dissolved Oxygen (1)	Minimum daily average 6.0 mg/l; minimum 5.0mg/l	CWF
Dissolved Oxygen (3)	For the period February 15- July 31 of any year, minimum daily average of 6.0 mg/l, minimum 5.0 mg/l. For the remainder of the year, minimum daily average of 5.0 mg/l, minimum 4.0 mg/l.	TSF
Dissolved Oxygen (4)	Minimum 7.0 mg/l	HQ-CWF
Iron	30- day average 1.5 mg/l as total recoverable	CWF, TSF, MF
Osmotic Pressure	Maximum 50 milliosmoles per kilogram	CWF, TSF, MF
pH	From 6.0 to 9.0 inclusive	CWF
Temperature	see Table 2.2	
Total Residual Chlorine	Four-day average 0.011 mg/l; 1-hour average 0.019 mg/l	CWF, TSF, MF

* Critical use: The most sensitive designated or existing use the criteria are designed to protect
** WC- *Water Contact Sports*-Use of the water for swimming and related activities

Table 2.2 Temperature criteria *(Source: Pennsylvania Code Title 25. Chapter 93)*

Period	**Temp. 1 (F) HQ-CWF, CWF**	**Temp. 2 (F) TSF**
January 1-31	38	40
February 1-29	38	40
March 1-31	42	46
April 1-15	48	52
April 16-30	52	58
May 1-15	54	64
May 16-31	58	68
June 1-15	60	70
June 16-30	64	72
July 1-31	66	74
August 1-15	66	80
August 16-30	66	87
September 1-15	64	84
September 16-30	60	78
October 1-15	54	72
October 16-31	50	66
November 1-15	46	58
November 16-30	42	50
December 1-31	40	42

Total Maximum Daily Load (TMDL)

The assessments completed by PADEP together with the federal Clean Water Act requirements are used to establish the maximum pollutant loading or "Total Maximum Daily Load". It is required by federal regulation (40 C.F.R. 130.7) that states develop lists of waters where the pollution controls are not stringent enough to meet water quality standards, develop TMDL's for streams not meeting water quality standards, establish priority rankings based on severity of pollution, and target those waters. Nonpoint source pollutants (pollution from areas other than pipes, which is regulated under the National Pollutant Discharge Elimination System) will be implemented through a combination of federal, state, and local programs that include regulatory, nonregulatory, and voluntary efforts (See Appendix A for PADEP's Fact sheet on TMDL's).

Based on the assessment completed by PADEP, TMDL's will be established for Laurel Creek, Havice Creek, portions of Honey Creek, portions of Kish Creek, Kings Hollow, and Little Kish Creek (See Figure 12, pg. 31). See Appendix B for the 2002 303(d) list of impaired waters as it applies to the Kish Watershed.

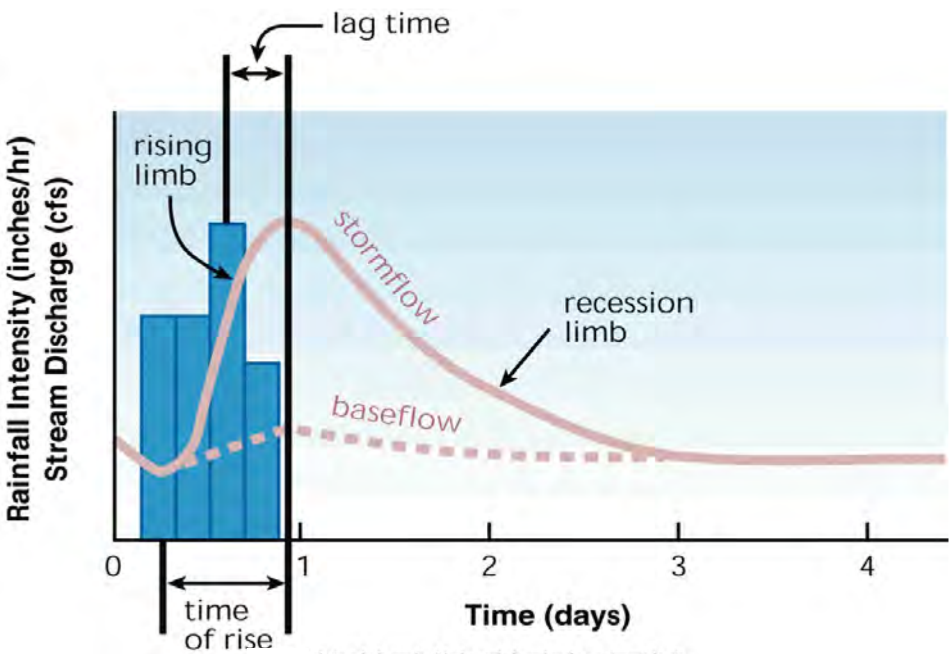
What is streamflow?

The source of all water in a stream, or streamflow, is ultimately precipitation. The source may be *stormflow*, or stormwater, the precipitation that reaches the channel over a short time frame, usually a storm (rain) event, through overland or underground routes, or *baseflow*, precipitation that percolates to the ground water and moves slowly though substrate before reaching the channel. Baseflow sustains streamflow during periods of little or no precipitation. At any one time, streamflow may contain one or both sources. If neither source is providing water to the channel, the stream will go dry. Which of these two paths precipitation takes to the stream channel affects many aspects of streamflow including quantity, quality, and timing[20].

Stormwater, tend to higher pollutant levels than baseflow. Water that flows overland picks up road grime (including oils, salts, and cinders) manure, chemicals such as fertilizers, pesticides and herbicides and many kinds of trash. Stormwater usually adds more water in a short time period. This quick addition of volume and velocity to a stream negatively impacts the channel if the channel does not have adequate buffers to help stabilize the banks and reduce the erosional impacts of these events.

Baseflow is the groundwater table reaching the surface. Because it is water that has been filtered through infiltration into the ground, testing streams at baseflow levels can give us an indication of the ground water quality. During our year-long assessment, we tested the streams during and following storm events, and also during periods when baseflow was the only source of water in the stream. This year was a drier year than most, so the majority of the tests were conducted during baseflow. Figure 14, pictured below, shows a storm hydrograph or the reaction of a stream to a precipitation event.

Figure 14. A Storm Hydrograph



- A storm hydrograph. A hydrograph shows how long a stream takes to rise from baseflow to maximum discharge and then return to baseflow conditions. In Stream Corridor Restoration: Principles, Processes, and Practices (10/98). Interagency Stream Restoration Working Group (15 federal agencies)(FISRWG).

Methods

Fifty-nine locations were selected to be sampled monthly for select water quality criteria. Sites were selected based on proximity to tributaries, landowner permission, and access to the streams. An attempt was made to sample upstream and downstream of all major tributaries, and at points along each contributing stream and the mainstem. These same locations (also referred to as "sample locations" or "sites") were also evaluated for twelve habitat parameters that directly relate to the protected use classifications. The macroinvertebrate community was assessed as a means to determine if water quality and habitat requirements were attained. Refer to Figure 15, pg. 53 to see all of the named sample locations north of Federal Highway 322 or Figure 16, pg. 54 for those south of Federal Highway 322.

Landowners were notified of the assessment through newspaper articles, a public meeting, mailings, and a public display in each township in the assessment area. A brochure outlining the assessment was developed and mailed to every landowner along Kishacoquillas Creek within the study area. This mailing also informed the landowner of a public meeting that was to be held in Belleville. Brochures were also handed out to additional landowners in the valley when district staff or field personnel had the opportunity (See Appendix C, Kishacoquillas Creek Watershed Assessment Brochure).

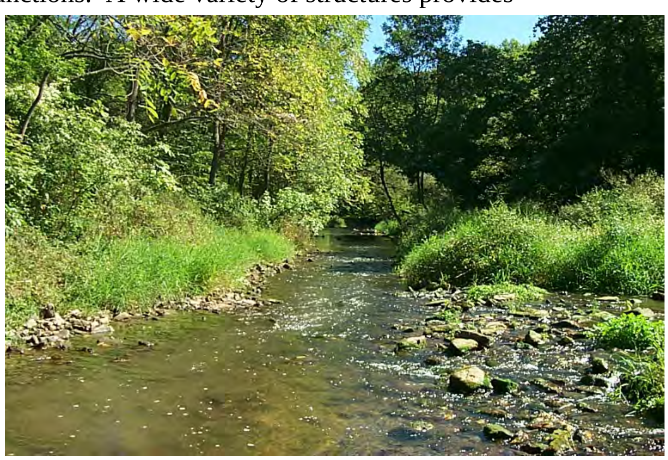
Habitat

Two individuals evaluated twelve habitat parameters at each sample location using the modified EPA Rapid Bioassessment Index score sheet used by PADEP biologists (See Appendix D, Modified EPA Rapid Bioassessment Habitat). A site specific Habitat Assessment Score was calculated using the individual scores for each category.

Definitions For Each Of The Twelve Habitat Parameters:

1. Instream Cover (fish)

Instream cover is a measure of the relative quantity and variety of natural structures in the stream, such as cobble (riffles), fallen trees, logs, and undercut banks available as refugia for feeding, spawning, and nursery functions. A wide variety of structures provides aquatic organisms a large number of niches and increases habitat diversity. A lack of structural diversity reduces the potential for recovery following disturbance. See Figure 17, pg. 55 for sites that scored "optimal", "suboptimal", "marginal" and "poor" for this habitat parameter.



2. Epifaunal Substrate

Epifaunal Substrate is the amount of niche space or hard substrates (rocks, snags) available for insects, snails, fish, and other aquatic species. Numerous types of insect larvae attach themselves to rocks, logs, branches, or other submerged substrates. The greater the variety and number of available niches or attachment sites, the greater the variety of insects in the stream. Rocky-bottom areas are critical for maintaining a healthy variety of insects. Snags and submerged logs provide additional areas for macroinvertebrate colonization, increase diversity, and provide important areas for fish. See Figure 18, pg. 56 for sites that scored "optimal", "suboptimal", "marginal" and "poor" for this habitat parameter.

3. Embeddedness

Embeddedness refers to the extent that rocks (gravel, cobble, and boulders) are surrounded by, covered, or sunken into the silt, sand, or mud of the stream bottom. As rocks become embedded, fewer living spaces are available to macroinvertebrates and fish for shelter, spawning and egg incubation[6]. To estimate the percent of embeddedness, observe the amount of silt or finer sediments overlying and surrounding the rocks. If kicking does not dislodge the rocks or cobble, they may be greatly embedded. It may be useful to lift a few rocks and observe the extent of the dark area on their underside. See Figure 19, pg. 57 for sites that scored "optimal", "suboptimal", "marginal" and "poor" for this habitat parameter.

4. Velocity/Depth Regimes

Fast water increases the amount of dissolved oxygen in the water, keeps pools from being filled with sediment, and helps food items like leaves, twigs, and algae move more quickly through the aquatic system. Slow water provides spawning areas for fish and shelters macroinvertebrates that might be washed downstream in high stream velocities. Similarly, shallow water tends to be more easily aerated, but deeper water stays cooler longer thus allowing dissolved oxygen levels to remain. The best stream habitat includes all four habitat categories of slow, deep; slow, shallow; fast, deep; fast, shallow. The general guidelines to separate the flow categories fast from slow are 0.3 m/sec (1 ft/sec), and 0.5 m (1.6 ft) to separate the depth categories shallow from deep. See Figure 20, pg. 58 for sites that scored "optimal", "suboptimal", "marginal" and "poor" for this habitat parameter.

5. Channel Alteration

Channel alteration is a measure of large-scale changes in the shape of the stream channel. Channel alteration includes concrete channels, artificial embankments, straightening of the natural channel, rip-rap, or other structures, as well as recent sediment bar development. Unnatural channel changes can negatively affect the stream below the alteration by increasing the velocity of the water which often causes even greater bank instability further downstream. See Figure 21, pg. 59 for sites that scored "optimal", "suboptimal", "marginal" and "poor" for this habitat parameter.

6. Sediment Deposition

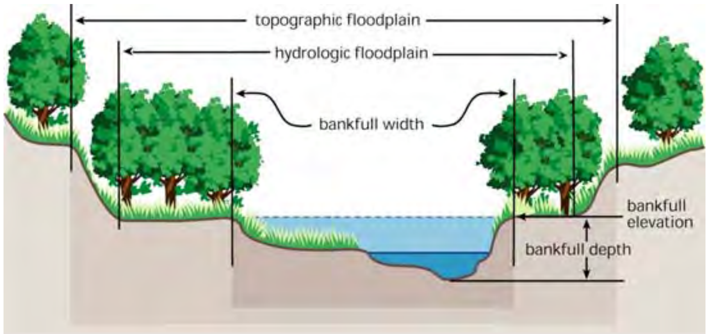
This parameter measures the amount of sediment that has accumulated in pools and the changes that have occurred to the stream bottom as a result. Sediment bars typically form on the inside of bends, below channel constrictions, and where stream gradient decreases. Bars tend to increase in depth and length with continued watershed disturbance. High levels of sediment deposition are symptoms of an unstable and continually changing environment that becomes unsuitable for many organisms. See Figure 22, pg. 60 for sites that scored "optimal", "suboptimal", "marginal" and "poor" for this habitat parameter.

7. Frequency of Riffles
Riffles are a source of high-quality habitat and diverse fauna. An increased frequency of riffle occurrence greatly enhances the abundance and diversity of the stream community. Riffles are important because they serve as spawning and feeding areas for fish, increase the amount of dissolved oxygen, and are the essential habitat required for many macroinvertebrates. See Figure 23, 61 for sites that scored "optimal", "suboptimal", "marginal" and "poor" for this habitat parameter.

8. Channel Flow Status
The degree to which the channel is filled with water. The flow status will change as the channel enlarges, or as flow decreases as a result of drought or diversions for irrigation. When water does not cover much of the streambed, the amount of suitable substrate for aquatic organisms is limited. See Figure 24, pg. 62 for sites that scored "optimal", "suboptimal", "marginal" and "poor" for this habitat parameter.

9. Condition of Banks
A measurement of whether the stream banks are eroded or have the potential for erosion. Steep banks are more likely to suffer from erosion than are gently sloping banks and are therefore considered unstable. Eroded banks indicate a problem of sediment movement and deposition. Signs of erosion include crumbling, unvegetated banks, exposed tree roots, and exposed soil. Assessments of both the upper and lower banks should be done concurrently. The upper bank is the land area from the break in the general slope of the surrounding land to the top of the bankfull channel (See Figure 25 below). The lower bank is the intermittently submerged portion of the stream cross section from the top of the bankfull channel to the existing water-line. See Figure 26, pg. 63 for sites that scored "optimal", "suboptimal", "marginal" and "poor" for this habitat parameter.

Figure 25 - Description of Banks



10. Bank Vegetative Protection

This measures the amount of vegetative protection afforded to the stream bank. The root systems of plants growing on stream banks help hold soil in place. This parameter supplies information on the ability of the bank to resist erosion as well as some additional information on the uptake of nutrients by the plants, the control of instream scouring, and stream shading. For the full benefit to be achieved, vegetation must be deep rooted. Cool season grass and other shallow rooted plants do not resist erosion or provide shade that positively impacts the temperature of the stream. Banks that have full, natural plant growth are better for fish and macroinvertebrates than are banks without vegetative protection or those shored up with concrete or riprap[6]. See Figure 27, pg. 64 for sites that scored "optimal", "suboptimal", "marginal" and "poor" for this habitat parameter.

11. Grazing or Other Disruptive Pressure

This is a measure of disruptive changes to the riparian zone because of grazing or human interference (e.g., mowing). In areas of high grazing pressure from livestock or where residential and urban development activities disrupt the riparian zone, the growth of a natural plant community is impeded. Residential developments, urban centers, golf courses, and rangeland are the common causes of anthropogenic pressure on the riparian zone. See Figure 28, pg. 65 for sites that scored "optimal", "suboptimal", "marginal" and "poor" for this habitat parameter.

12. Riparian Vegetative Zone Width

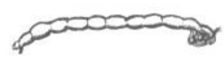
This measures the width of natural vegetation from the edge of the stream bank out through the riparian zone. A vegetative zone serves as a buffer to pollutants entering a stream from runoff, controls erosion, and provides habitat and nutrient input to a stream. A relatively undisturbed riparian zone supports a robust stream system. See Figure 29, pg 66 for sites that scored "optimal", "suboptimal", "marginal" and "poor" for this habitat parameter.

Biological

Benthic macroinvertebrates were collected from riffle habitats using a 1 meter x 1 meter kick seine held downstream with the lower edge in the bottom substrate of a riffle. An individual upstream disturbed the stream bottom by vigorously shuffling their feet as

they walked toward the seine. An area only as wide as the seine was disturbed. Bottom disturbance occurred for approximately one minute. Rocks in the sample area were rubbed by hand to collect additional organisms potentially not found in the bottom substrate. The seine was raised bottom first out of the water and spread in a flat portion of the bank to collect the organisms off the seine. This procedure (referred to as a "kick") was done twice at each sample location in two separate riffles. The results of each kick was recorded on PADEP's "Unassessed Waters Field Form: Wadable Streams" (see Appendix E, Unassessed Waters Field Form: Wadable Streams) and the information gathered was used to answer additional questions on the field data form. The organisms were identified to family and classified on Relative Abundance as (R)are < 3 individuals, (P)resent 3-9 individuals, (C)ommon 10-24 individuals, (A)bundant 25-100 individuals, (VA) Very Abundant >100.

In addition to the "Unassessed Waters" procedure, a more in-depth Hilsenoff Biotic Index was done in fall 2001 to evaluate the relative pollution tolerance of biological communities at 30 of the sample locations. We followed the procedure outlined in Hilsenhoff's article, "An Improved Biotic Index of Organic Stream Pollution" (Hilsenhoff 1987) and in the EPA's Rapid Bioassessment Protocols for Use in Wadeable Streams and Rivers: Periphyton, Bentic Macroinvertebrates, and Fish *Second Edition*. Macroinvertebrates were sampled from two riffles at each location using the procedure mentioned above. The net was rinsed into a bucket and then poured through a No. 30 standard testing sieve. All large debris items were washed off into the bucket and then discarded prior to straining the sample. Samples were then bagged and preserved with enough 90% ethanol to produce a concentration of about 70% ethanol when combined with the water in the debris. The samples were taken back to the office where the liquid mixture was replaced with 70% ethanol.



Midge larva

Illustrations Provided by: Aquatic Project WILD; *Water, Water Everywhere, But…*, from Hach Inc.; "Sport Fishes of Pennsylvania."

A flat pan marked with a 5 cm numbered grid was used to select macroinverebrates for identification. Four grid squares were randomly chosen for sampling and all arthropods in those four squares were selected. The target sample was 300 macroinverebrates. If four squares did not yield this number, additional grids were chosen at random until the sample target was met. All chosen grids were sampled completely. If greater than 360 were "picked", then the sample was sub-sampled to achieve the target. Sorted macroinverebrates were identified to genus using a dissecting scope and key and were recorded on a data form (See Appendix F, Macroinvertebrate Data Form).

Definitions For Macroinvertebrates:

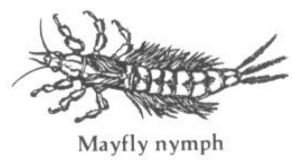
Scientific Classification and Names

To understand and communicate about the vast diverse groups of organisms

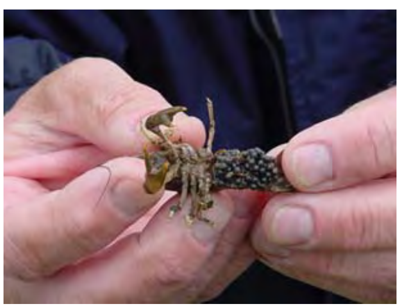
world-wide, a binomial naming system using Latin was established to identify all organisms. This science, called taxonomy, brings order to the diversity by using an increasingly specific series of questions to determine which category an organism belongs. A taxon (plural, taxa) refers to a group of organisms at any level of classification[31]. The seven levels of classification are as follows: Kingdom-Phylum-Class-Order-Family-Genus-Species

The following example of classification is for the small minnow mayfly *Baetis cingulatus* [31].

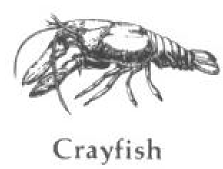
Kingdom- Animalia
- Phylum- Arthropoda
  - Class- Insecta
    - Order- Ephemeroptera
      - Family- Baetidea
        - Genus- Baetis
          - Species-cigulatus



Illustrations Provided by: Aquatic Project WILD; *Water, Water Everywhere, But*…, from Hach Inc.; "Sport Fishes of Pennsylvania."



In our assessment, we refer to all macroinvertebrates by their scientific names. Taxonomists assign a unique scientific name to each organism with care never to use a name twice. This eliminates confusion often associated with common names, which are often different in different regions. Teachers and students generally classify organisms to the Order level [31]. Our assessment classified organisms to the Family and Genus levels.



Illustrations Provided by: Aquatic Project WILD; *Water, Water Everywhere, But*…, from Hach Inc.; "Sport Fishes of Pennsylvania."

Invertebrates

Invertebrates are animals without backbones. They make up the majority of animal life on the planet. There are approximately 10,000 identified species of freshwater invertebrates [31].

Arthropods
Invertebrates with exoskeletons of chitin. The majority of invertebrates are arthropods [31].

Bentic- bottom of a water body

macro- relatively "large" (>0.2-0.5mm) and can usually be seen without magnification[31].

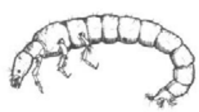
Bentic macroinvertebrates- relatively "large", bottom dwelling, invertebrates. They are vital to the ecology of streams. Macroinvertebrates act as the primary link between microorganisms, algae, and detritus, the base of the food chain, and higher predators such as fish. Approximately 33% of all fish in the United States feed specifically on macroinvertebrates [31].

Commonly found macroinvertebrates

Common Name	Scientific Order
mayflies	Ephemeroptera
stoneflies	Plecoptera
caddisflies	Trichoptera
dragonflies/ damselflies	Odonata
true bugs	Hemiptera
dobsonflies/ alderflies	Megaloptera
beetles	Coleoptera
true flies	Diptera
aquatic moths	Lepidoptera

These three orders are used together as a biotic health index called the EPT index.


Stonefly nymph


Caddisfly larva

Illustrations Provided by: Aquatic Project WILD; *Water, Water Everywhere, But…*, from Hach Inc.; "Sport Fishes of Pennsylvania."

Macroinvertebrate Functional Feeding Groups
Macroinvertebrates fit into one of five functional feeding groups that are based on their feeding adaptations and/or food preferences[31]. Knowledge of these functional groups can provide important clues about their roles in the environment, or what is present or absent at a particular site. We did not use this information in our analysis, but our assessment does identify functional feeding groups if someone else wanted to do an analysis of this information.

1. Shredders- dead leaves/live plants
2. Collectors- fine organic particles (live/dead)
    a. filter feeders- particles in the water column
    b. miners- buried particles
    c. browsers- bottom surface deposits
3. Scrapers- live benthic algae (diatoms)
4. Piercers- live filamentous algae and plants
5. Predators – other invertebrates and small fish


Water Penny
(beetle larva)

Illustrations Provided by: Aquatic Project WILD; *Water, Water Everywhere, But…*, from Hach Inc.; "Sport Fishes of Pennsylvania."

Biotic Indexes

Biotic index systems assign numerical scores to specific organisms at a particular

taxonomic level. Such organisms have specific requirements in terms of physical and chemical conditions and are therefore considered “indicator species”. Their presence or absence, change in numbers, morphology, physiology or behavior can indicate that the physical and/or chemical conditions are outside their preferred limits. The presence of numerous families of highly tolerant organisms usually indicates poor water quality.

There are many different biotic indexes. We used Taxa Richness, Hilsenhoff Biotic Index, Modified EPT Index, Shannon Diversity, % Modified Mayflies, % Modified EPT, % Intolerant taxa to develop a specific score for the thirty sites sampled at the more in-depth level. Table 2.3 shows the results from each of the metrics for each of the sample locations evaluated. Table 2.4 calculates the 5^{th} an 95^{th} percentiles, which are used in Table 2.5 to develop the scoring criteria used to calculate a total score for the site. Scores can be found in Table 2.11 in the Results and Discussion. We compared our scores to a score calculated using the Environmental Alliance for Senior Involvement (EASI) scoring system, a less rigorous system used by many community volunteer organizations (See Table 2.6).

Taxa Richness - the number of distinct taxa. It represents the diversity within a sample. An increased diversity suggests that habitat and food sources are adequate to support survival and propagation of many different species[6].

Hilsenhoff Biotic Index - Uses tolerance values ranging from 1-10, increasing as water quality decreases, to weight abundance in an estimate of overall pollution. Originally designed to evaluate organic pollution

$$HBI= \Sigma \, {}^{xi*ti}/n$$

Where *xi* is the number of individuals within a taxon, *ti* the tolerance value of that taxon, and *n* the total number of organisms in the sample

Modified EPT Index - Number of taxa in the insect orders Ephemeroptera (mayflies)- excluding the families Baetidea, Caenidae, Siphlonuridae; Plecoptera (Stoneflies); and Trichoptera (caddisflies)- excluding the families Hydropsychidae and Polycentropodidae.

Shannon Diversity - A species diversity index that takes into account the numbers of organisms of each species present in a given sample.

$$D.I.= -\Sigma \, {}^{ni}/N \log_e {}^{ni}/N$$

Where D.I. is the species diversity index, *ni* the number of organisms of species *i*, and *N* the total number of organisms in the sample

% Modified Mayflies - Percent of mayfly nymphs in a sample, excluding the families Baetidea, Caenidae, Siphlonuridae.

% Modified EPT - Percent of the composite of mayfly, stonefly and caddisfly larvae in a sample excluding the families mentioned above in the Modified EPT Index.

% Intolerant taxa - Percent of macroinvertebrate families in a sample considered to be tolerant of various types of pollution.

Table 2.3 Metrics Used For Biotic Index Score (IBI)

Site Name	Taxa Richness	Modified EPT Index (HBI <5)	Modified Hilsenhoff Index	% Intolerant Taxa (HBI <4)	Shannon Diversity	% Modified Mayflies (HBI <5)	% Modified EPT (HBI <5)
ALSP03	9	0	6	0	1.57	0	0
CORU01	15	5	4.78	22.6	2.34	1.7	3.7
HOCR01	19	6	4.06	31.7	3.13	30.8	47.3
HOCR03	14	6	4.24	19.7	2.54	17.2	36.9
HOCR07	17	4	4.65	14.4	2.98	10.4	24.2
HOCR09	23	13	3.81	26.4	3.49	21.5	57.6
HOCR10	23	15	3.32	34.8	3.59	24.5	58.9
HOCR12	27	12	2.46	58.4	3.81	16.4	70.3
KICR01	19	2	5.87	0.3	2.73	0.3	1.1
KICR03	14	3	5.14	5.6	2.36	6.3	8.9
KICR04	17	4	5.62	1.0	2.90	0.3	5.4
KICR05	23	9	3.83	30.6	3.67	18.3	30.6
KICR06	15	3	5.05	4.2	2.61	4.2	19.6
KICR07	19	1	5.47	1.5	2.40	0.0	2.2
KICR08	19	3	5.63	3.0	3.17	2.0	4.4
KICR09	16	4	5.60	1.0	2.36	1.4	10.7
KICR25	16	6	4.75	9.3	2.49	6.2	40.7
LACR03	19	10	4.15	25.7	2.87	26.4	71.3
LACR05	26	14	3.48	43.6	3.45	29.0	73.3
LACR07	21	12	2.99	41.8	2.99	3.6	79.2
LKCR04	14	1	6.20	0.7	2.46	0.0	0.7
LKCR06	12	2	6.94	0.7	2.31	0.0	1.1
SORU01	12	1	7.53	0.0	2.32	0.0	0.4
TECR02	11	4	5.53	1.9	1.76	2.5	11.1
TECR03	17	4	4.53	1.6	2.20	0.6	12.5
TECR06	23	13	4.38	26.4	3.01	8.1	25.7
TRRU02	14	3	4.16	18.2	2.80	16.0	50.9
TRRU03	14	6	3.52	35.2	2.89	34.2	40.8
TRRU05	26	13	2.51	61.5	3.51	48.3	72.9
TRRU06	24	13	3.44	50.8	3.92	29.1	55.8

Table 2.4 95th and 5th Percentile

Site Name	Taxa Richness	Modified EPT Index (HBI <5)	Modified Hilsenhoff Index	% Intolerant Taxa (HBI <4)	Shannon Diversity	% Modified Mayflies (HBI <5)	% Modified EPT (HBI <5)
ALSP03	9	0	6	0	1.57	0	0
CORU01	15	5	4.78	22.6	2.34	1.7	3.7
HOCR01	19	6	4.06	31.7	3.13	30.8	47.3
HOCR03	14	6	4.24	19.7	2.54	17.2	36.9
HOCR07	17	4	4.65	14.4	2.98	10.4	24.2
HOCR09	23	13	3.81	26.4	3.49	21.5	57.6
HOCR10	23	15	3.32	34.8	3.59	24.5	58.9
HOCR12	27	12	2.46	58.4	3.81	16.4	70.3
KICR01	19	2	5.87	0.3	2.73	0.3	1.1
KICR03	14	3	5.14	5.6	2.36	6.3	8.9
KICR04	17	4	5.62	1.0	2.90	0.3	5.4
KICR05	23	9	3.83	30.6	3.67	18.3	30.6
KICR06	15	3	5.05	4.2	2.61	4.2	19.6
KICR07	19	1	5.47	1.5	2.40	0.0	2.2
KICR08	19	3	5.63	3.0	3.17	2.0	4.4
KICR09	16	4	5.60	1.0	2.36	1.4	10.7
KICR25	16	6	4.75	9.3	2.49	6.2	40.7
LACR03	19	10	4.15	25.7	2.87	26.4	71.3
LACR05	26	14	3.48	43.6	3.45	29.0	73.3
LACR07	21	12	2.99	41.8	2.99	3.6	79.2
LKCR04	14	1	6.20	0.7	2.46	0.0	0.7
LKCR06	12	2	6.94	0.7	2.31	0.0	1.1
SORU01	12	1	7.53	0.0	2.32	0.0	0.4
TECR02	11	4	5.53	1.9	1.76	2.5	11.1
TECR03	17	4	4.53	1.6	2.20	0.6	12.5
TECR06	23	13	4.38	26.4	3.01	8.1	25.7
TRRU02	14	3	4.16	18.2	2.80	16.0	50.9
TRRU03	14	6	3.52	35.2	2.89	34.2	40.8
TRRU05	26	13	2.51	61.5	3.51	48.3	72.9
TRRU06	24	13	3.44	50.8	3.92	29.1	55.8
5th Percentile			2.72				
Median	17.0	4.5	4.59	16.3	2.84	6.2	24.9
95th Percentile	26.0	13.6		54.9	3.75	32.7	73.1

Table 2.5 Biotic Index

Metric	Percentile	5th or 95th	Scoring Criteria			
			6	4	2	0
Taxa Richness	95th	26	>19	19 - 13	12 - 6	<6
Modified EPT Index (HBI <5)	95th	13.6	>10	10 - 7	6 - 3	<3
*** Modified Hilsenhoff Index**	5th	2.72	<4.03	4.03 - 5.36	5.35 - 6.68	>6.68
% Intolerant Taxa (HBI <4)	95th	54.9	>41.5	41.5 - 27.7	27.6 - 13.9	<13.9
Shannon Diversity	95th	3.75	>2.81	2.81 - 1.87	1.86 - 0.92	<0.92
% Modified Mayflies (HBI <5)	95th	32.7	>24.5	24.5 - 16.4	16.3 - 8.2	<8.2
% Modified EPT (HBI <5)	95th	73.1	>54.8	54.8 - 36.6	36.5 - 18.3	<18.2

* 8.0 was used for top range of HBI

Classification	Very Good		Good	Fair	Poor	Very Poor
Total Score	**>34**		**34 - 26**	**25 - 18**	**17 - 9**	**<9**

Table 2.6 Macroinvertebrate Score From EASI

(Source: http://www.environmentaleducation.org/default.lasso)

Letter codes are be assigned by the database program: R (rare) = 1-9 organisms; C (common) = 10-99 organisms; or D (dominant) = 100-plus organisms.

Group I - Sensitive

Water penny larvae	Riffle beetle adults
Hellgrammites	Stonefly nymphs
Mayfly nymphs	Non net-spinning caddisfly larvae
Gilled snails	

Group II - Somewhat Sensitive

Beetle larvae	Scuds
Clams	Sowbugs
Cranefly larvae	Fishfly larvae
Crayfish	Alderfly larvae
Damselfly nymphs	Net-spinning caddisfly larvae
Dragonfly nymphs	

Group III - Tolerant

Aquatic worms	Midge larvae
Blackfly larvae	Snails
Leeches	

Water Quality Rating

Index values are calculated using the values provided, above.

Group I Sensitive	**Group II Somewhat Sensitive**	**Group III Tolerant**
(# of Rs) x 5.0 = (# of Cs) x 5.6 = (# of Ds) x 5.3 = **Sum of Index Value for Group 1 =**	(# of Rs) x 3.2 = (# of Cs) x 3.4 = (# of Ds) x 3.0 = **Sum of Index Value for Group 2 =**	(# of Rs) x 1.2 = (# of Cs) x 1.1 = (# of Ds) x 1.0 = **Sum of Index Value for Group 3 =**

The sum of the index values for each group equals the water quality score. Compare this score to the following number ranges to determine the quality of this stream site.

Good > 40	Fair 20 - 40	Poor < 20

Chemical

Stream sampling in the field was done using Hach chemistry kits. Seven parameters; temperature, dissolved oxygen, alkalinity, pH, conductivity, nitrate, and sulfate, were measured monthly and periodic samples were sent to Analytical Laboratory Services, Inc. for analysis of nitrate, sulfate, fecal coliform, total suspended solids, and total phosphorus. Samples were sent to Analytical Laboratory Services, Inc. for ammonia-nitrate during the last two months of sampling (March and April 2002), and total coliform was tested on a few occasions in 2001.

Photo Courtesy of *Lewistown Sentinel*

Stream Temperature was measured in Celsius to within 1 degree using a plastic encased thermometer. Temperature was measured in the middle of the channel by placing the thermometer on the stream bottom, except during peak flows in large streams when safety precautions precluded this. In those cases, the thermometer was placed at the farthest point into the channel that was safe to do so.

Dissolved Oxygen was measured using the Hach Company titration test kit 0.2-4 and 1-20mg/L range. Water was collected in the middle of the stream channel, in the middle of the water column, facing upstream, using the glass bottle provided in this kit. This test was completed streamside.

pH was measured using a calibrated, electronic, hand-held, "pocket pal" meter.

Conductivity was measured using a calibrated, electronic, hand-held, "pocket pal" meter.

Alkalinity was measured using the Hach Company titration test kit 5-100, 20-400 mg/L. Water samples were collected into a plastic bottle, in the middle of the stream channel, in the middle of the water column, facing upstream. This test was completed streamside.

Nitrogen was measured using the Hach Company low range nitrate test kit 0-1 and 0-10 mg/L. This kit uses a color wheel comparator to obtain the readings. Water samples were collected into a plastic bottle, in the middle of the stream channel, in the middle of the water column, facing upstream. This test was conducted in the office within four hours of collection from the stream.

Sulfate was measured using the Hach Company sulfate test kit. Water samples were collected into a plastic bottle, in the middle of the stream channel, in the middle of the water column, facing upstream. This test was conducted in the office within four hours of collection from the stream.

Air Temperature was measured in Celsius at each location by hanging the thermometer. An effort was always made to measure the temperature in the shade, however, some locations did not provide shade and in those cases the thermometer was hung on a fence in the sun.

Definitions Of Water Chemistry Analysis:

Stream Temperature
Stream temperature is of critical importance to aquatic life. It affects many biological and chemical reactions. Fisheries have typically been grouped as "Cold Water Fisheries" and "Warm Water Fisheries". These designations take into account the geology, topography, and receiving waters of the stream, but mostly, they refer to what life that stream can sustain. See the Discussion section for more detail on the importance of stream temperature.

Air Temperature
The air temperature was measured at each sample location every month. Temperatures change throughout the course of the day, and sample locations that offered permanent shade often had lower actual temperatures than the official temperature recorded for the day. Trees and other vegetation provide shade, which "buffers" the ground and streams from the warming effects of the sun.

Dissolved Oxygen

Oxygen is a basic requirement for all living organisms, including aquatic organisms. Larvae and juvenile fish are more sensitive to low dissolved oxygen concentrations than adults, but most sport fish species will also suffer if concentrations fall below 3 to 4 mg/L[20]. Oxygen dissolves in water directly from the atmosphere, or as a by-product of photosynthesis from plants. Cold water is able to hold more oxygen than warmer water. It is possible to have too much dissolved oxygen. Dissolved oxygen percent saturation rates greater than 125% is dangerous for some aquatic organisms. Description of Dissolved Oxygen Percent Saturation, Figure 30, demonstrates how to calculate percent saturation. Percent saturation values between 80-124% are considered “excellent”; 60-79% is considered “okay”; and below 60% is considered “poor”.

Oxygen is depleted from water during respiration and transpiration from plants and animals, decomposition of organic material such as dead plants and animals and waste, and warm water temperatures. Dissolved oxygen naturally fluctuates during the course of a day, but human activities that introduce large quantities of biodegradable organic materials, or plant growing nutrients, increases the peak highs and lows. Dissolved oxygen is also affected by water salinity, atmospheric pressure, wind and water depth.

Figure 30 – Dissolved Oxygen Percent Saturation

Dissolved Oxygen (DO) ***Dissolved Oxygen Requirements by Fish Community***

Cold Water Fishes: 6 mg/l and above **Warm Water Fishes:** 5 mg/l

Solubility of Dissolved Oxygen

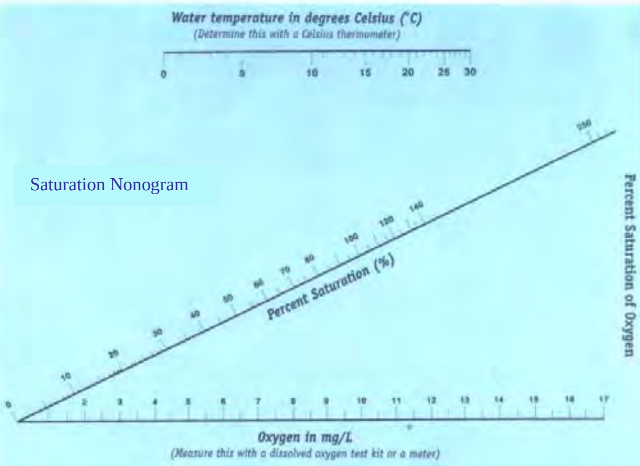
Solubility: Amount of dissolved oxygen that distilled water can hold at given temperature

Temperature (C°):	Solubility (mg/l)
0:	14.6
1:	14.2
2:	13.8
3:	13.5
4:	13.1
5:	12.8
6:	12.5
7:	12.2
8:	11.9
9:	11.6
10:	11.3
11:	11.1
12:	10.9
13:	10.6
14:	10.4
15:	10.2
16:	10.0
17:	9.8
18:	9.6
19:	9.4
20:	9.2
21:	9.0
22:	8.9
23:	8.7
24:	8.6
25:	8.4
26:	8.2
27:	8.1
28:	7.9
29:	7.8
30:	7.7

Dissolved Oxygen Percent Saturation

Directions

1. Determine water temperature in degrees C, and find that value on upper (temperature) scale. *To convert F to C: [(F-32) x 5]/9= C
2. Determine dissolved oxygen and find that value on the lower (DO) scale.
3. Using a straight edge (ruler, piece of paper), draw a line from the temperature value to the dissolved oxygen value. The point at which the line crosses the middle (saturation) scale is the percent saturation of oxygen.



Example:

Water sample at 15 C containing 11 gm/l of DO would be 110% saturated.

% Saturation Values & What They Mean

125% and greater: Too high, may be dangerous to fish

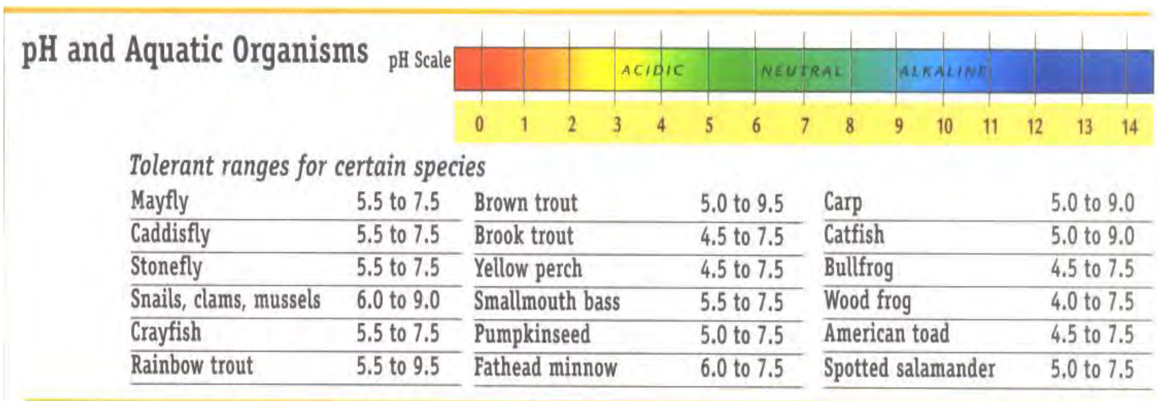
80-124%: Excellent 60-79%: Okay Below 60%: Poor

Adapted from: Water, Water Everywhere: Water Quality Factors Reference Unit, *HACH, Inc., Loveland CO, 800-227-4224.*

pH

pH is the measure of free hydrogen and hydroxide ions in the water which determines the acidity or alkalinity of the water. Most aquatic life prefers water with a pH between 5 and 9 (See Figure 31 below). The pH scale is logarithmic which means it changes by tens. Every change of one whole number equals a tenfold change in the acidity and a change of two whole numbers indicate a 100-fold change in acidity. Fish such as minnows and darters are sensitive to low pH levels. Mayflies seldom live in waters below 5.5 or above 8.8. pH outside of this range stresses the physiological systems of most organisms and can reduce reproduction. Low pH can also produce conditions that are toxic to aquatic life by allowing toxic elements and compounds to become available to organisms. The pH of runoff reflects the chemical characteristics of precipitation and the land surface.

Figure 31 Description of pH and Aquatic Organism's Tolerance Range



Mayfly	5.5 to 7.5	Brown trout	5.0 to 9.5	Carp	5.0 to 9.0
Caddisfly	5.5 to 7.5	Brook trout	4.5 to 7.5	Catfish	5.0 to 9.0
Stonefly	5.5 to 7.5	Yellow perch	4.5 to 7.5	Bullfrog	4.5 to 7.5
Snails, clams, mussels	6.0 to 9.0	Smallmouth bass	5.5 to 7.5	Wood frog	4.0 to 7.5
Crayfish	5.5 to 7.5	Pumpkinseed	5.0 to 7.5	American toad	4.5 to 7.5
Rainbow trout	5.5 to 9.5	Fathead minnow	6.0 to 7.5	Spotted salamander	5.0 to 7.5

Adopted from: Water, Water Everywhere: Water Quality Factors Reference Unit. Hach, Inc., Loveland CO.

Nationally, the average pH of rain is about 5.6 [20], however in Pennsylvania, the average pH of rain water is 4.3 [24]. Limestone neutralizes acidic streams. Streams in limestone valleys are commonly fed by ground water and are more basic. The average pH of ground water in the Kish watershed is 7.25.

Alkalinity

Alkalinity refers to the acid-neutralizing, or buffering, capacity of water and usually refers to those compounds that shift the pH in the alkaline direction. Carbonate and bicarbonate from dissolved calcium carbonate, increases the amount of buffering in a stream[20]. Streams that have a constant alkalinity measure of 140mg/L or more are considered to be true limestone streams[23]. Seventeen sites (29%) tested had constant alkalinity of 140 mg/L or more.

Conductivity

Conductivity measures the ability of water to conduct an electrical current. Inorganic pollutants (sulfates, metals and fertilizers) increase conductivity. Conductivity is primarily related to the geologic composition of the streambed and the presence of materials that ionize when washed into the water such as minerals, salts, metals and acids.

Nitrogen

In the aquatic environment, nitrogen can exist in several forms[20]. The most important forms in terms of their immediate impacts on water quality are ammonia ions (NH_4), nitrites (NO_2) and nitrates (NO_3). Nitrogen is a plant nutrient, therefore high levels of nitrogen increases aquatic algae growth. Nitrogen enters a stream from many different sources: from the air, from fertilizers applied to yards and fields, from wastewater treatment plants, from failing septic systems, and from cow or other sources of manure. The Environmental Protection Agency set drinking water standards for nitrogen at 10 mg/L. Three sites (5%) consistently exceeded this criterion.

Ammonia-nitrate

Ammonia-nitrate (NH_3-N) is toxic at <1 part-per million (ppm) in higher pH's[38]. Ammonia is often a problem associated with manure.

Sulfate

Sulfur in the form of sulfate is required by plants and animals in trace amounts. Sulfate concentrations normally range from five to 50 mg/l in streams, however, it should not exceed 250 mg/l in water used for drinking. Sulfate enters streams as a result of the natural weathering process of various common sulfur-containing sedimentary rocks, bacteria breaking down and releasing hydrogen-sulfide and sulfuric acid from acid precipitation. Although high levels of sulfate indicate a problem, the water's buffering capacity may be the key to whether or not the biological community is seriously impacted when sulfate levels are elevated[3].

Total Phosphorus

Although phosphorus is an essential nutrient for plants, an increase, even in modest amounts, can create algae blooms, lower dissolved oxygen levels, and accelerate eutrophication. Phosphorus binds to the soil. When such soil washes into the stream, it takes the excess phosphorus with it. Samples to be tested for total phosphorus were sent to a lab for analysis.

Total Suspended Solids

Suspended solids indicate that erosion or runoff is occurring. Suspended solids can also be an indicator of high levels of bacteria, protozoa, or viruses from animal or human waste. Solids suspended in the water column also decrease visibility for aquatic life, interfering with the ability of some organisms to find food, and increasing the risk of predation for many other organisms.

Fecal Coliform

Fecal coliform is found in the feces of all warm-blooded organisms and occurs naturally in our environment; however, it is a health risk when found in high concentrations which is one reason proper sewage treatment is important. Fecal coliform enters streams directly, or via groundwater. Usually, forested areas do not exhibit high concentrations of fecal coliform. Manure storage systems, proper manure spreading, pasture water systems (which provide water sources other than the stream), and vegetated buffers along streams help prevent livestock feces from entering streams directly.

Failing septic systems are a second source for elevated fecal coliform levels in streams. Leaching from the septic system can cause groundwater contamination. This is dangerous because not only does groundwater feed streams, it is the source of many drinking water wells.

PADEP's water quality standards, which include bacteria, apply to all surface waters. We know that many of the streams in this watershed are used for recreational purposes, so we decided to test fecal coliform levels. Samples were sent to the lab for analyses of fecal coliform during our normal sampling periods.

Groundwater

The term "watershed" describes a geographic area defined by all the land which water flows across, or beneath to drain to the nearest body of water. Since all land use practices affect water quality, even a landowner without a stream on their property has the potential to affect water quality. For this reason, a watershed study ideally tests ground water as well as surface water. This study offered homeowners a one-time test of their drinking water source, however only a few homeowners took advantage of this offer. A study conducted by the United States Geological Survey (USGS) in 1996 tested 15 wells in the valley (See Appendix K, USGS Groundwater Data). Those results are included in this assessment and follow the water chemistry results conducted during this study.

Wildlife

Small mammal traps were set on two farms along the mainstem of Kishacoquillas Creek. Both farms have fenced buffers along the stream. Eighty (80) Sherman Live traps and Havaheart live traps were used at each site. Traps were set for two consecutive nights on two separate occasions, once in spring 2001 and once in fall 2001. Traps were baited with a mixture of peanut butter and oatmeal and padded with lint for bedding.

Birds were identified by vocalization or by sight during January, February and the first half of March while at sample locations collecting chemical data. Sample locations in sight or hearing range from one another were combined for this survey.

Public Survey

A survey of residents of the Kishacoquillas watershed was conducted between April and May 2002. The survey focused on issues of growth and the quality of life within the Kish watershed. In accordance with established survey procedures that afford each resident an equal opportunity to respond, questionnaires were mailed to 664 randomly selected residents from Menno, Union, Brown, and Armagh Townships. To assure that each municipality was equally represented, 15% of the population in each of the four townships received a survey. Surveys were returned to Penn State Cooperative Extension, who then complied results, analyzed the data, and wrote the final survey report (See Appendix I, Public Survey Final Report).

Agricultural Best Management Practices

We looked at all of the Conservation Plans written for farms in the watershed and made an Excel spread sheet using conservation practice codes in the columns, and units in the rows (See Table 2.29 , pg.103). When the units for a practice code were acres, they were compared to the number of acres of farmland. This allowed us to determine what percent of the farmland was applying certain conservation practices. For a map of the Farms with Conservation Plans by Subwatershed, see Figure 32, pg. 67.

Flow Measurements

Measurements to calculate flow in cubic feet per second (cfs) were taken in summer and early fall. Total stream width was measured with a 100 ft tape. A Pygmy Meter was used to measure depth and velocity at multiple increments along the width. Increment number and width varied depending on the total stream width. Standard PADEP formulas were used to calculate flow from the width, depth, velocity and increment measurements. See Appendix G for complete flow data results.

Weather

Weather data was collected from the Lewistown Sentinel, the local daily newspaper. Sources for their weather include the National Weather Service in State College, and the Lewistown Waste Water Treatment Plant. Please refer to Appendix H for complete weather data.

Results and Discussion

Fifty-nine locations were selected to be sampled for habitat, biological conditions, and water chemistry. Additional information such as bird surveys, flow data, and at two locations, small mammal trapping, was also collected. One site on Laurel Creek, LACR01, was dry during the entire length of the study, but was checked every month. All other sites had water flowing during at least some portion of the study. Water chemistry results do not include LACR01 since there was never any water to test.

The results of our field work demonstrate that water quality is affected by more than just what is occurring at the specific location being sampled. Water quality is impacted by landuse in the watershed and the water's ability to filter nutrients and sediment. In areas where water flows through a continuous vegetated corridor with adequate width, our results showed less impairment. In areas where stream corridors were non-existent, or highly fragmented, results indicated impairments in multiple categories of habitat, biological, and water chemistry (See Figure 33, pg. 108). Refer to Figure 15, pg. 53, to see sample locations north of Federal Highway 322 and Figure 16, pg. 54, to see sample locations south of Federal Highway 322.

Habitat

An evaluation of habitat quality is an essential element of any watershed assessment. We evaluated twelve habitat parameters (See Methods Section, pg. 33) at each sample location (or "sites") using PADEP's modified Rapid Bioassessment Protocol data sheet (See Appendix D). Each sample location's individual habitat parameter scores and overall Habitat Assessment Score can be found in Appendix J. See Figure 34, pg. 109, for the overall habitat assessment scores by sample location. See Figure 35, pg. 110 for habitat impairment by sample location. Of the 59 sample locations, 33 were evaluated twice, once in January 2001 and once in the summer of 2001. Of the sites not evaluated twice, four sites were not evaluated in January because they were frozen and 28 sites were added following the January sampling season. Two locations were not evaluated at all because they were consistently dry. The 33 sites that were sampled twice were averaged for all analysis.

***Habitat alteration is a primary cause of degraded aquatic resources, and preservation of natural habitat is a fundamental requirement for maintaining a functional aquatic community*.**

Habitat alteration is a primary cause of degraded aquatic resources, and preservation of natural habitat is a fundamental requirement for maintaining a functional aquatic community. Aquatic fauna often have very specific habitat requirements that are independent of water-quality composition[6]. Our findings showed that sediment, embeddedness, condition of banks, and an absence of a riparian vegetative zone width are the lowest scoring habitat parameters and therefore are the greatest concerns facing the watershed (See Figure 36, pg. 70).

Habitat Assessment Scores

A comparison of all sample location's individual habitat parameters demonstrates areas that are doing well, and the areas that can improve. Table 2.7 breaks down all 57 sample locations by range and habitat parameter with the over all habitat assessment score listed by range at the bottom. Site-specific overall habitat assessment scores for each sample location were calculated by totaling the individual habitat parameter scores for each sample location. Fourteen sample locations (25 % of the total) had habitat assessment scores in the optimal range, 27 sample locations (47%) scored in the Suboptimal range, 11 sample locations (19%) scored in the Marginal range, and 5 sample locations (9%) scored in the Poor range. Figure 35, pg.110 shows the parameters that had the most scores in the "optimal" and "suboptimal" range included; channel alteration (81%), channel flow status (81%), instream cover (68%), and velocity/depth regimes (68%). Conversely, the parameters that had the most scores in the "poor" or "marginal" range included; Riparian vegetative zone width (60%), sediment deposition (51%), embeddedness (46%), and conditions of banks (44%) (See Figure 37, pg.70).

Table 2.7 Summary of the number of Sample Locations in each range by habitat parameter for 57 Sample Locations.

Habitat Parameter	Optimal Range	Suboptimal Range	Marginal Range	Poor Range
Instream Cover (fish)	30	9	11	7
Epifaunal Substrate	17	20	7	13
Embeddedness	11	20	15	11
Velocity/Depth Regimes	18	21	13	5
Channel Alteration	15	31	9	2
Sediment Deposition	11	17	17	12
Frequency of Riffles	26	10	8	13
Channel Flow Status	40	6	6	5
Condition of Banks	12	20	12	13
Bank Vegetative Protection	26	15	8	8
Grazing or other Disruptive Pressure	26	13	8	10
Riparian Vegetative Zone Width	15	8	12	22
Overall Habitat Assessment Score	14	27	11	5

Figure 36 Percent of Sites in the Poor and Marginal Range

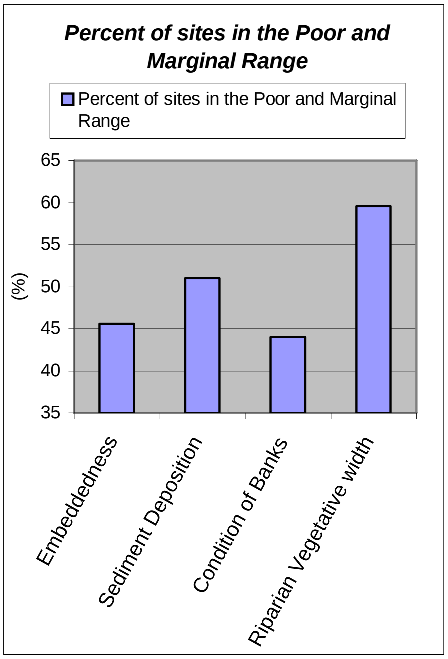
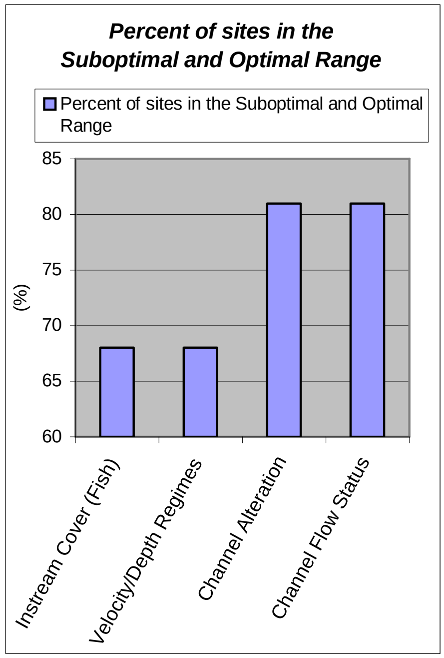


Figure 37 Percent of Sites in the Sub-Optimal and Optimal Range



A high percent of sample locations with optimal scores were mostly on streams north of Federal Highway 322. All five of the sample locations that scored in the "poor" range are located south of Federal Highway 322. Four of these five sample locations are located in the village of White Hall. The fifth sample location is just south of Belleville. See Table 2.8 for a break down of all 29 sample locations north of Federal Highway 322 and Table 2.9 for a break down of all 28 sample locations south of Federal Highway 322, by range and habitat parameter with the over all habitat assessment score listed by range at the bottom.

In general, the sites that scored better tended to use the stream as a natural edge and allowed trees and other vegetation to grow along the stream banks. Additionally, pastures tended not to include the whole length of the stream, but instead only included a portion of the stream. Roads did follow the streams with more frequency on the north side of Federal Highway 322 than on the south side, but again, natural vegetation was allowed to grow between the road and the stream.

Table 2.8 Summary of the number of Sample Locations in each range by habitat parameter for 29 sample locations north of Federal Highway 322 (including TECR06)

Habitat Parameter	Optimal Range	Suboptimal Range	Marginal Range	Poor Range
Instream Cover (fish)	25	3	1	0
Epifaunal Substrate	13	11	2	3
Embeddedness	10	14	5	0
Velocity/Depth Regimes	15	9	4	1
Channel Alteration	12	15	1	1
Sediment Deposition	9	12	8	0
Frequency of Riffles	19	3	4	3
Channel Flow Status	22	1	4	2
Condition of Banks	7	10	7	5
Bank Vegetative Protection	17	8	3	1
Grazing or other Disruptive Pressure	20	5	4	0
Riparian Vegetative Zone Width	11	8	8	2
Overall Habitat Assessment Score	12	16	1	0

Mainstem Honey Creek Sites

There were 11 sample locations on Honey Creek. Four overall habitat assessment scores were "optimal", seven Habitat Assessment Scores were "suboptimal" and none of the sample locations had Habitat Assessment Scores in "marginal" or "poor" range. Individual habitat parameters shows that all 11 (100%) of the sample locations scored "optimal" or "suboptimal" for instream cover (fish), epifaunal substrate, and velocity/depth regimes. A few of the individual habitat parameters did score in the "marginal" or "poor" range. Conditions of banks (45%), bank vegetative protection (36%), and grazing or other disruptive pressure (36%) had the most scores in the "poor" or "marginal" range

Havice Creek Sites

We sampled three locations on Havice Creek. One scored "optimal", one scored "suboptimal", and one scored "marginal" for the overall habitat assessment score. None of the individual parameters had all three sample locations scoring in the same category. Two of the three sites scored "optimal" or "suboptimal" for the following individual parameters: channel alteration, bank vegetative protection, and grazing or other disruptive pressure. Two of the three sites scored "marginal" or "poor" for the individual parameter frequency of riffles and velocity/depth regimes.

Treaster Run Sites

We sampled six locations on Treaster Run. Two (33%) sample locations scored in the "optimal" range. Four (66%) sample locations scored in the "suboptimal" range, and none of the sample locations scored "marginal" or "poor" for the overall habitat assessment score. Individual habitat parameters showed that instream cover (fish) (100%), bank vegetative protection (100%), grazing or other disruptive pressure (100%) and embeddedness (100%) had the most scores in the "optimal" or "suboptimal" range. Channel flow status (66%), condition of banks (50%) epifaunal substrate (50%) and riparian vegetative zone width (50%) had the most scores in the "marginal" or "poor" range.

Laurel Creek Sites

We established seven sample locations on Laurel Creek. Two were dry the entire year and we did not evaluate habitat parameters at those two locations. At the five remaining sample locations on Laurel Creek, three (60%) sample locations scored "optimal", two (40%) sample locations scored "suboptimal" and none scored "marginal" or "poor" for the overall habitat assessment score. Grazing or other disruptive pressure (100%), bank vegetative protection (100%), frequency of riffles (100%) and channel flow status (100%) had the most scores in the "optimal" or "suboptimal" range. Riparian vegetative zone width (60%), and condition of banks (40%) had the most scores in the "marginal" or "poor" range.

Tea Creek Sites

We sampled three locations on Tea Creek. Two of the three locations scored "optimal" for the overall habitat assessment score. The third location scored "suboptimal". Individual habitat parameters looked very good for these locations. The only scores that were not 100% in the "optimal" or "suboptimal" range were for embeddedness, sediment deposition and condition of banks.

Unnamed Tributary to Tea Creek

We sampled one site on an unnamed tributary to Tea Creek. It scored "suboptimal" for the overall habitat assessment score. The only scores that were not in the "optimal" or "suboptimal" range were for embeddedness and sediment deposition, both of which scored in the "marginal" range.

Sample locations on the south side of Federal Highway 322 had more habitat assessment scores in the middle two categories of "suboptimal" and "marginal". These sample locations frequently were in pastures or mowed lawns. These sample locations tended to have more active uses such as providing water for livestock, or recreation for families. Pastures tended to follow the length of the stream, and in residential areas, the stream edge was mowed for the entire property boundary. Roadways did not follow the stream, but rather were on higher ground; thus, no vegetated buffer was established between the roads and the streams, as was the case in many places north of Federal Highway 322.

Table 2.9 Summary of the number of Sample Locations in each range by habitat parameter for 28 sample locations south of Federal Highway 322 (not including TECR06)

Habitat Parameter	Optimal Range	Suboptimal Range	Marginal Range	Poor Range
Instream Cover (fish)	5	6	10	7
Epifaunal Substrate	3	10	5	10
Embeddedness	1	6	10	11
Velocity/Depth Regimes	3	12	9	4
Channel Alteration	4	15	8	1
Sediment Deposition	3	4	9	12
Frequency of Riffles	7	7	4	10
Channel Flow Status	18	5	2	3
Condition of Banks	5	10	5	8
Bank Vegetative Protection	9	7	5	7
Grazing or other Disruptive Pressure	6	8	4	10
Riparian Vegetative Zone Width	4	0	4	20
Overall Habitat Assessment Score	2	11	10	5

Mainstem Kishacoquillas sites

There were 12 sample locations on the mainstem of Kishacoquillas Creek. Two sample locations scored “optimal” (17%), four scored “suboptimal” (33%), four scored “marginal” (33%), two scored “poor” (17%) for the overall habitat assessment score. Individual habitat parameters shows that channel alteration (83%), channel flow status (83%), and bank vegetative protection (83%) had the most scores in the “optimal” and “suboptimal” range. Riparian vegetative zone width (83%), sediment deposition (75%), and embeddedness (75%), had the most scores in the “poor” or “marginal” range.

Little Kishacoquillas sites

There were six sample locations on Little Kishacoquillas Creek. None of those sample locations scored “optimal”. Three scored in the “suboptimal” range (50%), two scored in the “marginal” range (33%), one scored in the “poor” range (17%) for the overall habitat assessment score. Individual habitat parameters showed that velocity/depth regimes (67%) and channel flow status (87%) had the most scores in the “optimal” and “suboptimal” range. Embeddedness (67%), channel alteration (67%), sediment deposition (67%), and riparian vegetative width (100%) had the most scores in the “marginal” or “poor” range.

Kings Hollow and Unnamed Tributaries to Little Kishacoquillas and Kishacoquillas Creek Sites

We sampled one location on Kings Hollow, one unnamed tributary to Little Kishacoquillas Creek and one unnamed tributary to Kishacoquillas Creek. None of those sample locations scored “optimal”. Two scored “suboptimal” and one scored “poor” for the overall habitat assessment score. The following parameters each had two of the three sites scoring in the “optimal” or “suboptimal” range: embeddedness, channel alteration, frequency of riffles, channel flow status, condition of banks, and bank vegetative protection. The following parameters each had two of the three sites scoring in the “marginal” or “poor” range: instream cover (fish), epifaunal substrate, velocity/depth regimes, sediment deposition, grazing or other disruptive pressure, and riparian vegetative width zone. None of these parameters had all three sites scoring in just the “optimal”/”suboptimal” or “marginal”/”poor”.

Soft Run sites

We sampled three locations on Soft Run. None of those overall habitat assessment scores were “optimal”. One scored “suboptimal”, one scored “marginal”, and one scored “poor” for the overall Habitat Assessment Score. All three sites scored “suboptimal” under channel alteration. Two of the three sites scored “optimal” or “suboptimal” for channel flow status. The following parameters had two or more of the three sites scoring in the “marginal” or “poor” range: instream cover (fish); epifaunal substrate; embeddedness; velocity/depth regimes; sediment deposition; frequency of riffles; condition of banks; bank vegetative protection; grazing or other disruptive pressure; riparian vegetative zone width.

Alexander Springs sites

We sampled three locations on Alexander Springs. All three overall habitat assessment scores were “marginal”. All three sites scored “optimal” for the channel flow status parameter, “marginal” for velocity/depth regimes, and “poor” for both grazing or other disruptive pressure and riparian vegetative zone width. The following parameters had two or more of the three sites scoring in the “optimal”/ “suboptimal” range: epifaunal substrate; channel alteration; frequency of riffles and channel flow status. The following parameters had two or more of the three sites scoring in the “marginal”/ “poor” range: instream cover (fish); embeddedness; velocity/depth regimes; sediment deposition; bank vegetative protection; grazing or other disruptive pressure; riparian vegetative zone width.

Coffee Run site

Only one location was sampled on Coffee Run. It scored in the “suboptimal” range for the overall habitat assessment score. It scored “optimal” for instream cover (fish) and frequency of riffles, and “poor” for sediment deposition and riparian vegetative zone width.

Discussion:

Habitat includes all the requirements any given species needs to live in a specific location. All species need food, water, and shelter to survive. Streamside areas are significant sources of many of the requirements of stream dwelling creatures. Undercut banks provide cool areas and protection from predators, overhanging roots provide protected areas to escape, leaves from trees provide food and shelter for

macroinvertebrates, places to hide for smaller fish, material for spawning and many other benefits. Without the complete package, organisms can't survive. Our survey points to areas that can be improved as well as areas where restoration is not needed (See Figure 36 and Figure 37 on pg. 70).

In many cases, vegetated stream corridors are the last line of defense before the effects of degradation are felt in surface waterbodies. Vegetated stream corridors provide multiple functions. They provide the habitat components which allow species to live, reproduce, feed, and move; they act as a barrier that stops certain materials and organisms from entering the stream; they are a conduit that allows the system to transport other materials and organisms; they hold additional water in the soil and release it slowly back into the environment through plant transpiration. The two attributes most important to the operation of a vegetated stream corridor are its connectivity and its width[20]. These two attributes provide continuous protection to a stream, and allows the riparian buffer to function to the fullest by filtering out as many pollutants as possible. Roads provide many additional challenges and are the source of pollutants and increase storm water velocities. Roadside storm drains do not outlet into stormwater basins or treatment plants, but instead, outlet directly into streams. In addition to the untreated pollutants, the rapid increase in volume causes accelerated bank erosion. Vegetated stream corridors help protect and stabilize the banks and begin to filter the pollutants deposited in the stream. When an impervious surface such as a road follows a stream, it is very important to have an adequate riparian vegetative zone. Adequate riparian vegetative zones are one of this area's greatest challenges. We found that the roadways on the north side of Federal Highway 322 tended to follow streams. The unutilized area between the roadway and the stream often did provide a buffer that allowed natural vegetation to grow. Even with these additional roadside buffers, our results showed that 60% of all locations sampled scored in the "marginal" or "poor" range for Riparian Vegetative Zone Width. A riparian vegetative zone (a stream corridor, or buffer) is a diverse plant community of grasses, shrubs and trees along the bank. While most of the streams had grasses growing along the banks, the species of grasses found dose not do enough to reduce erosion, provide shade or provide most of the other benefits associated with adequately diverse vegetation along streambanks, especially when it is grazed or mowed short. Most grass species used in pastures or growing in lawns have shallow root system that do little to provide bank stability during storm events. Certain species of grasses, commonly called "warm season grasses" have a deeper, more stabilizing root system, but we did not encounter these types of grasses within the vegetative zone (See Properly Planted Riparian Buffers).

When erosion is accelerated beyond the sediment-transport capacity of a stream, it accumulates, affecting the biology, available habitat, water temperature, and water quality.

The importance of riparian buffers cannot be overstated. A buffer serves a diverse and important role in stream stability and health. During flood events, vegetation along a stream slows rising waters by creating friction as water flows over, through, or past it, thus reducing the erosional impacts of flooding by dissipating water and decreasing the velocity of rising waters. Vegetative buffers decrease streambank erosion. Roots help hold soils in place, and leaves, stems, and grass reduce the erosional impacts of rain hitting bare soil. Buffers help stop sheet erosion by filtering out the soil prior to the water reaching the stream. When soil enters surface water bodies such as streams, it is called sediment. One principal function of a stream is to transport sediment out of the watershed. When erosion is accelerated beyond the sediment-transport capacity of a stream, it accumulates, affecting the biology, available habitat, water temperature, and water quality[20].

While to some extent erosion is a natural process, our land use practices can increase the process, and an excess of sediment has many damaging effects on a stream. The degree of embeddedness of rocks and cobble is a result of sedimentation.

Embeddedness refers to an excess of fine sediment deposition that fills the spaces between gravel and cobble stream bottoms[20]. Sediment covers gravel beds and cobble bars, which are important spawning areas for many species of fish, and also smothers fish eggs and the aquatic insects fish eat. Sediment is abrasive and can clog gills and interfere with the breathing of many aquatic residents. Suspended sediment (turbidity) increases water temperature, reduces light penetration, and reduces the ability of fish to locate and capture prey by greatly reducing visibility[17]. An increase in temperature and limited light penetration also reduces the amount of available oxygen. This combined with a reduction in reproduction, and interference of the breathing mechanisms of aquatic species, can cause a sever decline in biotic abundance and diversity.

Nutrients and toxic chemicals can attach to sediment particles[17]. When these particles enter a water body, they can become soluble in the water column, or settle to the bottom[20]. These pollutants are consumed by macroinvertebrates that feed by filtering the water and in turn are consumed by other organisms. Pollutants concentrate in the tissues of animals at higher trophic levels. Occasionally there is a ban on fish consumption due to a toxic build up of certain chemicals in fish tissue. This is one sign of the effects of our actions on the biological community. An increase in sediment also increases the operating expenses for area municipal water authorities in many ways. Sediment reduces reservoir storage capacity. It has the potential to damage instruments and it increases the cost of water treatment. Decreases in water storage capacity caused by excessive

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sediment affect local landowners as well by increasing the potential for flooding. A channel that is full of sediment, but receives an increase in water, such as during a storm event, will overflow its banks. The increased pressure on the bank edges, if not stabilized by vegetation, will erode, thus perpetuating the problem downstream.

Biological

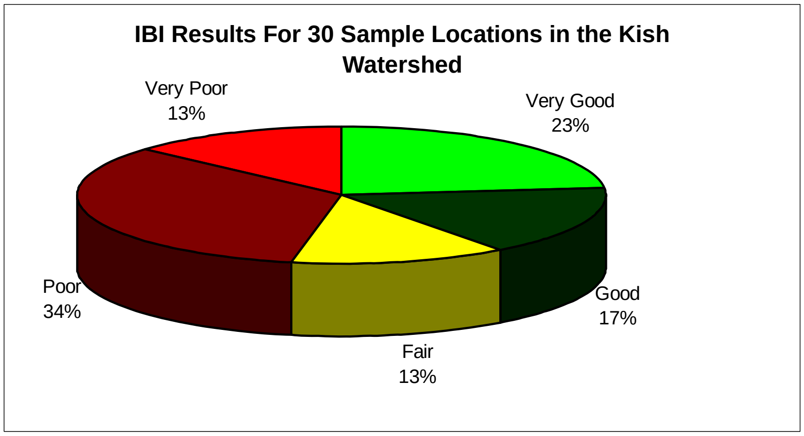
Most species of benthic macroinvertebrates have complex life cycles of approximately one year or more. As a group, they constitute a broad range of trophic levels and pollution tolerances, thus they provide strong information for interpreting cumulative effects of water quality[6].

We sampled macroinvertebrates using PADEP's "Unassessed Waters Field Form: Wadable Streams"(see Appendix E), which identified macroinvertebrates to the family level, at 54 sample locations. Thirty-one sample locations (57%) were sampled two times, once in the winter and once in the summer. Twenty-three sample locations (43%) were sampled in the summer only. If you are interested in this data, contact the Conservation District.

Thirty sample locations were selected for additional sampling using a more in-depth sample technique that identified macroinvertebrates to the genus level. (See Appendix P to review the data for the 30 sample locations , and Appendix L to review box plots of the data). This included using the procedure outlined in William Hilsenhoff's article, "An Improved Biotic Index of Organic Stream Pollution" which quantifies the data collected and therefore can be used to develop the metrics used for analysis. To see the improved biotic index (IBI) scores by sample location, see Table 2.10 or Figure 38, pg.111. To see a map of the sites that are biologically impaired, see Figure 39, pg. 112. Refer to the "Methods" section for a more in-depth look at metrics, definitions and the numbers used for scoring.

Limestone streams have a different macroinvertebrate community composition than free-stone and spring fed streams[29]. The Kish Watershed has limestone, free-stone and spring fed streams. Limestone streams are characterized by alkalinity greater than 140mg/L and a more constant temperature. About an eighth (13%) of the sites we sampled using the Hilsenhoff in-depth method are considered limestone streams by this definition. Macroinvertebrate communities in limestone streams tend to have lower diversity, but a higher density of those few taxa[29]. While we did calculate taxa richness (the number of distinct taxa) we did not use this metric alone to determine impaired areas.

Figure 40. IBI results for 30 sample locations in the Kish Watershed



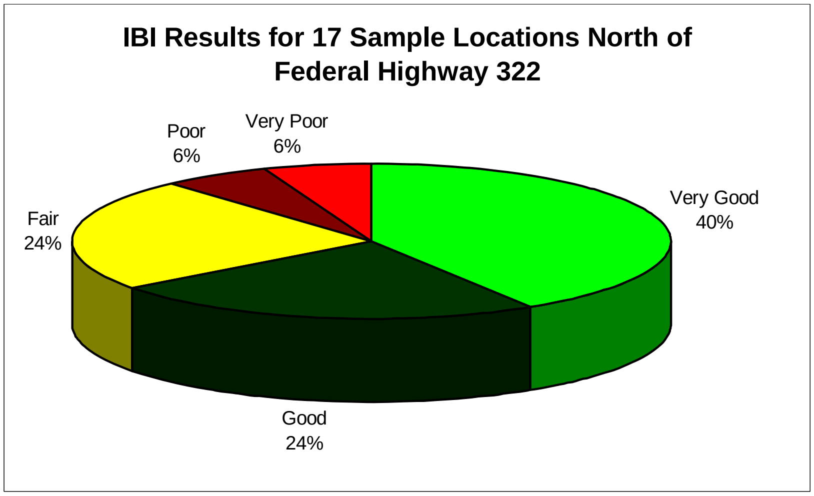
Of the thirty sample locations analyzed in-depth using multiple metrics, seven (23%) scored "Very Good", five (17%) scored "Good", four (13%) scored "Fair", ten (34%) scored "Poor" and four (13%) scored "Very Poor" (See Figure 40, above). To see which sites scored in each category, see Table 2.10.

Sample Locations north of Federal Highway 322 (including TECR06)

Just like the habitat results, most of the sample locations with an IBI score of "Very Good" or "Good" were on streams north of Federal Highway 322. Most of the seven sites that scored "Very Good" are located in forested areas of the watershed that do not have a lot of agriculture or permanent development upstream (See Figure 38, pg. 111). All four sample locations that scored "Fair" were located near a change in the landuse that may have impacted the biotic community. HOCR07 was located on Honey Creek just downstream from Alexander Cavern. Sample location HOCR03 was located on Honey Creek downstream from an agricultural area. Sample location TRRU02 was located immediately after the confluence of Treaster Run and Havice Creek. Sample location KICR25 was located on Kish Creek in Mann Narrows, just below the confluence of Honey Creek, Tea Creek and the mainstem of Kish Creek, and was within a mile of the duck ponds on Tea Creek in Reedsville and the Armagh Township Municipal Authority Sewage Treatment Plant.

The only sites north of Federal Highway 322 to score "Poor" and "Very Poor" were both located on Tea Creek. TECR03, a site downstream from a concentration of farms along the stream, scored "Poor". TECR02, a site located on Tea Creek just before it enters Kish Creek, scored "Very Poor". This site was approximately ¼ mile downstream from the duck ponds on Tea Creek in Reedsville. See Figure 41, pg. 80 for a breakdown of the percentages of sample locations north of Federal Highways 322 in each category.

Figure 41. IBI Results for 17 Sample Locations North of Federal Highway 322



Sample Locations south of Federal Highway 322 (not including TECR06)

Only one sample location south of Federal Highway 322 scored "Good". This sample location (KICR05) is located along the edge of Jacks Mountain and is 100% forested on one side of the stream, and 95% forested on the other side. Kish Creek follows the base of the ridge and flows through forested habitat for a number of miles prior to reaching this site. Nine of the ten sample locations that scored "Poor" and three of the four sample locations to score "Very Poor" were also located south of Federal Highway 322. All of the sites on the mainstem of Kish Creek located upstream from Union Mills scored "Poor". At Union Mills the stream takes a hard turn and then follows the base of Jacks Mountain. Both sites on Little Kish Creek and the site on Soft Run scored "Very Poor". No sample locations south of Federal Highway 322 scored "Very Good" or "Fair". See Figure 42, below, for a breakdown of the percentages of sample locations south of Federal Highways 322 in each category.

Figure 42. IBI Results for 13 Sample Locations South of Federal Highway 322

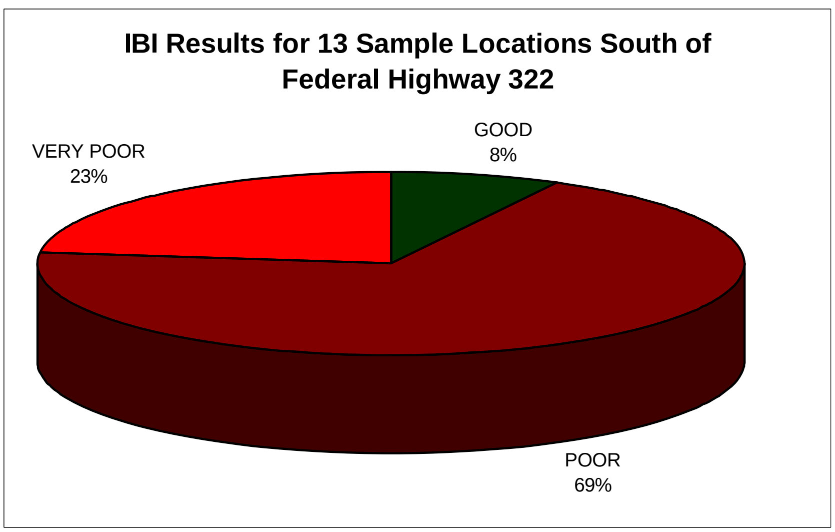


Table 2.10 Biotic Index Site Score

Site Name	Taxa Richness	Modified EPT Index (HBI <5)	Modified Hilsenhoff Index	% Intolerant Taxa (HBI <4)	Shannon Diversity	% Modified Mayflies (HBI <5)	% Modified EPT (HBI <5)	Total Score	Classification
LACR05	6	6	6	6	6	6	6	**42**	**Very Good**
TRRU05	6	6	6	6	6	6	6	**42**	**Very Good**
TRRU06	6	6	6	6	6	6	6	**42**	**Very Good**
HOCR12	6	6	6	6	6	4	6	**40**	**Very Good**
HOCR09	6	6	6	2	6	4	6	**36**	**Very Good**
HOCR10	6	6	6	2	6	4	6	**36**	**Very Good**
LACR07	6	6	6	6	6	0	6	**36**	**Very Good**
KICR05	6	4	6	4	6	4	2	**32**	**Good**
LACR03	4	4	4	2	6	6	6	**32**	**Good**
TRRU03	4	2	6	4	6	6	4	**32**	**Good**
HOCR01	4	2	4	4	6	6	4	**30**	**Good**
TECR06	6	6	4	2	6	0	2	**26**	**Good**
HOCR03	4	2	4	2	4	4	4	**24**	**Fair**
HOCR07	4	2	4	2	6	2	2	**22**	**Fair**
TRRU02	4	2	4	2	4	2	4	**22**	**Fair**
KICR25	4	2	4	0	4	0	4	**18**	**Fair**
CORU01	4	2	4	2	4	0	0	**16**	**Poor**
KICR06	4	2	4	0	4	0	2	**16**	**Poor**
KICR03	4	2	4	0	4	0	0	**14**	**Poor**
KICR04	4	2	2	0	6	0	0	**14**	**Poor**
KICR08	4	2	2	0	6	0	0	**14**	**Poor**
TECR03	4	2	4	0	4	0	0	**14**	**Poor**
KICR07	4	0	4	0	4	0	0	**12**	**Poor**
KICR09	4	2	2	0	4	0	0	**12**	**Poor**
KICR01	4	0	2	0	4	0	0	**10**	**Poor**
LKCR04	4	0	2	0	4	0	0	**10**	**Poor**
TECR02	2	2	2	0	2	0	0	**8**	**Very Poor**
LKCR06	2	0	0	0	4	0	0	**6**	**Very Poor**
ALSPO3	2	0	2	0	2	0	0	**6**	**Very Poor**
SORU01	2	0	0	0	4	0	0	**6**	**Very Poor**

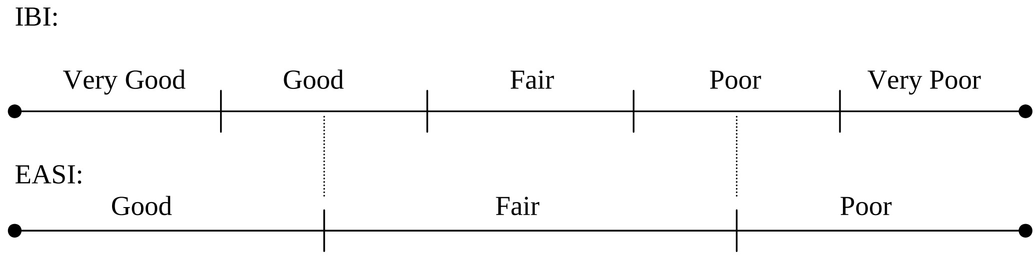
Table 2.11 EASI and IBI Macroinvertebrate Scores for Thirty Sample Locations

Site Name	EASI Score	EASI Rating	Total IBI Score	IBI Classification
KICR05	75	Good	32	Good
HOCR09	71	Good	36	Very Good
HOCR01	65	Good	30	Good
HOCR03	61	Good	24	Fair
HOCR10	58	Good	36	Very Good
LACR05	57	Good	42	Very Good
TRRU05	57	Good	42	Very Good
HOCR12	55	Good	40	Very Good
TECR06	53	Good	26	Good
LACR07	49	Good	36	Very Good
TRRU06	48	Good	42	Very Good
LACR03	47	Good	32	Good
KICR25	46	Good	18	Fair
KICR08	40	Good	14	Poor
TRRU03	40	Good	32	Good
TECR03	37	Fair	14	Poor
KICR06	36	Fair	16	Poor
CORU01	35	Fair	16	Poor
LKCR04	35	Fair	10	Poor
HOCR07	34	Fair	22	Fair
KICR07	31	Fair	12	Poor
KICR04	26	Fair	14	Poor
KICR01	25	Fair	10	Poor
KICR03	21	Fair	14	Poor
TECR02	21	Fair	8	Very Poor
KICR09	19	Poor	12	Poor
ALSP03	18	Poor	6	Very Poor
SORU01	15	Poor	6	Very Poor
LKCR06	No Data	No Data	6	Very Poor
TRRU02	No Data	No Data	22	Fair

Environmental Alliance for Senior Involvement (EASI) Scores:

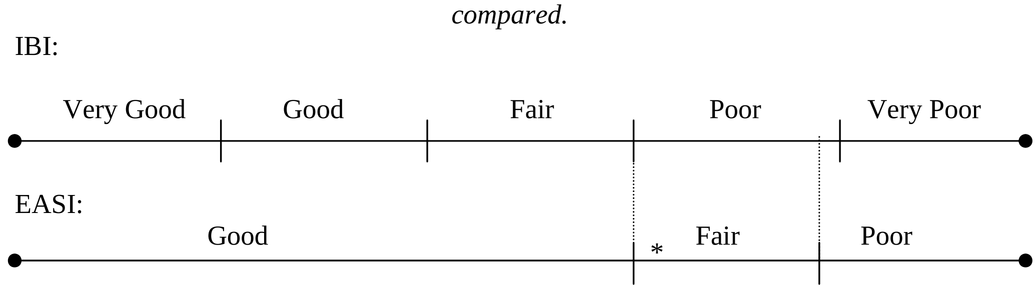
The IBI classification assigned the sites “Very Good” “Good” “Fair” “Poor” and “Very Poor”, where as the EASI scoring system only classifies sites as “Good” “Fair” or “Poor”. See Table 2.11 for the results of EASI and IBI scoring by sample location. If the scoring system was equal in value, sites that scored “Good” using the EASI system might have scored either “Very Good” or “Good” using the IBI system. Sites that scored “Fair” using the EASI system might have scored “Good” “Fair” or “Poor” using the IBI system. Sites that scored “Poor” using the EASI system might have scored “Poor” or “Very Poor” using the IBI system (See conceptual drawing below, Figure 43).

Figure 43 Conceptual drawing of the classification overlap between the EASI classification system and the IBI classification system.



A comparison of the 30 sample location scores calculated using the in-depth multiple metric approach (IBI) and the approach taken by EASI showed that seven (24%) received the same score, 13 (45%) had a higher EASI score and five (17%) had a lower EASI score. Of the 13 that had a higher EASI score, four had an IBI score of "Very Poor". The EASI system does not have a "Very Poor" rating, so nine (30%) sample locations that received an IBI score of "Good" "Fair" or "Poor" scored higher using the EASI method than the IBI method. All five sample locations that had a lower EASI score, scored "Very Good" using the IBI scoring method, and "Good" using the EASI scoring method. The EASI system does not have a "Very Good" rating; therefore all sites that are exceptional would automatically receive a "Good" rating using EASI's method. The conceptual drawing below (Figure 44) gives an example of how the systems actually matched up when comparing the scores for all thirty sample locations.

Figure 44 Conceptual drawing of the overlap between the EASI classification scores and the IBI classification scores as they appeared to rate for the thirty sample locations compared.



* Outlying example; EASI Score Good and IBI Score Poor

Discussion:

Macroinvertebrates are very important to the function of a stream and because of their life cycle, they are a good measure of water quality attainment (See Figure 44, above). As mentioned in the Methods section (See pg. 37) they breakdown leaves, twigs, organic particles, and algae. They are an important part of the food chain, providing food for other aquatic organisms as well as larger organisms such as fish, frogs, salamanders, mink, raccoons, and birds both while in the streams and once they have emerged. Mayflies and stoneflies in particular are important food sources for trout.

There are over 2,000 species of aquatic insects and at least 312 species of caddisflies in Pennsylvania[37]. Many of them have a life-cycle of about a year (except the dobsonfly which has a two-three year life-cycle and the dragonfly which sometimes lives for five years[37]) and live most of their lives in the water, but emerge and disperse in the adult stages of their lives. Certain macroinvertebrate families are more sensitive to pollutants than others and because they are not able to escape episodes of high pollutants, their presence generally means that their environmental conditions are being met.

Macroinvertebrate communities reflect the impacts different land use practices have on water quality. Many times the effect of a particular land use is evident downstream for long distances. Two sample locations that demonstrate the impacts of landuse upstream are sample location TRRU03 (score "Good"), located on Treaster Run just before the confluence with Havice Creek and sample location TRRU02 (score "Fair"), located immediately after Havice Creek joins Treaster Run. The worse score at TRRU02 is likely due to Havice Creek flowing through a farm pasture and other agricultural land just before it enters Treaster Run, and it flows through the village of Siglerville prior to the farms. On more than one occasion, HACR02, a site on Havice Creek behind the houses in Siglerville, smelled of septic sewage however no investigation was done to determine if the systems were actually malfunctioning.

All of the sample locations that scored "Very Poor" have been negatively influenced by a continuous concentration of waste from ducks, fish, and cows. Sample location TECR02 is located below the duck ponds in Reedsville, sample location ALSP03 is located below a fish hatchery, sample locations SORU01 and LKCR06 are both located below a concentration of farms that pasture their cows along the stream, don't have conservation plans, manure storage structures, roof gutters, concrete barnyards, or other conservation practices that help filter excessive nutrients and prevent erosion. High concentrations of organic nutrients negatively affect water quality and aquatic life. Any area of concentrated, untreated waste will have the same effect. The effects of the duck ponds may have also contributed to the score of "Fair" at site KICR25.

Some stretches of Kish Creek showed improvement in forested areas, however those improvements were offset further downstream when poor quality tributaries joined the creek. For example, only one site south of Federal Highway 322 scored "Good" or better, and that sample location is located along the base of Jack's Mountain where there is a vegetated buffer for a number of miles up stream as well as at the sample location itself. Then the tributary downstream, Coffee Run, scored “Poor” indicating that downstream tributaries to Kish Creek continue to affect water quality due to farming practices.

Waste and chemicals must be prevented from entering the stream. Failing septic systems, animal waste, fertilizer runoff, manure spills, chemical accidents, pesticides, these all impact the aquatic life, which in turn indicates that our water supplies are not healthy. Manure spreaders, chemical sprayers and other equipment should never be washed off, or rinsed in the stream. Farming practices that promote land stewardship do not have to reduce profit margins, and in many causes, actually increase efficiency and profits.

Our water chemistry tests did not look at commercially available chemicals, but we did occasionally measure fecal coliform levels. Fecal coliform levels were highest at sites south of Union Mills. Simazine and Atrazine were found in well water samples collected by USGS in 1996. All forms of pollution decrease the health of the watershed and those living in it including us.

Chemical

Water Chemistry

The chemistry of water is not constant and we have the ability to influence that chemistry. Water is the universal solvent. As it makes its way through the water cycle its chemistry changes. While in the air, water equilibrates with atmospheric gases. While in soils, it undergoes chemical exchanges with inorganic and organic matter and with soil gases. Minerals dissolve in ground water[20]. All along its journey, it changes depending on what it contacts.

Water is the universal solvent. As it makes its way through the water cycle its chemistry changes.

Our sampling demonstrated there are some widespread issues that preclude the use for which the stream has been designated (See Figure 45, pg.113). In many cases, there are some simple solutions, which would positively impact water quality. These solutions will be further explored in the discussion following the results.

Water chemistry was sampled for analysis at each location once a month for one full year from May 2001 to April 2002. Some of the sample locations were also tested sporadically between January 2001 and May 2001 and those results were also included in the analysis. At each location we sampled stream temperature, air temperature, dissolved oxygen, pH, alkalinity, conductivity, nitrate and sulfate. Periodically we sent water samples to a laboratory for analysis of nitrate (NO_3), total phosphorus, sulfate, total suspended solids, and fecal coliform. Although fecal coliform and nitrogen are only listed as a "critical use" for Water Contact Sports (WC) or Potable Water Supply (PWS), the standards do apply to all surface waters. Ammonia-nitrate was analyzed during the last two months of sampling and total coliform was analyzed on only a few occasions.

Sample Locations on Designated HQ-CWF streams

All of the Honey Creek basin, which includes Laurel Creek, Tea Creek, Treaster Run, and the un-named tributaries of these streams, is classified as High Quality- Cold Water Fisheries. The Frog Hollow basin, which includes Alexander Springs is also classified as HQ-CWF (See Figure 13, pg.32). Temperature, dissolved oxygen, pH, and alkalinity results were all compared to the specific water quality criteria for HQ-CWF (See Table 2.1, pg. 28). Two hundred one (49%) of the temperature readings at sample locations with this designation exceeded specific water quality criteria. Eleven (2.6%) dissolved oxygen readings at these sample locations were below the water quality criterion (7mg/L). Seven (1.7%) pH readings at these sample locations were below water quality criteria (6.0-9.0 inclusive). Eighty-one (12%%) of all alkalinity readings at these sample locations were less than 20mg/L, however, this is the natural condition of this stream and is not the result of acid mine drainages or other stressors. Twenty-one (10%) nitrogen readings at these sample locations exceed the PWS criterion (10mg/L) and 39 (62%) fecal coliform results for these sample locations exceeded the fecal coliform criterion (See Table 2.1, pg 28 for specific criteria).

Alexander Springs Sites

Twenty-four (58%) of the temperature readings at the three sample locations exceeded specific water quality criteria. Site ALSP02 was the warmest. Nine (64%) of the temperature readings at this sample location exceeded specific water quality criteria. pH readings for this stream were always within the specific water quality criterion. Four (9%) of the dissolved oxygen readings were below specific water quality criteria. Alkalinity readings were always greater that 140 mg/L Calcium Carbonate ($CaCO3$) signifying that this is a true limestone stream. Eight (66%) of the fecal coliform readings exceeded the criterion and twenty-one (100%) of the nitrate readings exceeded the criterion for drinking water. The average nitrate reading at these three sites was 10.6 mg/L.

Table 2.12 - Summary Water Chemistry Statistics for Alexander Springs

Category	Avg	Max	Min
Air Temp in C	13.571	27.500	0.000
pH	7.564	7.900	7.000
Stream Temp in C	11.341	20.000	3.000
Conductivity (mS)	636.615	743.000	513.000
Alkalinity (mg/L CaCO3)	285.714	340.000	200.000
Dissolved O2 (mg/L)	8.780	11.000	4.000
Nitrate (mg/L)	9.452	11.000	6.000
Sulfate (mg/L)	49.000	49.000	49.000
Nitrate-N (mg/L)	10.524	11.000	10.000
Total Phosphorus	---	---	---
Fecal Coliform (col/100m)	4121.500	21000.000	83.000
Total Suspended Solids mg/L	5.750	7.000	5.000
Ammonia-Nitrogen mg/L	0.500	1.000	0.000

Havice Creek Sites

Twenty-one (61%) of the temperature readings at the three sample locations exceeded specific water quality criteria. All pH readings at our Havice Creek sample locations were between 6.0 and 9.0. Three (9%) dissolved oxygen readings were below 7mg/L. All alkalinity readings were 20mg/L or above. Four (50%) of the fecal coliform readings exceeded the criterion. Our tests on this stream never found nitrogen levels to exceed 10mg/l, a “critical use” for drinking water.

Table 2.13 - Summary Water Chemistry Statistics for Havice Creek

Category	Avg	Max	Min
Air Temp in C	15.103	27.000	-2.000
pH	7.229	9.000	6.200
Stream Temp in C	11.618	26.000	1.000
Conductivity (mS)	192.176	784.000	50.000
Alkalinity (mg/L CaCO3)	88.939	340.000	20.000
Dissolved O2 (mg/L)	10.118	13.000	3.000
Nitrate (mg/L)	0.188	4.000	0.000
Sulfate (mg/L)	49.000	49.000	49.000
Nitrate-N (mg/L)	2.333	5.000	1.000
Total Phosphorus	1.000	1.000	1.000
Total Coliform (col/100m)	202.000	202.000	202.000
Fecal Coliform (col/100m)	6722.250	49000.000	7.000
Total Suspended Solids mg/L	17.400	54.000	5.000

Mainstem Honey Creek Sites

Sixty-five (45%) of the temperature readings at the 11 sites on this stream were above specific water quality criteria. One (0.6%) pH reading was outside specific water quality criterion. One location on Honey Creek, HOCR 03, had a July reading of 8.9, which meets the water quality criterion, but is above the “comfortable” range for mayflies. Three (2%) dissolved oxygen readings on this stream were below the specific water quality criteria. Twenty-three (14%) of all alkalinity readings were less than 20mg/L, however, this is the natural condition of this stream and is not the result of acid mine drainages, or other stressors. Three (9%) of the fecal coliform readings exceeded the criterion. Our tests on this stream never found nitrogen levels to exceed 10mg/l.

Table 2.14 - Summary Water Chemistry Statistics for Mainstem Honey Creek Sites

Category	Avg	Max	Min
Air Temp in C	13.631	32.000	-5.000
pH	7.426	9.000	5.900
Stream Temp in C	10.214	24.000	0.000
Conductivity (mS)	115.771	360.000	36.000
Alkalinity (mg/L CaCO3)	62.823	140.000	10.000
Dissolved O2 (mg/L)	10.616	15.000	6.000
Nitrate (mg/L)	0.188	3.000	0.000
Sulfate (mg/L)	49.000	49.000	49.000
Nitrate-N (mg/L)	0.857	1.000	0.000
Total Coliform (col/100m)	202.000	202.000	202.000
Fecal Coliform (col/100m)	213.778	1300.000	2.000
Total Suspended Solids mg/L	6.000	7.000	5.000
Ammonia-Nitrogen mg/L	---	---	---

Laurel Creek Sites

We had seven sample locations on Laurel Creek. One site, LACR01, was dry the entire length of the study, and LACR02 only had flowing water during the month of April. Dry periods were not included in calculations. Thirty-three (47%) of the temperature readings on this stream exceeded specific water quality criteria. All pH and dissolved oxygen readings were within specific water quality criteria. Seven (10%) Alkalinity readings were less than 20mg/L, however, this is the natural condition of this stream and is not the result of acid mine drainages or other stressors. None of the fecal coliform readings exceeded the criterion. Our tests on this stream never found nitrogen levels to exceed 10mg/l, a "critical use" for drinking water.

Table 2.15 - Summary Water Chemistry Statistics for Laurel Creek

Category	Avg	Max	Min
Air Temp in C	12.800	28.500	0.000
pH	7.287	8.600	6.000
Stream Temp in C	10.050	21.000	0.000
Conductivity (mS)	106.277	178.000	70.000
Alkalinity (mg/L CaCO3)	35.000	60.000	15.000
Dissolved O2 (mg/L)	10.914	15.000	8.000
Nitrate (mg/L)	.1025	8.000	0.000
Sulfate (mg/L)	63.803	201.000	49.000
Nitrate-N (mg/L)	.535	.560	.510
Total Phosphorus	0.220	.220	0.220
Total Coliform (col/100m)	---	---	---
Fecal Coliform (col/100m)	34.652	195.000	1.000
Total Suspended Solids mg/L	8.500	14.000	6.000

Tea Creek Sites

Twenty-two (55%) of the temperature readings at the three sample locations exceeded specific water quality criteria. TECR03, a spring fed site, was the warmest. Ten (83%) of the temperature readings at TECR03 exceeded specific water quality criteria. Winter temperatures at TECR03 were consistently higher than the air temperature, a common occurrence in streams fed by ground water. One (2.5%) pH reading was outside specific water quality criterion. All dissolved oxygen readings were within specific water quality criteria. Only TECR06 had alkalinity readings less than 20mg/L, however, this is the natural condition of this site which is along the ridge in Coopers Gap. Alkalinity readings at TECR02 and TECR03 were consistently greater than 140mg/L, signifying that these are true limestone sites. Eleven (83%) of the fecal coliform readings exceeded the criterion. Site TECR03 exceeded the criterion five out of six times tested. Fecal Coliform results at TECR03 were high, and were the highest in December (8050 col/100ml). Our tests on this stream never found nitrogen levels to exceed 10mg/l, a "critical use" for drinking water.

Table 2.16 - Summary Water Chemistry Statistics for Tea Creek

Category	Avg	Max	Min
Air Temp in C	12.987	27.500	-2.000
pH	7.556	8.300	5.800
Stream Temp in C	11.487	20.000	1.000
Conductivity (mS)	291.769	541.000	26.000
Alkalinity (mg/L CaCO3)	133.205	360.000	10.000
Dissolved O2 (mg/L)	10.500	16.000	7.000
Nitrate (mg/L)	2.028	5.000	0.000
Sulfate (mg/L)	53.649	85.000	49.000
Nitrate-N (mg/L)	3.563	5.000	2.000
Total Phosphorus 0.000	---	---	---
Total Coliform (col/100m)	202.000	202.000	202.000
Fecal Coliform (col/100m)	1936.143	8050.000	1.000
Total Suspended Solids mg/L	20.000	48.000	8.000

Treaster Run Sites

Twenty-seven (39%) of the temperature readings at the six sites exceeded specific water quality criteria. Five (7%) pH readings at the Treaster Run sites did not meet the specific water quality criterion. Each of those readings was on the acidic side of the 6.0-9.0 criterion. No pH readings were below 5.5, but one reading at TRRU 06, located on Treaster Run, was as low as 5.6. One (1.4%) dissolved oxygen reading was below 7mg/L. Twelve (16%) alkalinity readings were less than 20mg/L, however, this is the natural condition of this stream and is not the result of acid mine drainages or other stressors. Thirty-one percent (31%) of the fecal coliform readings exceeded the criterion for swimming areas. Our tests on this stream never found nitrogen levels to exceed 10mg/l, a “critical use” for drinking water.

Table 2.17 - Summary Water Chemistry Statistics for Treaster Run

Category	Avg	Max	Min
Air Temp in C	14.836	29.000	-3.000
pH	7.072	8.300	5.600
Stream Temp in C	10.603	26.000	1.000
Conductivity (mS)	125.366	329.000	20.000
Alkalinity (mg/L CaCO3)	77.437	200.000	10.000
Dissolved O2 (mg/L)	10.343	14.000	4.000
Nitrate (mg/L)	---	---	---
Sulfate (mg/L)	49.000	49.000	49.000
Nitrate-N (mg/L)	1.000	1.000	1.000
Total Coliform (col/100m)	237.750	345.000	202.000
Fecal Coliform (col/100m)	295.100	1300.000	0.000
Total Suspended Solids mg/L	10.000	13.000	7.000

Unnamed Tributary to Tea Creek

Nine (64%) of the temperature readings at this sample location exceeded specific water quality criteria. No other readings were outside of the criteria.

Table 2.18 - Summary Water Chemistry Statistics for Unnamed Tributary to Tea Creek

Category	Avg	Max	Min
Air Temp in C	14.214	26.000	3.000
pH	6.993	8.100	6.100
Stream Temp in C	10.500	21.000	1.000
Conductivity (mS)	94.077	240.000	47.000
Alkalinity (mg/L CaCO3)	45.714	140.000	20.000
Dissolved O2 (mg/L)	9.929	13.000	7.000
Nitrate (mg/L)	---	---	---
Sulfate (mg/L)	49.000	49.000	49.000
Fecal Coliform (col/100m)	25.500	32.000	19.000
Total Suspended Solids mg/L	37.000	69.000	5.000

Sample Locations on Designated CWF streams

All of the Kish Creek basin, which includes Coffee Run, Kishacoquillas Creek, Kings Hollow, Little Kish Creek, Soft Run, and the un-named tributaries of these streams, is classified as Cold Water Fisheries. The Frog Hollow basin, which includes Alexander Springs, is not included in this classification, but is designated HQ-CWF. Temperature, dissolved oxygen, pH, and alkalinity results were all compared to the specific water quality criteria for CWF (See Table 2.1, pg.28). One hundred eighty-five (74%) of the temperature readings at sample locations with this designation exceeded specific water quality criteria. One (0.4%) dissolved oxygen reading at these sample locations was below the water quality criterion (7mg/L). Three (1.2%) pH readings at these sample locations were outside the water quality criterion (6.0-9.0 inclusive). Eight (3.1%) alkalinity readings at these sample locations were less than 20mg/L, however, this is the natural condition of this stream and is not the result of acid mine drainages or other stressors. All the sites met the criterion for nitrogen. Fifty-one (62%) fecal coliform readings exceeded the criterion.

Coffee Run Sites

The sample location on Coffee Run exceeded the criteria range for temperature and pH. Eight (57%) temperature readings were outside of PADEP criteria levels. One pH reading was extremely high with a pH reading of 10.5. All of the other parameters met the “critical use” criteria for CWF.

Table 2.19 - Summary Water Chemistry Statistics for Coffee Run

Category	Avg	Max	Min
Air Temp in C	11.464	22.000	-3.000
pH	8.369	10.500	7.400
Stream Temp in C	11.071	19.000	-1.000
Conductivity (mS)	465.923	520.000	356.000
Alkalinity (mg/L CaCO3)	232.857	300.000	200.000
Dissolved O2 (mg/L)	10.214	13.000	8.000
Nitrate (mg/L)	6.071	8.000	3.000
Sulfate (mg/L)	49.000	49.000	49.000
Nitrate-N (mg/L)	6.857	8.000	6.000
Fecal Coliform (col/100m)	1055.000	2700.000	130.000

Kishacoquillas Creek Sites

Ninty-two (77%) of all of the temperature readings at the 11 sample locations exceeded specific water quality criteria. Three (2.4%) readings at sites along Kish Creek, and one reading along Coffee Run, were above pH 9.0, exceeding the 6.0-9.0 inclusive criterion. In addition to the 4 readings above 9.0, three sites along Kish Creek also had readings above 8.8, the upper limit for mayflies. All dissolved oxygen readings met the criteria. One (0.8%) alkalinity reading was less than 20mg/L, however, this is the natural condition of this stream and is not the result of acid mine drainages or other stressors. Twenty-five (76%) of the fecal coliform readings exceeded the criterion. Four sites, KICR01, KICR02, KICR03, KICR07 exceeded the criterion 100% of the time tested. KICR04 and KICR06 also exceeded the criterion 100% of the time tested, but they were only tested one time. Our tests on this stream never found nitrogen levels to exceed 10mg/l, a “critical use” for drinking water.

Table 2.20 - Summary Water Chemistry Statistics for Kishacoquillas Creek (except KICR25)

Category	Avg	Max	Min
Air Temp in C	15.553	32.500	-4.000
pH	8.033	9.200	6.800
Stream Temp in C	12.368	27.000	0.000
Conductivity (mS)	428.179	596.000	62.000
Alkalinity (mg/L CaCO3)	201.393	260.000	15.000
Dissolved O2 (mg/L)	11.602	19.000	7.000
Nitrate (mg/L)	4.697	7.000	0.000
Sulfate (mg/L)	49.222	68.000	49.000
Nitrate-N (mg/L)	5.672	7.000	2.000
Total Phosphorus	0.136	1.000	0.000
Total Coliform (col/100m)	202.000	202.000	202.000
Fecal Coliform (col/100m)	4362.242	36000.000	0.000
Total Suspended Solids mg/L	41.360	145.000	5.000
Ammonia-Nitrogen mg/L	---	---	---

Kings Hollow Sites

Four (40%) of the temperature readings at this location were outside of the criteria. All pH and dissolved oxygen levels were within the criteria levels set for CWF. Six (60%) alkalinity readings were less than 20mg/L, however, this is the natural condition of this stream and is not the result of acid mine drainages. Nitrogen levels were not detected by the lab in any of the samples sent to them, and fecal coliform levels were all within the criterion.

Table 2.21 - Summary Water Chemistry Statistics for Kings Hollow

Category	Avg	Max	Min
Air Temp in C	15.450	27.500	-2.000
pH	6.520	7.400	5.800
Stream Temp in C	9.200	18.000	1.000
Conductivity (mS)	30.800	47.000	26.000
Alkalinity (mg/L CaCO3)	26.500	60.000	10.000
Dissolved O2 (mg/L)	10.700	14.000	9.000
Nitrate (mg/L)	---	---	---
Sulfate (mg/L)	49.000	49.000	49.000
Fecal Coliform (col/100m)	22.500	60.000	1.000
Total Suspended Solids mg/L	5.000	5.000	5.000
Ammonia-Nitrogen mg/L	---	---	---

Little Kish Creek Sites

Forty-nine (69%) of the temperature readings at the six sample locations exceeded specific water quality criteria. It was interesting to note that nine (75%) of all temperature readings at site LKCR03, a site located within a concrete channel exceeded temperature criteria established for CWF. Even more interesting was that at site LKCR04, a site a bit farther down the stream where the water had flowed a greater distance through the concrete channel exceeded temperature criteria ten (83%) times it was evaluated. All pH readings were within the criterion level set for CWF. One (1.4%) dissolved oxygen reading was outside of the established criterion. All alkalinity readings were greater than 20mg/L. Seventeen (61%) of the fecal coliform readings exceeded the criterion set for this use. Nitrogen levels did not exceed the criterion.

Table 2.22 - Summary Water Chemistry Statistics for Little Kish Creek

Category	Avg	Max	Min
Air Temp in C	15.654	39.000	0.000
pH	7.545	8.400	6.600
Stream Temp in C	12.938	28.000	1.000
Conductivity (mS)	366.569	732.000	128.000
Alkalinity (mg/L CaCO3)	145.758	280.000	35.000
Dissolved O2 (mg/L)	10.250	21.000	4.000
Nitrate (mg/L)	2.862	8.000	0.000
Sulfate (mg/L)	63.803	201.000	49.000
Nitrate-N (mg/L)	3.900	7.000	1.000
Total Phosphorus	0.250	1.000	0.000
Total Coliform (col/100m)	202.000	202.000	202.000
Fecal Coliform (col/100m)	2185.483	22000.000	2.000
Total Suspended Solids mg/L	15.667	46.000	5.000

Soft Run Sites

Twenty-three (79%) of all of the temperature readings at the three sample locations on Soft Run exceeded specific water quality criteria. Both SORU01 and SORU02 exceeded the temperature criteria 16 (80%) times it was evaluated. All pH and dissolved oxygen levels were within the criteria levels set for CWF. Thirteen (55%) fecal coliform readings exceeded the criterion. Site SORU01 had exceptionally high fecal coliform levels, with the highest in January (32,000 col/100ml), and also exceeded the criterion six out of seven times tested. Nitrogen levels did not exceed criterion set for drinking water.

Table 2.23 - Summary Water Chemistry Statistics for Soft Run

Category	Avg	Max	Min
Air Temp in C	16.250	29.000	1.000
pH	7.363	8.400	6.200
Stream Temp in C	12.448	25.000	1.000
Conductivity (mS)	193.367	333.000	70.000
Alkalinity (mg/L CaCO3)	72.333	120.000	25.000
Dissolved O2 (mg/L)	9.931	13.000	6.000
Nitrate (mg/L)	1.148	7.000	0.000
Sulfate (mg/L)	49.567	60.000	49.000
Nitrate-N (mg/L)	1.909	5.000	1.000
Total Phosphorus	---	---	---
Total Coliform (col/100m)	2350.000	2350.000	2350.000
Fecal Coliform (col/100m)	5411.833	32000.000	0.000
Total Suspended Solids mg/L	33.286	80.000	5.000
Ammonia-Nitrogen mg/L	---	---	---

Unnamed Tributary to Kish Creek

This site was dry most of the time, but when it had water in it, it exceeded temperature criteria set for CWF. No other parameters exceeded the criteria set for CWF, PWS and fecal coliform was not tested at this location.

Table 2.24 - Summary Water Chemistry Statistics for Unnamed Tributary to Kish Creek

Category	Avg	Max	Min
Air Temp in C	18.100	29.000	1.000
pH	6.900	6.900	6.900
Stream Temp in C	20.000	20.000	20.000
Conductivity (mS)	108.000	108.000	108.000
Alkalinity (mg/L CaCO3)	30.000	30.000	30.000
Dissolved O2 (mg/L)	8.000	8.000	8.000
Nitrate (mg/L)	---	---	---
Sulfate (mg/L)	49.000	49.000	49.000

Unnamed Tributary to Little Kish Creek

Eight (80%) of the temperature readings at this location exceeded specific water quality criteria. All pH readings were within the criterion range set for CWF. Dissolved oxygen level exceeded the standards one time (10%). Ten percent (10%) of all alkalinity readings were less than 20mg/L, however, this is the natural condition of this stream and is not the result of acid mine drainages or other stressors. Four (67%) of the fecal coliform readings exceeded the criterion. Nitrogen levels did not exceed criterion set for drinking water.

Table 2.25 - Summary Water Chemistry Statistics for Unnamed Tributary to Little Kish Creek

Category	Avg	Max	Min
Air Temp in C	18.222	29.000	1.000
pH	6.910	7.300	6.400
Stream Temp in C	12.100	22.000	1.000
Conductivity (mS)	93.700	180.000	52.000
Alkalinity (mg/L CaCO3)	55.500	80.000	15.000
Dissolved O2 (mg/L)	8.800	14.000	5.000
Nitrate (mg/L)	1.000	3.000	0.000
Sulfate (mg/L)	49.000	49.000	49.000
Nitrate-N (mg/L)	3.000	4.000	2.000
Fecal Coliform (col/100m)	1494.167	3100.000	0.000
Total Suspended Solids mg/L	13.500	17.000	10.000

Sample Locations on Designated TSF streams

Only one sample location was located on a Trout Stocked Fisheries (TSF) designated section of stream. (See Table 2.1, pg. 28 for specific criteria). This designation allows for warmer temperature ranges and has less stringent pH and dissolved oxygen requirements than the other designations in the watershed.

Kishacoquillas Creek

One (6%) temperature reading at this one location exceeded the specific water quality criterion. No other parameters exceeded the criteria.

Table 2.26 - Summary Water Chemistry Statistics for one location on Kishacoquillas Creek (KICR25)

Category	Avg	Max	Min
Air Temp in C	15.255	32.500	-4.000
pH	8.024	9.200	6.800
Stream Temp in C	12.273	27.000	0.000
Conductivity (mS)	413.000	596.000	62.000
Alkalinity (mg/L CaCO3)	193.029	260.000	15.000
Dissolved O2 (mg/L)	11.504	19.000	7.000
Nitrate (mg/L)	4.385	7.200	0.000
Sulfate (mg/L)	57.667	68.000	52.000
Nitrate-N (mg/L)	5.288	7.280	.910
Total Phosphorus	0.270	0.600	0.110
Total Coliform (col/100m)	202.000	202.000	202.000
Fecal Coliform (col/100m)	3581.844	36000.000	4.000
Total Suspended Solids mg/L	39.889	145.000	5.000

Ground Water:

Groundwater is not "pure". As water percolates into the ground, landuses, soil types, and geologic composition heavily impact the waters chemical composition. In a 1996 groundwater study conducted by USGS, 15 wells were tested in Big Valley (See Appendix K, USGS Groundwater Data). They found that the water is very hard (> 180 CaCO3mg/L) meaning it is high in calcium, magnesium, iron, manganese, dissolved solids and nitrate. Of these constituents, only nitrate is a known health risk. Out of the 15 wells tested in the valley, three of them exceeded EPA's drinking water standard of 10 mg/L of Nitrate. In addition, one had a level of 9.9 mg/L and three others had concentrations greater than 5 mg/L. The median nitrate level for all the wells tested was 5.9 mg/L. Concentrations in excess of 10 mg/L nitrate, are known to cause methemoglobinemia, commonly called "blue baby disease" in infants, which often results in death. Methemoglobinemia is caused by blood cells carrying nitrates instead of oxygen[11].

One of the wells tested was know to have been contaminated by a leaking gasoline tank (Well 272). This contamination may account for the elevated iron and manganese levels[11].

USGS also tested groundwater for organic compounds that are commonly used to control weeds (herbicides). Of the seven compounds evaluated during the analysas, two, Simazine and Atrazine were found in the samples. EPA has not established drinking water standards for either of these chemicals[11].

Discussion:

Water chemistry for aquatic organisms is as important as air quality is for terrestrial organisms. Just as your skin may develop a rash, or you may develop breathing problems if the air is polluted, aquatic organisms become sick and may die if the water is polluted. In addition to those sites that did not meet PADEP's chemical water quality standards, we found high levels of fecal coliform in many samples, which indicated that many streams were not be safe for some recreational activities. Signs that our air or water is polluted should be addressed, because they signify an unhealthy change in our environment and ultimately affect our own health. For aquatic organisms, keeping water quality within the ranges of all the criteria is critical, because any deviation from those ranges may cause death to some species.

All of the sample locations experienced stream temperatures in excess of PADEP's listed designated use standards. Dissolved oxygen, pH, nitrogen and fecal coliform also exceeded the criteria set by PADEP for every designated use level except TSF (KICR25). Sample locations that exceeded any criterion range more than 50% of the times sampled were determined to be chemically impaired (See Figure 46, pg.114). Although downstream from several impaired sites, sample location KICR25 was not determined to be impaired because it is classified as TSF, and the criteria for TSF are less stringent than for other designated uses. KICR25 did meet the less stringent TSF water quality criteria.

Fifty-six sites had at least one reading that did not meet the temperature standards in the winter and spring months of November through May. Fifty-one sites had at least one reading that did not meet the standards for these criteria in the summer and fall months of June through October. During the course of the year, fifty-three sites had multiple readings that did not meet the standards for these criteria.

Stream temperature is a crucial factor to stream health for a number of reasons. Temperature governs many biochemical and physiological processes in cold-blooded aquatic organisms. Rapid changes in temperature can cause fish kills, while changes in temperature over the course of a season are handled more easily. Many aquatic organisms can tolerate only a limited range of temperatures. Increased temperatures can increase metabolic and reproductive rates throughout the food chain[20]. Aquatic organisms are subject to increased stress because increases in temperature affect many abiotic chemical processes. Maintaining or restoring normal temperatures is an important goal in restoration.

Temperature governs many biochemical and physiological processes in cold-blooded aquatic organisms. Maintaining or restoring normal temperatures is an important goal in restoration.

Stream temperature is affected by many factors including the temperature of water upstream and the temperature of influent water. Impervious surfaces such as paved surfaces heat surface runoff and increase the temperature of streams that receive that runoff[20]. Direct sunlight on the stream or a decrease in a streams baseflow will also increase the temperature in the stream. In Karst topography, groundwater is a major source of year round stream flow and averages 7 – 16.5 degrees Celsius[11]. The 1996 USGS study found the average temperature to be 12.7 degrees Celsius. In the Kish watershed, impervious surfaces are not a significant land cover and groundwater is the major source of influent water. Therefore we believe that direct sunlight and wider, shallow channels are the primary reasons for increased temperatures. As noted in our habitat results, many of the sites did not have adequate riparian buffers that would provide shade to the stream.

The Kish watershed benefits from a limestone soil base in the valley, but watershed wide testing did highlight areas where pH is a concern. The adults of many species of fish are able to tolerate a wider range of pH, but developing eggs and larvae have a much more narrow tolerance level [24]. When pH decreases below 6.0, important aquatic plants can die, decreasing the food supply. Four sites along ridges, TRRU05, TRRU06, TECR06 and HOCR12 all experienced pH levels below 6.0. Three of these sites were the last sample locations on those streams. Because they all experienced low pH levels, it is expected that the upstream portion is experiencing low pH levels as well.

While our study did not look at heavy metals, the pH of water influences the amount of metals that can dissolve in water. Metals dissolve more readily in more acidic conditions. Pennsylvania experiences some of the most acidic rain in the country. While our soils are not rich in heavy metals, burning certain types of trash and fossil fuels releases heavy metals into the atmosphere. Acid rain, formed when moisture in the clouds mixes with sulfur or nitrogen in the air, carries these heavy metals back to the ground and to receiving streams.

Wildlife Surveys

We conducted bird surveys at 55 of the sample locations during January, February, and the first half of March. Migration patterns beginning in the spring change bird composition, therefore surveys in the winter months identify only winter resident birds. Some of the sites where collected our water data are in close proximity to each other, and were combined for the bird survey. Fifty-five different locations were surveyed. We also surveyed small mammals on two separate occasions at two different farms that had fencing along the stream. One of those farms had a 25 foot average width buffer that had been planted with a variety of vegetation, while the other farm had a 7 foot average width buffer that consisted of reed canary grass.

Birds

We identified 36 different species of birds by vocalization or by sight. All birds that were seen or heard while at that site were recorded, regardless of if they were flying or perched. No single species was present at every sample location.

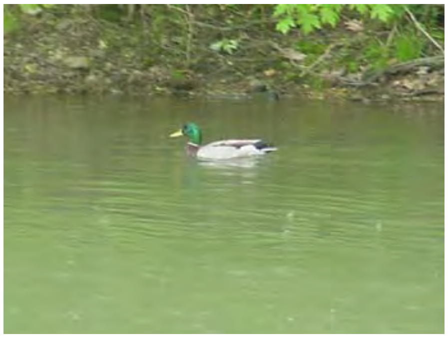


Table 2.27 Summary of the Bird Species surveyed and where they were identified

Bird Species	Number of sites	% of sites
American Crow	33	60%
Blue Jay	30	55%
House Sparrow	27	49%
Black-capped Chicadee	25	45%
Downy Woodpecker	21	38%
White Breasted Nuthatch	20	36%
American Goldfinch	18	33%
Tufted Titmouse	18	33%
White throated Sparrow	18	33%
Red-bellied Woodpecker	15	27%
Northern Cardinal	11	20%
Rock Dove	11	20%
Dark-eyed Junco	10	18%
Hairy Woodpecker	9	16%
Carolina Wren	8	15%
Starling	8	15%
Mallard Duck	7	13%
Northern Flicker	1	2%

Bird Species	Number of sites	% of sites
Song Sparrow	7	13%
Purple Finch	6	11%
Killdeer	5	10%
Golden Crowned Kinglet	4	7%
Mourning Dove	4	7%
Broad Winged Hawk	3	5%
Fish Crow	3	5%
Pileated Woodpecker	3	5%
Red-tailed hawk	3	5%
Rough Legged Hawk	3	5%
Brown Creeper	2	4%
House Wren	2	4%
Mockingbird	2	4%
Snipe	2	4%
Tree Sparrow	2	4%
Winter Wren	2	4%
Belted Kingfisher	1	2%
Yellow Bellied Sapsucker	1	2%

The intersection of Locke Mills Road and Lower Creek Road, where Treaster Run and Havice Creek come together had the highest bird diversity. Twenty-one species of birds were identified at this location. This intersection includes sample locations TRRU02, TRRU03 and HACR01. TECR03, the site of a former PennDot mitigation project, had the second highest diversity with eighteen species identified. This sample location has been fenced and the banks have had vegetation planted along them.

Several sample locations did not have any birds identified at them. These sites include KICR10, LACR05, LACR06, LKCR05, and UNKC01. Additionally, KICR11, LACR01 and SORU03 each had only one species identified. See Appendix M for the complete breakdown of species by sample locations.

Small mammals

Springtime trapping did not yield any success at either site. The temperature at 7:15am was 29 F on 4/3/01, and our conclusion was that it was too cold for small mammals to be active. Trapping in the summer was more successful.

KICR01, the site with the wider vegetated riparian zone had a more diverse plant composition and had a more diverse small mammal population. Five different species of small mammals were identified at KICR01 while only one species was identified at KICR03, which had a vegetated buffer zone of only seven feet. The list of mammals found appears in Table 2.28 below.

The plant composition at KICR01 includes a mix of cool season grasses and 23 different shrubs, trees, and flows planted by the Alliance for the Chesapeake Bay. Additionally, this buffer included a few existing mature trees. The average width of this buffer based on three transects is 25 feet from the streambank. The plant composition at KICR03 is monoculture reed canary grass with one small patch of shrubs.

Table 2.28 Summary of small mammals surveyed during July 2001

Species	KICR01	KICR03
Meadow Vole	3	1
House Mouse	4	
Harvest Mouse	2	
White-footed Mouse	4	
Masked Shrew	2	

Discussion:

Sample locations with a more diverse vegetated buffer, had more diverse wildlife populations. Diversity is important for a variety of reasons. In areas with a diverse plant and animal population, density of each species is usually less than in areas dominated by one species. This is important because although food sources may overlap among species, damage to one single food source is reduced because fewer total animals are consuming it. Native plants and animals are not as destructive as some introduced species and usually do not displace other species as do some introduced species.

Native plants and animals usually are not as destructive as introduced species and usually do not displace other species.

Competition among species is beneficial. When we reduce the number of different animals that can live in an area, we begin to experience widespread damage by whichever species takes their place. Higher diversity means less destruction to crops and buildings.

We were pleased that we did not capture any Norway rats during our small mammal sampling. This may be because Norway rats, a pest species, are not commonly found in tall vegetation, but instead prefer short grass and other areas with good visibility. No trapping was done along unfenced stream banks because we did not want cattle to disturb the traps.

Public Outreach

The Mifflin County Conservation District informed the public about the watershed assessment and its importance through newspaper articles, public meetings, brochures, public displays, educational outreach based on the *Home*A*Syst* book, free well water testing, and a public survey. Approximately one dozen articles were printed in local papers on the efforts the Conservation District was making in the watershed. A brochure was designed (See Appendix C, Kishacoquillas Creek Watershed Assessment Brochure) and mailed to the over 140 residents in the watershed that boarder directly on the creek informing them about the assessment. A letter was included in the mailing inviting them to a public meeting in Belleville to find out more and ask questions. The meeting was also advertised in the paper and through fliers hung in public places, and was well attended. A public display was created and displayed for two weeks at each of the following locations, the Allensville branch of the Mifflin County library, Kish Bank in Belleville, Milroy branch of the Mifflin County library and the duration of the Mifflin County Fair. Four evening workshops to explain and distribute the *Home*A*Syst* book were offered to residents in the watershed. All participants received a free book and free well, or spring water testing. Finally, the Conservation District along with Penn State Cooperative Extension, conducted a public survey regarding the quality of life in the watershed.

As a result of the increase in awareness, a local watershed association, The Kishacoquillas Creek Watershed Association, was formed by concerned citizens to address some of the issues, and preserve some of the qualities found in the watershed. This association provided an additional forum for the Conservation District to continue providing information to the public regarding the assessment findings, ask for input such as values, concerns, visions, and goals, and discuss the issues important to residents of the watershed. Meetings have been advertised in the paper and still continue for those who would like to become involved. If you are interested, contact the Conservation District for more information.

Public Survey

A survey of residents of the Kishacoquillas watershed was conducted between April and May 2002. Questionnaires were mailed to 664 residents randomly selected from Menno, Union, Brown, and Armagh Townships. To assure that each municipality was equally represented, 15% of the population in each of the four townships received a survey. In accordance with established survey procedures, all samples were randomly selected to afford each resident an equal opportunity to respond to the survey.

Of the 664 surveys mailed, 83 were undeliverable due to address change making the actual survey size 581 resident households. A total of 196 (33.7%) usable surveys were returned for analysis. Based on this response rate, and the sampling techniques employed, findings from this survey can be considered representative of the entire population, plus or minus 3.5 percentage points.

The survey included 20 questions that focused on issues of growth and the quality of life within the Kish watershed. Overall the responses were positive and demonstrated that residents enjoy the area in which they live and feel the natural environment plays an important role in their appreciation. Similar surveys have been conducted in other watersheds, yet few have so strongly identified a commitment to natural resources. These commitments are in keeping with a rural lifestyle, and need to be maintained and preserved in order to protect the reasons people choose to live in this area.

- Slightly less than four out of every ten area residents (37%) feel that the area will become more desirable in the next ten years, while 42% think that it will stay about the same. Only 16 percent feel that it will become a less desirable place to live (See Figure 47).

- Almost two out of every three residents (63.3%) feel that “while future growth is inevitable, we

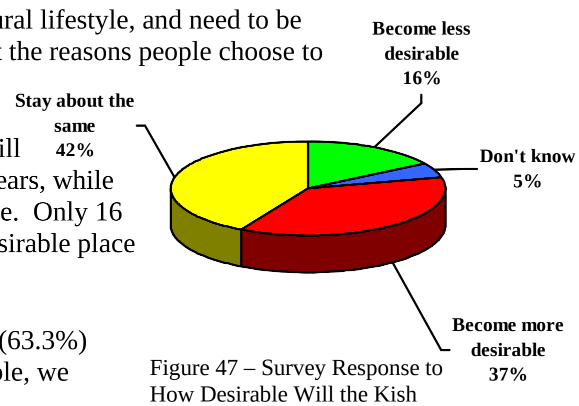


Figure 47 – Survey Response to How Desirable Will the Kish Watershed be as a Place to Live

should plan for it so that it is directed toward areas where its impact will be the least." In addition, one in five (19%) think that growth should "be discouraged wherever possible through the development and enforcement of strong land use controls." Conversely, less than one in ten residents (7.6%) feel that "growth should be encouraged wherever possible with a minimum of land use regulations."

- Most residents also placed a fairly high priority on proactively managing our natural resources and the issues that surround them. "Increasing public awareness of environmental issues"; "Preparing community plans to guide further growth"; and "Using land use controls to guide the quality of future development" were all identified by a majority of residents as high priorities.

- When asked about how best to ensure environmentally responsible behavior, residents chose, by substantial margins, enforcing existing regulations, increasing public education, and providing tax incentives over developing new regulations.

- The issues area residents rated as the severest problems in the watershed include illegal dumping; loss of agricultural land to development; loss of habitat for wildlife and native plants; loss of open space; loss of forest land; recycling service; stream and river pollution; and ground water pollution.

- In a separate question, residents identified the following as the most critical problems facing the area. Loss of farmland to development; agricultural chemical and nutrient runoff; maintaining good water quality; illegal dumping; industrial pollution; maintaining adequate water supplies; and loss of wildlife habitat are viewed by the greatest number of residents as being the most critical issues facing the watershed.

- Issues the most residents feel should be given a high priority in the next five years include protecting farmland and open spaces from development, monitoring the quality of drinking water, improving the quality of streams and lakes, preserving habitats of fish and game animals, preserving woodlands for wildlife and recreational use, strengthening the regulation of mining and drilling operations, and preserving habitats of plants and wildlife for their own sake.

- When residents were asked to name the most important environmental resources in the watershed, the most frequently mentioned include: good streams and rivers; abundant forests and woodlands; agriculture and farmland; open space; abundant wildlife and wild areas; clean air; and scenic beauty.

Some of the interesting points that reflect an appreciation and desire to protect the rural character of the area include the priority given to the problem of illegal dumping, the concern over loss of agricultural land to development, the concern over loss of habitat for wildlife and native plants, the importance placed on abundant forests and woodlands, and the concern for water quality. Knowing what residents value is important in any local decision-making. While the area is currently facing an economic recession and residents are concerned about jobs (also reflected in these survey results), residents clearly stated that quality of life issues, open space, and natural resources are important and need to be preserved.

The Conservation District is hopeful that local governments will be able to use this survey to help them understand what is important to area residents and work to provide solutions to the issues that have been identified. For a full look at the survey results, please see Appendix I.

Discussion:

At a public meeting presenting the results, participants were pleased to see that so many others had identified issues that they themselves had identified as important. One participant was pleased to see that a community organization he belongs to is addressing issues of water, and he was hopeful that those who had identified water as important would learn more about his organization and join. Similar sentiments were expressed in regards to other identified issues as well.

One participant noted that these are just opinions and perceptions. While we agreed this is true, people do make decisions based on those perceptions. If they are inaccurate, then areas for further education have been identified. Based on the comments of participants, it is apparent that many residents are involved and organizations are currently formed and meeting for those who share the same concerns. We hope, their combined voices are being heard.

An additional note about this survey that makes it unique to the Kish Watershed is that this area has a significant Amish population. A survey of this sort gives everyone, including the Amish, the opportunity to provide input using a confidential and anonymous means. Although members of the Amish community may or may not show up at a Township meeting to voice their opinions, their opinions matter. The Amish are a significant part of this watershed, they do have to abide by the county and municipal ordinances and regulations, they do have an impact on the quality of life in the area, and they do provide a lot of services. This survey was able to capture their opinions and reflects their views as well.

Agricultural Best Management Practices

Out of the 112,089 acres in the portion of the Kish watershed that we studied, 32,514 acres (29%) are agricultural. Of those, only 6,935 acres (21%) have “Conservation Plans”

BMP’s have been designed and approved to minimize soil erosion, increase infiltration, and prevent stormwater and wastewater damage.

designed by the Natural Resource Conservation Service establishing conservation Best Management Practices (BMP's).

Conservation Plans are written to assist farmers reduce soil erosion by recommending various BMP's that have been tested out around the country. Soil productivity is an important aspect of farming, and farming practices that increase soil erosion decrease productivity. Of the 176 different identified BMP's, only twenty-one (21) different BMP's are currently identified as recommended in Conservation Plans in the watershed (See Table 2.29 for a list of the BMP acres by practice in the watershed).

The Conservation Practice (CP) recommended for the most acreage is Conservation Crop Rotation (20% of all agricultural acres in the watershed and 95% of acres with Conservation Plans). Contour farming is the second most recommend practice (18% of all agricultural acres in the watershed and 84% of acres with Conservation Plans). Conservation Practices Filter Strip and grassed waterway are currently enrolled on less than one percent (<1%) of all agricultural acres in the watershed and less than one percent (<1%) of acres with Conservation Plans. Conservation Cover and Prescribed Grazing is currently enrolled on less than one percent (<1%) of all agricultural acres in the watershed and one percent (1%) of acres with Conservation Plans.

Table 2.29 Best Management Practices currently in use in the Kishacoquillas watershed.

PRACTICE NAME	UNIT	PRACTICE CODE	TOTAL AMOUNT USED IN KISH WATERSHED	% of ag. acres enrolled in the watershed	% of ag. acres enrolled with Conservation Plans
Conservation Cover	ac.	327	92.5 ac.	<1	1
Conservation Crop Rotation	ac.	328	6603.8 ac.	20	95
Conservation Tillage System	ac.	329	5468.7 ac.	16	79
Contour Farming	ac.	330	5792.9 ac.	18	84
Cover Crop	ac.	340	2572.4 ac.	7	37
Diversion	ft.	362	1265.0 ft.		
Field Border	ft.	386	800.0 ft.		
Filter Strip	ac.	393	6.5 ac.	<1	<1
Grassed Waterway	ac.	412	29.1 ac.	<1	<1
Nutrient Management	ac.	590	4312.4 ac.	13	62
Pasture & Hayland nt	ac.	510	176.0 ac.	<1	2
Prescribed Grazing	ac.	528A	112.0 ac.	<1	1
Residue Management	ac.	344	4836.0 ac.	15	70
Roof Runoff Management	no.	558	2		
Stripcropping Contour	ac.	585	1914.8 ac.	5	28
Stripcropping Field	ac.	586	238.5 ac.	<1	3
Structure for Water Control	no.	587	7		
Subsurface Drain	ft.	606	3335.0 ft.		
Underground Outlet	ft.	620	4.2 ac. 3476 ft.		
Waste Management System	no.	312	2		
Waste Storage Facility	no.	313	4		

Discussion:

BMP's do help and should be encouraged wherever possible. A list of the approximately 129 Natural Resource Conservation Service approved BMP's can be viewed at the http://www.pa.nrcs.usda.gov/techguide/sec4/sec4index.htm website. A select listing of those BMP's can also be found in the Restoration Plan. BMP's have been designed and approved to minimize soil erosion, increase infiltration, and prevent Stormwater and wastewater damage. They are also practices that help farmers be more efficient and therefore save time and money.

If there are only 21 different practices in use, then only 16% of the approved BMP's are being utilized in the watershed. While we are pleased to see so many acres (4836.0 acres) using the Seasonal Residue Management (CP344), it is disappointing to see so few (6.5 acres) Filter strips (CP393). Filter strips are designed to remove sediment, pesticides and fertilizers before they reach waterbodies. It is also disappointing to see that no Conservation Plan recommended No-till Residue Management (CP329A). No-till Residue Management allows a farmer to plant a new crop without plowing the field first, reducing its vulnerability to erosion. No-till planting protects the soil, reduces evaporation by holding moisture, builds organic material back into the soil, and adds additional nutrients.

There are only 800 ft. of Field Border (CP386) planned in the Kish watershed. Field Borders protect the edges of fields from excessive sheet and rill erosion. A field border consists of a strip of perennial vegetation, such as a grass or legume, around the field. Just like a filter strip, field borders trap sediments before they wash onto a road, farm lane, or into a waterbody.

Practices that maintain ground cover such as cover crops, filter strip, field borders, shelter belts, and grassed waterways provide many benefits. These practices utilize nutrients remaining in the root zone following harvest of primary crop thus reducing the transfer of nutrients into the watershed. They reduce erosion, keep the ground cool through shading and reduce evaporation, increase transpiration, reduce the need for chemical fertilizers, and increase income by providing a secondary crop.

Soil erosion is a concern. The erosion hazard for Hagerstown and Murrill soils is moderate to very severe on slopes of more than 3 percent. For agricultural purposes, this loss of topsoil can be especially damaging in Hagerstown soils that have a layer in or below the subsoil that limits root penetration[16]. Erosion is also especially damaging to receiving streams.

We believe that the list above does not accurately reflect the number of BMP's that are currently being used in the watershed. These numbers reflect what is written in current Conservation Plans. Some farmers do not have plans, and others do not have updated plans. Our tally of Conservation Plans did not include plans written before 1987. Farms that do not have Highly Erodable Land (HEL) do not need Conservation Plans. Many Mennonite and Amish farmers do not participate in government programs and

do not have Conservation Plans for their farms; however, many of those farmers do use some of the Best Management Practices.

Many farmers had plans written prior to 1987 and have not had them updated to reflect additional practices they are using. For example, we counted only four waste storage facilities (PC313) written in the Conservation Plans, but the NRCS Technician has worked on 41 waste storage facilities in the watershed. For the past few years, the Chesapeake Bay Technician for the Conservation District and the NRCS Technician have been installing roof runoff management systems and waste storage facilities, however, they are not written in the Conservation Plans, and so they are not reflected here.

Updated plans can be a valuable tool for the farmer and are often a necessary step for additional funding assistance. Many government programs require farms to have Conservation Plans to receive payments. Recently grant money has been available to assist farmers install BMP's. Grants are a competitive funding source. Most grant providers also require various plans such as current Conservation Plans, and nutrient management plans be written before a farm is eligible to receive funding. The Conservation District encourages farmers to update their Conservation Plans, and also discuss those BMP's that are not currently in use on the farm. The goal of the Conservation Plan is to reduce soil erosion, reduce ground and surface water contamination and make the farm more productive, so it is in the farmers best interest to keep it up to date.

Total Maximum Daily Loads (TMDL's)

During the PADEP assessment of the Kish watershed, PADEP biologists found portions of Honey Creek, portions of Kish Creek, Kings Hollow, Little Kish Creek, Havice Creek, to be impaired due to nutrients and siltation and have added these streams to the states 303(d) list of impaired waters (See Figure 12, pg. 31 and Appendix B). For more information on TMDL's, see the Assessment section of this document, or Appendix A for the PADEP fact sheet.

Once a stream is listed on the 303(d) list of impaired waters, action must be taken to meet the water quality standards listed for that stream. Installing BMP's that reduce soil erosion and filter nutrients is one way to begin voluntary efforts. One of the goals of the Mifflin County Conservation District is to assist farmers install BMP's. This is accomplished by meeting with farmers and landowners who are interested in working with the District, providing technical assistance, and where possible, funds to complete projects. Funds are provided to the District by state programs and various grant sources and are available on a limited basis for many different types of BMP's. The District encourages farmers to write a Conservation Plan and establish a list of BMP's. From this Plan, the District can apply for grant funds to assist with the installation of these practices.

Conclusions:

Our results found that only six of the 59 sample locations sampled were not impaired. Almost a quarter (23%) of the habitat scores were "Marginal" or "Poor" (See Figure 34, pg 109). Almost half (48%) of the sites sampled for macroinvertebrates scored "Poor" or "Very Poor" (See Figure 39, pg. 112). Almost half (43%) of the sites exceeded at least one of the designated use criteria more than 50% of the times sampled, and were determined to be chemically impaired (See Figure 46, pg.114). All 21 of the 57 sample locations (37%) that suffered multiple impairments were south of Federal Highway 322 (See Figure 33, pg. 108).

One sample location that was not impaired, KICR25, seemed as if it should be given that multiple impaired streams converge just above this site. KICR25 was not impaired chemically because of the less stringent criteria for the TSF designation. Its habitat score was "optimal" and biologically it scored "Fair".

Our more comprehensive assessment found that a larger percent of the streams in the watershed are not attaining the water quality criteria set by the EPA's CWA (See Assessment) than was originally found by PADEP. Habitat and biological impairments south of Federal Highway 322 were caused by siltation, nutrients from agriculture, lack of vegetated riparian buffers, and lack of habitat. North of Federal Highway 322, the impairments were mostly chemical. Chemical impairments were mostly due to warm stream temperatures, but occasionally were due to low pH. Fecal coliform levels are significant in the whole watershed. Based on our findings, all of the streams in our assessment area should be placed on the state's 303 (d) list of impaired waters for various reasons.